

*Full Length Research Paper*

# Digitizing, preparing application and setting plan by using GPS: A case study from agricultural faculty area of Tekirdag

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Accepted 20 April, 2010

The objective of this study was digitizing and preparing application and setting plan of Tekirdağ Agricultural Faculty Area by using handling type GPS. Three different methods were used in the measurement of application area. These are; 1.) To measure the area and surrounding by using electronic planimeter; 2.) To measure the area by using electronic theodolit; 3.) To measure with GPS, the results of the measurement compared to the deed of real estate value. Electronic planimeter, electronic theodolite and 3 hand type GPS were used. MapSource and Trackmaker software was used to transfer the measurements done with GPS devices to the computer as digitized. ArcGIS 9.0 and ArcView 3D Analyst softwares were used in processing the data transferred into the computer and the three dimensions analyses. The Triangulated Irregular Network (TIN) was used to obtain a three-dimensional view and to determine the slope of the research area on digitized data. The minimum area was 936 703 m<sup>2</sup> from the title deed and the maximum area was 957 434 m<sup>2</sup> from the theodolite measurement. The results of the electronic planimeter and GPS measurements were between 941 000 and 947 000 m<sup>2</sup>.

**Key words:** GPS, electronic theodolit, electronic planimeter, ArcGIS, ArcView 3D analyst.

## INTRODUCTION

Rapid development in computer technologies has led to new dimensions in importance and usage of information. Numerical maps have been created with the aid of computer and a new area has begun in cartography. All applications of numerical maps are included in Geographic Information Systems (GIS). Geographic Information System (GIS) means that numerical maps are transformed to a wise state and therefore positional analysis can be done on it. In the other words, GIS is defined as a system in which geographic topology is described. Application areas of GIS has been increasing parallel to the developments in numerical map technologies, especially, in the selection analysis of suitable place, for a specific purpose selection of a route, studies of farm planning, planning of a city and region and

forestry (Sener and Albut, 2009). The principal of the system is based on modeling in computer together with graphic information of a region. Obtaining numerical maps of the region, relations between the objects on the maps (Topology) are defined and explanatory information of every object is associated with graph. Thus, user can arrange analysis about the region on the model (Turoglu, 2000).

Four factors, namely, data collection, usage, software and hardware are effective in the success of the study connected with GIS. Among these four factors, data collection is the most important to enhance the sensitivity of the study. Considerable part of data collection with GIS is realized by field survey studies. Data collection through survey studies can be done using Global Positioning System (GPS) or Tacometric Measurements (TM). Global Positioning System (GPS) comes to more sensitive and faster conclusion than the other techniques. The biggest advantage of GPS over other techniques is that the measurements are done with the assistance of

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satellites. The matters and points in a area can be easily determined with using of this method. The data obtained by GPS are joined in computer and desirable maps can be easily produced or an available map can be updated easily. Road, soil, forest or topographic maps can also be produced easily (Turoglu, 2000).

## LITERATURE

Although Global Positioning System (GPS) was first designed for military purpose; GPS has taken became indispensable for cartography due to the advantages of it contributions to all areas. GPS is a satellite based methods which provides topographic measurements in cm or m levels depending on the characteristics of measurement techniques. At the same time, fields can be delineated easily and rapidly by GPS (Zavalaa, 1994). Nowadays, numerical data received from LANDSAT, SPOT and IRS satellites are processed through GIS software together with the maps transformed into numerical type and used for these purposes. The maps are checked with survey studies to correct their geographic position. This is done by GPS. Interrogating and joining processes of GIS are used to produce soil maps and thematic maps in the desired scales and details for one or more characteristics on the soil map. When soil survey and mapping processes are done by computer systems, 80% of consumed time for field studies may be saved in comparison to the conventional methods. Moreover, 90% accuracy is possible to achieve depending on the detail of the study (Başayığıt and Dinç, 2001). Colorized Infrared Air Photographs (CIR) developed approximately 40 years ago had been using in observing flora and pastures in natural life. In this method, the images in the air photographs had been corrected with field surveys. In a study, GPS was used successfully in orienting cattle to suitable pasture and therefore, not only the pasture was benefited effectively but also fresh and good quality fodder was supplied to the cattle (Sickel et al., 2003). One of the latest innovation in GPS technology, which has been experiencing a very rapid development since used for the first time, is the Real Time Kinematics (RTK). The RTK has created a revolution in surveying industry by extending the study area limited with polygon and landmark measurements. Used widespread in every field in USA and Europe, it will surely offer many advantages in our country, too.

The selection of a reference landmark in the RTK is vital, because the accuracy of determined coordinates depends on the accuracy of truth in determined of the coordinates with RTK relate to sensibility of selected reference landmark (Aydın et al., 2002). Especially in the last decade, using of the GPS to determine the positions has led to substantial changes in Turkey as has in many other countries. Three dimensions coordinates prepared

rapidly, easily and precisely with the aid of GPS, are widely used to produce large-scale maps and data collected for GIS applications. The latitude and longitude obtained by GPS are usually used either directly or transformed into but ellipsoidal altitudes are not employed in the application. Rodriguez Perez et al. (2007) compares four low-cost GPS receivers, in order to determine the most suitable receiver for position assessment under different forest canopy covers, in terms of ease of use, accuracy, and reliability. Results showed that there were significant differences between the receivers regarding accuracy and precision measuring coordinates. Therefore, practical recommendations for each case were settled in order to help foresters to select the most suitable receiver. Moreover, key forest variables regarding GPS performance were identified, so that forest environments could be effectively clustered by them. For conversion from ellipsoid altitudes to orthometric altitudes used in the applications, accurate geoid altitudes need to be known. At the present, Turkey geoid 1999A is in use in Turkey and studies to calculate a new Turkey geoid are about to be completed. Parallel to the increases in the use of GPS technique, present regulations related to the production of large-scale maps should be changed and must be transformed into a suitable form for GPS applications. Recently prepared draft regulations sketch includes necessary measurement and calculation methods to determine the orthometric latitude besides other applications of GPS. In the draft regulation sketch, four general methods are listed to transform ellipsoid altitude form into orthometric altitude. These methods are directly used of TG99A geoid models, using TG99A geoid model after correction with local GPS or nivelman points, balancing GPS or nivelman point nets taking orthometric altitude differences of base vectors into account and directly used of a local geoid model based on local GPS or nivelman points. In a study, two methods recommended by the draft regulation sketch were applied in the test regions and it was found that TG99A geoid model updated with local GPS or nivelman points or balancing GPS or nivelman point nets technicians produced good results (Kılıçoğlu and Firat, 2004).

## MATERIALS AND METHODS

### Materials

#### *Geographic position of research area*

The campus area of Tekirdag Agricultural Faculty was selected as research area to determine its settlement and application plan using Global Positioning System (GPS) in this research. The area of Tekirdag Agricultural Faculty takes part within Tekirdag city border in Thrace Region and between 40° 59.36' and 40° 59.95' N and 27° 34.65' and 27° 59.48' E (Figure 1). The research area is on Tekirdag-Istanbul D110 international main highway and 7 km off the Tekirdag city center. The size of Tekirdag Agricultural Faculty's

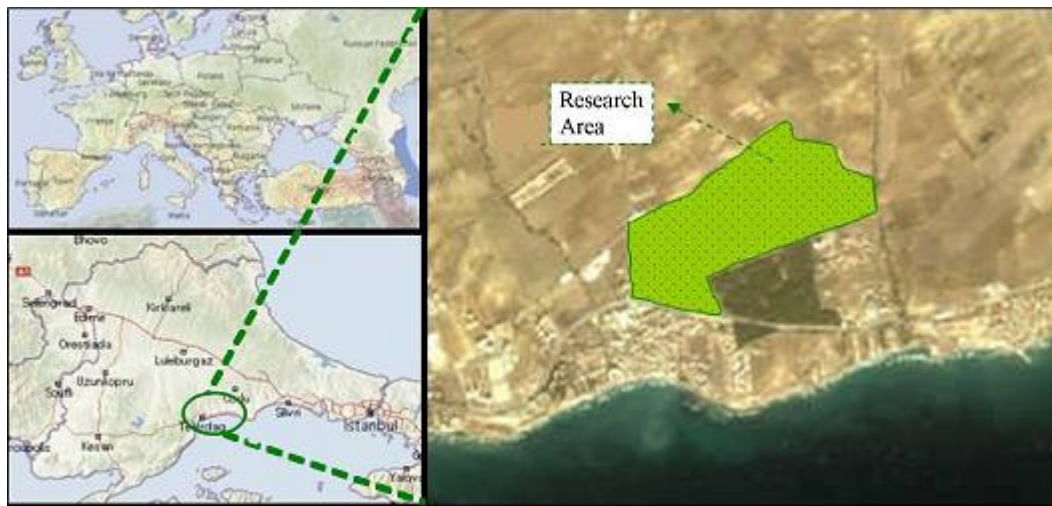


Figure 1. Location of the Tekirdağ agricultural faculty's area.



Figure 2. Electronic theodolite and electronic planimeter.



Figure 3. Global positioning system (GPS) devices.

campus area is approximately 93.7 ha according to the official registrations. A 2/3 part of this area is under cultivation while the rest is used for education and service buildings, dormitory, spore and social establishments and forestation area.

**Instruments, equipment and hardware used**

An electronic theodolite of EP series was used in survey measurement to determine topographic and physical characteristics

of the campus area (Figure 2a). An electronic planimeter was used to determine the size and surrounding length of the campus area on the plan which was drawn using the results of measurements done by electronic theodolite (Figure 2b). Three GPS, (Garmin Etrex Legend and Magellan GPS 315) devices were used to determine coordinates of the campus area (Figure 3). Table 1 shows the technical specifications of the GPS devices. The data obtained from the electronic theodolite were transferred into MSEXCEL program in the computer and necessary computations were done in this program. Data obtained from the GPS devices were transferred into computer by RS-232 adaptor and Trackmaker software was used to work on this data. Then, three dimensional analysis of this data were done in the computer using ArcGIS 9.1 and ArcView 3D Analyst software.

**Methods**

**Survey measurements and computation**

First a closed polygon was formed in the campus area (Albut, 1998; Ayyıldız, 1994; Okuroglu et al., 1993a; Okuroglu et al., 1993b; Yuksel and Albut, 1995). The data of the landmarks in the region was provided from Tekirdag Title Deed and Cadastral Directorship to select the starting point (landmark) near to the campus area before the measurements were started. However because, the four landmarks provided from Tekirdag Title Deed and Cadastral Directorship were lost for unknown reasons, landmark selections were not done. Hence, a corner point in the entrance of the campus was selected as landmark to start to the measurements and they were done with electronic theodolite. Using the digital data from electronic theodolite, horizontal and vertical distances were calculated with following equations (Albut, 1998; Ayyıldız, 1994; Okuroglu et al., 1993a; Okuroglu et al., 1993b, Yuksel and Albut, 1995).

$$E = 100 * L * \sin^2 Z \quad (1)$$

$$h = \frac{1}{2} * 100 * L * \sin^2 Z \quad (2)$$

**Table 1.** Technical specifications of the GPS devices.

GPS models	Company	No. waypoints	of Routes/ legs	Trackpoints	Basemap	Add. map options	Dimens. (cm)	Battery life	Compass barometer	and
GPS-315	Magellan	100	1/10	N/A	N/A	N/A	15.7 x 5.1 x 3.3	20h/2AA	N/A	
Etrex legent	Garmin	500	20/50	2048	Worldwide city database	MapSource Pts of Interest CD	11.1 x 5.1 x 3.3	20h/2AA	N/A	

Where;

E: Horizontal Distance (m),  
 h: Vertical Distance (m),  
 L: Difference between Mira values (m), and  
 Z: Zenith angle (grad)

The height differences between the two points were then calculated from equations (Albut, 1998; Ayyıldız, 1994; Okuroglu et al., 1993a; Okuroglu et al., 1993b; Yuksel and Albut, 1995).

$$H = h + a - m \quad (Z < 100^g) \tag{3}$$

$$H = h + m - a \quad (Z > 100^g) \tag{4}$$

Where;

H: Height difference between two points (m)  
 h: Vertical distance (m),  
 a: Height of the optic axis of the theodolite (m), and  
 m: Middle stadia hair value in the mira (m).

Having computed the horizontal distance and height differences between the points topographic angles, bearing angles and X, Y coordinates of the mira points in the campus area were calculated with following equations (Albut 1998; Okuroglu et al. 1993b).

$$\beta_{ic} = (n - 2) * 200^g \tag{5}$$

$$\alpha_1 = \alpha_0 + \beta \mp 200^g \tag{6}$$

$$Y_1 = Y_b + S * \sin \alpha \tag{7}$$

$$X_1 = X_b + S * \cos \alpha \tag{8}$$

Where;

$\beta$  and  $\beta_{in}$ : Topographic angles (grad),  
 n: Number of the points,  
 $\alpha_1$  and  $\alpha_0$ : Bearing angles (grad),  
 $Y_1$  and  $Y_b$ : Ordinates of the points,  
 $X_1$  and  $X_b$ : Abscissas of the points, and  
 S: Distance between the points (m).

Size of the campus area was determined by Gauss Area equations (9) with the aid of coordinates determined from the equations (Okuroglu et al., 1993b).

Gauss area equation:

$$2A = X_1(Y_2 - Y_n) + X_2(Y_3 - Y_1) + X_3(Y_4 - Y_2) + \dots + X_n(Y_1 - Y_{n-1}) \tag{9}$$

After providing a 1/5000-scale map of the research area from Tekirdag Title Deed and Cadastral Directorship, distance and area measurements were done on this map by the electronic planimeter as three replications (Albut, 1998; Ayyıldız, 1994; Okuroglu et al. 1993, Okuroglu et al. 1993b; Yuksel and Albut, 1995).

**Global positioning system (GPS) measurements and digitizing**

Three GPS devices did the measurements in Tekirdag Agricultural Faculty's area. In these measurements, the corner point in the entrance of the campus was selected as a landmark as was in electronic theodolite's measurements. The reason for using three GPS devices at the same time was to decrease possible errors resulting from usage and device during the measurements to minimum and data from these three devices were presented together

on the same figure.

The measurements done with GPS devices were transferred to computer as digitized by Map Source and Trackmaker software's. ArcGIS 9.0 and ArcView 3D Analyst software's were used in processing the data transferred into the computer and three dimensions analyses (ESRI, 2004). The Triangulated Irregular Network (TIN) command in AcrGIS was used to obtain a three dimensional view and to determine the slope of the research area on digitized data. The principle of the TIN model is a structure arising from point, line and area between itself of each height value transferred from GPS and other neighboring data (Zeiler, 1999).

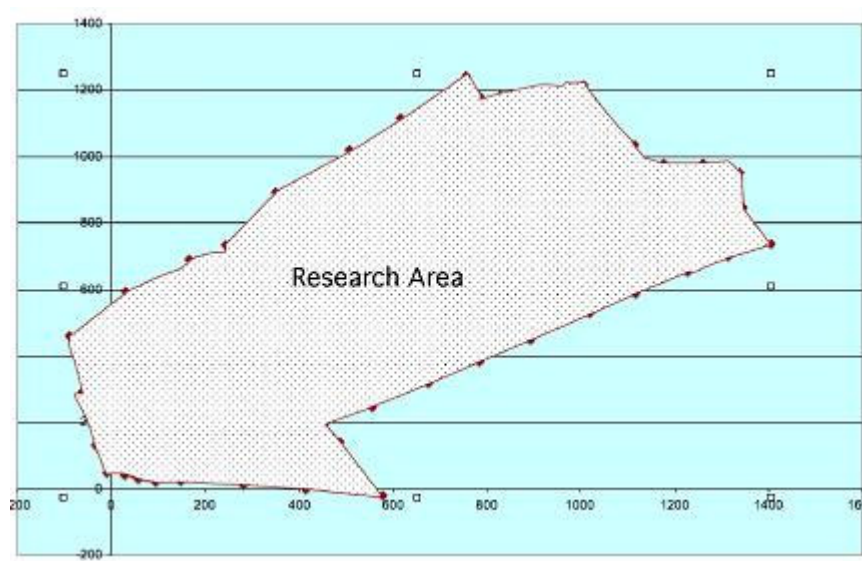
**RESULT AND DISCUSION**

The total of the campus area was calculated as 936 703 m<sup>2</sup> from 32 title deeds arranged by Tekirdag Title Deed and Cadastral Directorship. The size and surrounding length of the area calculated from the electronic theodolite, GPS and electronic planimeter measurements on 1/5000 plot were compared each other in Table 2. The size and surrounding length of the campus area are calculated from title deed and the measurement methods were different. The minimum area was 936 703 m<sup>2</sup> from title deed and the maximum area was 957 434 m<sup>2</sup> from theodolite measurement.

The result of the electronic planimeter and GPS measurements were between 941 000 m<sup>2</sup> and 947 000 m<sup>2</sup>. It is difficult which method was the most reliable since there was not any reference point in the campus area. The same condition is true for surrounding length of the area calculated

**Table 2.** Size and surrounding length of the campus area.

Methods	Area (m <sup>2</sup> )	Surrounding length (m)
Title deed	936 703.00	-
Electronic theodolite	957 434.49	4 458.62
Electronic planimeter	942 515.00	4 724.14
<b>GPS</b>		
Garmin Etrex legend -1	946 000.00	4 480.00
Garmin Etrex legend -2	947 000.00	4 530.00
Magellan – 315	941 000.00	4 290.00

**Figure 4.** The campus area obtained by theodolite calculations.

by different methods. The same results were found by other researchers. Wei et al. (2007) noted that the area surveying precision of GPS in forest sub compartment was compared compass referenced with total station instrument. The result showed that the precision of compass was excelled that of handset GPS in a small area. The error of GPS was less than that of the compass in large area. Crown density distinctively influenced the area surveying with GPS in forest, shrubby and woodland and the error was increased with crown density.

### Theodolite measurement

The research results measured by electronic theodolite and a map of research area prepared using calculated coordinate values of the polygons were presented in Figure 4.

### GPS measurements

The data obtained by three GPS devices were first transferred into the computer by Map Source and Trackmaker software's (Figure 5). Data from GPS transferred into the computer were transferred to ArcGIS format to do three dimensional analyses (3D Analyst) with Map Source and Trackmaker software's and these data were analyzed by 3D Analyst an assistant software in ArcGIS.

First of all, the points outside of the campus area were cleaned (Figure 6). Then, three dimensional view of the research area was obtained with the assistance of "Create TIN" command in 3D Analyst software (Figure 7). A 5 m counter lines were drawn by ArcGIS on the same image (Figure 8). As a result, size, surrounding length and topographic structure of the Tekirdag Agricultural Faculty's campus area were investigated by measurements done with electronic theodolite, electronic planimeter and

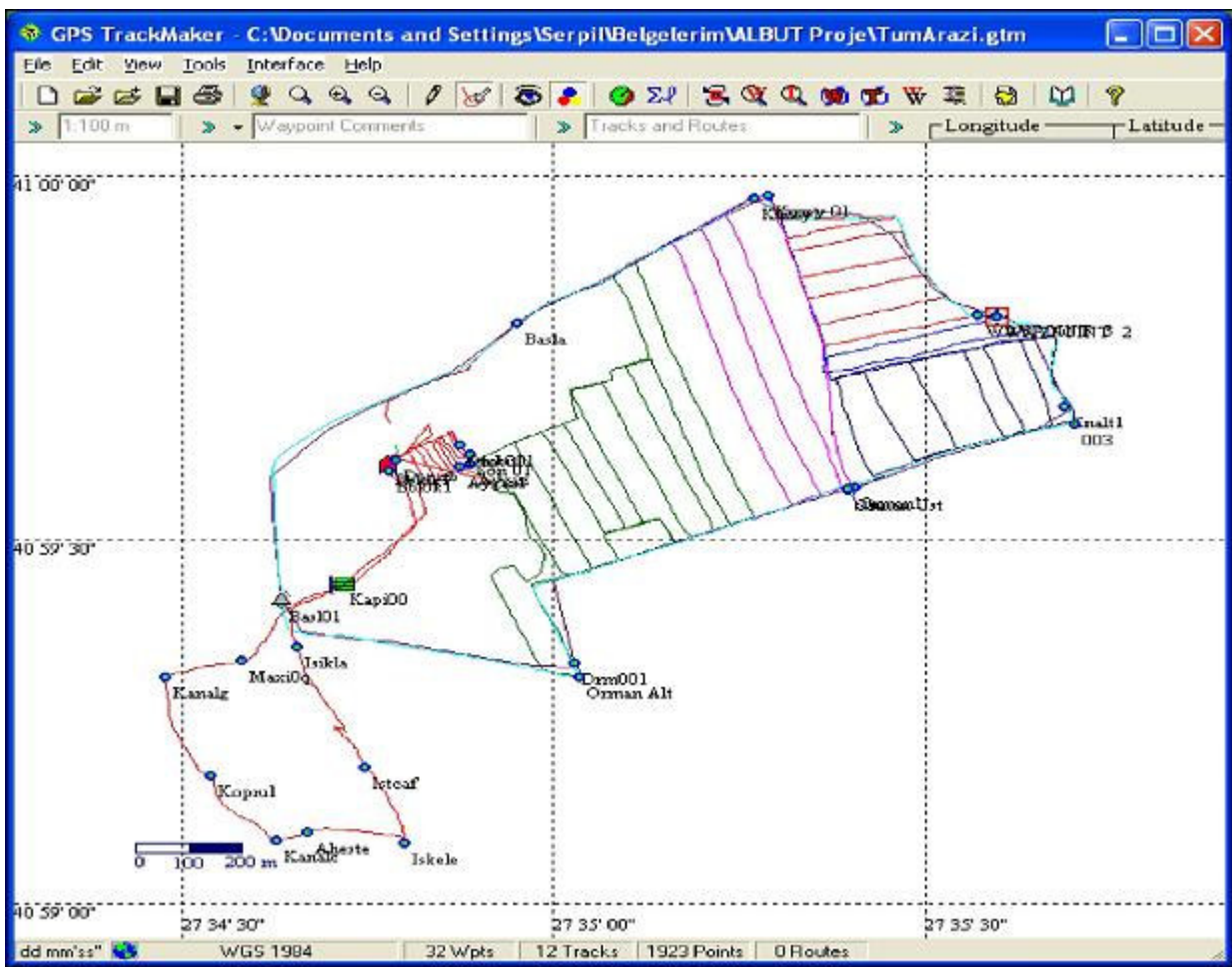


Figure 5. Transferring GPS data into the computer.

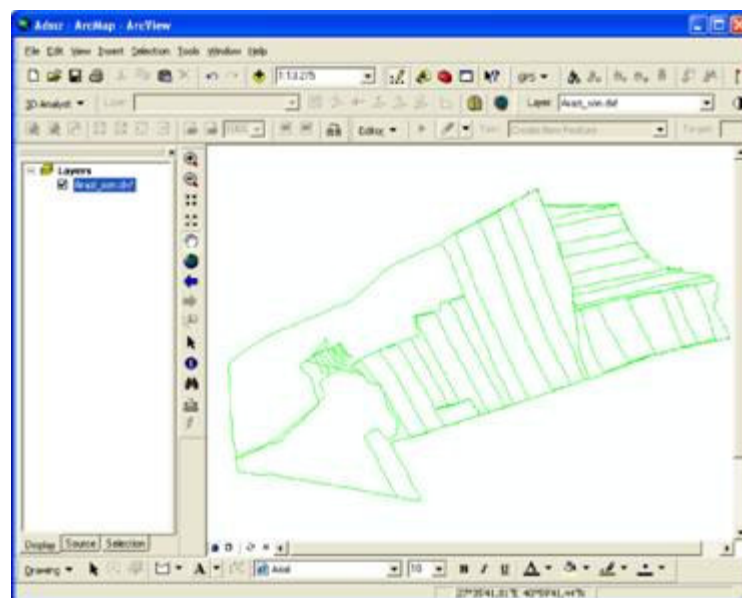


Figure 6. Arranging the research area with ArcGIS.

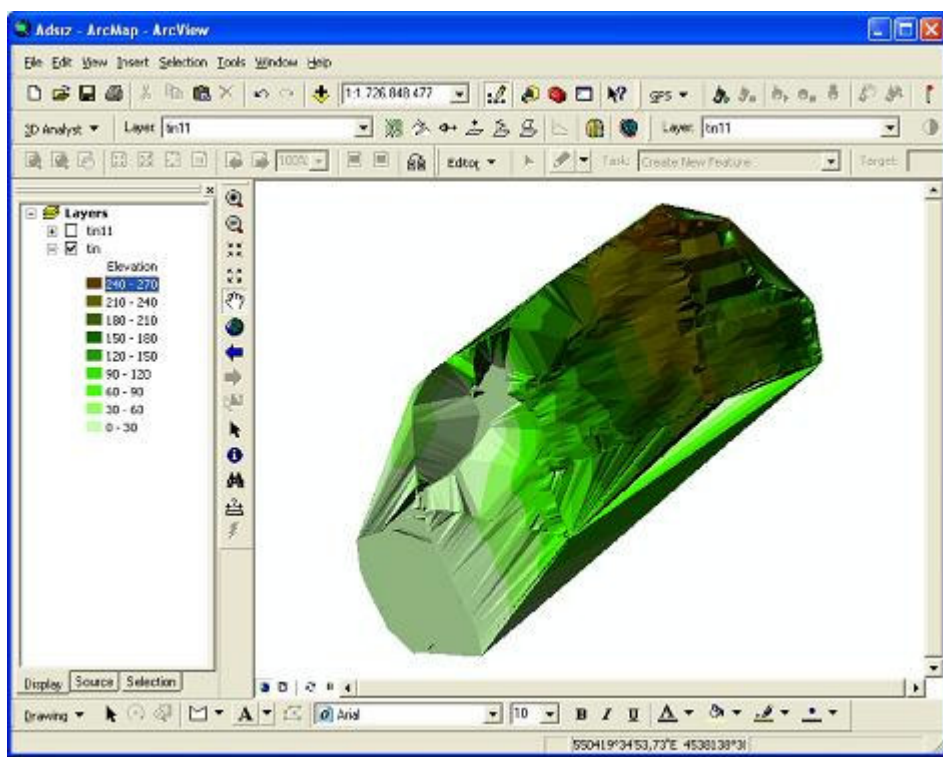


Figure 7. Triangulated irregular network (TIN) vision of the research area.

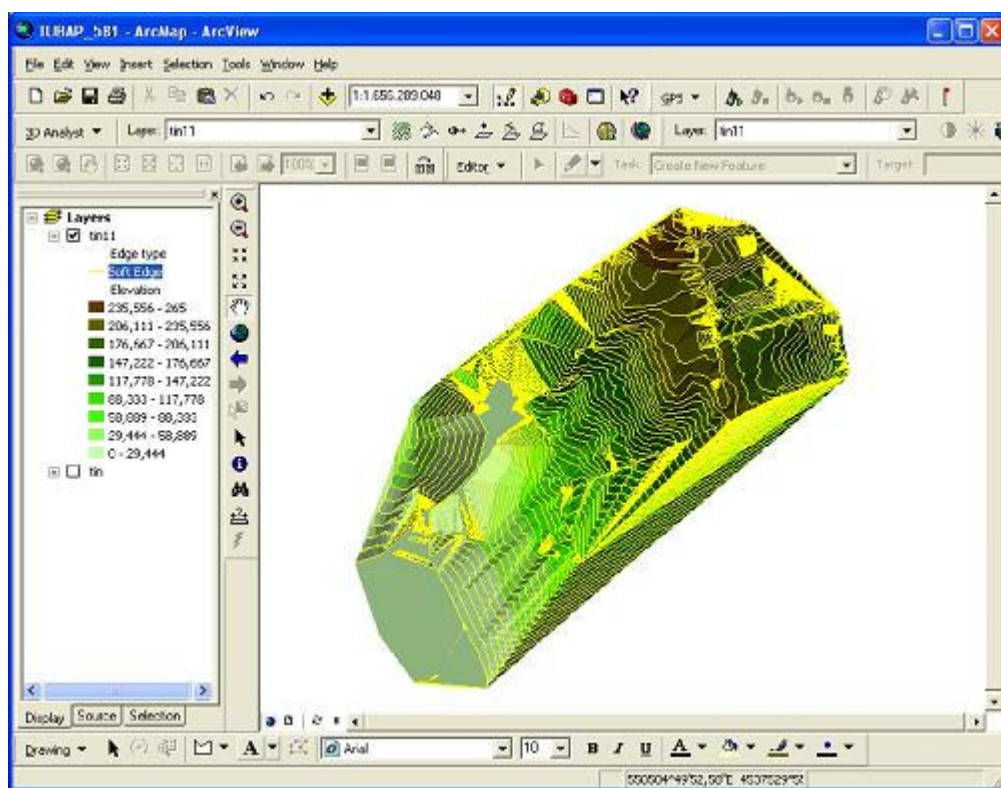


Figure 8. Drawing of the 5 m spaced leveling curves on the 3D vision.

GPS and by digitizing of these data in the computer. Although instruments and methods produced different results from each other and among themselves GPS may be used in similar studies as a simple when compared to the other methods and reasonably reliable method since there is not much difference between the data obtained.

## ACKNOWLEDGEMENT

This project was supported by Trakya University Scientific Research Project Commission. Project number is 581.

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