THE COST ANALYSIS OF SATELLITE IMAGES FOR USING IN GIS BY THE PERT

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ABSTRACT:

The method of collecting, saving, storing of geographical information with and without a location on the earth, the other data related to these information, and to get the result in the quickest way by means of analyzing them through a security can be managed by Geographical Information System (GIS).

The important one of the basic elements of Geographical Information System comes firstly DATA. In collecting data there are various methods of them, GPS or classical measurement, Aerial Photographs, Satellite Images and Digitizing of Map and Documentary are the principle methods. The cost calculation of the provision of satellite images by evaluating through Image Processing is a determinant critical point in the selecting of the method of data collection up to the stage of using them as a cadastral map for the Geographical Information System.

In this study, in selecting of Satellite Images that is one of the methods of collecting data in order to be cadastral map for the Geographical Information System, the result of cost analysis carried out by the Method of Program Evaluation and Review Techniques (PERT) will be introduced.

1. INTRODUCTION

The Geographic Information System (GIS) is a relatively new technology that joins the computer science advantages with the modern systems of capture of data so that it will allow the integration and the treatment of all types of information of a computer team, in a simple way on the part of any user that requires to work with this information(Duran and Toz, 2002).

A working GIS integrates five key components: hardware, software, data, people, and methods.

That the data are correct, actual and reliable constitutes 80% of the basis. This percentage shows how important selecting of data collecting methods are.

In GIS data have been obtained from different resources by using software, hardware and technology (Figure 1).

Since geographical data cover a huge place, collecting and evaluating of data are both expensive and time consuming (Magure et.al., 1991).
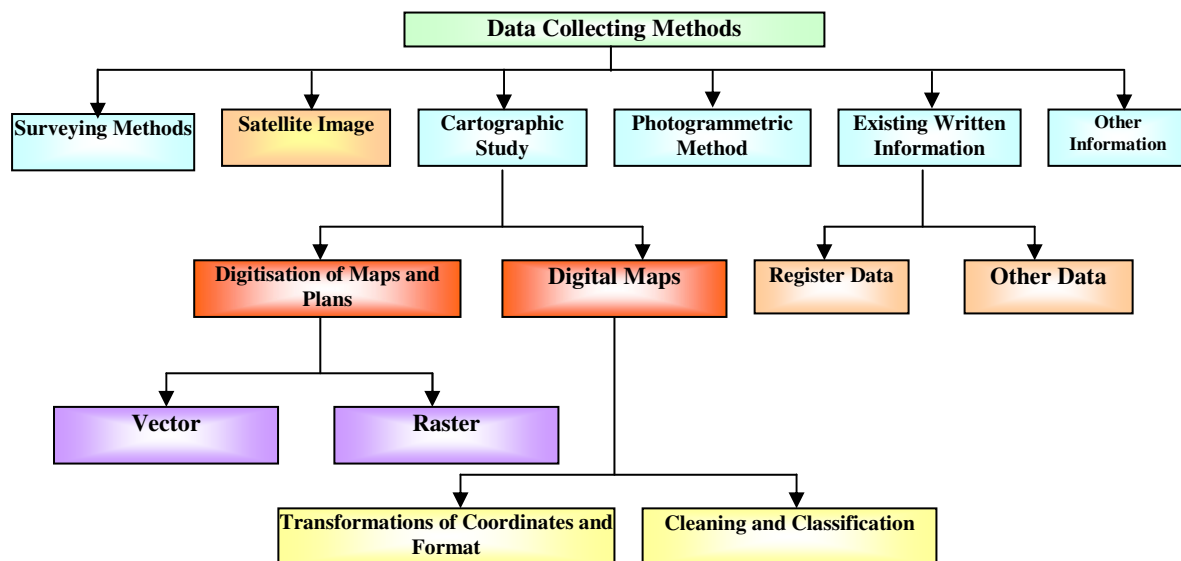

Figure 1. Methods of collecting data in GIS

Satellite image is the easies way to obtain geographic information. Generally, average cost of a raw satellite image is approximately one dollar for each sq km. The important point here is whether the data which are obtained from satellite image will give required accuracy in GIS or not.

The strong improvement in space-borne data and consequently in the reference scale, can be evaluated by considering the following features:

- from 1 (Ikonos) to 0,61 m (Quick Bird) of panchromatic resolution at nadir
- from 4 (Ikonos) to 2,44 m (Quick Bird) of multi-spectral resolution at nadir
- simultaneous panchromatic and multi-spectral acquisitions
- radiometric range of 11 bits (2048 levels of grey) instead of the usual 8
- panchromatic band ranging from blue to near infrared

The two last characteristics in particular enable, through a proper spectral and radiometric enhancement (vs. analogical air photos e.g.), to reach a better contrast, visibility and information content and then a better target distinction (Rossi, 2003).

2. GEOGRAPHIC INFORMATION SYSTEM AND SATELLITE IMAGE

Aerial photographs and data of satellite image are the most important resources to provide data of GIS in both Photogrammetry and remote sensing(Onder, 2003).

According to international resources, total cost of data collecting and processing are 65% of total cost. This shows how important is data Figure 2 (Kokturk, 2003).
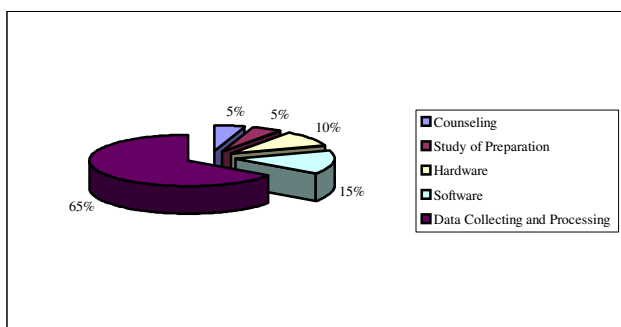

Figure 2. Cost shares by component of GIS

Satellite image involves actual information such as aerial photos. At the beginning, although satellite images have usually been used for producing the maps of 1/50000 and 1/100000, today can be used for producing the maps of 1/25000 and 1/5000. Additionally in GIS setting they have been used as a data resource, which aims at planning (Figure 3).

In this study, high resolution IKONOS satellite image, which can be used in GIS, has been selected and planning have been done in accordance with this.

High resolution satellite imagery on the wide area can be achieved more repeatedly and economically compared to the aerial photos (Jeong et al., 2003).
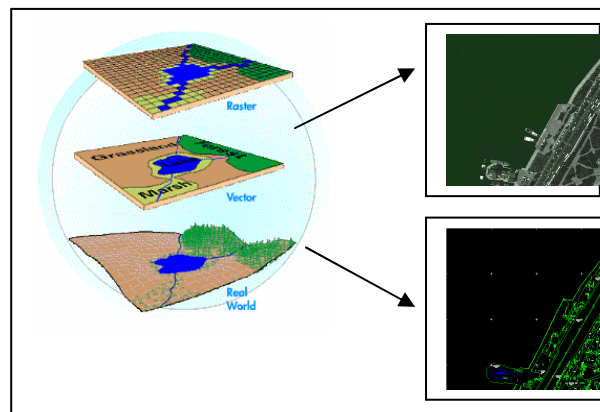

Figure 3. Using of satellite image in GIS

As primary future users of image data from 1m satellites, the photogrammetric mapping and GIS communities have shown considerable interest in this new technology (Froser, 1999).

Though the production of topographic maps from satellite image data is basically very similar, it was ignored by the cartographic community for a long time. It is of course obvious that the use of satellite remote sensing for the production and revision of maps is only of interest if the data can be extracted with the appropriate accuracy, completeness and reliability. This however has to be examined. It is reasonable for related investigations to study the two major elements of topography, i.e. planimetric mapping and the height measurements, separately (Albertz and Wiedeman, 2003).

In a study, it shows that IKONOS imageries can only supply the data for a preliminary or provisional revision of 1:5000 scale topographic maps or for the rapid but incomplete revision of existing maps at this scale. Regarding the tests carried out in this project the IKONOS data seem to be rather deficient in providing the complete details required for the production of a final edition of a 1:5000 scale map or for the comprehensive revision of an existing published map at this scale. These deficiencies are particularly apparent with regard to the buildings and small man-made structures. In order to overcome these deficiencies, which could be as high as 25% of the total map content in urban areas, a complementary fieldwork is necessary. The overall evaluation, by taking both geometric stability and the information content of the image, seems to indicate the feasibility of a complete map revision process for the scale of 1/10000 using IKONOS Geo-panchromatic images (Samadzadegan et.al,2003).

3. CPM-PERT METHOD

Managers can easily estimate total completion time and finishing time of any projects by means of CPM-PERT method. Its essential aim is to ease the project planning and its control, to determine and to remove the free time in the project and to help to complete the project on planned time. The method has been developed considering those unexpected conditions such as bad weather, health and etc. while doing time estimations and computing total project time (Ozsu 1986). This method is also used in the cases of when the exact time of the project activities are not known or depend on some guesses (Tekin 1992).

3.1. CPM-PERT Cost and Time Analysis

PERT cost technique has two major aims. As first it provides to make reasonable cost estimations to complete the project with minimum cost in shortest time. As second, it helps to maintain project planning and its control. Then, PERT cost extraction technique, comparing the activities in the project according to time and cost, completes them with minimum cost in shortest time. The costs used in this method are direct costs.

Activities and events are shown as those in Figure 4 for any project (Biyik and Uzun, 1992). Lengths of the arrows are not important, but their direction. They show progress of the project.
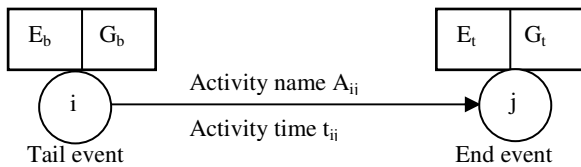

Figure 4. Starting and finishing times of a project in CPM-PERT method

Critical way is accepted as the way that needs longest time, which is the time accumulated between starting and finishing points.

In CPM technique, five types of time computations are done. They are early starting, early finishing, late starting, late finishing and free time computation processes.

Early starting time (E_b) is earliest starting time of an activity and the activity waits until the finishing time of previous activity.

Early finishing time (E_t) is computed adding activity time (t_{ij}) to early starting time (E_b).

$$E_t = E_b + t_{ij} \tag{1}$$

Late starting time (G_b) is computed subtracting activity time (t_{ij}) from late finishing time.

$$G_b = G_t - t_{ij} \tag{2}$$

Late finishing time (G_t) is computed going backward from finish point in PERT diagram. In some cases, it is possible to go to the event point of the same activity by multipath starting from end point of the diagram. Here, the shortest computed times gives the late finishing time (Uzel, 1986).

Activities in a project can be divided in two groups as critical and uncritical. Uncritical activities are the activities that do not change total time of the project if they are finished in loose time intervals fount out for them from CPM-PERT diagram. Such activities are also called as activities of loose time.

In CPM-PERT method, six essential procedures must be followed in order for any project planning and its control. They are as followings:
- Determination of project and project activities,
- Determining how the activities follow one another and forming relations between them,
- Drawing a diagram shown the relations between the activities,
- Time and cost estimation for every activities,
- Drawing the critical way on the diagram that has the longest time,
- Carrying out planning, programming and controlling procedures by means of the diagram.

3.2. Estimate Activity Times of PERT

A distinguishing feature of PERT is its ability to deal with uncertainty in activity completion times. For each activity, the model usually includes three time estimates (www.netMBA.com):
- Optimistic time (t_a) : generally the shortest time in which the activity can be completed. It is common practice to specify optimistic times to be three standard deviations from the mean so that there is approximately a 1% chance that the activity will be completed within the optimistic time.
- Most likely time (t_m) : the completion time having the highest probability. Note that this time is different from the expected time.
- Pessimistic time (t_b) : the longest time that an activity might require. Three standard deviations from the mean are commonly used for the pessimistic time.

PERT assumes a beta probability distribution for the time estimates. For a beta distribution, the expected time for each activity can be approximated using the following weighted average:

$$\text{Expected time } (t_e) = (t_a + 4t_m + t_b) / 6 \tag{3}$$

This expected time may be displayed on the network diagram.
To calculate the variance for each activity completion time, if three standard deviation times were selected for the optimistic times, then three are six standard deviations between them, so the variance is given by:

$$\sigma_{te} = (t_b - t_a)/6$$
$$\sigma_{te}^2 = [(t_b - t_a) / 6]^2 \tag{4}$$
$$R = (P_t - t_e) / \sigma$$

Where;
σ_{te} = standard deviation
σ_{te}^2 = variance
R= Standardized deviation
P_t = programmed finishing time

As the variation t_e of the activity rises, the possibility of finishing reduces in estimated time. As the difference between optimistic time and pessimistic time rises, the differences between variation and standard deviation rises as well.

4. PLANNING AND ANALYSING ACTIVITIES OF SATELLITE IMAGE PROCESSING

Algorithm showing the evaluating and processing of raw satellite image which was recorded in GIS is shown in Figure 5 (www.gis.tagem.gov.tr).
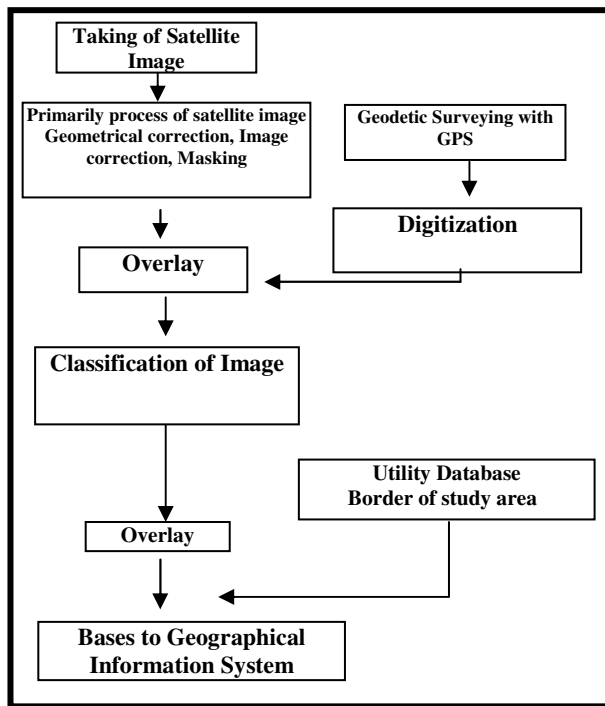
Figure 5. Steps of image processing

5. CASE STUDY

Project area; the settlement of Konya Municipality has been chosen. The borders are 50 km between South and North, and 40 km between East and West. Distribution of 75 triangulation points planned in the case study has been given in Figure 6.
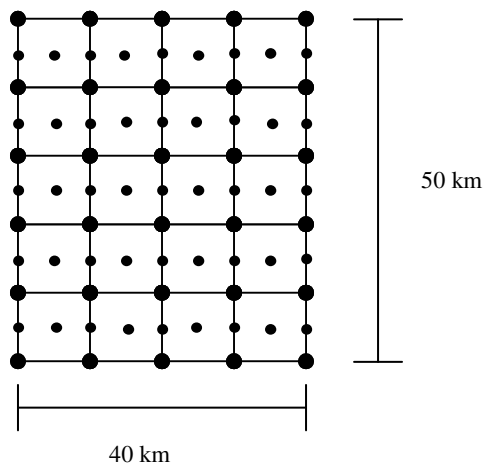

40 km

Figure 6. Distribution of triangulation points

In order to evaluate the satellite image, although 15 triangulation points are sufficient for accuracy here, 75 triangulation points are given for us to complete the increasing distribution of triangulation point which are necessary for the geodetic study (Cadastre, Plan application).

In land study Magellan hand GPS and Leica GPS instrument have been planned. The survey will be carried out in that way: While stationary receiver have occupied a station for an observation section, the other one or two receivers will visit to the other points for a half hour. The observations will be processed in SKI software.

Satellite image will be obtained from IKONOS satellite. Erdas imagine software will be used in rectification procedures.

5.1 Main activities and their time estimations:

Main activities, optimistic times (ta), most likely times (tm), pessimistic times (tb) and expected times (te) of activities and total cost of case study are presented in Table 1.

Drawing the PERT diagram:

Procedures in order must be carried as followings to draw PERT diagram.
- Relations between activities must be shown,
- Determining event number for every activity, and
- Drawing the PERT diagram according to event numbers (Figure 7).

5.2. Total Cost Calculations For project and Its Activities

Total cost of the activities were calculated with respect to the unit prices defined by the Turkish Chamber of Surveying Engineers for the first half of 2003 and given in Table 1. The price of a GPS set with **three** receiver on work for 1 hour:

The price of a GPS set of **three** receivers and
their assessors   (A)   : 39,000 $
Annual working time   : 960 hours,
Time of Amortisation   : 5 years,
Cost of Amortisation:
20/960x1/100*A=0.00020833A   : 8,12487 $
Instalment and service tax : % 14.4
                              :14.4/960x1/100xA=0.00015A:5,85$
Service and maintenance:
 1/ 960 x 1 / 100xA= 0.0000104 A   :   0,4056$
                                                        Total: 14,38047 $

The price of the same GPS set on work for1 day(6 rs):86,28282$

According to the unit prices of the first half the year of 2003 for the maps and plans subject to registration and endorsement determined by the Chamber of Surveying Engineers.

According to the classical method, cost of 200 000 ha mapping is 29 932 000 $. (1 ha = 149,66 $) and time duration of the project is 10 mounts with 10 group.

Estimate of finishing project in programmed time :
P_t= 90 days (estimated)
T_e= 70 days (calculated).
σ = 9.98 (Table 1)

$R= (P_t-t_e) / \sigma = (90 - 70) / 9.98 = 2$

To table of normal distribution the value of R= 2 is 0,977250. To this result the project can be finished in 90 days by 97% estimate.

Number	Symbol	Activities	ta	tm	tb	σ	σ²	te	Producer	Daily cost ($)	Total cost ($)	Final cost ($)
1	A1	Determination of project area	1	1	1	*0*	*0*	**1**	Concerning unit	-	-	-
2	A2	Obtaining of the 1/25000 and 1/100000 maps	1	2	3	*0,33*	*0,11*	**2**	1 Surveying Engineer	63	126	126
3	A3	Reconnaisance of triangulation point and measuring of the coordinates from the maps on 1/25000 scaled maps	1	2	3	*0,33*	*0,11*	**2**	1 Surveying Engineer 2 Surveying Technician	63 42	126 168	294
4	B1	Finding of the triangulation points with GPS in working area	3	6	9	*1*	*1*	**6**	1 Surveying Engineer 2 Surveying Technician 1 Vehicle	63 42 30	378 504 180	1062
5	B2	Construction and sketching of triangulation point and Painting of the control points	10	15	20	*1,67*	*2,78*	**15**	1 Surveying Engineer 2 Surveying Technician 1 Vehicle	63 42 30	945 1260 450	2655
6	B3	GPS Surveying and Coordinate Calculations (For 75 Points)	10	15	20	*1,67*	*2,78*	**15**	2 Surveying Engineer 2 Surveying Technician 3 GPS receivers 2 Vehicle	63 42 86 30	1890 1260 1290 900	5340
7	C1	Interview with the companies for obtaining of the IKONOS Satellite İmage of 40km*50km area	2	5	7	*0,83*	*0,69*	**5**	2 Surveying Engineer	63	630	630
8	C2	Fixing day of the taking images of the satellite	2	3	7	*0,83*	*0,69*	**4**	2 Surveying Engineer	63	504	504
9	C3	Taking image of the satellite and take delivery of satellite image ($40*50 \text{ km}^2 = 2000 \text{ km}^2$; $1 \text{ km}^2 = 118$ \$)	2	3	7	*0,83*	*0,69*	**4**	2 Surveying Engineer Stereo Satellite Image	63 -	504 236000	236504
10	D1	Rectification	2	3	5	*0,5*	*0,25*	**4**	2 Surveying Engineer	63	504	504
11	E1	Determination of the projection systems produce maps and legend making	1	2	3	*0,33*	*0,11*	**2**	1 Surveying Engineer	63	126	126
12	E2	Digitisations of Image Satellite	2	5	7	*0,83*	*0,69*	**5**	1 Surveying Engineer 1 Surveying Technician	63 42	315 210	525
13	E3	Output materials and basis to GIS +	2	5	7	*0,83*	*0,69*	**5**	1 Surveying Engineer	63	315	315

1\$ = 1 400 000 TL   Total = 9,98   10,59   70

Total = 248 585 $

%25 Company profit and other expenses = 62 146 $

2000 km² = 200 000 hectar = 310 731 $ (1 hectar = 1,55 $)   Total Cost = 310 731 $

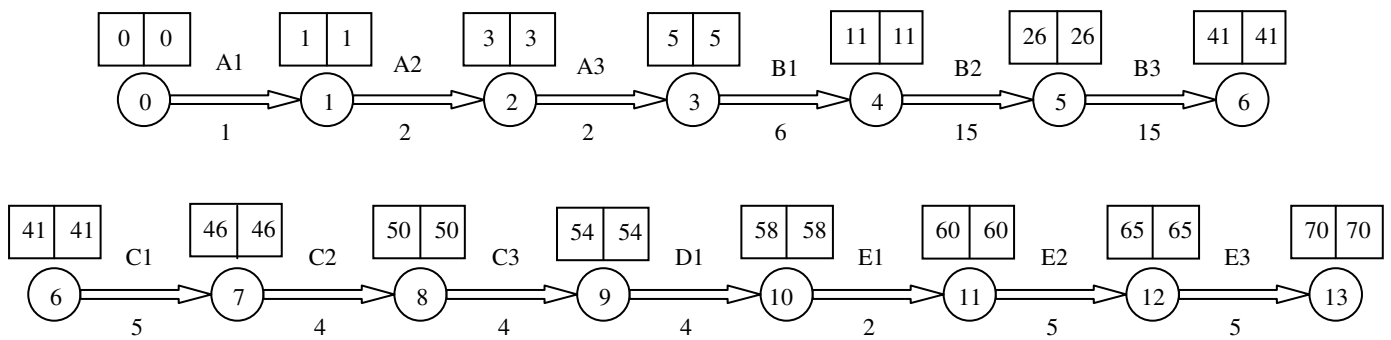Table 1. Projects main activities, total cost and their duration

Figure 7. PERT chart of the project

6. CONCLUSION

Satellite images have quite importance in choosing the most suitable data collecting which answers the expectations of accuracy speed, cost, time to establish every kind of GIS.

PERT is useful because it provides the following information:
- Expected project completion time.
- Probability of completion before a specified date.
- The critical path activities that directly impact the completion time.
- The activities that have slack time and that can lend resources to critical path activities.
- Activity start and end dates.

According to the PERT method, map production cost of IKONOS Satellite Images is 310 731 $ and calculating durations is 70 days. Same project cost is 29 932 000 $ and duration 10 mounts with 10 geodetic groups. Therefore, by the use of satellite image 99 percent cheaper than classical map production method and 77% in the time can be saved.

Hectare cost of the maps we have obtained from satellite images varies according to the dimension of the area. The cost of 1 hectare for the area of 10 km to 10 km is 4.38 $. The cost of 1 hectare for the area of 5 km to 5 km is 12.78 $. Therefore the area of 40 km to 50 km, the one-hectare cost can be found much lower (1 he= 1.55 $), due to the optimum size of satellite image.

The completion probability of the project with in the required period has been calculated as 97%.

It was recognized that the use of satellite image is more economical in terms of cost and time rather than the use of classical process. When the time is considerate, cost and accuracy criteria rectificated satellite images have important advances for most of GIS applications.

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