INTRODUCTION OF DATA RESOURCES TO BE USED IN THE ESTABLISHMENT OF A GEOGRAPHIC INFORMATION SYSTEM (GIS)

M. Özbalmumcu

General Command of Mapping, Photogrammetry Department, 06100 Dikimevi, Ankara, Turkey
mozbalmumcu@hgk.mil.tr

Commission II, WG II/IV "Automated Geo-spatial Data Production and Updating"

KEY WORDS: GIS, Mapping, Photography, Resources, Method.

ABSTRACT:

Today, like in many other scientific fields, it is well known that the great efforts have being spent on the establishment of the Geographic Information System in mapping field which includes spatial (graphic) data and attribute (non-graphic) information. Lately, thanks to the important progresses occurred in the computer technology, Digital Geographic Databases (DGB) and Geographic Information Systems (GIS) have being started to be established by using spatial/geographic data and attributes belonging to the topographic features on the ground in many disciplines and mapping field.

Geographic Information System helps to the solution of planning, management and analysis problems by means of combining of the geographic data collected from different resources. The most important components of a GIS are the geographic data. This data can be collected from many data resources like terrestrial and aerial photographs, satellite images, terrestrial, geodetic and tacheometric observations, maps and plans, reports, records etc. In establishing a GIS, the process step which is the most expensive and requires personnel, time and money is the data collection.

In this article, different data resources that can be used in the data collection step for establishing of a GIS data base which includes graphic data and attribute information about the topographic land cover and earth surface have been searched and, various explanatory information and offers related to the determination of the most suitable data resources which can be used for many purposes, for example in the digital mapping and creation of GIS data bases have been given. Additionally, the data resources for the creation of a GIS given in the paper have been explained in detail with their advantages, disadvantages and other properties.

1. INTRODUCTION

Geographic Information System is a technology which includes the basic components of personnel, graphic data, non-graphic information, computer hardware and software. A GIS data base is usually established in order to increase the capabilities of making a decision of the managers in the planning and management activities and to provide time, money, cost and personnel savings.

The basic steps of establishing a geographic information system are the collection of graphic (spatial) data and non-graphic (attribute) information related to the geography and physical earth surface by using different data resources; storing, processing, analyzing and presenting of the collected digital data.

As it is seen in the definition given above, geographic information system is related to the graphic and non-graphic information of the objects, details and features (natural and artificial features) existing in the earth surface. There are lots of data resources for the creation of any GIS data base related to the mapping or any other discipline. The data collection, the fist step of establishing a GIS, contains approximately 80 % of all GIS processing steps in view of time, cost, man power, job intensity and other consumptions. Regarding this, this article has been prepared to give useful information about this important subject to the users.

2. MAIN DATA RESOURCES TO BE USED IN SETTING UP A GEOGRAPHIC INFORMATION SYSTEM

2.1 Aerial Photographs

Aerial photographs are generally offered to the users by producing as photographic cards or transparent diapositives in analog format. Recently, they have being started to produce directly in digital form by using digital cameras. Mono or stereo aerial photographs taken with different scales have been using successfully in various topographic applications and data collection activities for many years. Aerial photographs are the most accurate, reliable and appropriate data resources which can be used in the production of analogue or digital maps, the creation of a Geographic Data Base (GDB) and Geographic Information System (GIS) (Krauss, 1993).

According to the results obtained from several investigations and experiences gained in many years, it has been understood that the use of the aerial photograph scales given in Table-1 would be appropriate and reasonable for the production of the vector and orthophoto maps in different scales. The photograph scales given in Table-1 reflect the opinions of the writer. An example of colour aerial photographs is shown in Figure-1.

Up-to-date aerial photographs are used for the creation of both a vector GIS and a raster GIS. All topographical graphic vector data which can be seen on the photographs can be captured from the aerial photographs, but, it is not possible to extract attribute information from them easily.

MAP SCALE	VECTOR / ORTHOPHOTO MAP TYPE	IDEAL PHOTO SCALE
1/500	Vector plan/chart	1/3.000
1/500	Orthophoto / orthophoto map	1/4.000
1/1.000	Vector plan/chart/city map	1/4.000
1/1.000	Orthophoto / orthophoto map	1/5.000
1/2.000	Vector route map	1/8.000
1/2.000	Orthophoto / orthophoto map	1/10.000
1/2.500	Vector route map	1/10.000
1/2.500	Orthophoto / orthophoto map	1/10.000
1/5.000	Stand.topog.(ST) vector map	1/16.000
1/5.000	Orthophoto / orthophoto map	1/18.000
1/10.000	Vector map	1/20.000
1/10.000	Orthophoto / orthophoto map	1/25.000
1/25.000	Topog.vector map production	1/25-30.000
1/25.000	Topog.vector map revision	1/35-40.000
1/25.000	Orthophoto / orthophoto map	1/40.000
1/50.000	Topog.vector map production	1/50.000
1/50.000	Topog.vector map revision	1/60-70.000
1/50.000	Orthophoto / orthophoto map	1/70.000

Table 1. Appropriate photograph scales for the production of vector and orthophoto maps in different scales

Figure 1. An example of colour aerial photographs

2.2 Satellite Images

After the artificial satellites put into place to the orbits in the space around the world, a new era has started in the scientific research field. The first artificial satellite named Sputnik was launched to the space on the 4th October 1957 by the S.S.C.B. By now, many satellite systems have been developed for different purposes by many countries and the satellite images having different resolutions have been started to use successfully in various disciplines (Örüklü, 1988).

Images are classified by three different groups in connection with the kinds of sensors used. These are the data collected by the photographic systems, scanners and radar systems. The basic and common property of the satellite images is to contain much spatial data belonging to wide terrestrial areas. For the production of topographic maps from the satellite images, three kinds of quality expectations should be provided for the users. These are the planimetric (horizontal) accuracy, height (vertical) accuracy and feature detectability (feature interpretation and recognition) (Wiley, 1986).

Because the satellite orbits are too high, the satellite images are not the products of the central projection and, they can be considered as the vertical projection products. In the other words, in the satellite images, the geometrical perturbations occurred from the height differences existed in the field surface are too small and can be neglected. In spite of this, the other geometric perturbations and defects occurred due to the earth curvature and other factors are so much effective and should be taken into account. But, all these errors can be corrected by using various computerized techniques and software, and finally, the existing errors can be nearly reduced to only one pixel size (Wiley, 1986).

Recently, due to the small pixel sizes of satellite images, their spatial resolutions have increased very much and thanks to this development, the man-made features and details having 5 meter or smaller size on the ground can be detected from them. In the last years, the most important development occurred in the satellite images is that the spatial resolution has diminished below 1 meter (between 0.6-1 m) in black/white (B/W) images, approximately 2 meter in colour images. These resolution rates correspond to the sufficient planimetric and height accuracies necessary for the production of 1/25.000 scale topographic maps. It is also assumed that the high resolution (one meter or better) satellite images would have the sufficient spatial resolutions for the production of 1/10.000 scale vector maps. The main disadvantage of high resolution satellite images is that one image covers a small area such as maximum a 15 km x 15 km area, minimum a 10 km x 10 km area in the field. Another important development occurred in the satellite images is to gain the possibility of getting stereo pairs at the same time at very short time intervals such as 5-10 seconds over the same satellite orbit (Önder, 1997).

Today, the earth observation satellites are being mostly used in the mapping technology, forestry and agricultural areas. In the next years, it is expected that the high resolution satellite images will be able to be used in the city planning, traffic planning and the public area arrangements. By the help of stereo imaging capabilities of new satellite images, it could be possible to use them for the production of precise Digital Elevation Model (DEM) data.

The efficiency of the satellite images in the creation of a new GDB and GIS has gradually increased. The kinds and resolution levels of the satellite images and ideal/optimum vector map scales to be produced from the satellite images which are widely used in today's and expected to be used in the near future are shown in Table-2. The vector map scales given in Table-2 reflect the opinions of the writer.

The most important developments occurred in the high resolution satellite images (1 meter resolution or more precise images) are the decrease of the production cost, increase of launching capacity of the satellite, obtaining of stereo images under the same orbit and observation conditions, the use of instantaneous exposure technique, the availability of good quality products, getting of digital data which can be easily combined with GIS, obtaining of satellite images having under 1 meter (0.6-1 m) resolution in Panchromatic (P) mode and approximately 2 meter resolution in color/multispectral (MSS) mode, reaching at the command possibility to the satellite for the countries which have the satellite ground stations, the decrease of archiving costs and finally, taking of the images belonging to the same area in a short time interval for example in 1 or 2 days (Clauss, 1995).

SATELLITE IMAGE TYPE	PIXEL SIZE	IDEAL VECTOR MAP SCALE
SPOT-1, 2, 3, 4 P	10 m	1/50.000
SPOT-1, 2, 3, 4 XS	20 m	1/100.000
SPOT-1, 2, 3, 4 P+XS	10 m	1/50.000
LANDSAT-1,2,3,4,5 MSS	80 m	1/250.000
LANDSAT-1,2,3,4,5 TM	30 m	1/100-250.000
ERS-1/2 SAR Radar	30 m	1/100-250.000
KVR-1000 (Russian)	2 m	1/25.000
KFA-1000 (Russian)	5-10 m	1/50.000
TK-350 Camera (Russian)	10 m	1/50.000
MK-4 Camera (Russian)	12-24 m	1/100.000
KATE-200 (Russian)	10-30 m	1/100.000
MOMS-01/02 PAN	4.5 m	1/50.000
IRS-1C/1D Radar	6 m	1/50.000
EROS-A PAN	1.3 m	1/25.000
EROS-B PAN	1 m	1/25.000
EROS-A/B MSS	4.5 m	1/50.000
SPOT-5 P	5 m	1/50.000
SPOT-5 XS	10 m	1/50.000
SPOT-6 P	2.5 m	1/25.000
LANDSAT-7 P	15 m	1/100.000
LANDSAT-7 MSS	30 m	1/100-250.000
IKONOS P	1 m	1/10-25.000
IKONOS MSS	4 m	1/50.000
IKONOS P+MSS	1 m	1/10-25.000
EyeGlass TM	1 m	1/10-25.000
QuickBird P	0.6-0.8 m	1/10-25.000
QuickBird MSS	2 m	1/25.000
EarlyBird P	3 m	1/25-50.000
EarlyBird MSS	15 m	1/50-100.000

Table 2. Suitable map scales recommended for the production and revision of vector image maps from various satellite images

The probable matters which are expected to continue in the high resolution satellite images are to be some limitations in the band numbers (minimum 1, maximum 4 bands), to provide the possibility for the production and revision of maximum 1/25.000 or smaller scale maps, to cover a fairly small areas such as maximum a 15 km x 15 km and minimum a 10 km x 10 km, to reach to 30-40 days of the period of a satellite coming to the same observation point, to continue to be affected from many meteorological conditions such as cloud, fog, haze, rain and snow, and, not to know exactly to whom belongs the priorities in the satellite ground stations which enter the effective area to each other (Clauss, 1995).

Satellite images can be in analogue or digital formats (mostly digital). They can be obtained with two different ways; programming (new and up-to-date images) and archived images (old images). Satellite images are used for the creation of both a vector GIS and a raster GIS. All topographical graphic vector data which can be seen on the images can be captured from the satellite images, but, it is nearly impossible to extract attribute information from them. An example of satellite images (Landsat-MSS) is shown in Figure-2.

Figure 2. An example of satellite images (Landsat-MSS)

2.3 Sensor Data

The sensor data are the data resources collected from various sensor systems, namely laser profiling systems and radar systems mounted on the aircrafts and satellites. The most significant difference between the sensor data and other satellite camera/scanner data is to obtain this data from the microwave region of the electromagnetic spectrum (EM) instead of visible light. All these data are completely offered in digital format to the users. Multiband sensor images have been started to use in the production of middle and small scale topographic maps, geodetic activities, creation of GIS data bases and some military applications in connection with their resolution rates and pixel sizes (Wiley, 1986).

The sensor data can only be in digital format. In view of the use in the creation of a vector or raster GIS and obtaining graphic and non-graphic data, the sensor data are the same as the satellite images. But, they are generally used for the collection of some thematic information necessary for a GIS.

2.4 Printed Maps

Analogue (line) printed maps produced with various methods are important data resources which are commonly used in the creation of a GIS. For establishing of a GIS by using of the printed maps as sheet layouts, the main important points which are necessary for paying attention are explained below. The printed maps should be up-to-date; be produced by reliable methods such as geodetic, topographic, tacheometric and photogrammetric methods; be compatible to the final aim and the scale of GIS to be set up; contain all features and details which the map scale requires; not be shifted in a large amount; provide for the possibility of reading 3 dimensional coordinates (X,Y,Z) of the features and points in the ground surface. But, in the printed maps, there are various errors such as cartographic drafting and printing errors, photogrammetric stereo map compilation errors, some errors occurred in the drafting and inking of the photogrammetric revision plates, topographic map completion errors etc. The most important advantage of the printed maps regarding to other geographic data resources is to have many attribute data in addition to the graphic data. The main important disadvantage of them is usually not to be up-to-date (Özbalmumcu, 1999).

The printed maps are mainly used for the creation of a vector GIS by digitizing the features. The printed maps contain both graphic and non-graphic data and, existing graphic and attribute data can be extracted from them. Printed maps can be in analogue or scanned (digital) form. The manual digitization method is applied on the printed analogue maps placed on a digitizing table. The heads-up digitization method is used in scanned digital maps loaded on the computer. An example of printed maps is shown in Figure-3.

Figure 3. An example of printed maps

2.5 Map Printing Plates

The map printing plates are the data resources which are obtained by the way of separating the features to four different colours (black, green, blue and red/brown) in the map sheet original plates, which are exposed to some stable transparent plates such as astrolon, polyester, cronoflex and triasetat, which are more reliable and useable than the printed maps and other printed materials because of the stability and, which are not generally up-to-date. Many errors mentioned about the printed maps exist in the printing plates too. In the data collection activities for GIS purposes, the map printing plates should be used together with the existing printed maps. The graphic data should be extracted from the printing plates, the attribute information should be produced from the printed maps or by topographic map completion in the field (Özbalmumcu, 1999).

The map printing plates are the original sheet layouts and only contain graphic vector features in 4 different colour layers. They don’t have any attribute information. They are only used for the creation of a vector GIS by digitizing the features. Map printing plates are generally in analogue sometimes digital form. The main principles of vector data collection from the map printing plates are the same as the printed maps.

2.6 Up-to-Date Revision Information Plates

By using analogue stereo photogrammetric map compilation instruments, the map production at different scales can be performed with the use of up-to-date aerial photographs. The result data obtained from these instruments are plotted onto stable (unchangeable) transparent plates such as astrolon, cronoflex, polyester, triasetat etc. Compared to the printed maps, map printing plates and other printed materials, up-to-date revision information plates are really important data resources which can be used in the data collection for GIS purposes by the cartographic digitization method because they contain original, up-to-date, true, accurate and reliable data, they are processed onto unchangeable plates, they don’t have any cartographic drafting, editing, and printing errors. But, instead of using these materials by themselves in the data collection for GIS purposes, it is more advisable to use them together with the existing map sheet plates. The attribute information collected by the topographic methods and existed in the printed maps can also be included directly to a GIS. In the data collection process performed by using all printed materials (like printed maps, map printing plates and up-to-date revision information plates). 2-dimensional (2D) digital data obtained from the printed maps, plans and graphs should be finally transformed to 3-dimensional (3D) digital data by combining with the existing DEM data (Özbalmumcu, 1999).

Up-to-date revision information plates are similar to the map printing plates in view of the content, use and technical properties. They only contain graphic data, not non-graphic data. They are only used for the establishment of a vector GIS.

2.7 Orthophoto Maps

An orthophoto is a photographic image which has a specific, stable scale like a map and is obtained by eliminating the image displacements occurred due to photo tilts and azimuths and the effect of the height differences on the ground surface. If new cartographic information such as map sheet border information, grids, contour lines, geographic place names and other cartographic data are added to an orthophoto, this new product is called as an orthophoto map or photo-map. An orthophoto is basically a map in the photographic form. An orthophoto mosaic or photo mosaic is a new orthophoto image which is produced by combining of many orthophoto images. An example of orthophoto maps is shown in Figure-4 (Krauss, 1993).

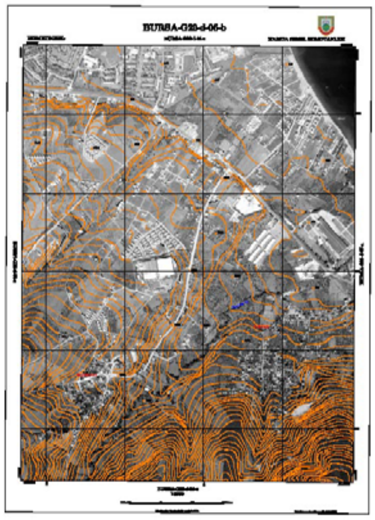

Figure 4. An example of orthophoto maps
produced from aerial photographs

The most important advantages of orthophoto maps are mentioned below: Vector data can be digitized in digital format on the orthophoto maps. The orthophoto maps can be used as a basic information resource or a base layout in each type of data bases. The most important disadvantages of orthophoto maps are explained below: Each topographic detail/feature can not be seen easily on the orthophoto maps. Understanding and interpretability of an orthophoto map is closely connected to the photographic interpretation capabilities of the map users. Some topographic features such as narrow roads, fountains, ditches in the borders of the roads can not be demonstrated by exaggerating in the orthophoto maps. All natural and artificial features are indicated in their original and real sizes in the nature. Against this, all features are demonstrated by exaggerating on the vector maps in order to interpret the map and detect the features easily. Additionally, when going further away from the photographic centre point, the image tilting errors happen because of appearing of side surfaces of some high features and natural details such as hills, buildings, suspended bridges, block rocks, towers etc (OEEPE Official Publications, No: 25, 1991).

Orthophotos and orthophoto maps are mainly used for the creation of a raster GIS data base. They can be in analogue or digital form. If it is necessary, the graphic vector data belonging to the features can be manually digitized from the analog orthophoto maps placed on the digitizing tablet or they can be collected from the digital orthophoto maps with the use of the heads-up digitization method.

2.8 Image Maps

An image map is produced by adding various cartographic elements such as region/mountain/hill/stream names, other geographic place and feature names, grid lines and other cartographic map sheet border information to an ortho-rectified satellite image (ortho image). This map is usually produced in the dimensions and scales of the standard topographic maps. The image maps are completely similar to the orthophoto maps in view of the use and properties. Optimum/ideal ortho-image and image map scales to be produced from various satellite images commonly used in the world in today's are indicated in Table-3 (Baltsavias, 1993).

SATELLITE IMAGE TYPE	PIXEL SIZE	IDEAL ORTHO IMAGE MAP SCALE
LANDSAT-1,2,3,4,5 MSS	80 m	1/250.000
LANDSAT-1,2,3,4,5 TM	30 m	1/100.000
SPOT-1,2,3,4 XS	20 m	1/100.000
SPOT-1,2,3,4 P	10 m	1/50.000
KFA-1000	5-10 m	1/25-50.000
KVR-1000	2 m	1/10-25.000
MOMS-02	4.5 m	1/25-50.000
ERS-1/2 Radar	30 m	1/100.000
IRS-1C	6 m	1/50.000
LANDSAT-7 MSS	30 m	1/100.000
LANDSAT-7 TM	15 m	1/50-100.000
SPOT-5 XS	20 m	1/100.000
SPOT-5 P	10 m	1/50.000
SPOT-6 P	10 m	1/50.000
IKONOS P	1 m	1/5-10.000
IKONOS MSS	4 m	1/25-50.000
QUICKBIRD P	0.61-0.8 m	1/5.000
QUICKBIRD MSS	2 m	1/10-25.000

Table 3. Suitable map scales recommended for the production and revision of ortho image maps from various satellite images

2.9 Digital Elevation Model (DEM) Data

DEM data contains the selection and measurement of the cluster of points which reflect the real shape of the ground surface in a suitable way. For using DEM data in a GIS data base, it is an appropriate way to take of DEM point configuration and densification as a grid network form. The resampling points used in DEM can be in the form of irregular points taken in the ground surface, points taken on the structure lines and breaklines, the characteristic points taken in the ground surface or intersection points of the grid network. In order to collect DEM data, various data collection methods are used. These methods are the geodetic, topographic, tacheometric and photogrammetric methods, the digitization of existing maps and plans, the data collection with the systems mounted on the aerial vehicles and platforms (aircrafts and satellites) and finally, the combination of these data collection methods (Gruen, 1998).

The production of DEM consists of three different processing steps: These are the data collection (measurement and capture), data processing (evaluation) and data presentation (displaying and printing). DEM data have widely being used in the topographic map production and all kinds of non-topographic activities. By using stereo aerial photographs and satellite images, necessary DEM data can be collected with manual and semi automatic data collection methods by using the absolute oriented stereo models prepared in the analytical stereo plotters and with manual, semi-automatic and automatic data collection methods by using the stereo models prepared in the digital stereo plotters with the use of digital image matching techniques (Alkış and Özer, 1996).

2.10 Existing Digital Map, GDB and GIS Data

The existing digital maps, GDB or GIS data, graphic and non-graphic information can be transferred directly into a new GIS. If the existing digital maps are not up-to-date, firstly, they should be revised by using up-to-date data resources (generally aerial photographs). This digital data resources mentioned above are used as the basic and original sheet layout in the computer supported map revision. The digital map data collected by few reliable resources are the data which can be used directly in establishing of a GIS. In the case of the digital map data are available, their revisions can be performed in a very short time and economically. Thus, a great speed and economy can be provided in forming of a GIS. The most important deficiency of the existing digital maps is generally not to contain the attribute information belonging to the topographic features. The existing GDB and GIS data don't usually have this disadvantage, but revision of this data and adding of some new information is necessary (Bank et.all, 1995).

2.11 Atlases

In view of their structures, the atlases are the documents which contain some graphic, thematic and attribute data relating to some topics. But, the graphic data existed in the atlases are generally used in establishing of a GIS which are related to small scale maps such as 1/500.000 and 1/1.000.000. In the processes of establishing a GIS related to 1/25.000 or larger scale maps, various attribute information and thematic data existed in the atlases (such as the geographic feature and place names, road types, the names of urban areas and cities) can be used. The data obtained from the atlases are usually complementary data of a GIS and used generally as the secondary data resources (Özbalmumcu, 1999).

2.12 Geographic Feature Names Catalogue (Gazetteers)

These documents generally contain up-to-date names of geographic locations, urban, rural and regional area, natural and artificial features such as hills, mountains, bridges, roads, towers etc. In up-to-date catalogues; the names of new settlement areas, the names of the villages and cities which were removed from the settlement and all the changes of the names of urban areas are offered to the users on various maps, graphs, plans and documents. This data is generally in the form of attribute information which has a complementary specification of an existing GIS (Bank et.all, 1995).

2.13 Reports, Records and Documents

Other data resources which can be used in the creation of a GIS are the documents and information resources which contain several attribute data belonging to the topographic features. The data resources included in this group are: the reports, records, documents, some statistical data; some notes, papers and information forms which are hold in doing the stereo photogrammetric map compilation; the data collected by the topographic map updating and completion, topographic information plates; inventories, 3-dimensional coordinates (X,Y,Z) and DEM files in ASCII format. The attribute data are the secondary date resources (Bank et.all, 1995).

2.14 Existing Project Data Obtained From the Governmental Organizations

Analogue or digital maps, graphic and thematic data registered onto printed materials, some graphic and attribute data obtained from the documents, reports, inventories, the records obtained from the projects realized by the governmental organizations can be additionally used in establishing of a GIS. The data resources in this group are really easy to use and economic. The availability of up-to-date, accurate, reliable graphic and non graphic data has really a great importance. The project data in digital form obtained from the governmental organizations can be used directly in the GIS by applying for several transformations. But, for the use of the graphic project data produced in analogue form, it is necessary that these data should be firstly digitized 2-dimensonally with a cartographic digitization method in accordance with the kinds of available data resources, and then the, 2-dimensional graphic data should transformed to 3- dimensional data (Özbalmumcu, 1999).

3. CONCLUSION

In order to create GIS data bases for different purposes, many different data resources explained in detail in the article can be used. These data resources are the terrestrial and aerial photographs, satellite images, sensor data; printed maps/plans/graphs, map printing plates, up-to-date photogrammetric/topographic revision information plates; ortho images, orthophoto maps, image maps; Digital Elevation Models (DEM), Digital Terrain Models (DTM), existing digital maps, Geographic Data Base (GDB) and Geographic Information System (GIS) data; atlases, gazetteers records and documents. Some of them (ex: printed maps, map printing plates) are mainly used for the establishment of vector GIS data bases, some of them (orthophotos, orthophoto mosaics) are generally used for establishing of raster GIS data bases. Some data resources are only used for the collection of graphic data (ex: aerial photographs, satellite images), some of them are only used for the collect of non-graphic information (ex: some documents, reports, gazetteers, reports), a few of them are used for the collection of both graphic and non-graphic data (ex: printed maps, map printing plates) The basic concept in the establishment of any GIS data base should be to use the most reliable, up-to-date, accurate and appropriate data resources for the final aim of the user.

References from Journals:

Baltsavias, E., P., 1993, Integration of Ortho-Images in GIS, Photogrammetric Week'93, Stuttgart, Germany, pp.261-272.

Clauss, M., 1995, Demands on Electro-Optical Cameras for Sensing and Mapping, Photogrammetric Week'95, Fritsch/Hobbie (Eds.), September 1995, Stuttgart, Germany, pp.37-44.

Gruen, A., 1998, Data Handling II-Digital Terrain Models Generation and Visualization Symposium on Digital Photogrammetry, İTÜ, İstanbul, Turkey, pp.1-16.

OEEPE, 1991, Test on Orthophoto and Stereo Orthophoto Accuracy, OEEPE Official Publication, No:25, May 1991, Enschede, Netherlands.

References from Books:

Krauss, K., 1993, Photogrammetry Volume-1, Fundamentals and Standard Processes, Fourth Edition, Ferd Dümmler Verlag, Bonn, Germany.

Örüklü, E., 1988, Remote Sensing Notebook, Official Publications of YTÜ, No:198, İstanbul, Turkey (Turkish).

Wiley, J., 1986, Remote Sensing Methods and Applications, USA.

References from Other Literature:

Alkış, A., Özer, H., 1996, The Height Information Data Base for the 3rd Dimension in the GISs, CBS-96, Geographic Information Systems Symposium, Yıldız Technical University (YTÜ)-Istanbul Technical University (İTÜ), İstanbul, Turkey, pp.339-341 (Turkish).

Bank, E., Özbalmumcu, M., Taştan, H., Tekgül, A., 1995, A Method Design for Updating and Revision of Digital Vector Maps, the 100th Year of Turkish Mapping History, The Paper Book of TUJJB and TUFUAB Congresses, Ankara, Turkey, Vol.4, pp.1230-1239 (Turkish).

Önder, M., 1997, Performing of Brief Evaluation About the Contribution of the Satellite Images in the Topographical Application and the Expectations in the Near Future, TUFUAB, A Seminar of 3rd Remote Sensing and Its Applications in Turkey, 16-18 May 1997, Uludağ University, Bursa, Turkey, Vol.VII, pp.27-41 (Turkish).

Özbalmumcu, M., 1999, Investigation of Data Resources, Data Collection Systems and Spatial Data Collection Methods Used for the Creation of A Geographic Information System (GIS), Ph.Thesis, 15 Nov 1999, YTÜ, İstanbul, Turkey, pp.37-56 (Turkish).