Geographical Information Technologies and Availability of Spatial Data in Israel

Dan G. Blumberg
Ben-Gurion University of the Negev*

The field of geographic information technologies (GIT), including geographical information systems (GIS) and remote sensing, is at the forefront of geographical research today. GIS and remote sensing methods are used by some of the local municipal councils and governmental institutions in Israel with several new institutes being added every year. The Survey of Israel (SOI) is one of the leading governmental institutions in this field in Israel and is in the process of creating a national GIS. This GIS will allow full supervision of information from all authorities belonging to a statutory region, and also will advance urban and regional management. As the process of implementation takes place, technological improvements are being made, with the result that more and more end users can access the GIS. Israel is also at the forefront of GIT in its remote sensing capabilities. The Imagesat International (ISI) Company of Israel launched the first of a series of satellites with high-resolution cameras in December 2001. The camera deployed in the first satellite is already operative and data are available commercially with a spatial resolution of 1.8 m. There is no doubt that GIT offers many advantages in the decision-making processes and management of regional information, in addition to data collection and storage.

Keywords: GIT, GIS, remote-sensing, National GIS in Israel.

The field of geographic information technology (GIT) lies at the forefront of current geographical research. This includes remote sensing as an information-gathering tool, and geographical information systems (GIS) as a work and organizational tool. Geographical information systems (GIS) are numerical, alphanumeric and graphical data management systems with spatial relevance. All the data can be organized and sorted spatially. The systems link the geographic location with other attributes, which may be descriptive, textual, quantitative, or graphical, and they allow the above information to be presented as a hard copy, a digital map, or in tables. In addition the information systems are able to sort the information, ask and answer questions, and assist in the analysis of the spatial of relationships.

In this paper GIS basics and GIT capabilities in Israel will be described. Before stepping into the process and description of the GIT capabilities in Israel, a brief

* Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Beer Sheva, Israel. E.mail: blumberg@bgumail.bgu.ac.il

introduction to GIT is provided. Antenucci et al. (1991) define GIS (geographical information systems), on the basis of Hanigan (1988) as information systems that can: a. collect and store information of a spatial nature; b. investigate systems of relationships between data bases in the same region; c. analyze data to aid decision-making; d. assist in the choice of relevant information and its transformation to analytical models in order to evaluate various alternatives; e. display the region in graphical and numeric forms, before and after analysis.

In order to achieve the capabilities described above, every GIS needs to have certain components, and should therefore incorporate the following components:

1. A system for collection of digital information. This component can be constructed or programmed by the GIS itself, but frequently the GIS operators will prefer to use data collection programs such as Autocad or Microstation;
2. A software component to process regional information, location and projection dealing with different requirements;
3. A system to analyze networks so that systems of regional relationships can be ascertained;
4. A data base and the software suitable for information management;
5. Software for displaying information on screen or as a printout.

In the past half-decade, there have been major improvements in GIS including the introduction of additional components of GIS such as tools that permit the information to be transferred over the Internet. These tools, still in their infancy, are gaining momentum as the number of users increases. The strength lies in the fact that they allow authorities that do not want to, or cannot, maintain their own GIS to access information from other sources, paying for these services as necessary. Alternatively, these tools also allow citizen involvement in the planning process by providing them with up-to- date maps and spatial information.

CREATION OF DIGITAL REGIONAL DATA BASES

Most governments, whether national or local, tend to maintain their own mapping agency and database regarding ownerships of land. Nowadays, these are termed national or regional GIS. The computer, of course, is an important cartographic tool in the 21st century, and the task of transferring information gathered in the past from hard copy to digital databases is no simple matter. Information transfer requires suitable provision of software for scanning and digitization, the cost of which is still very high. Transfer of information from the scanner to the computer is carried out in a rasterized form, that is, the value of every pixel of an image is preserved, requiring a very large digital storage area. Finally, the rasterized images are converted to vector data, a work-intensive procedure involving expensive quality control. In Israel, for a little more than a decade, the government has taken upon itself the massive effort of transferring spatial information into a GIS. Hereafter, the process and state of affairs of transferring hard copy maps to GIS databases in Israel will be described.

GIS IN ISRAEL AND THE NATIONAL GIS

In 1989, the Survey of Israel (SOI) began to set up a geographic information system to store the various geographical data of Israel. The two principal components contained in this database include the topographical and cadaster databases. The topographical database incorporates topographic and urban maps. In order to construct such databases, the decision was made to remap all of Israel from aerial photographs, to a geometric accuracy of two meters. This database is now in its final stages and, as noted by Peled and Haj Yichiyeh (1999), the major problem today is not the creation of the databases, but keeping them up-to-date.

Keeping the topographical database current is crucial so that the GIS will maintain its value and meet its goals. Moreover, in a country with rapid population growth, such as Israel, large areas are undergoing topographical changes as a result of accelerated construction and development. Therefore, as Peled and Haj Yichiyeh (1999) note, the database must be continuously refreshed at a rate that will cover 20–25 percent of the country every year. Hence, the entire country should be re-mapped every 4–5 years. To this end, SOI, in coordination with researchers from the University of Haifa and private industries, is concentrating on developing tools for automatic identification of periodic changes in the GIS on the basis of aerial photographs and inclusion of these changes in the GIS.

The national topographical database is constructed from 10 layers of information (see Table 1).

Table 1: Layers of information in the national database.

Layer	*Details included in layer*
Transport	Roads, railways, paths, etc.
Infrastructure	Electricity lines, oil pipelines, water pipes, etc.
Hydrology (linear)	Streams, water channels, etc.
Hydrology (Polygons)	Lakes, water bodies, etc.
Elevation data	Digital model of topographical heights
Ground cover	Plantations, orchards, river silts, etc.
Buildings	Buildings identified in aerial photographs
Localized items	Wells, caves, etc.
General linear items	Fences, walls, cliffs, etc.
General polygonal items	Hospitals, railway stations, universities, etc.

Elevation Layer

One of the most important layers in the Israel National GIS is that of elevations, or the digital elevations model (DEM). This layer is based on photogrammetric information. The model is constructed as a lattice with fixed spans of 50 meters, and an elevation point at every intersection on the lattice. In addition, distinctive points are measured, including mountain peaks, valleys, and topographical shear lines such as river beds and mountain ridges. The vertical accuracy of the topographical data was set at two meters. A digital topographical model now exits for the entire area north of latitude 460 (The New Israel Grid).

In addition to the new digital mapping, there also exists a digital map based on the digitizing of topographical maps with a scale of 1:50,000 (Doytsher and Hall, 1997). The lattice density in this model is 25 meters, but its accuracy is far less than that of the new mapping.

TOPOGRAPHICAL SATELLITE MAPPING (INTERFEROMETRY)

As this article is being written, an international project to create a topographical map of 80 percent of the landmass of the Earth is underway, under the auspices of the space agencies of the United States, Germany and Italy. The project employs an innovative method using remote sensing. The experiment is called the Spaceborne Radar Topography Mission (SRTM) and is based on using 'interferometrics', with the help of two radar antennae positioned on the space shuttle 'Endeavor'. The shuttle and radar antennae were launched on a 10-day mission in February 2000. Currently the data are still being processed and calibrated.

The method employs radar signals that are beamed from the shuttle and are then backscattered to it from the Earth, using two different antennae 60 meters apart. The differences between the signals received by the two antennae, as expressed by variance in the wave phases, correspond to topographical changes. There can be no doubt that this method in general, and the project in particular, will provide unprecedented digital topographical information regarding many areas of the world, not to mention the region in discussion, especially the area of the State of Israel, which lies on the margin of the unmapped desert areas. The quality of the mapping will not exceed the new photogrammetric mapping by SOI, but will certainly provide a unified database that can then be linked to worldwide mapping—which is important in its own right.

To assist in this project, the Remote Sensing Laboratory in the Department of Geography at Ben-Gurion University of the Negev deployed several radar reflectors in key locations in the Negev. This way, the data can be better calibrated and geometric constraints can be improved for the mapping of Israel. While this new method cannot currently compete with traditional aerial photography of a small country like Israel, it is certainly conceivable that in the future it will. This method can be almost automatic, spanning the entire country using very few images and providing much faster updating of the DEM.

Monitoring Tectonic Motion in Israel by GPS

Another innovative method of topographic mapping is the Global Positioning Satellite System (GPS). This system consists of a network of 24 high-altitude satellites that circle the Earth and beam radio signals to ground-based receivers. The system was originally designed to improve the ocean-going navigation of the US naval fleet, but its potential for civil navigation and, in particular, for accurate mapping has rapidly become apparent. Individual GPS positioning systems can attain an accuracy of about 5 meters. Nevertheless, by using a number of GPS receivers, it is possible to achieve accuracies better than a meter, using a differential method (DGPS).

Israel is located on the western side of the Dead Sea fault line, along which exists a lateral motion between the Arabian Plate and the Sinai sub-plate. The relative motion is estimated at 0–10 mm/yr. However, exact values require continuous long-term monitoring. The deployment of the DGPS stations throughout Israel and Jordan provides an opportunity for such monitoring.

Within the framework of long-term research, Israel has begun to install a network of permanent GPS stations with transmitters, allowing very accurate DGPS measurements to be made. This effort is sponsored jointly by the SOI and the Israel Space Agency (ISA). The aim of this network is to enable a geodetic network to utilize the DGPS in Israel, in order to trace the movements of the tectonic plates and distortions of the Earth's crust (Widowinski and Bach, 1999). To date, there are eleven active stations, and in the near future more will be established.

Cadaster Mapping

The statutory division of land in the State of Israel is founded on cadaster mapping, which was established in this country by the British in 1926. This mapping is based on the Torrance method, in which a parcel of land and its area are defined according to official measurements and mapping is carried out by state authorities. In this procedure, land is registered by block and parcel numbers under the names of the owners, and the measurement is related to the national network of coordinates (Doytsher, 1999). According to field measurements carried out by surveyors, the particulars of the owners and the code of the parcel in the cadaster are recorded in the surveyors' file, and these are then transferred and recorded in the land registry.

As part of the national GIS project, SOI has begun to record all the cadaster blocks and parcels in a digital database. The reliability of the cadaster registration makes it an essential component in all stages of planning and initiatives in the development of the country. Despite this, divergences of up to a maximum of two meters have been found between the records of the surveyors and some values calculated by the digitization of control points (Doytsher, 1999). As a result, great care is needed when transferring the graphical information in the surveyor's files to the national GIS. In order to overcome such problems, a number of bodies are presently focusing on the preparation of algorithms for the intelligent and controlled transfer of the relevant information (Felus and Lida, 1999; Doytsher, 1999).

Urban Management with GIS

The use of GIS systems for urban mapping allows more than just the mapping of the city. GIS systems improve the management of all the aspects of local administration, because of the connectivity between the map and the database. Thus, the GIS can help in the execution of mapping, planning and maintenance of the urban area. In addition, the GIS can aid in the management of municipal resources, the formulation of master plans and city plans. In the USA, for example, full uniformity of geographical information systems of the various local authorities has been attained. Some of the local authorities already manage their tax collection, the planning of the educational and traffic systems, and even garbage collection, by means of their GIS.

Currently in Israel, only a very small number of local authorities maintain an urban GIS. These include the major cities of Tel-Aviv, Jerusalem and Haifa, and among smaller authorities, Kfar-Sava and Rehovot. In some cases, the work is being carried out by municipal employees, and in others, by external private companies. The three leading software programs in Israeli municipalities for GIS management include ArcInfo and ArcView, marketed by ESRI, and MapInfo. However, many other local authorities have not yet begun to set up a GIS.

The Jerusalem municipal system represents a successful example of executing an urban GIS in Israel. This GIS incorporates a large part of the fields of urban planning, land registry and city transport. A great part of the information on the site is made available to city residents via the Internet. Furthermore, planners can download plans and in return upload plans for approval.

In addition to Israeli local and municipal authorities, other authorities are currently making efforts to create a GIS. These include, among others, the Israeli Central Bureau of Statistics, the National Parks and Nature Reserves Authority, which has already set up a GIS, the Antiquities Authority, which has started to map and manage antiquities sites with the aid of a GIS, and the Nature Protection Society, which has also set up its own GIS.

REMOTE SENSING AND GIS INTEGRATION

The increase in computing power and the reduction in hardware costs now make it possible to incorporate satellite remote sensing data in an operational GIS, and expand its use beyond research only. In addition to the changes in costs, institutional activities are also advancing the integration of the two technologies. The European Commission has based its last announcement of opportunities (5th Framework Program) on the use of up-to-date, cross-border information for environmental monitoring, identification of changes, and mapping of land use. The only way to obtain the information relevant to these needs on a wide regional scale is to use satellite remote sensing and incorporate data received from remote sensing in a GIS, for regional analysis and presentation of results.

In the not too distant past, the best information was received from a) the Spot satellite, with three channels in the visible spectrum and one in near infrared, with a 20 m resolution ability and b) Landsat, with an improvement from an 80 m to a 30 m capability. Today, there are additional satellites with much greater resolution. The first commercial civilian spy satellite was recently launched in the USA, and it has a resolution of 1 meter. The quality of information and resolution power is accurate enough to be of concern to the Israeli security authorities and those of the US, as well. Therefore, it is prohibited to market the information relating to the area of Israel, except at a poorer resolution of two meters. This power is similar to that of Russian satellites, information from which is already available on the free market.

The advantage of satellite information in setting up a GIS lies in its accuracy and 'up-to-the-minuteness'. The information is gathered at fixed time intervals, is digital, and can be immediately included in the GIS. Also, it has extensive coverage. Thus, this information is considerably preferable to the aerial photographs, which were previously the basis for mapping.

In December 2000 an Israeli company, Image Sat International (ISI), launched an Earth Observation Satellite called EROS. The Sensor onboard the satellite is capable of imaging Earth at a resolution of 1.8 m. This resolution is almost unprecedented in commercial sensors except for the USA commercial IKONOS sensor. The EROS satellites are designed for Low Earth Orbits (LEO) and have a lifetime expectancy of four years. EROS A1 should be followed by EROS A2 and then EROS B1–B6. This series of satellites places Israel in the forefront of Remote Sensing with a select few countries that have executed an Earth observation program from launch capabilities to data reception.

Table 2: Present civil data satellites and their properties.

Satellite	*Visible light channels*	*Infrared channels*	*Panchromatic channels*	*Visible light resolution (m)*	*Infrared resolution (m)*	*Panchromatic resolution (m)*
LANDSAT 7	3	4	1	30	30	15
SPOT 5 (2001 launch)	2	2	1	10	20	5
IRS P6 (2001 launch)	2	1	–	6	23	–
IKONOS	3	1	1	1	3.3	–
EROS 1A	1	–	1	1.8		1.8

Availability of Satellite Data

The satellites active today, which have good mapping capabilities, include the American Landsat, the French SPOT, and the Indian IRS. Recently, the American IKONOS was launched, and the data collected by Russian spy satellites has been made available to the general public. Table 2 summarizes the available information.

CONCLUSION AND PROSPECTS

As in the rest of the world, the field of geographical information in Israel is gaining momentum. Although research into remote sensing and satellite data gathering is largely being conducted and led by Israeli universities, the development of geographical information systems and databases in Israel is being carried out by and large by the private sector and the Survey of Israel. The shift to GIT began in the 1980s. In the 1990s, a national GIS was set up, incorporating 10 layers of basic information. The main effort in creating the local GIS in Israel lies with the local authorities.

After years of struggle with cumbersome technology that required specialized personnel, there are now much simpler systems that bring GIT right to the desks of planners and decision-makers. GIT is becoming an integral part of every large organization, and, in particular, local and governmental authorities. The GIS creates a network framework for geographical measurements, in both the dimensions of space and time. Thus, there is no doubt that in the coming decade, geographical information technologies will incorporate data from many sources, such as local tax management systems, electricity and water infrastructure systems, property management, and even retail management.

Recently, Israel also joined a small club of distinguished members that have launched Earth Observation Satellites. The Israeli built EROS-A1 has high spatial resolution capable of being used as a data source for many GIS applications. Efficient use of GIT will lead to better decision-making processes, faster reactions to problems by the authorities, research into regional problems at greater depth, and better exploitation of models developed in the geographical sciences. There can be no doubt that GIT is advancing and will continue to advance the geographical sciences.

If the experience of the last few years is any indication, the future of geographical information technologies is rosy. There is ample evidence indicating a continuous growth in the fields of remote sensing and GIS. Despite the drastic reduction in costs, there has been a considerable increase in profits of GIS companies, and predictions show an even greater growth in the near future. A major part of the above increase in growth is due to the integration of various technologies, such as remote sensing, including satellites, together with GIS, and combinations of raster GIS and vector GIS. This description is most probably true also for the prospects of the field of GIS and GIT in Israel.

REFERENCES

Antenucci, J.C., Brown, K., Croswell, P.L., and Kevany, M.J. (1991) *Geographic Information Systems: A Guide to the Technology*. New York: Van Nostrand Reinhold.

Doytsher, Y. (1999) Analytical/digital cadaster in Israel in three and four dimensions. In Forai, Y. and Priacta, R. (eds.) *Proceedings of a Symposium on Research Projects Funded by the Survey of Israel*. Tel-Aviv: Survey of Israel, pp. 40–43.

Doytsher, Y. and Hall, J.K. (1997) Interpolation of DTM using bi-directional third degree parabolic equations, with FORTRAN subroutines. *Computers and Geosciences,* 23:1013–1020.

Felus, Y. and Lida, E. (1999) Expert cadaster system. In Forai, Y. and Priacta, R. (eds.) *Proceedings of a Symposium on Research Projects Funded by the Survey of Israel*. Tel-Aviv: Survey of Israel, pp. 35–39.

Hanigan, F.L. (1988) GIS recognized as valuable tool for decisionmakers. *The GIS FORUM,* 1:5–8.

Peled, A. and Haj Yichyeh, B. (1999) Updating the National GIS. In Forai, Y. and Priacta, R. (eds.) *Proceedings of A Symposium on Research Projects Funded by the Survey of Israel*. Tel-Aviv: Survey of Israel, pp. 12–13.

Widowinski, S. and Bach, Y. (1999) Network of permanent GPS stations for mapping and interpretation. In Forai, Y. and Priacta, R. (eds.) *Proceedings of A Symposium on Research Projects Funded by the Survey of Israel*. Tel-Aviv: Survey of Israel, pp. 9–11.