A GIS Based Cadastral Database at the Survey of Israel - Infrastructure for Future Modern, High Accuracy Cadastre

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SUMMARY

By the year 2000 the Survey of Israel (SOI) had accomplished the creation of a GIS driven cadastral database and the main efforts were turned to updating and maintenance.
Data was collected by digitizing over 15,000 Cadastral maps since 1992 when the project began.
Since 2000 the data is updated constantly by new surveyed mutation plans which are handled digitally and embedded in the data. This improves the data towards a coordinate based cadastre.
Today the data is distributed and used by the SOI in the main office and in the office of district surveyors, other government organizations, surveyors and the public.
The database is designed to support computer based procedures for checking mutation plans and mutation plans. A connection to the SHALOM management system ensures a seamless data flow for monitoring and quality control.

This Cadastral database is the foundation for the future modern cadastre in Israel, complying with the principals of Cadastre 2014. The goal is seamless cadastral high accuracy data which will enable easy and more efficient data retrieval by surveyors and better service for the public.

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1. INTRODUCTION

The land registration method in Israel is based on the Torrens system (registration of titles). The state (through the services of the Survey of Israel, SOI) is responsible for the description of the land parcel boundaries as registered in the Land Registry Office (Forrai et al, 2004).

SOI is the top professional geodetic and surveying authority in the country, setting standards, initiating legislations, licensing surveyors, supporting and initiating research and development, actively managing and maintaining the national geodetic infrastructure, the national GIS, and is responsible for mapping, topographical and cadastral. SOI supervises, approves, collects and maintains all cadastral mapping.

The land administration practice in Israel involves both the governmental and the private sectors (Kraus and Forrai, 2006). Although the part of the governmental authorities is relatively dominant, there is a growing trend of deeper involvement of the private resources in the process. This tendency is based on different backgrounds and motivations, some derived from ideologies and some based on economic considerations.

The private sector (which is composed of some 500 active licensed surveyors) carries out a great variety of tasks. One of the most important of them is the preparation of mutation plans, which serve as required technical documentation of any change in land registration.

According to the existing law, each mutation plan has to be carefully checked and approved by SOI before starting with its registration procedure. SOI should complete increasing supervising tasks with permanently decreasing professional personnel. These opposite trends result in queue of mutation plans waiting for the beginning of their examination.

Each year, some 1200 – 1600 mutation plans and some 200 new cadastral block maps have to be examined and finally confirmed under the full responsibility of SOI. An optimal management method can essentially contribute to the effective completion of the task.

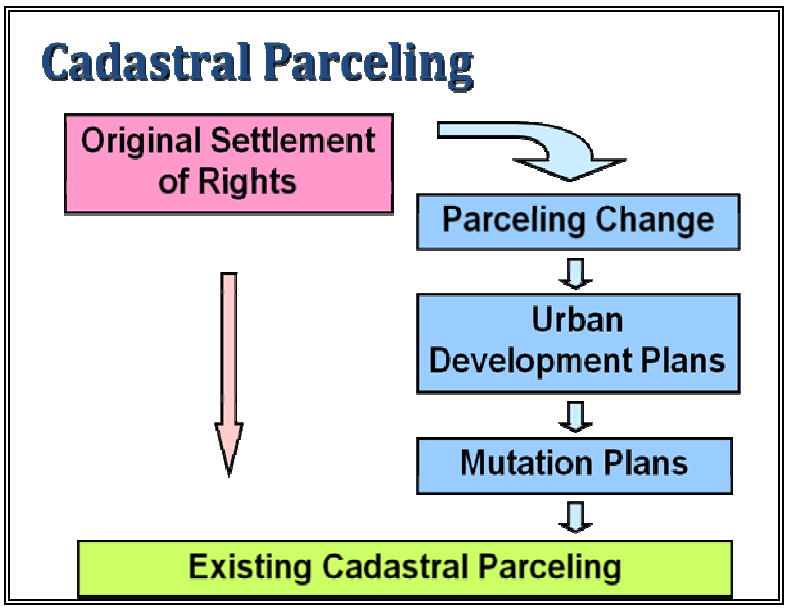
This idea resulted in a decision to develop a comprehensive, fully computerized management system for the management and control of the cadastral activity at the Survey of Israel.

2. THE CADASTRAL PROCEDURE IN ISRAEL

For the application of the Torrens registration method in Israel ("registration of titles"), the State is responsible for maintaining the geodetic control network which enables precise reconstruction of surveyed boundaries in the future (Forrai et al, 2008).

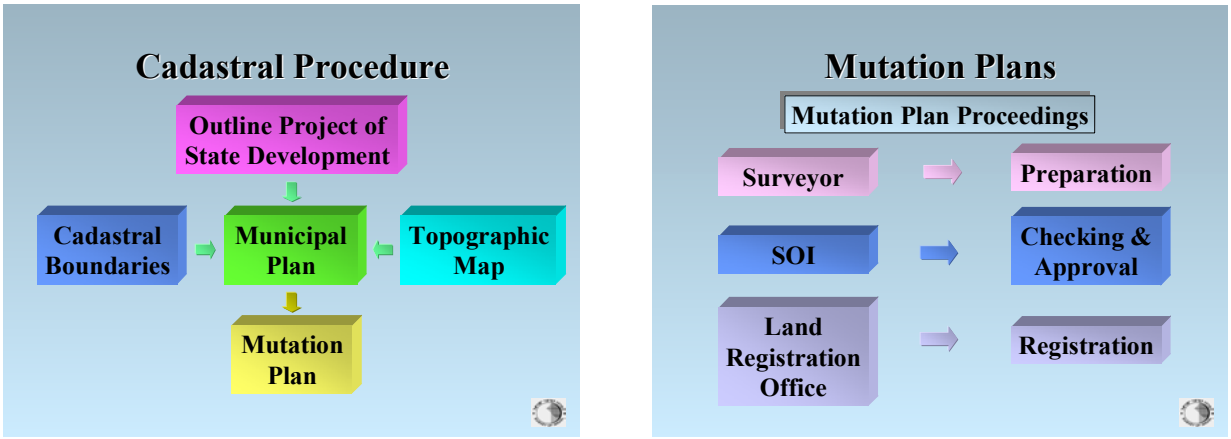
According to the Torrens principles, the subject of registration is the land parcel. The boundaries of a parcel and the objects situated inside the parcel (such as buildings, walls and fences) are thoroughly surveyed, and the area of the parcel is calculated. This type of registration ensures an effective and convenient way for proper real estate management, effective planning and land transactions.

Settlement of rights, according to the Torrens principals, began in 1928 and has been in progress ever since. The state initiates and finances settlement procedures. Up to now 95% of the country has been settled.
From the beginning of settlement of land rights and registration, some 18,000 blocks and more than 800,000 parcels were established and registered.



Picture no. 1 : Cadastre processes

Any change in the original settlement of land rights (like merging or subdivision of existing parcels) has to be carried out by means of preparation of a so called mutation plan, made by a private licensed surveyor. (pictures no. 1, 2)
According to the Israeli Law of Planning and Construction, the preparation of a mutation plan has to be carried out on the basis of municipal plans (urban plans) approved by the competent authorities of planning and development. The municipal plan, frequently drawn on the background of a topographic map, sketches the approximate position of new cadastral boundaries and the intended use of new parcels (e.g., residential area, industrial zone, public area etc.). The accurate position of boundaries is defined in a mutation plan, on the basis of precise surveying. (Forrai et al., 2004.)



picture no. 2: Mutation plan procedure

Examination process of mutation plans starts in SOI in one of five District Surveyors' Offices, where the original cadastral drawings are kept and used for the mutation plan preparation by licensed private surveyors. The most important part of the checking process concerns the correct reconstruction of parcels boundaries according to available legal sources, while the registered area of the original parcels is strictly preserved. Another important part of the check process deals with performing the computerized test of submitted work files, prepared according to pre-defined standard formats. Following a successful examination procedure, these work files are uploaded into the database of the national cadastral GIS.

The surveyor provides the new parcels of a mutation plan with a temporary numbering (commonly, starting from number 1) and calculates the area of the new parcels. As soon as the plan is accepted by SOI as "approved for registration", it may be presented to the Land Registry Office, which provides the new parcels with final numbering (starting from the last number of the parcel registered in the specific block), registers the area of each new parcel and its ownership. The "final numbers" of new parcels are transferred then back to the SOI in order to update parcel numbering on the original mutation plan drawing, on the cadastral block map and in computerized database.

3. SPATIAL DATA BASE – OBJECTIVES

The Cadastral information system at the Survey of Israel was initially established at the end of nineteen eighties within the general framework of the national GIS.
The objectives of the computerized system were to bring cadastral information to be available to the Survey, private surveyors, government offices and private citizens. The idea was the display and query of the required Cadastral information.
This was a revolutionary idea: availability, uniformity homogeneity and quality control.
The computerized system is based on the database management software and also on software which permits display and query. This is a combination of the standard GIS software

combined with tables of information managing software (non spatial) as a complement of the GIS system in a CLIENT/SERVER configuration.

4. PROJECT HISTORY

4.1 Project initiative

When first established, the GIS Cadastre Database was seen as an instrument for management and dissemination of Cadastral information. Traditionally all Cadastral documents were in conventional form: field books, observation records, plotted sheets and files (paper files) containing computations and maps.
The cadastral maps and survey records were used as the source of information to surveyors and those dealing with real estate. This meant extracting the documents from the archive and presenting them to the client, a very labor intensive process and one which leads to the deterioration of the records. In addition, it requires the clients to present themselves in order to identify and order copies of the records.
Preparation of mutation plans which are the basis of changing the original settlement requires intensive use of cadastral documents from the archives. Thus, the establishment of cadastral GIS that can serve as a main source for records has to be based on all the archived documents; otherwise it stands in danger of failure.

4.2 The establishment of the system

The establishment of the computerized system has taken a long time. The Survey of Israel went through procedures leading to acquisition of hardware and software of a very high quality and undertook training of a large number of personal. The Survey employed some new programmers and also relied on obtaining software from private companies. A private contractor was engaged for digitizing and tracking.
The project took a turn when a joint project was established with the Directorate of Lands, which had similar objectives in mind. A large number of problems were encountered, technical, organizational and budgetary.
In the year 2000 the data acquisition was completed and a new project for updating the information through approved mutation plans started.
The Cadastral GIS was extended over the years until it became an important means in projects such as accelerating registration and "on line" government (e-government). Since 2005 practically all divisions of the Survey relied on the GIS Cadastre Database as routine in their current tasks. This was the original objective of the system. The Cadastral database is referred to as the "National Cadastral GIS".

4.3 Data acquisition through digitization

There were two alternatives. One was feeding the cadastral GIS with the best available original survey data, i.e. field books and changes from mutation plans, a procedure resulting in optimal accuracy of data. The other alternative was to digitize cadastral maps.

Studying the cost and time consuming of the alternatives led to the decision to build the database by digitizing. Each block would be digitized separately and only after quality control tests an adjustment procedure of block boundaries was carried out. Boundaries had to be adjusted because the cadastral principal is that there must be no overlapping or gaps between parcels (and blocks).
Digitizing the block was carried out, at first, by employees of the Survey. A joint project was established with the Directorate of Lands in order to boost the project. Two private companies were chosen through a tender process to carry out the digitization and another company was hired for quality control. A special team at the Survey was responsible for answering questions about discrepancies that were found by the companies. The question answering team responded to over 16,000 questions (on the average of one per block).
Here are some examples of questions:

- Discrepancy between the area computed and the area registered: Discrepancy between the area computed and the area registered was the most often encountered. In at least 75% of the blocks, there was a discrepancy exceeding the tolerance. The discrepancy was measured by the formula contained in survey regulations : $\Delta A = 0.8\sqrt{A} + 0.002A$ where A is the registered area in square meters and ΔA is the maximum permitted difference between two measurements. The decision was always difficult because the area registered is statutory and any change requires the consent of the Settlement Officer, or in the case of a mutation plan, the preparation of an additional mutation plan. Since the problems encountered were many it was decided to compromise and deal only with discrepancies larger than 5 times the permitted one. As a result the data base contains parcels with discrepancies above the permitted tolerance.
- Discrepancy between borders of neighboring blocks: (approx. 20% of all block boundaries). The discrepancy was in general due to transformation from the maps to files, based on control points on the Cadastral maps. Another reason was mistakes on the maps caused when mutations were drawn.
- "Disappearance" of a parcel: This was a rather rare occurrence (approx. 3%) caused in most cases by errors in plotting block boundaries from mutation plans.

4.3 Accuracy

The accuracy level of the data acquired by digitization has been evaluated in many researches. In order to learn and asses what the best accuracy one could reach, some researches studied the original measurements. The accuracy is defined as the matching between coordinates that were calculated from the original measurement documents and the coordinates obtained from new, modern instrument use, measurements. Results show a built in error of 20 cm. in the original measurements. (Gavish, Doytsher, 2002), (Steinberg, 2001). This means that that is the best accuracy that could be reached by digitizing methods.
Comparing the digitized data to that calculated from the original field books or from surveying parcel boundaries showed that 80% of the data was in the 10-35 cm. When the control point on the cadastral maps were of pour quality or were missing accuracy dropped to 1 m. and in some cases to 2 m.

During digitization the parcel area was calculated and compared to the registered area. As mentioned above in about 75% of the blocks there was at least one parcel with a big (more than the criteria) difference.
The way to improve the data is to use newly surveyed data and embed it into database and replace the digitized data. This method is elaborated in paragraph 5.2 .

5. PRESENT DAY PROCEDURES: TECHNOLOGIES, UPDATING, IMPROVEMENT, DISSEMINATION, A WIDESPREAD USE

The gist of the National Cadastre Database is the creation of a GIS Cadastre database containing the country wide registration layer (cadastral parcel layer) which becomes a computerized database, providing an infrastructure for a future modern cadastre. This is the only way to generate quality of information and increased efficiency. All tasks will be based on the potential of the computerized database. All new information products will be based on it. The new ordinances, instructions and standards will become a legal infrastructure of the cadastre in Israel. The work plan for 2006-2008 was influenced by the considerable change in technologies and the number of users. The project "SHALOM" – Control and Monitoring – has been largely developed in 2008 and will continue through 2009. It will provide a basis for new applications (Gavish, Voznesensky, Forrai, 2009).

5.1 Technology of the information system

When established, the National Cadastre Database worked on the basis of standard ArcINFO software by ESRI and ORACLE. The system deals with input, updating and querying boundaries of cadastral parcel registration. In 2007 the Survey began a plan for updating the National Cadastre Database. This was necessary because of two major changes:

- ESRI technology changed from ArcINFO to ArcGIS;
- Changes planed in Israel's' ordinance;

The database was redesigned and includes five basic components:

- SDE technology database which includes the data base for information and all work procedures;
- An updating component and additions on the basis of settlement blocks and mutation plans;
- A database querying component for the purpose of supplying information to the users and clients. This was designed on a browser platform to provide the possibility for other applications to use the querying tools;
- New settlement and data correcting component;
- Mutation plan quality control component.

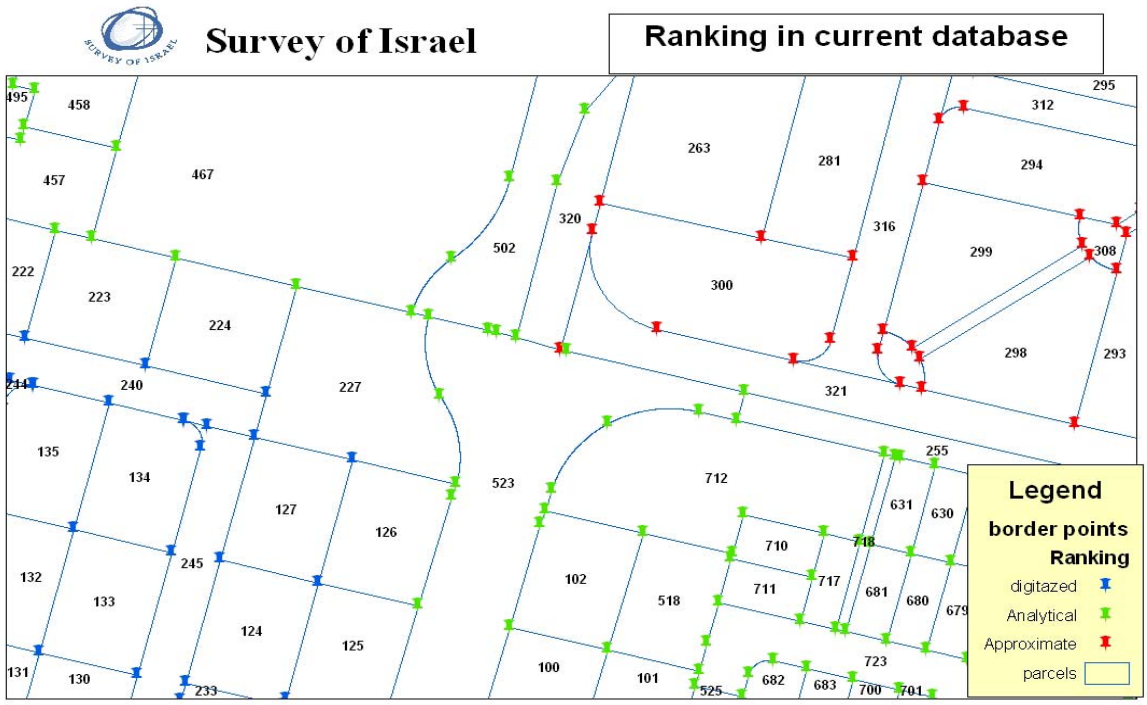
5.2 Operations concerned with editing and updating cadastral information

As mentioned above, the database was first built by digitizing cadastral maps. All the updating is carried out from newly settled blocks or by mutation plans. Surveyors, working

according to the ordinances, instructions and standards, provide newly measured data with high accuracy. The expected accuracy is 5 cm. (Steinberg, 2001).
Updating of the parcels layer is done on the basis of a mutation plan module or new settled blocks. In each mutation plan the update includes the cancellation of parcels which are changed by the mutation plan and their transfer to a history layer and their replacement by the new parcels created by the mutation plan. The new parcels are of high accuracy according to the survey method.
In cases where high accuracy data exists in the cadastral archives it is used to replace digitized data.
The present National Cadastre Database has 3 ranks for border points according to their source. The lowest rank is assigned to points which were obtained by digitization, the highest rank to points measured with high accuracy surveying equipment like RTK GPS, Total station based on GPS measured control points. The third rank is granted to border points that were obtained by calculation of original documents but not surveyed again. Picture 3 shows a cadastral block from the National Cadastre Database where parcels have different ranked border points. This block was digitized and parts of the data were improved by new measurements or by using old measurements. The 3 ranks are:

- Digitized data – the lowest accuracy - Blue
- Analytic data - the highest accuracy - Green
- Approximate data – data acquired from old measurements - Red

This is the foundations of Coordinate Based Cadastre.



Picture no. 3: ranking of border points

Other operations on the data, except continuous updating, can improve the accuracy. These operations are mainly recalculating while implying geometrical and topological constraints. The digitized cadastral data should be further processed to minimize inherent errors in the data conversion procedure, to resolve inaccuracies in the original parcel maps, and to fit them to the new GPS-based coordinate system with high precision (Felus 2007). Using a new rubber sheeting technique that includes linear features and boundary lines in order to locally translate, rotate, and scale the map in alignment with ground monuments, measured boundary lines, and surveyed topographical features.

The authors believe that a continuing updating process together with special projects as described in the next chapter will improve the accuracy to the desired future database.

6. DIRECTIONS TO THE FUTURE

6.1 Coordinate Based Cadastre GIS

Coordinate based cadastre is the modern conception of a cadastral database that can obtain measurement data and keep reference to the accuracy of each border point. In this way it is possible to manage the cadastral data and eventually to allow a legal status to the electronic data too, not only to the printed documents. A legal status will allow surveyors to start working without wasting time on calculations of the original survey documents and without retrieving documents from the archives.
The accuracy reference is scaled according to the border points' qualities and defined in a ranking table.
The qualities are:

- A newly established point;
- An original point (measuring an original point is the highest);
- Method of surveying: GPS is the highest;
- Calculation from field books;
- Digitized data.

In general, point ranking is determined by the accuracy. Accuracy is calculated from the data (control points and redundant measurements) and is given as the upper limit circular error with 95% confidence.

A suggestion for ranking cadastral border points is shown in table 1.

Point Ranking	Accuracy	Marking type	Source data	Definition in current database	
1	"0"	A point measured and/or calculated as part of an analytical cadastre project in state owned open areas or with the Director Generals' approval			
2	0.05	Ground monument	Original point or newly established	None	
3	0.2	No found	Field books	Analytical	
4	0.5	No found	Field books	-	
5	0.8	No found	Geometrical	Approximate	
6	Scale depended	No found	From digitized maps	Digitized	
9	>0.8	A point with calculation error or any other problem that prevent accurate rank determination			

Table no. 1: Table of point ranking

During 2008 and 2009 the Survey of Israel is engaged in projects aiming to establish the foundations of Coordinate Based Cadastre (Klebanov et al, 2009) these projects aim at obtaining improved digital data, based on original cadastral documents (block maps) having legal validity. Project results are expected to be complete and accurate and qualify for rank 1. This data will replace exsisting data obtained by digitaization in the National Cadastral GIS Database and build the new ranked database.
As explained in section 5.1, the Survey of Israel is in the midst of redesigning the National Cadastre Database. The new design, together with the SHALOM project, will ensure the possibility of managing Coordinate Based Cadastre.

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BIOGRAPHICAL NOTES

Johanan Gavish received his B.Sc. from the Technion – Israel Institute of Technology, Division of Geodetic Engineering in 1979. In 2001 he received his M.Sc. form the Technion, also in Geodetic Engineering. Since 1982 he has been with the Survey of Israel, where he was involved in cadastral measurements during the period 1983-1990. As a head of the GIS department 1990 - 2008, his main responsibility was the defining and building the Israel National Cadastral Database. In 2008 he was nominated as Deputy Director General of the Survey of Israel for Geo-information and Mapping.

Ester Benin is studying for her B.A. in public policy. Since 1976 she has been with the Survey of Israel where she has been involved in surveying and computing of measurements. Since 1994 she has been a project manager in the GIS Cadastral project. She was responsible for administration and quality control. Since 2001 she is the head of the project and in 2006 was nominated head of Cadastral GIS department.

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