

Implementation of Coordinate Based Cadastre in Israel: Experience and Perspectives

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SUMMARY

A long term process aiming to modernize the national cadastre system by implementing coordinate based cadastre, recently started by the Survey of Israel (SOI). This process is officially considered by SOI as one of its most important, strategic goals.

In the beginning of 2009, SOI has launched a project aiming to determine optimal coordinates for parcel boundary corner points in the southern part of Israel, over the Negev Desert, containing about 50% of the country's area. Advanced GIS tools were applied to process, analyze, store and manage the cadastral data, along with GPS technology for the measurement of parcel boundary corner points in the field.

Following a successful public bid, the project contractor carried out the following work: collection of all the existing cadastral information about the project area (scanned block maps and mutation plans, data concerning international boundary monuments, measurements of boundary-defining topographic features, coordinates of geodetic control points, surveying notes, and other documents), measurement of existing authentic parcel boundary corner points, adjustment of input data and calculation of precise coordinates for boundary corners. At the same time, SOI started intensive activity on preparing the integration of the newly obtained adjusted data in the cadastral database of the national GIS, maintained by SOI.

The experience gained by the SOI during handling the project, has a great importance towards the completion of the coordinate based cadastre project in national dimension.

The paper details the current status of performed work and the perspectives of future work on implementation of coordinate based cadastre in the country.

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1. INTRODUCTION

The land registration method accepted in Israel (Registration of Titles) is based on the Torrens principles. 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).

The establishment of the land settlement in the country has been started following the First World War, in the early years of the British mandate in Palestine. (At the present, some 5% of the area of the country is still not settled.) Rights to land are registered as a result of the original land settlement. Any change in the land register should be initiated by a municipal plan and carried out through a so-called mutation plan prepared by a licensed surveyor.

The land administration practice in Israel involves both the governmental and private sectors. Although the part of the government authorities is still relatively dominant, there is a growing trend of deeper involvement of the private resources in the process.

In cadastral surveying and mapping practice, the government is represented by the Survey of Israel. 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 (including current geodetic datum based on permanent GNSS stations network), the national GIS, and is responsible for topographical and cadastral mapping. SOI supervises, confirms, coordinates and maintains all cadastral mapping in the country.

According to the existing law, each mutation plan has to be carefully checked and approved by SOI before starting with its registration procedure.

The private sector (which is composed of some 700 active licensed surveyors) carries out a great variety of tasks, amongst them geodetic control network densification, engineering measurements, topography, photogrammetry, GIS related updating and – particularly – cadastral measurement and mapping. One of the most important of the surveyor's cadastral tasks is the preparation of mutation plans, which serve, as previously mentioned, as the required technical documentation for any change in land registration. During the last five years, a number of private surveyors, nominated by the DG of SOI as "supervising surveyors", are also involved with the supervision of mutation plans prepared by other licensed surveyors (Forrai & Kirschner, 2009).

A number of governmental agencies are involved in the land administration practice. The "main actors" are the Land Settlement and Registration Department (Ministry of Justice) and the Survey of Israel. The Israel Land Administration is the government agency responsible for managing 93% of the land in Israel which is public domain. The Ministry of Interior is involved through the municipal committees of planning and construction. The Ministry of Construction and Housing is responsible for major development projects in the country, and is one of the main clients of fast, exact and secure registration of rights. The Ministry of Finance is connected both through state budgeting and as the head of an inter-ministry committee for land registration improvement, composed of all the agencies mentioned in this paragraph.

Historically, the cadastral process, based on hand made maps and manual geodetic calculations, was always accompanied by the maintenance of basic information at the SOI for a subsequent data supply to professionals. Providing this information by SOI is a starting point of the cadastral process. Before beginning of his work, the surveyor undertakes search actions in the SOI archives and data bases in order to define the mutation plans which determine the position of relevant existing parcels boundaries. At the final point of the cadastral process, when the mutation plan arrives, firstly, to the SOI for check performance and, afterwards, to Land Registry for statutory registration, plan's identification number, parcels temporary and final numbers are registered at the SOI.

All this relevant information is stored at SOI and provided to surveyors through Internet (Forrai & Klebanov, 2006), assisting their cadastral work. On the one hand, according to the Surveying Regulations, each new mutation plan should be compatible with cadastral blocks and previously approved mutation plans. On the other hand, each time the surveyor identifies an authentic boundary or control point which was measured during former relevant cadastral procedures, he has to re-measure this point and adopt its position in the current national geodetic datum. This obligation of re-adjustment, and the possibly low accuracy of the old measurements, result in changes of cadastral boundary point coordinates again and again, causing technical-, planning-, financial and \ or legal difficulties.

Meanwhile, the improvement of the national geodetic infrastructure and the cadastral measurement techniques based on it (Forrai, 2009, Salmon et al., 2009) make it possible to determine coordinates of cadastral boundary points, at any time, with a 2-5 centimeter accuracy. On the basis of these coordinates, parcel areas can be computed more accurately than the previously registered ones. The new possibilities coincide with the public demand for determination of accurate boundaries and their registration.

In principle, a new land settlement (based on modern satellite geodetic field measurement) would be desirable and could basically contribute to a very "smooth" cadastral practice in the future. Unfortunately, this solution is not feasible. Land settlement is a difficult procedure, composed of legal and technical components. As mentioned, even nearly 90 years of cadastral practice was not sufficient to finish the "first round" of the original land settlement.

Therefore, a "quasi-new arrangement" was proposed, the legal Coordinate Based Cadastre (CBC) (Steinberg, 2001). The idea is to create an optimal set of parcel boundary point

coordinates within a cadastral block (adjusted with neighboring blocks, in the current, accurate geodetic datum), and to legislate a new rule stating that authentic field marks will no more determine the position of cadastral boundaries but the "legal coordinates".

Technical, legal and economic aspects should be practically examined and verified towards CBC implementation on the nationwide level. A number of R&D pilot projects have been already executed in different regions (Mediterranean Coast, Central and Southern Israel). The first wide scale project in the Southern part of the country (Southern Negev Area) has been started in 2009, as a result of a public tender, and is planned to be finished in the first part of 2010 (see section 2). Meanwhile, further, less deserted continuous areas of the Northern Negev are ready for work following the results of a new tender (see section 3).

2. THE SOUTHERN NEGEV PROJECT

In 2008, SOI has launched the project of implementation of Coordinate Based Cadastre in the Southern part of the Negev Desert region, spreading on almost 50% of the territory of the State of Israel (Klebanov et al., 2009). It was decided that the project would be performed in the non built up areas spreading over about 200 cadastral blocks (about 2600 cadastral parcels) that include most of the Negev Desert territory (see Figure 1). Those non built up areas are lacking detailed information concerning corner point position, except cadastral block maps drawn at the scale of 1:20,000 at the stage of original settlement of proprietary rights. All the project area is in State possession and most of the parcel boundaries have not been marked on the ground. According to the project terms, parcel corner point position should be determined by means of coordinates in the highly precise new Israeli geodetic grid – IG05 (Steinberg & Even-Tzur, 2004) for further marking, if necessary, with analytical accuracy of modern geodetic instruments (a number of centimeters).

The project has a number of specific conditions. First of all, the geodetic control points physically marked on the ground were partly used as the parcel corner points. According to the existing law, they should be re-measured by one of the techniques permitted by present Surveying Regulations (ground surveying, satellite technology). The reason for their new measurement was the fact that in the past they were measured by means of geodetic instruments that according to the present Regulations do not meet any more the accuracy requirements. The additional reason was the fact that point coordinates were computed in geodetic control grid that is not in use in Israel anymore. Additionally, the road parcels (their axes or margins) in the project area had to be measured as the authentic (physical) evidence of parcel boundaries location. Considering the large extent of the project area, the latter task demanded involvement of great financial and human resources.

The main goal of "Southern Negev Cadastre" project has been determined as transformation of existing parcellation into analytical coordinate based data characterizing by strong topological compatibility between adjacent cadastral blocks. The task was to obtain optimal corner point coordinates that eventually would be declared as those having juridical validity for parcel point's restoration. As has been decided, the basic data of the project would be the

existing digital data of national GIS which will be improved aiming to bring it to maximal compatibility with the physical block maps (see section 2.1.4).

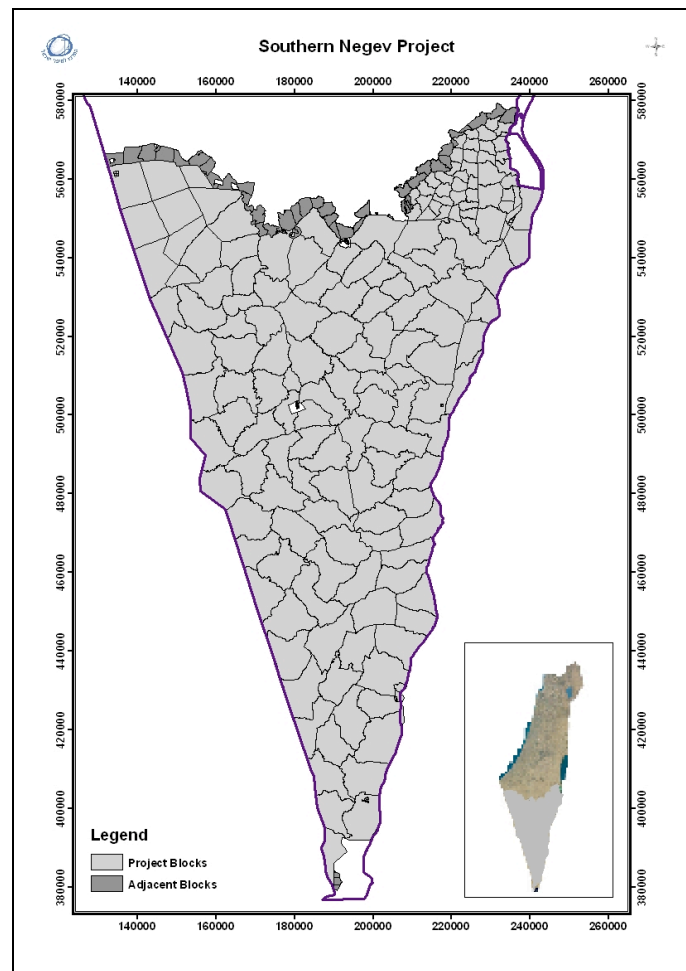


Figure 1. Southern Negev Project.

According to the pre-defined schedule, the results of the project have been obtained by the end of 2009. At the present, they are under the check procedures.

2.1. Project Highlights

The "Southern Negev" project included a number of tasks performed according to the technical specification and pre-defined schedule.

2.1.1. Authentic Points Identification

The geodetic control points and the points situated on margins of road parcels (or on road axis) served as the original corner points in current project. They served as the base points for parcel boundaries adjustment. Regarding the road parcel corner points, the check has been

made whether the route of the road had not been changed - situation that often happens in the desert region. The contractor performed the search of the authentic points on the ground. Considering the significant geographical scope of the project, it was one of the most time-, cost- and labor-consuming tasks. Aiming to reduce required resources and to intensify the whole process, it was determined to perform the measurements by means of satellite technology.

2.1.2. Geodetic Measurements

The modern cadastre requires usage of appropriate geodetic instruments enabling to obtain parcel boundary point coordinates with the required accuracy. Satellite technology and its RTK application, being used for this purpose, is one of those instruments representing advanced method of point definition. The use of satellite technology in the measurement of road parcels having dozens of kilometers in length definitely enabled to carry out geodetic measurements of the project at high technological level and relatively fast. However, there were some difficulties in applying the GPS based technology in the current project, e.g. lack of cellular covering in some remote areas of the desert region which is essential for applying the GPS-RTK method (see section 2.2.1). Therefore, in the "Southern Negev" project, cadastral surveying has been implemented as a combined method which included both RTK and static satellite technology as a principal tool and EDM measurements as a complementary one.

2.1.3. Connection to Adjacent Areas and International Boundaries

As the outer frame of the project region there have been used i) some adjacent to the project area blocks having more detailed information, including the enclaves of built-up regions in interior areas, and ii) the international boundaries.

In those adjacent areas the work has been performed according to the requirements of the Surveying Regulations regarding restoration of parcel boundaries. That means processing of detailed cadastral information aiming to obtain corner points coordinates and further examination of the presence of corner points marking on the ground, checking their authenticity and eventually ground surveying of the found points by means of conventional EDM measurements or by satellite techniques.

The international borders between Israel and neighboring countries (Egypt and Jordan) were determined as part of the peace treaties and the international boundary points have been fixed on the ground and measured with reference to a geodetic grid (see Srebro & Shoshany, 2007).

2.1.4. Improvement of GIS data

The cadastral layer of the national GIS has been served as an initial dataset for the project. These data were created by digitizing the original cadastral block map and subsequent fitting in actions. As a result they suffer, on the one hand, from some mismatches compared to the original maps. On the other hand, these data have legal validity for parcel boundaries

restoration as the exclusive cadastral material in the project area. Consequently, the contractor was obliged to improve the digital data of the national GIS by means of comparison with the original maps and further correction of erroneous or not sufficiently accurate data.

2.1.5. Data Adjustment

Following the aforementioned stages, all digital data have been integrated and adjusted. A data adjustment process has been performed by the contractor in order to achieve the required accuracy and to combine all the different factors and constraints. This operation, termed rubber sheeting, scales, rotates, and translates a sub-area or portion of the digital map in a non-uniform manner, such that spatial co-registration between the digital map and the surveyed points and features is accomplished. The rubber sheeting technique employs a triangulation to divide the area into small units, in each unit the transformation parameters are calculated from the constraints.

2.2. **Difficulties of Realization**

During performing the project, the contractor encountered the following difficulties.

2.2.1. Problems of Cellular Covering

As mentioned in section 2.1.2, because of the large geographic extent, the geodetic measurements in the project areas were intended to be performed mainly by means of satellite technology in its RTK mode. Due to the fact that cellular covering in remote regions of Negev Desert is characterized by weak signal or even complete lack of it, the contractor has been forced, in many places, to perform measurements on the ground and their processing in the office in the separate mode, termed as Post Processing (PP). Some limited project areas were measured by means of EDM technology. This situation certainly caused some complication of project performance, mainly in the measurement of long road parcels.

2.2.2. Partial Lack of Authentic Control Points on the Ground

Existence of authentic control points on the ground is crucial for accomplishing the adjustment procedures of original digital data. Control points serving as parcel boundaries corner points play the role of the base points for rubber sheeting adjustment technique (see section 2.1.5). In spite of preliminary estimate regarding the number of control points, after thorough check performed by the contractor on the ground, only several tens of such points have been found in the whole project area. Certainly, this fact affected the accuracy of final results.

2.2.3. Route Changes of Original Roads Defined as Parcels

Good road maintenance in desert conditions requires the need of their frequent checkup and reconstruction, if necessary. This situation causes inevitable route changes that give rise to the

excessive differences, or complete lack of accordance, between presently measured road parcels and their original position obtained from the cadastral layer of national GIS.

Turning points of the original road parcels being one of the two types of authentic points have been determined to serve as the base points in adjustment process. The contractor, according to the technical specifications of the project, had to measure axes or margins of the roads by means of satellite technology (in its static or kinematic mode depending on quality of cellular covering). Provided the known (declared) width of road parcel, this enabled to define parcels boundaries as the offset lines parallel to the measured road axes or margins. After accomplishing measurement process, estimation of obtained results has been done on the matter of authenticity of road routes. The estimation has been performed by means of integration of cadastral GIS layer information and newly measured road routes and checking the difference between them. Due to the fact that cadastral digital data in the project area have been obtained based on graphic description of boundaries upon the block maps, it was decided that difference threshold would be defined as a function of block map scale (1 mm on the map). That means that if the difference between the digital data and the modern measurement for certain sections of road parcel boundaries exceeds the pre-defined threshold, it could be assumed that the original road route in those sections has been changed. As a result, in such cases, it is impossible to consider newly measured turning points of the roads as the authentic points in the adjustment process.

Notwithstanding, there were measured road sections having route geometry very similar to the geometry of the original route but still excessive location differences (mainly, boundary shift). The contractor submitted to SOI the drawing file describing sections with such excessive differences. SOI in cooperation with the contractor after detailed analysis made a decision for every section – to adopt the measured version as the authentic one or to reject it.

2.2.4. Parcel Boundaries Discrepancies

As it was mentioned in section 2.1.4, due to the situation of almost complete lack of detailed cadastral information concerning project blocks, cadastral maps drawn at the scale of 1:20,000 have been used as a statutory base material for parcel boundaries definition. The job of bringing to accordance between the digital data of national GIS and the handmade cadastral maps having legal validity is crucial but not trivial. Two kinds of discrepancies have been found during project performance – i) discrepancies between digital data and physical maps and ii) discrepancies between digital data of neighboring blocks even after accomplishing the improvement procedure. The first kind of discrepancies is relatively simple to deal with and correct. Usually, it is caused by general shift of the graphical map, or by skipping, or by false appearance of boundary point occurred during digitization process. The second kind of discrepancies originates from general inconsistency of currently existing cadastral materials constituting statutory base of the Israeli cadastre system. Dealing with this sort of problem by means of correction of parcel boundaries position or by change of shape of original parcels aiming to create homogeneous cadastral continuity may cause land disputes between the neighboring holders.

Generally, the latter problem becomes worse whenever the base materials are graphical maps (as in our case) whose accuracy may reach decimeters and even lower. However, in our case of non built up territory in the Negev Desert region, where all project lands are in the governmental possession and most of the interior and exterior block boundaries are analytical lines having no ground marking, the aforementioned problem is not critical, but still it demands proper treatment.

2.2.5. Problem of Parcel Areas

According to the existing Surveying Regulation, there is an allowed difference between the registered (in the National Registry Office) parcel area and the area calculated from analytical coordinates of measured parcel corner points. 15% of over 2600 cadastral parcels of the project were found with excessive area difference. Treating the problem may be done in one of two possible ways. One way is fixing the positions of parcel corner points aiming to define their coordinates that would enable to obtain calculated area with allowed difference. The second way is to change registered area in accordance with newly computed area. Generally, the preferable way is the first one since it prevents possible claims of individuals against the State as the guarantor of possession rights. However, because of some additional conditions and constraints, sometimes there is no possibility to meet all the requirements regarding parcel boundaries position. In such cases the SOI may make an appropriate request to the National Land Registry, aiming to solve the area problem by changing parcel registered areas. In our case, this solution could be even more preferable than its alternative, due to the fact that all project areas are in the governmental possession. Anyway, the contractor has to make maximal efforts to keep the area differences within the allowed limits. The final decision about the possible change of parcel areas will be made by the SOI after completion of the project.

2.3. **Result Submission and Check**

According to the pre-defined schedule and contract terms, at the end of 2009 the contractor submitted results of the project to SOI for checking procedure. Submitted materials included the following data:

- Report file in PDF format containing general explanations about project performance, all geodetic calculations carried out by the contractor and detailed information about decision making in problematic cases
- Coordinate based cadastral analytical data in CAD format containing the position of parcel boundaries
- ASCII files formatted according to the special pattern (so-called SRV files) designated for computerized checking procedure of digital data and its loading to the cadastral layer of national GIS
- Spatially registered raster files of scanned cadastral block maps
- Auxiliary files in MS Excel format containing information about differences between measured (or calculated) values and registered (or normative) ones regarding parcel areas and fronts, coordinates of control points

2.3.1. Checking Process

The process of submitted data check has been divided between different SOI units according to the area of their professional responsibility. It was performed both in the intermediate stages during project performance as a part of routine supervision and finally after project completion. First of all, the interim results of field measurements regarding geodetic control network and road parcels have been checked by the special combined team of SOI field surveyors and geodetic computation experts. Then, during performance of the job, the contractor has been provided with the detailed instructions from SOI employees responsible for original settlement of land rights regarding parcel boundaries of certain cadastral blocks. Those employees were also responsible for checking final digital data submitted by the contractor. Finally, all digital data have been checked by SOI cadastral experts by means of computerized technique accepted in SOI for routine cadastral work and by additional applications developed for special cases. Computerized technique currently existing in SOI compares the new digital data versus digital data of settlement of rights and mutation plans.

Result check, besides the computerized technique, included also manual examination due to the situation that currently existing historical cadastral materials (physical maps and written documents), although containing numerous discrepancies and mismatches, have legal validity.

2.3.2. Data Assimilation

The obtained data regarding new position of parcel boundaries are supposed to replace the existing data of cadastral layer in national GIS. Currently in SOI there are two types of automated input processes of cadastral data assimilation – input of original data of possession rights settlement (original block data) and input of changes in original block parcellation (mutation plans data). The project data do not pertain to any one of the aforementioned types. It belongs to the area where original settlement of rights has been already accomplished and it does not change the existing parcellation but just improves point position accuracy within the project area. Nowadays, SOI makes great efforts to develop fully automated process of the third type of data input that would meet the requirements of the new kind of cadastral activity – projects of implementation of CBC. But meanwhile, the process of project data input should be done by means of interactive, not fully automated procedure.

3. **NORTHERN NEGEV PROJECT**

During performance of the Southern Negev Project, the decision has been made to continue the process of CBC implementation northward (see Figure 2). The main objectives of the decision were: i) to continue currently started process of implementation of CBC in Israel and ii) to test currently used techniques in the region with more complex cadastral background.

3.1. General Characteristic

The Northern Negev Region is characterized partly by desert conditions similar to those of the southern part (in the east and in the south, Sites No. 1-3) and partly by more favorable climate conditions (in the north-west of the project area, Sites No. 4-6). As a result, the region is characterized by denser population and more intensive human activity in comparison to the southern part. General intensification of human activity gives rise to cadastral activity that means more complex cadastral background in comparison to the southern part.

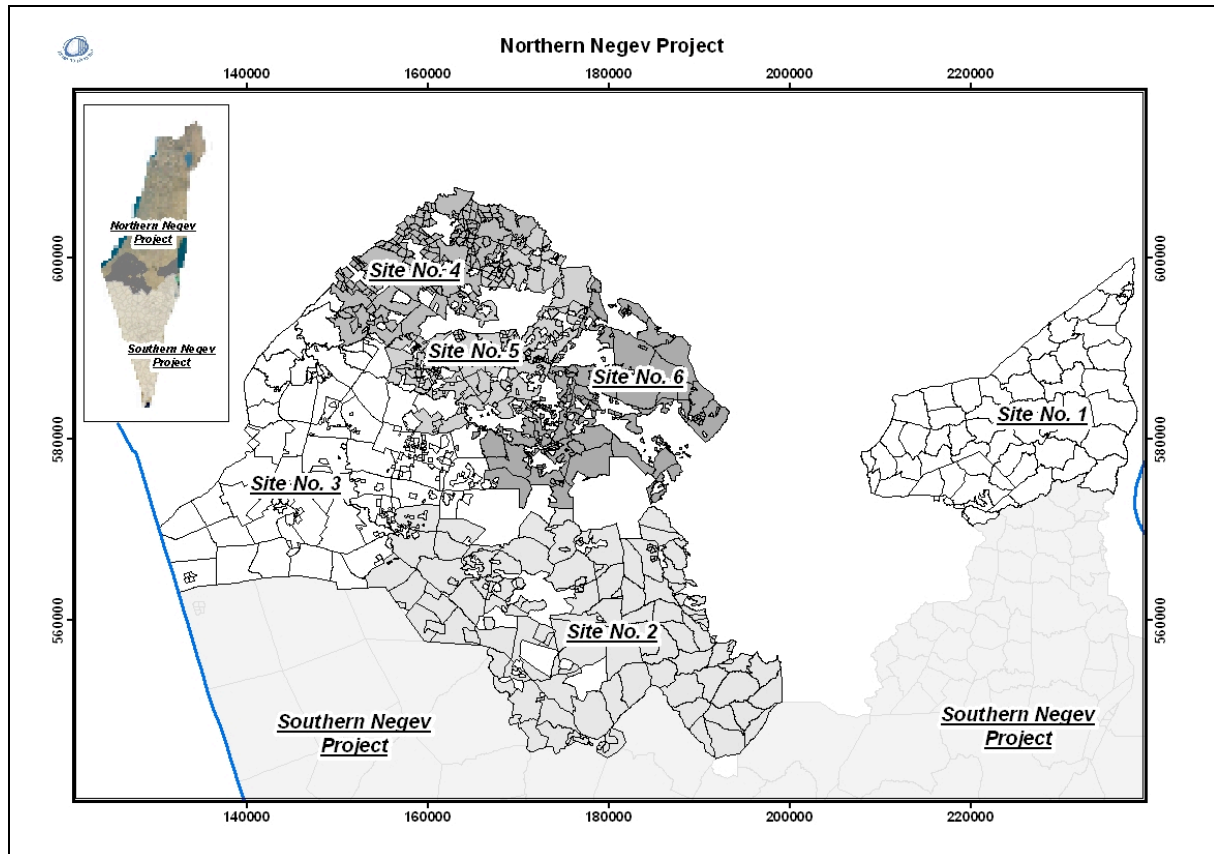


Figure 2. Northern Negev Project.

3.2. Site Planning

According to the decision made by SOI, the areas included in the project should be generally similar by their cadastral background and additional conditions to those of the project in the southern part of Negev. It means that the blocks of the project should be chosen according to the simplicity of the cadastral background, and preferably in the non built up areas. Accordingly, the project site planning was carried out meticulously based on the relevant layers of national GIS system maintained in the SOI.

As planning background, orthophoto layer, cadastral layers of blocks and parcels and layer of the mutation plans were used. Two kinds of areas have been chosen as the project areas – i)

non built up areas even though they have small parcels as a result of re-parcellation in mutation plans; ii) built-up areas that still do not have cadastral re-parcellation (mutation plans) dividing original parcels into smaller ones according to the new built-up situation. The first kind of areas is characterized by the (complete or partial) absence of buildings, walls and fences on the ground. Even if the mutation plans have been prepared in those areas, the situation of absence of physical objects makes the job of parcel boundaries reconstruction much easier. The second kind of areas is characterized by absence of mutation plans. Even if those areas are covered by physical objects (buildings, walls, etc.), they do not affect the location of original parcel boundaries. The both kinds of project areas are characterized by relatively minor extent of required ground surveying and not too high complexity of geodetic computations and data processing. Notwithstanding, the general complexity of the blocks chosen for the Northern Negev project is much higher than the complexity of the blocks of Southern Negev project, gearing SOI up for CBC implementation in the regions with complex cadastral and physical background.

It was decided to divide the project area into 6 sites having adjoining boundaries. This decision has been made to execute the project in a modular way according to different technical and financial considerations. Some statistic data of the cadastral background of each one of the project sites could be seen in Table 1. As one can see, Northern Negev project having one fourth of Southern Negev project area has four times more cadastral blocks, parcels and mutation plans. The latter is one of the most crucial factors affecting cadastral block internal and external homogeneity. Being prepared on the part of original block, e.g. involving part of block parcels, mutation plans often give rise to the discrepancies on its margins - between involved parcels and not involved ones of the block or between adjacent blocks.

Table 1. Statistical Data of Negev Projects – Southern & Northern.

PROJECT		NO. OF BLOCKS	NO. OF PARCELS	NO. OF MUTATION PLANS	AREA, SQ. KM
Southern Negev (1)		192	2,368	55	9,454
Northern Negev	Site 1	59	365	9	443
	Site 2	131	1,379	24	643
	Site 3	131	2,536	40	602
	Site 4	170	3,659	127	184
	Site 5	163	1,152	9	189
	Site 6	156	1,443	28	240
	Total (2)	810	10,534	237	2,301
Ratio (2)/(1)		4.2	4.4	4.3	0.24

As a result of planning process, detailed list of cadastral blocks included in each one of the project sites and site maps were prepared and attached to the project tender documents.

3.3. Technical Specifications

As opposed to the technical specifications of the Southern Negev project characterized by relatively homogeneous cadastral background, in the technical specifications of the Northern Negev project three categories of blocks have been defined according to their cadastral background:

- *Blocks with solid cadastral background*

This category contains the blocks having various kinds of cadastral background which generally can include – block maps (maps showing up-to-date situation of cadastral parcellation of the block), field sheets (maps showing cadastral parcellation after original registration of land possession rights), field books (brochures documenting ground surveying carried out during registration of land possession rights), mutation plans (maps showing the change in cadastral parcellation after original registration of land possession rights) and computation brochures (brochures containing ground surveying processing, parcel corners computed locations and parcel areas computations). The aforementioned background requires thorough consideration and processing of all available information regarding position of cadastral boundaries. Firmness of cadastral background is accompanied in many cases by numerous discrepancies between its different components – for instance, lack of agreement between computed and formally registered values (e.g. of parcel fronts and areas), lack of agreement between computed results from different sources of information (field sheets data vs. mutation plans data), etc.

- *Blocks lacking solid cadastral background*

This category contains the blocks having block maps as the only source of cadastral background. In such situation, position of cadastral boundaries is defined through digitization process of the maps. Considering the fact that the project blocks belonging to this category have been drawn at the scale of 1:10,000, their boundaries position could be determined with very low accuracy. But once determined by means of coordinates in precise geodetic grid – IG05, they could be marked, if necessary, on the ground with analytical accuracy of modern geodetic instruments (cadastral blocks of Southern Negev project mostly belong to this category).

- *Blocks with "mixed" cadastral background*

This category contains blocks having solid cadastral background within a part of their area and complete lack of it within the rest of these blocks. This situation requires different approaches to parcel boundaries reconstruction within one cadastral block.

According to the technical specifications, different categories of the blocks included in the project would be processed in different ways. The first category would be processed according to the requirements of the Surveying Regulations regarding parcel boundaries reconstruction. That means that all kinds of source cadastral information would be processed,

verified on the ground and adjusted according to different constraints and conditions. The second category would be processed on the base of currently existing analytical GIS data, considering boundaries position upon the physical block maps having exclusive legal validity for this case (Klebanov et al., 2009). The thorough comparison will be set between digital GIS data and scanned physical block maps aiming to correct, if necessary, the former one according to the latter. The third category would be processed in a mixed manner combining the two aforementioned approaches. All kinds of project data – source and pre-processed – would be eventually adjusted aiming to create a seamless cadastral continuity. The latter will be assimilated in national GIS and will replace currently existing cadastral digital data. Those precise data will serve in the future as a basis for legal CBC system on nationwide level.

3.4. Project Tender

According to SOI strategic decision, the implementation of CBC will be carried out mostly by the private sector by means of public tenders. The SOI involvement in the process will include general supervision, assimilation of obtained digital data in the cadastral layers of national GIS and issuing of up-to-date technical instructions regarding the use of the new precise cadastral data.

In view of this decision, in the middle of 2009, the work of preparation for the new cycle of CBC tender to perform the Northern Negev project has started. This work included preparation of the following documents and maps: the request for proposals (RFP) addressed to licensed surveyors whose professional experience and activity, both geodetic and cadastral, are appropriate to performing the required work; detailed list of cadastral blocks and site maps; technical specifications; schedule; contract draft and some other documents.

At the end of 2009 the tender has been published. The call to participate in the project has been published in press and on the SOI web site. It was decided that the whole work (both of the contractors and of the SOI) should be finished within one year, by the end of 2010, with optional possibility for extension.

The potential contractors have been asked to submit, along with their bids, the documents certifying their professional skills, experience in use of satellite technology, list of required equipment (with the emphasis on equipment for satellite measurements), CV of personnel in charge, and recommendation letters. These tender requirements had dual purpose – to serve as threshold conditions and as a basic level of qualitative criteria of a chosen contractor. Even if the choice of the winners was principally based on the lowest bid, the quality requirements contributed to a reasonable general level of the candidates.

The exclusiveness of the project, its conceptual significance and geographic extent, contributed to a great interest it gained among the professional community. At the end of the process of bid evaluation by the special team of SOI experts, the contractors that met the pre-defined requirements have been chosen in each one of 6 project sites.

Shortly after winning the tender, the contractor obtained all the necessary materials as follows:

- Scanned cadastral block maps for comparison between digital GIS data and physical block maps having legal validity
- Digital data of parcel boundaries obtained from relevant layers of national GIS and converted from ESRI format to CAD format
- Orthophoto of the project area

In January 2010 the project has started.

4. RESULTS OBTAINED SO FAR AND FUTURE WORK

By performing the Southern Negev Project, SOI obtained digital data characterized by optimal position of cadastral boundaries in the project region. The data accuracy was mainly influenced by the quality of background cadastral materials. A priori estimate of point position accuracy has been proven as realistic during project performance (numerical analysis and accuracy results are planned to be published in a future paper). The obtained analytical data have been characterized by matching to various cadastral constraints and conditions pre-defined in technical specifications of the project. Following the checking process, the new data have been assimilated in national GIS and replaced formerly existing data regarding cadastral boundaries.

In view of the fact that the process of CBC implementation requires joint efforts of representatives of different geodetic disciplines, one of the important lessons of the project was the acute necessity for cooperation between SOI units participating at different stages of project performance. It means that from organizational point of view, there is a crucial need to establish a special cadastral unit, permanently operating and supervising CBC implementation on nationwide level and fully engaged in the process. As an alternative, the integrated team composed of interdisciplinary representatives partially engaged in their native departments and partially in CBC unit according to the need could be considered. As an additional alternative, services of private sector (similar to services provided by supervising surveyors, see Forrai & Kirschner, 2009) could be engaged by SOI by means of public tenders.

The experience gained up to now shows that CBC implementation could be planned and performed as an ongoing process. That means that the interdisciplinary personnel involved in CBC implementation including work groups responsible for planning, tender preparation, project management and supervision, and result check and assimilation could work as a "cadastral conveyor".

One of the significant conclusions of Southern Negev project is general feasibility of CBC implementation on nationwide level by means of a mechanism chosen by SOI administration. The promising results obtained up to now by the SOI, the way of tender arrangement, project management and supervision indicate that the chosen direction is the right way to the implementation of Coordinate Based Cadastre in Israel (see also Srebro, 2010).

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BIOGRAPHICAL NOTES

Mr. Michael Klebanov graduated from the Technical University of Cheliabinsk, Russia, in 1985 and received his Engineer Degree (cum laude) in Civil Engineering. In 2000-2002, he completed advanced studies at the Technion - Israel Institute of Technology, Division of Geodetic Engineering, towards a Licensed Surveyor Degree. He received in 2008 a Master Degree in an Master/Ph.D. direct track in Mapping and Geo-Information Engineering from the Technion and is currently a Ph.D. candidate. Since 1991, he has served with the Survey of Israel. Presently he serves as the Head of Department of Coordinate Based Cadastre and Advanced Applications.

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