On The Way To a Coordinate Based Cadastre (Cbc) in Israel

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SUMMARY

Following a vision of transforming the traditional demarcation based and graphic driven Cadastre to a Coordinate Based Cadastre (CBC), the Director General (DG) of the Survey of Israel introduced at the end of 2003 a goal to take practical measures in order to pave the way towards a CBC in Israel.

These measures included the establishment of a formal supporting Geodetic environment including the expansion of a country wide Satellite Active Permanent Network (APN) and complementary regulations and instructions; An economic feasibility study and analysis; Feasibility studies and pilot projects in various environments (from private owned dense urban areas to State owned non used rural areas); Feasibility studies and pilot projects of transforming archival blocks that were defined precisely by GPS measurements during the last decade; Building a comprehensive long term program; Implementing practical transformation projects; Analyzing and preparing legal complementary support.

Many parts of this puzzle have already been implemented. In parallel to the studies, the chosen strategy, of a cost effective investment, lead to an achievement of coverage of near 50% of the country area by coordinate based blocks towards the end of 2009 and near 60% towards the end of 2010.

This article elaborates on the above mentioned program including lessons learned along the process and vision to the future.

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The Roots of the Israeli cadastre

The roots of the Israeli cadastre are based on the 1928 Land Ordinance of the Government of Palestine under the British Mandate. This law provided for the cadastral and fiscal reform to support land settlement and the registration of rights to land property.

This law adopted Torrens Principles, based on land surveys and the division of lands into blocks and parcels for title registration and for ongoing registration and management of rights to land property.

The responsibility for the process in Israel is divided between two Government Agencies. The Department of Land Settlement and Land Registration under the Ministry of Justice is responsible for the two channels of initial land settlement and of the registration of ownership and of rights of use and changes of rights to the lands.
The Survey of Israel is responsible for the inspection and approval of the cadastral plans, including the mutation plans, which supply the geographic-geometric presentation of the lands. The activities of the Survey and of surveyors were organized initially in the 1929 Survey Ordinance, which is augmented and adjusted by survey regulations.
The cadastre plan contains the drawing of the boundaries of the parcels, which are demarcated in the field by physical markers, as well as by significant features like buildings, fences etc.
The Survey of Israel has also responsibility for a national geodetic infrastructure to support the cadastral activities. This is reflected today, in addition to the regulations, in The Israel Grid 2005 based on the APN (Steinberg and Even-Tzur 2004, 2005, Forrai, 2009, Srebro, 2009).

The state of the cadastre in Israel today

Ninety three percent of the lands in Israel are owned by the State and handled by the Israeli Land Authority.

As mentioned, there are two main channels regarding the cadastre in Israel. One refers to the initial land settlement process. The other refers to the preparation of mutation plans, which reflect the changes to land blocks and parcels that are required because of new planning of an area, to be followed by fitting construction and development of the area.

More than 95 percent of the lands of Israel already went through the initial land settlement process (See Figure 1). This covers almost 16,000 blocks and around 800,000 parcels. The rate of annual additional new settled blocks is 100-200. Most of the remaining unsettled lands are concentrated in the northern part of the Negev, where there are disputed claims regarding

the Bedouin population, and some are in the old cities like Jerusalem, Acre and Safed where there are disputed claims since the Ottoman regime (See Figure 1).

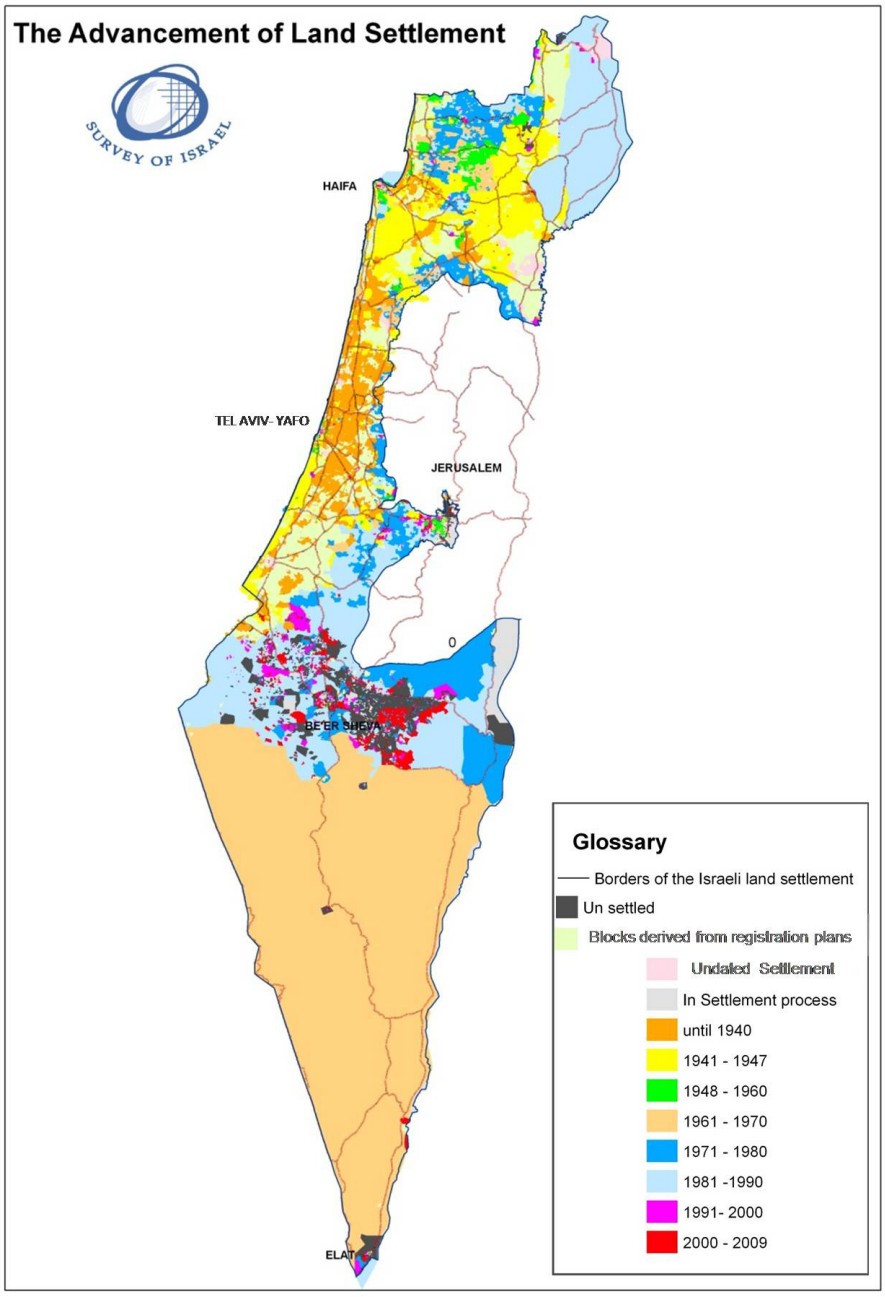

Figure 1: The Advancement of Land Settlement since 1920.

The estimated number of new blocks to cover the disputed lands in the rest of the State is 3,000 blocks.
The total number of mutation plans that were prepared in the settled lands is around 70,000. The annual rate of new mutation plans today is 1200-1500.

The official land registration refers only to the surface of ground, while the extracted rights cover the space under and above the ground.
In addition to the registration of blocks and parcels there is a registration of apartments in the land settled areas, where the buildings are cooperatively owned.
1.3 million apartments are already registered in the Registry. The Survey of Israel is not required by law to control the plans of the apartments, but their official registration requires preliminary registration of blocks and parcels. The estimated number of non registered apartments comes to several hundred thousand.

Due to this situation, the Israeli Land authority that manages the State owned lands, about 93% of the country lands, the Ministry of Construction and Housing and housing companies handle alternative sub-registries, to keep track on rights in apartments in urban areas until their formal registration in the Land Registry. The Israeli Land Authority handles an alternative sub-registry of lands in agricultural settlements like Kibbutzs and Moshavs.

An initiative of 3D sub-parcel registration (Doytsher et al., 2001) was followed by an R&D project led by the Survey of Israel (Forrai and Kirschner, 2003 and Benhamu and Doytsher, 2003), the results of which were published in 2004 (Shoshany et al, 2004).

This has not been integrated yet by the Registry in the registration process but has been followed by a legal work not yet finished (Kaine, 2009). The Survey of Israel continues to prepare 3D pilot projects for the Israeli Land Authority.

Problems in the existing situation

Since 1928 there is an accumulation of about one million documents, including surveying books, surveying sheets and graphic plans. A large part of the plans are worn out, and difficult to be interpreted. In addition, part of them are missing coordinate grid. Part of the plans include data, the accuracy of which does not meet present standards. Their measurements were based on the use of contemporary equipment and technologies, which do not fit the present regulations. They were based on non accurate and non uniform geodetic infrastructure in comparison to the present APN.
The non accurate data, based on non uniform geodetic network, cause inconsistency between mutation plans. In addition, a preparation of a new mutation plan requires from the surveyor a long and tedious research process, not only professional work, the expected results of which are sometimes ambiguous.

Due to the problems regarding the existing materials, the preparation of a mutation plan may lengthen even to one year. Following this, the time of control of the experts of the Survey of Israel, who have to control and approve the mutation plan for registration, may also be

lengthened to one year, if re-measurements and re-preparation of material by the surveyor are required.

The lengthening of the registration process harms the transactions of real estate, as well as property rights. In addition, according to appraisals, the economic value of real estate properties decreases as long as the land property is not properly registered.

This situation has a negative impact on the management of the land registration and causes inaccuracies.

It also causes problems to the process of controlling plans for construction permits, in comparison to a mutation plan, and may result in inconsistencies and un-revocable construction failures.

The Suggested Solution: A Coordinate Based Cadastre (CBC) - principles and benefits

The principles:
The boundaries of blocks and parcels will be defined by coordinates in an accuracy which is better than five centimeters at 95% confidence level (Steinberg, 2001).

Every mutation plan will be based on the Israeli Grid 2005 (IG05), meaning either on the APN or on control points which are directly connected to the APN.
There will be full uniformity between neighboring and non neighboring mutation plans.

The significant benefits of a transition to a CBC in Israel will be:
A creation of an accurate infrastructure for the land registration in the State of Israel;
Shortening the required time for preparation of a mutation plan by a surveyor down to a period between days and several weeks;
Shortening the quality control and approval time of a mutation plan by the staff of the Survey of Israel to days;
Enhancing planning in Israel and its fit to the terrain, and enabling improved control of the adjustment of the construction to planning and the adjustment of planning and construction to the land registration; That includes an initial quick and detailed on site quality control;
Creation of an essential infrastructure for 3D cadastre;
Saving significant economical assets and investments to the Israeli economy; This conclusion is based on an economic feasibility study;
Acceleration of development and land based economic activity.

The economic feasibility study

Due to the high cost of the CBC project, the comprehensive achievement of which was estimated twenty years ago to exceed one billion dollar, and following much lower updated estimates of the Survey of Israel for the technical work, due to technological development of computers and satellite surveys, versus an enormous advantage to the Israeli economy, there

was an agreement between the Ministry of Treasury and the Survey of Israel to conduct an economical feasibility study.

The study took place in 2006. After interviewing tens of leading persons from the private market, including surveyors, from the Government, including the Survey of Israel, and from the Academy, and after analyzing many documents, including the tender of the pilot project of the land blocks along the coast, the study came to the following conclusions:
The estimated cost of technical work of defining the boundaries of the land blocks by coordinates is around 100 million dollars.

The recommendation was to achieve it in ten years around 10 million dollars a year.
The estimated direct saving to the surveying market is around 15 million dollars a year, while the estimated contribution to the construction and entrepreneur market is 100 million dollars a year, in addition to a breakthrough in improvement of the service of many Government offices to entrepreneurs and to the public, including the Ministry of Construction and Housing, the Ministry of Interior, the Israeli Land Authority, the Survey of Israel and the Registry at the Ministry of Justice, the reputation of which will be highly upgraded.
The study highly recommends the transition to a CBC and offers practical ways of promoting and handling the project (Amir, 2006).

The suggested plan

The main components of a required plan for a CBC are:

- A geodetic supporting infrastructure including a country wide APN.
- Regulatory supporting measures.
- Conversion of the existing demarcation based and graphic driven data base to a CBC.
- Re organization of the registration process at the Registry in the Ministry of Justice to integrate CBC in the system.
- Changing the order of precedence of the definition of cadastral boundaries giving registered coordinates priority over physical markers and graphic documents.

Stages in the transition to CBC:

- Creating of an accurate geodetic infrastructure to support an accurate cadastre:
  An adequate network has already been constructed, based on 19 GPS (half of them include reception of GLONASS satellites) receiving stations (G0) and 1,300 control points, which were connected directly to the APN (G1 and G2) (For a detailed review on this see Forrai, 2009 and also Srebro, 2009).
- Preparation of regulatory measures:
  Such measures were taken during the years 2003-2008, by publishing professional instructions by the DG regarding the geodetic control. These instructions should be complemented by publishing professional instructions for the preparation of mutation plans. In addition, an initial version for new geodetic and cadastral regulations has been prepared (Steinberg, 2006).
- Conversion of the existing cadastral data base:

The graphical data base had been scanned since the 1990ies and managed in a cadastral GIS. Following enhancement the data is available on line since 2008. But, due to technological constrains it is not accurate enough for a legal CBC. Thus, another big effort is required for such a conversion. Since a full re survey of the cadastre would cost billions and would cause difficult legal problems, the direction is to go to a gradual conversion process, which composes existing registered data, including data from the computerized graphic (scanned) cadastral data base at the Survey of Israel and field survey of authentic physical points* using up to date satellite survey technologies for the transformation (Steinberg, 2001, Klebanov and Forrai, 2010).
This process should take into consideration two conclusions:
In most of the open, non built up State owned, lands the implementation is easy. The task is mainly technical and the cost is low. On the other hand, in the built up areas the process is complicated due to professional problems of bad adjustment between cadastral registered boundaries. These complex problems require high expertise, the solutions are slow and costly and involve legal problems.
An important factor in the practical solution is the availability of authentic physical points, which are usually destroyed during fast development in urban areas.
The high cost of the process in built up areas was a major reason to decide on a gradual implementation.

- A continuous process of updating, maintenance and upgrade of the cadastral data base, should also be considered and taken care of during the process of converting the data base.
- Legal measures:
  In order to integrate the CBC in the legal registration process, a legislation effort should be taken care of, including settlement of conflicts of rights arising from differences between the definition of accurate areas of blocks and parcels, as a result of the CBC process, and between registered areas that are not necessarily accurate and representing the real de facto areas.

* Authentic physical points consist of three kinds: One kind refers to original control points that were used for the original cadastral surveys. The second kind refers to authentic boundary markers which were used for the demarcation of the cadastral boundary. The third kind refers to physical features, like buildings that were defined by measurement with reference to the cadastral boundary. The existence of these authentic physical points enables the preparation of a proper transformation of the original data following a re-measurement of the authentic points using precise uptodate technologies and the Israeli Grid 2005.

The doubts of the Ministry of Treasury and their implications

The Ministry of Treasury is responsible in Israel for the budgets of the Ministries and Government Agencies.
Although their representatives were convinced that the transition to a CBC is important, they hesitated to fund it.

Their main fears were, and still are, that the changes of the dimensions of parcels and especially the areas of the parcels, due to new and much more accurate satellite based surveys, will cause a flood of private claims against the Government that may cost the Government billions. The ground of their fear is anchored in the fact that the registration of land rights is guaranteed by the State, and once the State changes their rights, the State has to compensate for the loss of property value or loss of rights, like construction rights, in the case that there is such loss. On the other hand, it will be a problem, if not impossible, to demand payment from those whose property value or rights increase.

In order to prove the added value of the CBC project over the risks of investment, an economic study was launched. But, in spite of the attractive figures of the economic study it didn't remove the fears. They still look for a full legal solution that will assure the removal of risks of claims.

This obstacle had been put aside by the DG of the Survey of Israel by making two decisions. The first one, as described in the following chapter, was to implement the CBC project in the rural open non populated State owned areas. This neglects the fears regarding large parts of the State. The second decision was to implement the process, for the time being, only on the surveying stages, leaving the legal registration stage as it is today. In this way, surveyors can use the resulting CBC data, saving themselves the need for most of the field work and trace of all documents, but without an accomplishment of a CBC registration, which can be postponed to a later stage, when the legal issues and their practical projection, with reference to registration of possible changes of property rights, will be solved.

The Decisions of the Director General

Taking into account the limited resources and the lack of attraction of the investment in survey of authentic physical points, the estimated required budget for which is more than 40 million dollars, and considering the little experience in the process of transforming the graphical data to coordinate based blocks, the DG of the Survey decided not to enter into a long R&D process, but to push forward practical work in low cost areas. This approach could be achieved in open areas of State owned lands, where there are no conflicts of rights of ownership or of rights of use. In these areas there were no risks of costs due to claims resulting from changes of the areas of blocks, due to new measurements using precise satellite technologies based on the APN of the Survey of Israel. Parallel to the practical activities, R&D efforts could also be practiced, as well as development of a process of integration of the results into the cadastral GIS. In his view, a fast large coverage, accompanied by additional conceptual and technical measures, should serve even psychologically when time comes to decide on large investment in the built up area. In addition, the legal required measures to integrate the results of the CBC in the registration are relatively very easy, since there are no conflicts of rights between neighbors (The State is the land owner on both sides of the boundaries). This could also encourage the legal authorities and enable them to analyze the legal requirement and projections through a long and gradual process.

An analysis of the existing cadastre showed that around 86 percent of the area of Israel is considered open non built-up areas, with no or low potential of conflicting rights to the land. Most of these lands are in the south of Israel, The Negev, which covers more than fifty percent of the country.

In spite of the objection, that preferred the urban areas where the value of land is high, the DG decided on the CBC activities in open areas, where the cost of preparation of a CBC is around 200-500 per square km versus more than 5,000$ and much more per square km in other areas. Behind this decision was also an additional thought. Due to lack of availability of lands in the urban areas, and the high and growing cost of land, the trend should be to develop the open areas including the Negev. Once a CBC is prepared for these areas, the development can be much faster, planning will be more accurate and faster, the construction and control will be more accurate and easier and so will be the final registration. All these benefits can be obtained at a very low cost as long as the area is open and free of conflicting rights.
Thus, the decision assigned first priority to the definition by coordinates of boundaries of blocks and parcels in open areas that are neither allocated to specific uses nor leased to private users.
In addition, the decision referred to gradual activities, including transformation to CBC of large recent projects of the Ministry of Construction and Housing, transformation of recent and compatible blocks and parcels, that are taken care of by implementation of accurate surveys, and tight control and inspection, out of 1200-1500 annual mutation plans and 100-200 new annual block plans.

The advance of transformation to CBC in additional areas should be a result of available budgets, as well as of the interest of the public. This referred also to reconnaissance and survey of existing authentic physical points. In addition, the decision was to develop tools and a process for integration of CBC results into the cadastral GIS, including accuracy gradation of points, and to get organized to be able to approve plans for documentation of cadastral boundaries, which are a new kind of plans that support a creation of a CBC framework of the cadastral boundaries, not including all the contained internal features.

A Pilot Study in Modiin

Modiin is a new city. Most of the built up area was surveyed and registered using GPS equipment following the 1998 regulations, and the plans were prepared and controlled using digital files. One of the suburbs was surveyed using older version of regulations. Due to the fast development and heavy construction most of the authentic points in the relatively old area were destroyed.
The city was developed by the Ministry of Construction and Housing, which develops large settlements in Israel, using a supervising surveyor who coordinates all the surveying activities on the site, including the registration.
The central coordination of the site, and the modern surveying methods used there, influenced the decision in 2005 to launch a pilot study in this site that will serve also for similar large projects over the country.

The goals of the R&D pilot study were to analyze the data and material required to construct pilot CBC in Modiin and to define standards, working procedures, technical specifications and guidelines to enable a legal CBC. The specific targets included enhancement of the existing procedures, developing special software tools for adjustment between analytical blocks and for building a prototype CBC DB.
The results analyzed the existing data and documents that were assembled and processed. Recommendations were made for the preparation of documents and data, for enhancement of existing working procedures and for improvement of specifications for future projects. Recommendations were also made for priorities of activities in the promotion of a CBC, especially referring to the destruction of authentic points. Special recommendations were given for large development projects.

Pilot Project along the Mediterranean Coast

Following the initial pilot study in Modiin the next step was to convey a pilot project in different types of areas. These areas should cover the range from a state owned open area to a dense urban area. In addition, following an initiative of the DG to promote a marine cadastre in the Israeli marine areas, including the Israeli Territorial Sea, a coordinate based cadastre along the coast appeared to be a preliminary requirement.

The decision was to choose a few areas along the coast, covering various types of lands, according to the expected difficulty regarding the time and quality of the original land settlement, regarding the development of the area including changes through time that were reflected in mutation plans, regarding the existence of authentic physical points etc.
In addition, the tender of this pilot project included a requirement, from the companies that participated in the tender, to develop transformation models from the data based on the original old coordinate system to new coordinates in the Israel 2005 coordinate system, taking into account the requirement for minimum differences between the area computed from the new boundary coordinates and the registered area that is the legal one. The transformation had to consider the period of the old surveys, the geodetic control, the surveying methods and equipment, the type of terrain and location, the existing physical situation of the borders, etc.

Four surveying companies were nominated in the tender. Each one surveyed a site in a different location along the coast line covering 15 block plans. A total of 60 block plans were included in the project out of 275 settled blocks along the coast (See Figure 2. Each polygon represents a cadastral block).
The maximum differences between the computed coordinates and the physical boundaries on site were in the range of 12 cm in a site that covered a dense built up urban area (average of 7 cm), and 30 cm in the open areas (average of 15-20 cm).

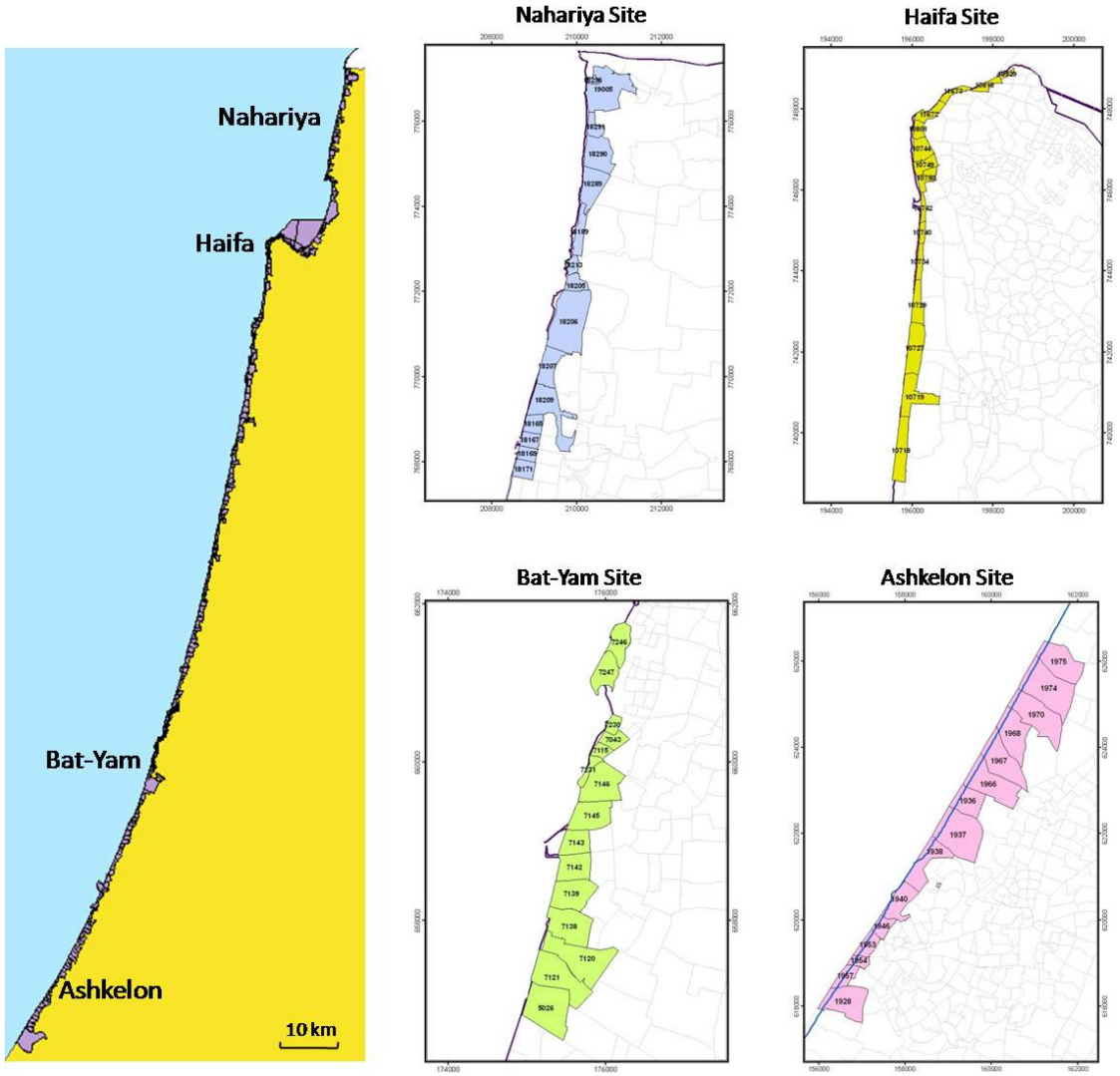

Figure 2: Pilot Project of Land Blocks along the Coast

At that time the development of methods and process of integration of the results in the existing cadastral data base only began. Until the integration process was accomplished and the final coordinates of these blocks were published and are available to surveyors, additional mutation plans were prepared for part of the block plans, changing the state of these blocks. As a result of this, suggested boundary coordinates were published for only 50 block plans.
Many lessons were learned during this project regarding the quality of the existing cadastre, the availability of old authentic physical points, regarding the accuracy of the boundaries and the registered areas, regarding the alternative transformation methods that were developed by the contractors, regarding the feasibility of the transition to a CBC and even regarding the cost of such projects in various areas. These lessons served for improvement of the specifications of the next CBC projects.

The lessons learned emphasized the importance of reconnaissance of original documents and existing authentic physical points and the importance of re-measurement of authentic physical points for the transformation, as well as the importance of adopting or developing tailored transformations for different areas (Gelbman, 2009 and Gelbman and Doytsher, 2009).

The Lachish project

As a first project of implementation, the Ministry of Treasury gave precedence to the area of Lachish that was allocated for a large development of settlement. All of this area included State owned lands, most of which were open areas, mainly agricultural lands, that were supposed to be re-planned for new settlement.
The Survey of Israel prepared the required materials for a tender to prepare a CBC over this land settled area. Two contractors executed the work, that covered 351 km^2 divided to 69 land blocks, during 2008 (See Figure 3). Following the assessment and integration of the output of these blocks, the resulting coordinates of the boundaries will be soon available for the use of surveyors.

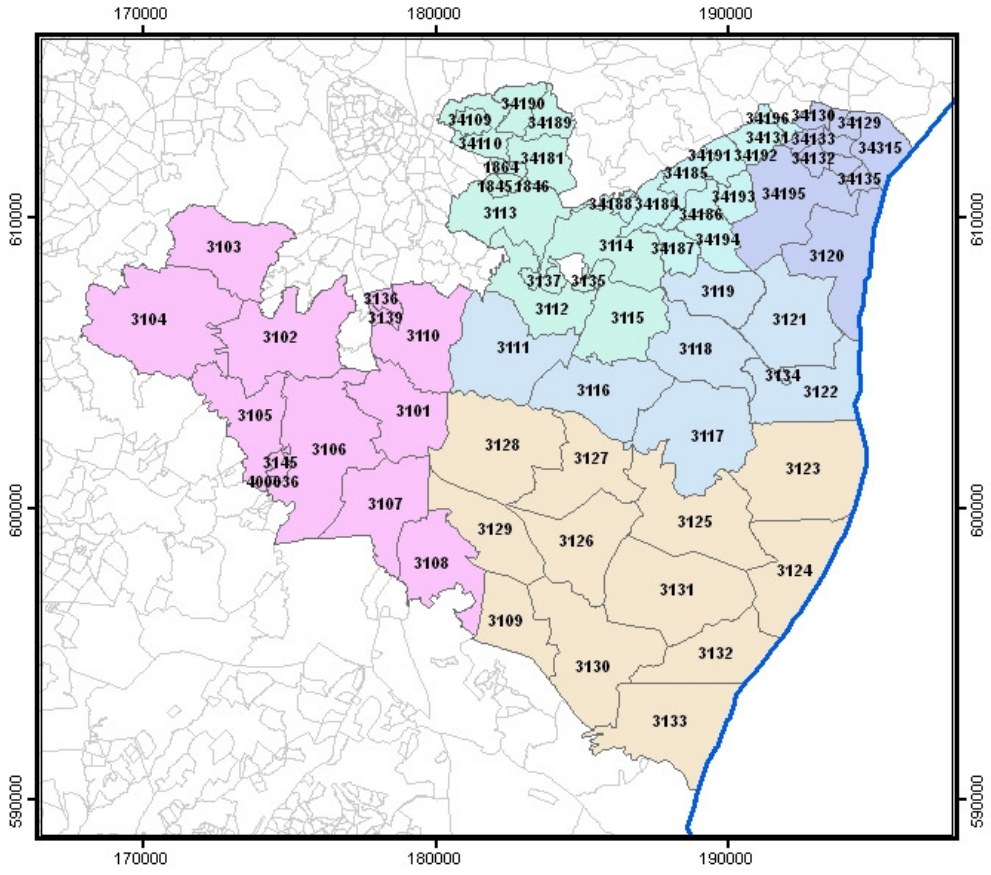

Figure 3: The Lachish Project

A pilot study in the Negev

In addition to the Lachish project, there was an internal effort to promote a pilot study in the Negev during 2008, in order to be better prepared for big projects covering the Negev, which covers more than half of the land area of Israel, in the following years.
This project, that covered 12 block plans in open state owned lands, was taken care of internally but only for the purpose of study.
The same area was later on included in the 2009 CBC projects of the Negev, which were executed by external contractors.

The Southern Negev project

One special mission in the Southern Negev project was to adjust the outer limits of the blocks neighboring the International boundaries between Israel and Egypt and between Israel and Jordan. These Boundaries were jointly surveyed by satellite surveying and documented in coordinates by the surveying teams of Israel and its neighbors (Srebro, 2005). These coordinates are binding and take precedence over the boundaries of the internal cadastre. Thus, they are considered as constraints.

The project succeeded to achieve this goal. A detailed report on the project can be found in (Klebanov and Forrai, 2010). Discrepancies of computed areas of parcels exceeding the permitted tolerance defined in the regulations were found in 15% of the parcels in this project. This, and the correction of adjustments to the International Boundaries, should be taken care of by the Registry. Due to the fact that all these lands are State owned this will hopefully be relatively easy.

This project covers 192 land blocks covering 45 percent of the area of Israel (See Figure 4). It covers State owned open lands, not including settlements. The few settlements in the area like the City of Eilat and the towns of Mitzpe Ramon and Yeroham were excluded from the project. Very few authentic points exist in the area (1-2 per block) and the anticipated efforts to implement the project were relatively low. As mentioned before, the DG decided to give priority to this project because of a few reasons:
The low cost and the fast coverage of half of the country can promote the overall idea of CBC in Israel because of the visual impact of the coverage diagram.

The importance of the Negev to the Future of Israel is very high, as already stated by the first Prime Minister Ben Gurion, the founder of the State of Israel. The fast exploitation of lands in the north will push the development southwards. A CBC will boost and save a lot of time and budgets for any preparation, re planning and development for a low investment in the present.
It will be relatively easy to convert the technical CBC to a legal CBC, including the change of registered areas to computed real areas, since the State is the owner of both sides of the cadastral boundaries. In addition, the original land settlement in this area in the 1960^{ies} was concluded on 1:20,000 graphic plans, and the boundaries were not demarcated physically on the ground. This leaves flexibility for a significant tolerance.

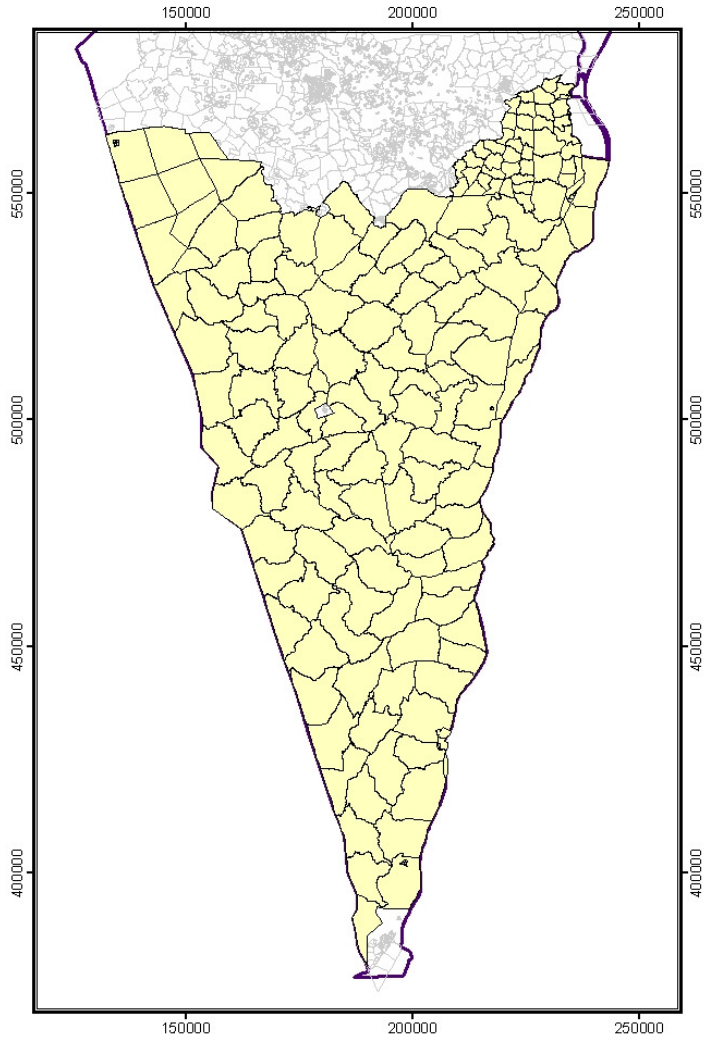

Figure 4: The Southern Negev Project

Surprisingly or not, this trend of the DG of the Survey to prefer fast coverage of areas by cadastral activities was not new. In the 1960[ies] the DG of the Survey of Israel participated in taking similar decisions regarding the primer land settlement in the Negev because of similar reasons. In the late 1920[ies] the DG of the Survey of Palestine decided to exclude the populated settlements, during the land settlement process, because these areas were a cause for a significant slowdown in the advance of the process . . .

The Northern Negev project

The Northern Negev covers an area that is neighboring the Southern Negev. This area is not as deserted as the southern one. It is characterized by more agricultural areas and with a

higher density of population with small villages or Bedouin communities. This area contains the largest area of Israel that has not been settled yet.
For the CBC projects we look only into land settled areas, therefore, dealing with this area, unlike the South Negev project, refers to a non continuous coverage of blocks, usually agricultural state owned, relatively large blocks, but not as large as those of the Southern Negev.

Most of the blocks are in open areas but there are islands of unsettled areas and islands of small villages. In addition, though it's not a dense built up area, the existence of rights, mainly to the use of lands, is not rare. It should be mentioned that there is a difference between the south and east sub-regions of this area and between the north part of the area. While the south and east areas are similar or one step forward, regarding the complexity of the blocks in the Southern Negev, the north part is an additional step or more than that regarding complexity, neighboring the area of the Lachish project. Part of the blocks, mainly the northern ones, contain mutation plans, in addition to original settled blocks which contribute to the complexity.

This situation led to the division of the area of the Northern Negev, which covers about ten percent of the country, into six sub regions as can be seen in figure 5. The three southern sub-regions contain bigger blocks. Except the eastern region that is more similar to the Southern Negev the two other regions, though covering each only an area of few percent of the southern Negev project, contain two thirds to three quarters of the number of blocks each plus more than a thousand up to a few thousands parcels.

All the six regions were included in one tender and the regions were allocated to different contractors. The average cost of a block was about three times higher than Southern Negev, but the variance was high. The cost per block in the most complicated sub-region of the six was about two and a half times more than the simplest sub-region. The higher cost is similar to the cost of the Lachish project, and gives a reference to the expected costs of the next projects in the open areas. The implementation of the Northern Negev is only in its beginning but it is a very important step towards mass production, teaching about the future of the CBC plan.

The first lesson is about costs. The cost of the total Northern Negev project is about ten times more than the cost of the South Negev project, though including four times more blocks, covering only one fifth of the area. Furthermore, the most complicated sub-region in this area, which was included in the project, also in order to serve as a pilot project for the typical areas of the rest of the open areas, costs five times more per block.
These figures serve us for an improved estimation of the rest of the CBC project.
The volume of work required for the inspection of the various contractors, for the analysis of the products and for the integration of the results in the database of the Survey of Israel, requires a construction of a special team or taskforce for this mission and for the preparation of additional areas for next projects.

The main technical lessons, as well as managerial lessons, will be learned only at the end of the Northern Negev project, and they will influence the whole program of Coordinate Based Cadastre project at the Survey of Israel.

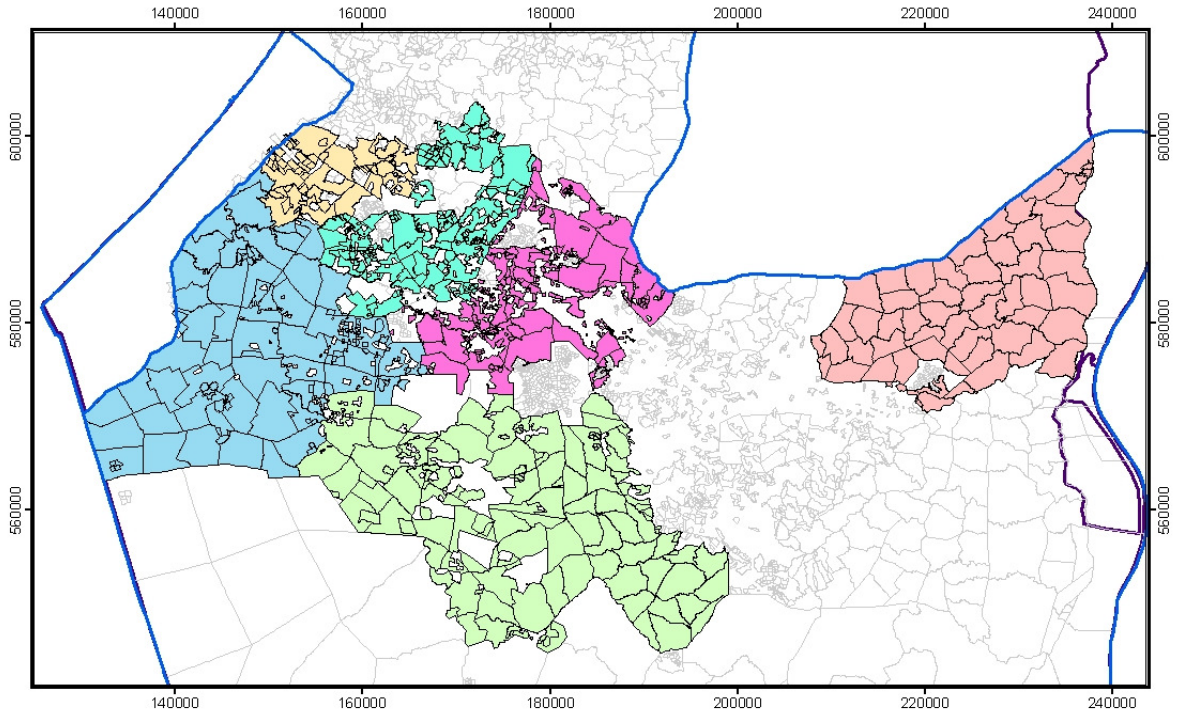

Figure 5: The Northern Negev Project

The integration of large projects of the Ministry of Construction and Housing

The Ministry of Construction and Housing used to play in the past a big role in development and construction of new towns and suburbs and villages in Israel. The main reason for that was the fast grow of the population, which was multiplied almost ten times since the independence of the State of Israel. The biggest challenges for housing were during the big immigration waves during the 1950^{ies}, the 1960^{ies} and the 1990^{ies}. While until the 1990^{ies} the cadastral support for these projects was based on traditional surveying, since the 1990^{ies} new technologies were implemented, including GPS surveys. These projects cover large areas, including the new city of Modiin, and are an important potential to be integrated in the CBC infrastructure.

For this reason, the first effort for a feasibility study was located in the city of Modiin and proved to be successful. In addition, in 2009 was launched an R&D project in two sites, one of which in Modiin and the other one in a new suburb of the City of Beer-Sheba, that was recently built up by the Ministry, to serve as pilot projects for similar projects all over the country. These projects which are in built up areas, and are spread in many locations, may

also serve as regional anchors for the CBC program. The data was already assembled and analysis is scheduled for the first half of 2010.

The integration of regular activities

As mentioned earlier, there are two outputs of the regular cadastral activities. One includes 100-200 new blocks annually. The other includes 1200-1500 new mutation plans annually. Both activities are executed using modern high precision technologies. According to the DG professional instructions (Survey of Israel, 2007), the surveys of the control points are based on Israel Grid 2005 (IG05) which is based on the APN.

This makes all the resulting new plans having a potential to fit the CBC standards, producing coordinates for the boundaries of the blocks and parcels. This enables the integration of new plans in the CBC project. Since the use of IG05 is already regulated since 2007 by the DG instructions to surveyors, this doesn't refer to earlier plans. Furthermore, since the use of technology of GPS and the precise surveys, are in use for more than 15 years, accurate plans, which had been prepared after 1998, following the 1998 regulations, can also be potential for integration in the CBC after proper transformation from the New Israel Grid to IG05. This may add a potential of thousand blocks that were prepared in the past and over ten thousand potential mutation plans that may be integrated in the CBC. But, this is not yet a straight forward option, since DG instructions for preparation of mutation plans have not been prepared yet.

While the new blocks of land settlement are mainly in rural areas, most of the mutation plans are located in urban areas, or areas under development. This is important due to the fact that the blocks and parcels are also legally registered, and they serve as anchors of CBC for future CBC activities.

Eventually, these potential new plans in built up areas can be integrated following two additional important measures.
The first one is the development and publication of new instructions by the DG for preparation of mutation plans on the base of the IG05 network. The second one is a significant upgrade of the inspection process to check more thoroughly and strictly in the field the new mutation plans, to avoid any doubt regarding the results, and thus limiting the risk of legal complications.

Since the mutation plans cover only parts of blocks, the adjustment between these parts and between neighboring parts in the blocks, and the re-adjustments of these blocks, are essential, before an integration of the data into the CBC. In addition, the goal of the CBC in built up areas to achieve 5cm accuracy, requires very thorough inspection by the Survey of Israel supervisors, including also strict checks in the field for the trace of authentic points. In order to meet these requirements, the Survey of Israel intends to develop proper instructions for preparation of mutation plans to fit the standards of a CBC, and new instructions to define new standards and a process for the inspection in the office and in the field. This is scheduled

for 2010. The requirement for qualified personnel, whether internal or external supervising surveyors, is another issue to be solved.

Following proper checks, new blocks plans, especially in open areas and part of the new mutation plans, can be certified as fitting the CBC standards.

These areas can serve in the future as anchors for transformations and cadastral triangulation (Klebanov and Doytsher, 2009) to transfer existing cadastral plans in built up areas to CBC.

It should be mentioned that, after a proper approval, the results of the CBC Negev project, as well as the results of every new settled block plan, every new mutation plan and every new boundary documentation plan are real world operational data and not just recommendations.

Marine Cadastre

Another area that fits very much the concept of CBC is the marine cadastre. Very few physical topographic features exist on the surface of the sea. Therefore, there is no way to demarcate the cadastral boundaries in the sea, and the only way to delimit cadastral boundaries in the sea is by coordinates. Since there is still no cadastral infrastructure or heritage in the Israeli marine area, the implementation of a marine cadastre in Israel can be very fast and at low-cost. On the other hand, due to the fast development and exploitation of lands along the coastal environment, that causes a rise in the cost of lands along the coast, and due to the construction of marinas, enlargement of ports, laying gas pipes and launching feasibility studies for development of the marine environment, including artificial islands and potential construction of an airfield and roads in the sea, the DG of the Survey of Israel promotes the idea of a marine cadastre, conveying practical measures for its implementation, covering at first stage the breadth of the Israeli Territorial Sea area (Srebro et al, 2010). The proposition, regarding an implementation of a marine cadastre in the Israeli Territorial Sea in the Mediterranean, introduces about 200 cadastre blocks between the coast line and the outer limit of the Territorial Sea, most of which cover an area of 5x5 km each. Other Israeli water areas, like in the Dead Sea and the Red Sea, are already covered by a land type cadastre.
The suggested Marine Cadastre in the Mediterranean Sea is seen in Figure 6, which presents the aforementioned activities regarding the implementation of a CBC in Israel.

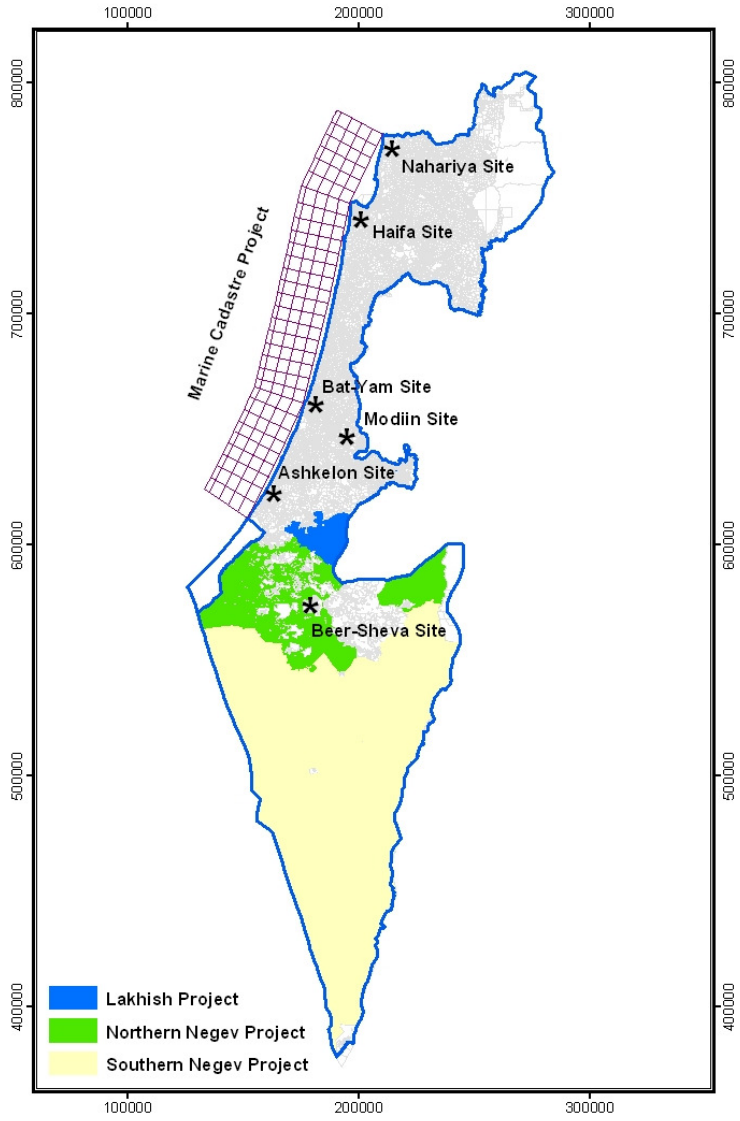

Figure 6: General Diagram of CBC Projects

Multidimensional Cadastre

Following an initiative to implement a 3D Cadastre in Israel (Doytsher et al., 2001), and a long process of studies, a R&D project was concluded in 2004 (Forrai and Kirschner, 2003, and Benhamu and Doytsher, 2003). The result of the project was a recommendation to implement a 3D cadastre in Israel (Shoshany et al, 2004). The project covered multidisciplinary areas, including surveying, legal aspects, engineering and planning. The outcome of the project was a very detailed document that included even practical forms for the administrative work. The adopted approach is to register three dimensional sub-parcels above or beneath the ground surface. The intention has been to implement it only where

required in spatial complexes. The only way to define the three dimensional boundaries of these sub-parcels is by coordinates. This requires a CBC infrastructure where ever a 3D cadastre is required. Unfortunately, for the time being, only pilot 3D Cadastre projects are performed, until the Registry will accomplish a transition to a new modern system, that enables the employees to visualize and register the three dimensional sub-parcels, to be followed by proper legislation (Kaine, 2009).

It should be mentioned that the third dimension is not the only one that should be dealt with. Considering the changes that are made during time there is a requirement to keep track and to monitor and manage temporal changes. In addition, the goal of achieving 5cm accuracy requires monitoring temporal changes of control points, even due to tectonic movement in the magnitude of centimeters of the surface of the earth. This requires a dynamic cadastre (Jarroush and Even-Zur, 2009).

Authentic physical points

Existing authentic physical points, which include originally measured markers that define the cadastral boundaries, are an essential component when re-measured using modern accurate equipment, technologies and infrastructure (e.g. the APN network and IG05 geodetic reference) for the transformation of original cadastral data to the existing infrastructure on the way to a CBC.

The importance of the use of these was highlighted by all the researches and pilot projects since the first pilot study in Modiin and the implementation pilot project along the coast (Gelbman and Doytsher, 2009) and in the following projects like the Southern Negev (Klebanov and Forrai, 2010).

On the other hand, the practical situation in the real world is that in the built up areas, where existing authentic physical points are essential, they are destroyed during the development and construction. This was faced even during the first pilot study in Modiin which is a new city.

This situation led to a recommendation to begin the CBC project by a precise survey of existing authentic physical points. The estimated cost of such a project was around 40 million dollars. The idea was rejected due to non sufficient economic immediate justification.

In fact, in the CBC practical projects in the open areas, this was one of the tasks of the contractors. In addition, the Survey of Israel assigned a special team to take care in surveying authentic control points for future projects.

The integration of the results of the CBC projects using the cadastral GIS

The process of integration of the data, which is supplied by the contractors carrying out of the CBC projects, involves many activities within the Survey of Israel. These activities include an intensive use of the cadastral GIS of the Survey that became an integral component of the

working process. In order to automate the working process to its possible extent a new production process is now under development expected to be ready in a few months.

For the time being the integration of the CBC data is manual (interactive) and slow and the current integration refers to the 2008 Lachish project. The next step, after the approval and integration of the CBC data, is to publish to the surveyors that such analytical data and recommended coordinates exist. Until the stage that the CBC will be announced, wherever approved, as a legal CBC, with the coordinates taking precedence over any other source regarding the cadastral boundaries, these coordinates will be regarded as a recommendation. The surveyors have an option to use the coordinates and are recommended to check for authentic points in the immediate vicinity, which may not have been integrated in the process (as suggested in Steinberg, 2001).

The results of the CBC projects are loaded on to the cadastral GIS and thus enhancing its quality, replacing previous data, sometimes data that was originally scanned from graphic block plans and adjusted with neighboring block scans.

This continuous process of enhancement requires additional tools to enable the surveyors to make best use of the enhanced data. One of these tools is a development of a gradation model of the accuracy of the data. This model consist of five grades, moving from the highest grade of the CBC which is better than 5cm down to the lowest level of worse than 0.5m for digitized data.

In addition, the gradation is also reflected in special symbols that will make it more user-friendly. This development is scheduled to be ready in mid 2010 (Other developments of the Cadastral GIS can be found in Gavish and Benin, 2009).

Legal activities

The required legal activities are divided into two categories.
One category refers to the surveying regulations and DG professional instructions to surveyors. These are required in order to enable a proper implementation of the above mentioned CBC program. These are taken care of by the chief scientist of the Survey of Israel supported by the legal adviser of the Survey. These measures will be, hopefully, implemented until mid 2011. Additional activities, which reflect cooperation between the professional staff of the Survey and the legal adviser, are reflected in nomination of supervising surveyors (Forrai and Kirschner, 2009). A similar measure may be chosen for the advancement of the CBC program.
The second Category refers to the full legalization of the CBC. These activities should be made in cooperation with other Ministries under the leadership of the Ministry of Justice, that is also the Ministry responsible for the Division for Registration and Land Settlement (The Registry).

An inter-ministerial committee has already been constructed. The result of this work should include amendments to laws, if required, and publication of proper regulations by the relevant

Ministries (The Ministry of Justice, The Ministry of Interior which is responsible for regulation of planning, The Ministry of Construction and Housing, The Survey of Israel and The Ministry of Treasury).

The overall goal is that the coordinates will be the legal definition of land boundaries in the State of Israel, taking precedence over any other source.

Summary and Conclusions

Following many years of discussions, regarding the need for a breakthrough in the Israeli cadastral infrastructure, in order to overcome the inherent problems that have been accumulated during 80 years of its existence in the cadastral data, and due to the negative influence of the existing situation regarding disputes over property rights, due to conflicting and equivocal cadastral sources, and regarding the lengthening of cadastral activities, resulting in cumbersomeness and lengthening of enterprises and construction projects, the DG of the Survey of Israel decided at the end of 2003 to resume preparations for a transition to Coordinate Based Cadastre.

Due to the legal implication of a comprehensive transit on property rights and on rights of use, and the legal responsibility for registration of the Registry under the Ministry of Justice, the decision referred temporarily only to the cadastral components, defining the boundaries of blocks and parcels which are under the responsibility of the Survey of Israel. Furthermore, the decision refers only to a recommendation to surveyors to use the coordinates that are the outcome of the process. In addition, the surveyors, using the recommended boundary coordinates, are advised to check in the field for existing authentic physical points that had not been integrated in the process.

The next big step forward, after the adoption of the boundary coordinates of blocks and parcels by the Survey of Israel and by the surveyors who prepare mutation plans wherever required, is the formal adoption of these coordinates by the Registry as legal delimitations of the boundaries of the blocks and parcels in the registered files, replacing the existing hard copy plans.

The final and the utmost step will be when the list of boundary coordinates will take precedence over any other document, including physical boundary markers. The adoption of such a final status of a boundary definition by coordinates was already adopted in the Israel-Jordan Peace Agreement regarding the International Boundary (Srebro and Shoshany, 2007).

Following an initial learning process, that included a construction, by the Deputy DG for cadastre, of an open brain trust and thinking forum, including the Survey of Israel, the Association of Licensed Surveyors and the Academy, and in order to proceed as fast as possible under budget constraints, taking into account lack of essential required knowledge, the decision was to advance gradually in a controlled process.
The practical meaning of it was to promote parallel activities that include professional analysis regarding the legal situation and the required changes in regulations and in DG

professional instructions to surveyors, and regarding an economic feasibility study and implementation of pilot projects.
Each pilot project had specific targets, the results of which should serve the preparation and updating of a comprehensive plan, including requirements for R&D parallel projects and requirements for changing the order of precedence of practical activities according to lessons learned.

The economic feasibility study, launched in 2005 and concluded in 2006, showed an unequivocal justification for the project, regarding the surveying market in Israel and even much more impressive economic justification to the entrepreneur and construction market as well as an improvement of the service of the Government offices to the public.

The pilot projects included the following:
A pilot study in 2005 of assembling the required data and documents and tracing the existence of authentic physical points for potential data transformations in the new city of Modiin;
The first practical pilot project in 2006, executed in the field in 2007, took place in four different areas along the coast, each containing 15 blocks, in typical areas, the variety of which covers areas from a fully open state owned area to private densely built up urban area. This project intended to check the preparedness of the surveying market for transition projects to CBC, from the economic aspect, including the significance of it on the overall preliminary budgetary considerations, as well as checking many professional aspects, including requirement for R&D and recommendations for transformation models;
An internal study in 2008 in a typical state owned open desert area in the Southern Negev, to check the feasibility to use the National Cadastral GIS as a source of data for transformation to CBC in the Southern Negev, and to serve for the improvement of the specifications for a comprehensive implementation of a CBC project in the Southern Negev, covering almost half of Israel;
A pilot project in 2008 in Lachish, which was practically a full implementation project, to check for the costs and implications of a CBC project in state owned agricultural areas; This area is typical to large areas in Israel;
In 2009, R&D feasibility studies in Beer Sheba and Modiin were launched, in cooperation with the Ministry of Construction and Housing, to check for the cost, for the consequences and the contribution of transforming to CBC many other construction projects of the Ministry all over Israel; In addition, the Survey of Israel is conveying internal feasibility studies, including pilot projects of field measurement of authentic original projects.

Parallel to the pilot projects and feasibility studies, R&D projects and activities were taken care of, including the following:
Development of models of transformations to CBC in various types of environments, ranging from GIS based small scale 1:20,000 blocks with no authentic physical points and accurate features, to small blocks in dense built up urban areas, containing authentic points and physical features and many documents including registered block plans, mutation plans, field sheets, field blocks etc., including internal contradiction and conflicting data between neighboring parcels inside a block or between neighboring blocks;

Development of technical tools to analyze and control results of CBC projects and a technical process of checking the data with the reference Cadastral GIS data and integration of the new data into the National Cadastral GIS. This is supported by development and augmentation of the existing Cadastral GIS to manage the accuracies of the data contained and especially the accuracy of the coordinates of the points defining the boundaries of the parcels;
In addition, a new kind of plan is required to document the coordinate based parcel boundaries, since the current CBC plan covers only the cadastral boundaries and not all the features that are included in a block plan and thus supplying only a framework for a comprehensive data base;
Additional R&D projects are defined along the advancement of the CBC plan like the one referring to integration of local projects like those of the Ministry of Construction and Housing into the CBC data base;
Three Additional types of R&D projects may be referred to the CBC implementation: The implementation of 3D CBC sub parcels; The implementation of a coordinate based marine cadastre (Srebro et al., 2010) and the management of a temporal cadastre that records and manages the cadastral changes during time (Jarroush Even-Tzur, 2009) due to change of coordinates, even potential change of a few centimeters of coordinates of control points.

The legal activities include the continuation of the legal inter ministerial team regarding the legal implications of a transition to CBC with reference to the registration of property rights, as well as rights of use, related to a land parcel. This issue should take care of a special issue resulting from the discrepancies between the registered areas of parcels and between the real world areas as surveyed and computed from coordinates; Other legal issues that should be dealt with refer to the implication of CBC on the implementation of the law and regulations of planning and on the implementation of the surveying regulations and technical instructions regarding the Survey Ordinance.

Following the major step forward in the implementation of the CBC projects in the Negev, the time has come for re-planning the working environment and the whole implementation program.

Regarding the preparedness to "digest" the big Negev projects, a dedicated team should be constructed to inspect, analyze and integrate the results of Negev projects that will be supplied by the contractors towards the end of 2010. This dedicated team/taskforce should be based on internal staff that has to be transferred from other duties and probably on additional external professional staff.

In the mean time, in order to take advantage of the success of the first CBC projects covering more than 50% of the country, the CBC program should be accelerated and dedicated staff should prepare additional regions for tenders.
Such an acceleration of the CBC program requires much bigger budgets and, therefore, requires the partnership of the people of the Ministry of Treasury, as well as the Minister who is responsible for the activities of the Survey of Israel.
This crucial stage requires an additional look into the figures. The total number of settled blocks is about 15,500 block plans which cover about 95% of the area of the State. About

9,500 of these blocks are in open areas covering about 86% of the area of the State. The remaining 6,000 blocks cover 9% of the State's area in built up areas, either in saturated built up areas or in low construction areas.
These 6,000 blocks cover the cities and settlements and include numerous mutation plans. The conflicts of rights in these areas are expected everywhere. The process of transition to CBC in these areas will take long time, the cost of the process will be very high and the legal conflicts will be the most complicated, including the involvement of courts.
The economic feasibility study referred to a figure of 100 million dollars for a transition to CBC for the boundaries of the parcels.

Following the experience of the implementation projects in the open area, including about 1,000 block plans, covering 57% of the State lands, we can estimate, roughly, the expected cost of CBC projects in the rest 29% of the state open area lands.
If we refer to a mean cost of an open area block according to a mean cost of a block of the Lachish area project, we have to multiply 3,000$ per block by 8,500 blocks. This shows an estimated cost of 25 million dollars in addition to a cost of 2.5 million dollars already spent. The meaning of these figures and this analysis is that for less than 30 million dollars a coverage of 86% of the State, with relatively limited complications, can be achieved, while the rest 9% of the State settled lands will be much more complicated professionally, legally and economically.

Thus, the author, in his position as DG of the Survey of Israel, decided, practically, to define at this stage that the Coordinate Based Cadastre will be limited to the open areas, covering about 86% of the State, at limited cost and complications and a fast straightforward process.
In the view of the author additional parallel low cost activities should be performed. This will include a marine cadastre, technological and R&D activities as mentioned above, advancing legal steps like regulations, publishing DG professional instructions and a possibility to adjust (correct) registered areas to real areas in open land areas.

In addition, there should be an integration of new land settled blocks and mutation plans, that are based on Israeli Grid 2005, into the CBC data base and the transformation of recent projects of the Ministry of Construction and Housing into the CBC data base. All these latter mentioned coordinate based data should serve as CBC anchors for future CBC projects in the built up areas (Klebanov and Doytsher, 2009). Thus, this gradual "natural" advance in CBC coverage in built up areas will be practically funded by entrepreneurs and contractors at a neglected rate of their investments in construction projects.

The decision about a possible full CBC project in the built up areas, funded by the Government, can be taken in the future on much more stable ground, on the base of the accumulated data and experience, as well as the technological, managerial and legal tools that will be developed in the coming years during the implementation of the CBC project in the open areas. Such a decision should take into consideration major economic considerations.

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