

IMPLEMENTATION OF LEGAL DIGITAL CADASTRE IN ISRAEL

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INTRODUCTION

The Survey of Israel (SOI), Israel's national surveying and mapping agency, plans to implement full legal digital cadastre (LDC) in Israel by 2010. By LDC we mean definition of the cadastral boundaries by coordinates in a homogenous and accurate geodetic control network.. The ultimate goal is to achieve an accuracy of 5 cm (at 95% confidence level). The New Survey Regulations of 1998 (Forrai et al., 2000), was written in order to make sure that this accuracy will be achieved in every new cadastral project. About 7000 mutation cadastral plans ("re-parcellations") and about 400 registration blocks that was prepared by the SOI since 1994, also meet this goal. It was achieved by using combination of GPS horizontal control and EDM, in the New Israeli Grid (Adler, Papo, 1984). The modern Israeli cadastre was established in 1920 by the British mandate in Palestine, and was based on Torrens principles. About 21000 square km of the registered area (about 5% of the area is not registered yet) are divided into about 15000 registration blocks, and about 750000 parcels. The area included in each block sheet changes according to the block's boundaries and especially according to its scale. The scales are from 1:625 down to 1:50,000. The sheet size is about 60x70 cm. Most of the sheets are in 1:1,250 and 1:2,500. The accuracy in which the boundaries are defined is quite heterogeneous as a result of the survey methods and equipment that were used. The Survey Regulations for the triangulation and especially for its densification by traverses that was in use until 1987 was too liberal. For example: a traverse could be 3000 meters long, with 49 permitted legs (longer than 60 meters) and the linear miss- closure was 1 to 1500 in urban area and 1 to 1000 in rural area. There was no hierarchy for the traverses and there was no limit for the suspension of one traverse on another, as long as it conformed to the requirements of the permitted miss-closure. The cadastre was based mainly on the measurement of boundary marks and other objects, most of which were destroyed with the fast development of the state of Israel. Until the early seventies, the cadastral mapping was based on tape (and/or chain) measurements using the orthogonal (offset) method. It was plotted without computing the coordinates. The original measurements are kept in about 30000 "field books". The plotted measurements (on "field sheets") was taken to the field, where the "examiner" added direct distances ("fronts") between the corners of the narrow side of the parcels. These distances were used as a check to the graphical plotting, and were also used partly to calculate the area of the parcels by semi-graphic methods. The area of other parcels was measured graphically, mainly by "planimeter". Sometimes the examiner has changed the location of several points on the field sheet without recording the change anywhere else. The field books and field sheets of quite large area were lost during the Independence War of Israel. What were kept, were only the registration block sheets, which are copies of the field sheets on transparent paper, without written distances on them. Since the introducing of EDM in the early seventies, the coordinates of the

cadastral boundaries are computed and checked against the direct tape measurements of the fronts. Also some tens thousands of mutations in the cadastre (called also “registration plans”), are computed. These are “islands” of higher local accuracy, but they suffer from the distortions of the old geodetic network. In order to achieve homogenous accuracy of 5 cm, we have to reconstruct and measure most of the boundaries that were already measured in the past. That is an enormous task, the economic importance of which is doubtful, and the probability of its implementation is poor. On the other hand, the present situation in which we do not have digital legal definition of the cadastral boundaries is not reasonable and is not proper for a modern state in the new millennium. The situation is very bad once we understand that there is no unique definition to the boundaries, and that the possible errors in reconstruction of boundaries might reach some decimeters. This situation is getting worse with the development of the country, which involves destruction of old objects that can still be used for the reconstruction of boundaries. The harder the reconstruction of boundaries becomes, the more it causes delays in new measurements and their approval, followed by investment of multiple economic resources and growing of the possible errors. We also have to keep in mind that at the same time, the value of the land is growing constantly. Today we already have many areas in which the value of a strip of land 5 cm wide and 20 meters long is more than 1000 U.S.\$. A lot of surveys, which contain reconstruction for boundaries, and are used for building projects, are done in Israel with no necessity for cadastral mutation plans. Non-reversible facts are actually established in the area, without the approval of the SOI and without considering a wide picture of the cadastral connections. It can cause a situation in which a parcel between two others that were reconstructed separately would lose a substantial part of its area while every thing was done legally. Digital legal definition of the land boundaries would prevent of course all such problems, and it would dramatically fasten the work and decrease the price of any measurement for reconstruction of boundaries. Here are some examples of its influence on our life: A basic condition for approval of mutation plan in Israel, is its conformity with a detailed municipal plan. The cadastral layer in those plans is based usually on digitized graphic material from the registration blocks. This material does not guarantee the requested suitability and causes in advance inaccurate municipal plans. Available LDC will be the solution for this problem and will significantly contribute to acceleration in the preparation and approval of municipal plans and of cadastral mutation plans. Once we have LDC we can plan, mark in the field, and check immediately every building project. Actually, very soon we shall not understand how we could live without it. The question is how to achieve it efficiently and in reasonable time. Following are some ideas the implementation of which will bring us to our goal.

IDEAS FOR IMPLEMENTING LDC

1. Ongoing cadastral projects

By cadastral projects we mean both mutation plans in registered area and measurements of new registration blocks in unregistered area. As mentioned above, all the cadastral projects that were prepared by the SOI (by contracts with private surveyors) since 1994, meet the accuracy criteria of the LDC. The basic geodetic control for all these projects were done by GPS measurements, tied mostly to 3rd order “triangulation” control points that was readjusted to be a homogeneous accurate horizontal geodetic control, and have coordinates in the New Israeli Grid (NIG). Since 1996 there is a directive published by

the SOI that every mutation plan containing more than 5 new parcels or larger than 10 dunams (10000 sq. meters) must have coordinates in the NIG. The need for coordinates was already one of the regulations in the Ordinance Surveys of 1987, but the change was the necessity to use the NIG. This demand meant mostly use of GPS measurements, because of the impossibility to tie the surveys to control points of the lower order that exist in the field but were not computed in the NIG, due to the incompetence of its measurements (as described in the introduction). The new Survey Regulations were published in July 1998 and every cadastral mutation plan that is brought to approval at the SOI since January 1999 must be prepared according to them. In addition to the use of NIG in every cadastral project, it has to be presented on electromagnetic media, in a special format of the data, which would enable easy check and almost automatic storage in the cadastral database .

The annual rate of cadastral projects is about 1200 mutation plans and 100 new registration blocks, spread over an area of about 100 square kms. There are also intentions to accelerate the work in the unregistered area in order to finish it by 2010.

2. Legalizing the digitized cadastre of the Israeli Land Administration

About 92% of the land in Israel, belongs to the state and is managed by the Israeli Land Administration (ILA). Tenure of these lands is done through a long term leasing in a variety of ways. The status of the cadastre in most of the area does not fit its actual use. In every case of preparing a mutation plan in such an area according to its real use, or according to new municipal plans and new development projects, the registered boundaries are canceled and new boundaries are created instead of them. It means that there is no importance to the accuracy of the registered boundaries, even when they are marked in the field. The SOI is completing digitizing and “stitching” all the registered block sheets of Israel. This is based on graphic material, and so the accuracy of the product (called “cadastral GIS”), is changing from some decimeters (large scale block sheets) to some meters (small scale block sheets). The ILA is managing a parallel system of the land-use. The idea is to adopt the inaccurate coordinates of the “cadastral GIS”, in all the places where the ILA is ready for it, and declare these coordinates as LDC. Boundaries between this area and other kind of land use (private or long lease in urban area) will be treated as in the following paragraph 4. Until this treatment (which might take some time) is completed, we should work according to special restrictions about how close to the other kind of land-use we can adopt the cadastral GIS. The adoption will not be done in areas, in which there are already approved mutation plans with coordinates. An un-prevented result of this legalization act is a massive change of the parcels area in the Land Registration Office, so that the area will fit exactly the coordinates of the boundary framework. Otherwise, the area of too many parcels will not stand in the permitted tolerance of the difference between computed and registered area. This result has clear advantages (no more dealing with discrepancies between registered and computed area), and it is easy to be done (legally) once the lands owner (ILA in this case) agrees to do it.

Most of the land of Israel belongs to the category of this paragraph.

3. Growing skeleton of LDC by every-day building activity

According to the new Survey Regulations, every new mapping, although not for registration, should be done by the same methods and accuracy of the Regulations.

Survey works involved with reconstruction and/or measurements of boundaries, take place every day. The idea here is to collect all this information from the surveyors. Every parcel that is measured and has coordinates in the NIG, will become a growing skeleton structure of LDC and will be used as spread islands helping to anchor other measurements. The availability of the information to all the surveyors will ease their work near locations of previous work and will enable them to check their work and be sure it was done properly.

4. Approximate LDC

As was said in the introduction, it is a huge task to achieve the desired goal of full accurate LDC. Reconstruction and measurement of all the cadastral boundaries (even without those detailed in paragraph 1 above) should cost about 500 million US\$. The economic importance of performing this task is doubtful. It is also not realistic for the surveyors' resources of Israel to fulfill such task within 10 or even 20 years. The solutions described in the first three paragraphs meet the requested accuracy of 5 cm at a confidence level of 95%. In this paragraph we bring a solution, which is a reasonable substitute to the desired product, with the cost of about 10% to 20% of it. This solution, which we call approximate LDC (ALDC), will be implemented in the area that was not dealt with in the previous paragraphs. The solution will be executed in the following way:

- a. Gathering of all the existing measurements data from the field books, field sheets, mutation plans, digitized graphic material (when no other data exist), and the coordinates of the control points that were used in the measurements. Other sources of information are the topographic GIS and the orthophoto coverage, in which one can identify objects that appear in the original measurements.
- b. About 5% to 10% of the original control points, or boundary points, or objects, which exist in the field and are supposed to be authentic (belong to the original measurement), will be measured by the combination of GPS and total-stations. When such details are not found, effort will be made to locate and reconstruct authentic objects by the use of old air photographs. Substantial built up fences will be measured too.
- c. A sophisticated least square adjustment will be done with all the new measurements of (b) and the old data of (a). The adjustment will be made with consideration of geometric information like straight and parallel lines and width of roads as in (Doytsher, 1981 and 1997).
- d. The least square adjustment is accompanied by accuracy estimate. It will give the idea whether we have to measure more objects and also whether we can adopt substantial fences (which are not authentic) as if it is authentic. The idea here is to adopt physical evidence as long as it stands with in the accuracy that can be achieved, even when we know that it is not exactly in its original location. In that case another iteration of the adjustment will be made, including the additional data.

Some experiments and research that were done, see e.g.(Fradkin ,Doytsher, 1997) show that we should expect to get standard deviation (**s.d**) in the range of 5 cm to 25 cm. We

should not expect to reach low and homogenous standard deviation everywhere, due to different accuracy of the original measurements and to different conditions in the field. The least square adjustment should give us the indications for improving the results through adding of measurements (when possible), including the use of old air photographs. The result of the adjustment is ALDC. The coordinates of the cadastral boundaries (except those of the authentic ones that were measured), will be considered correct and legal as long as there is no better contradicting evidence. In every case of reconstructing boundaries by the data of the ALDC, the surveyor will have to check for existence of authentic objects that enable more accurate reconstruction. The searching distance (radius) for such objects will be derived from the **s.d** of the adjustment. Reasonable distance is 25 meters for every 10 cm of **s.d** . Once authentic objects are found, they will be measured. Those new measurements will be added to the observation-equations through a process of sequential least square adjustment. Every new reconstruction of boundaries (although when no additional authentic objects are found, and the reconstruction was based on the ALDC), will be registered, and will be used in the future as authentic data. The same rule will be used also with substantial physical boundaries (fences) that are built in the range of 3 times the **s.d** , as long as the “fronts” of such boundaries, as well as the other fronts (that are not built) between these boundaries will conform to this criterion .As a matter of fact, this idea is already a long time a part of the Survey Regulations for “graphic” reconstruction of boundaries. The rule in this case is to search for original boundary marks within a radius of 1 meter when the digitized block sheets are in the scale of 1:1,250 and a radius of 2 meters when the scale is 1:2,500. There are difficulties with the fact that such measurements get an official recognition only as an approval of mutation plans. Now, it will belong to the LDC with every reconstruction of boundaries, as a part of paragraph c above.

Most of the work and the resources to be invested are in the category of this paragraph.

SUMMARY

A rough estimate of the cost of the project in Israel is in the range of 50 to 100 million U.S dollars. About half of the cost is needed for fieldwork and the other half to office activity. It means an expense of less than 2\$ per capita for the next 10 years. It is a reasonable price, and there is no doubt about its necessity in the long run. The LDC will make a revolution with all the surveys that are connected to planning, building and registration of land. Planning will be based on available digital cadastral layer. Marking of parcels for building will be based on available digital material, which can be used fast and easy in the GPS era. The above is good also for authorities supervision of building according to the approved plans. Available LDC will fasten and reduce the cost of preparing, checking and approval of cadastral mutation plans. The citizens' right for information includes the information about their most valuable property, which are their house and land. Available LDC will supply every one with immediate information about the exact location, shape and area of their property. Implementing of LDC is the basic condition for 3 dimensional cadastre, which is in its first steps (Doytsher, Forrai, Kirschner, 2001). It complies also with the FIG Vision for a Future Cadastral System-Cadastre 2014 (Kaufmann, Steudler, 1998).

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BIOGRAPHICAL NOTES

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Societies

Israel's delegate to commissions 5 and 7 of FIG.

Rotary International

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