Registration of Cadastral spatial Rights in Israel – A Research and Development Project

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Key words: spatial sub-parcel, spatial parcel, a plan for spatial registration purposes.

SUMMARY

During the last years a number of initiatives were considered in Israel towards replacing the existing two-dimensional (2D) cadastral system by a three-dimensional (3D) one. One of the steps undertaken is a research and development project, initiated and specified by the Survey of Israel (SOI), starting in September 2002 and carried out by a team of experts from several disciplines. The project is due to be completed in August 2004.
The principal objectives of the project are to find geodetic, cadastral, planning, engineering and legal solutions, for utilizing above and below surface spaces, thus defining the characteristics of the future analytical, 3D and multilayer cadastre that will complement the existing 2D cadastre.
This paper introduces the alternatives examined for a spatial registration and management of spatial rights and the recommended solution chosen. It presents the computerized multilayer GIS model for registering and visualizing property rights in all the three spaces (terrain space, subterranean space and above-terrain space).

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1. INTRODUCTION

In 1928, the British mandatory government has introduced the existing legal cadastre in Israel *(Benhamu and Doytsher, 1997)*. The existing cadastral system is based on Torrens principles (Registration of Title), is 2D, dealing only with surface properties. Whilst already there are many buildings and substantial number of infrastructure elements below the surface, the current cadastral system barely deals with them *(Benhamu and Doytsher, 2001)*.

In recent years, the State of Israel has entered the post-industrial era, characterized by fast economic development driven by population growth, expanding economy and a rising standard of living. This is accompanied by the constantly increasing building density, primarily in the central areas of the country that are the preferred place of residence due to employment and commercial opportunities. Moreover, the growth in population, projected to rise to nine million by 2020 and to more than thirteen million by 2050, accentuates the urgent need to find new solutions for building new infrastructures, while preserving the remaining open spaces. Therefore, Israel has a particular interest in the immediate exploitation of the spatial potential, especially in the central area of the country.

Both, the existing cadastre and the Land Law (1969) do not provide a solution for multilayer activities related to land parcels. Under the Israeli Land Law, the property right in a land parcel, extends from the center of the earth and radically outwards into space, including all that is built or cultivated upon its surface. Therefore, there is a growing awareness of the necessity for finding a legal and a cadastral solution for registering rights of multilayer cadastral reality.

The Israeli government decided in 1999 to improve the efficiency of the land use *(Benhamu and Doytsher, 2001)*. This decision reflects the government's interest in the multilayer cadastre. Furthermore, it is necessary to regulate the laws and the conditions that will facilitate utilization of a land site for a number of uses, both above and below the surface. Following this, the Survey of Israel nominated a team of experts as stated above in the abstract. The various issues that have been examined by the team, within the registration of cadastral spatial rights R&D project, are detailed in the following paper.

2. RESEARCH AND DEVELOPMENT PROJECT

During the last years a number of initiatives have been taken in Israel, aimed at the conversion of the existing 2D cadastral system into a 3D system, amongst them the R&D project described here.

One of the objectives of that project is the establishment of an active computerized model of registration of rights of land in a spatial concept. This objective will be achieved through a number of subsidiary objectives as follows:

- 3D Definition and registration of spatial parcels.
- Proposals for changes in the existing Land Law, the Planning and the Construction Law and the Survey Ordinance, considering the applicable engineering and planning constraints.
- Accumulation of the altimetric data to be added to the 2D cadastre, thus creating the 3D database.
- Solution to the management of analytical cadastral information, in 2D and 3D GIS environment.
- Development of suitable software for the visualization of 3D cadastre.
- Modification of the Survey Regulations in order to facilitate registration of 3D cadastre.

The R&D project is carried out by a small group of experts coming from different disciplines: Cadastre, Geodesy, GIS, Law, Planning and Construction, Geology and Soil Engineering. The SOI, which is steering the R&D project, has formulated a two-year timetable for it (see appendix).

The Ministry of Finance has approved a budget of approximately one million US$ for the R&D project and for four pilot projects. One of the pilot projects is a multistory building in the center of Tel-Aviv that includes subterranean parking on several layers. The second one is in the center of a new town (called Modi`in), currently under development and construction. The other pilot projects are in the ancient town of Acre, which include two layers of buildings. The lower layer includes buildings and tunnels from the Crusader's ancient period and the upper layer-buildings from the Mameluke period, which serve nowadays as residential structures, churches and mosques.

Two governmental commissions monitor the work of the R&D team. The first one monitors the research work. The second examines the legal changes recommended by the R&D team, and will present them to the government at the end of the R&D project.

3. THE SPATIAL REGISTARTION OF PROPERTY RIGHTS

Under the Israeli Land Law, the property right in a land parcel extends from the center of the earth and radially outwards into space, including all that is built or cultivated upon its surface. It would be appropriate to mention here that the Israeli Land Law is not alone in defining such an extent of the land property concept. This concept is practiced in many countries. Some of them limit the concept only to the feasible exploitation extent.

In order to practice the 3D exploitation potential by different interested parties, it is necessary to define a legal and cadastral solution capable of registering rights of a multilayer cadastral reality. In order to do so, the R&D team examined the following four alternatives:

- The Amended "Land Law" Alternative: The activities in the subterranean space and the air space will be possible by changing the extent of rights in a parcel of land, within the Land Law *(Benhamu and Doytsher, 2001)*. The infinite extent of rights will be limited to a specified height above and/or depth below the surface of the parcel, within the applicable exploitation limits. This can be achieved either through a general limitation of spatial rights, or a limitation imposed specifically in places where spatial activities are planned. These limitations apply only to "Rights of Use" and not to the all including "Property Rights" (see fig. 1).

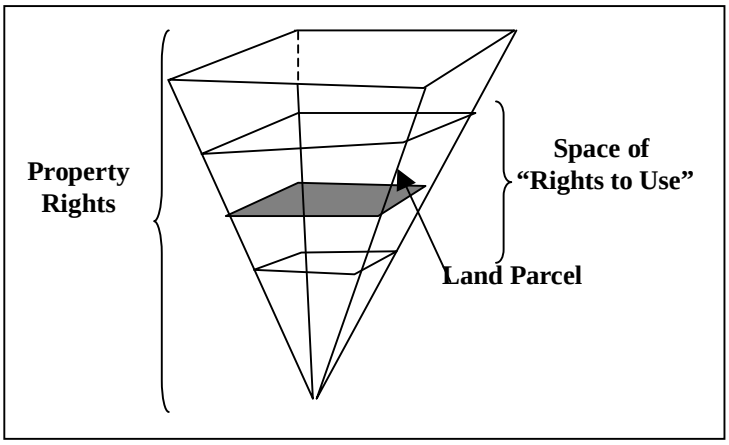

Figure 1: The limitation of the infinite property rights (the "cone" model)

As the Basic Law of "Human Dignity and Liberty" states that "there shall be no violation of the property of a person", any change in the definition of the "Property Rights" in the Land Law, might be considered as limiting the full constitutional rights of the registered owner.

This Basic Law permits the infringement of a person's property only subject to three sequential conditions: conformance with "laws befitting the values of the State of Israel", a "proper purpose" and only "within the strictly required extent". It is feasible that courts of justice will address the essential need to effectively exploit the earth resources as "a proper purpose". However, many landowners will oppose the damage in the extent of property rights and therefore, many legal suits are to be anticipated, including compensation claims.

The Israeli High Court of Justice issued a verdict in January 2003, concerning the construction of car traffic tunnels under privately owned parcels of land. The verdict demands that the government must only consider expropriation of the subterranean land, in a case where the project is clearly for a proper purpose and for public use. The court stated in its verdict also the necessity for a new legislation for this purpose.

- The Alternative of "Registration of Condominiums": Since most condominiums consist of several apartments built mostly on top of each other, it is possible to refer to the condominium as a vertical sub-parcellation *(Benhamu and Doytsher, 2001)*. This vertical sub-parcellation is due to coexistence of many different owners in the parcel's space and

many different properties on the same parcel. The Registration of Condominiums by the Land Law governs the status of the rights of the several property owners on the same land site, and provides a judicial solution of separate ownership on levels. An apartment in a condominium is a separate entity regarding ownership, rights and transactions. It should be pointed out that the method of registration of condominium buildings has been practiced in Israel for several decades and there is a cumulative and considerable good experience in its application.

This method offers the best solution for the different ownership registration in the vertical dimension. However, it may not be the optimal solution for 3D cadastre, because the registration of condominium buildings has not been conceived with complexity of the cadastral spatial reality in mind *(Benhamu and Doytsher, 2003)*. The registration of condominium buildings may be adapted to the adjacent subterranean spaces connected to the surface. It is not suitable for the registration of subterranean spaces, which are absolutely separate from the surface exploitation. In addition, a difficulty may arise in formulating the legal relationships between those who exploit the deep subterranean layer and those who use the surface layer of the parcel because a possible conflict of interests. For those cases where there is no construction on the surface layer of the parcel, the existing law does not facilitate a condominium building registration at all.

Application of the condominium registration alternative to the complex future multilayer reality is not optimal, since the method of registering condominiums refers only to the specific case of "orderly" vertical construction in apartment buildings. The R&D team recommends using this alternative in cases where it is possible to regard the subterranean project as a condominium building by itself, separately from the existing condominium on the land surface. All this provided that the law will be amended in order to accommodate this and will provide a solution for the spatial sub-parcel registration.

- The “Objects Registration” Alternative: This alternative consists of the establishment of an “objects registry” for spatial objects, totally separated from the existing land registration *(Benhamu and Doytsher, 2003)*. The objects registry will deal only with spatial objects. This is an easy and simple solution, but it may undermine the public faith in the land registration system and its reliability. A great difficulty is foreseen in establishing an appropriate relationship between the existing system and a separate spatial objects registry.

- The “Spatial Sub-Parcel” Alternative: This alternative provides a solution for the registration of spatial objects, not adjacent immediately to the registered surface parcel, whereas each one of those spatial objects is subject to defined rights and obligations. The activities in the subterranean space and in the above-terrain space will be made possible through an allotment or expropriation of specific parts of the space included within the vertical boundaries of the surface parcel.

  The High Court in Israel ruled in January 2003 that in the case of expropriation of subterranean space for car traffic tunnel construction, that the state is obliged to

expropriate only the minimal volume required for the construction. Any additional space and especially unlimited expropriation were not permitted.

This alternative of creating spatial sub-parcels has been selected by the R&D team, as the proposed solution for the registration of rights in space. The monitoring commissions approved the recommendation.

4. "SPATIAL SUB-PARCELS" – PRINCIPLES OF THE PROPOSED SOLUTION

As stated before, the Israeli Land Law defines the property right in a land parcel as extending from the center of the earth, radially outwards into space.
The principles, which guided the R&D team in formulating the solution to the spatial cadastral registration and its adoption to the existing cadastral reality, were to avoid infringement upon the existing system, as follows:

- The spatial registration will be achieved by sub-dividing the surface parcel space into spatial sub-parcels (see fig 2). The definition of the surface parcel will remain unchanged. Any project established in one of the spatial sub-parcels (above or bellow the surface) will be bounded and defined stereometricaly by a final 3D outline and its volume. A spatial project, which extends above or below a number of surface parcels, will be thus subdivided into spatial sub-parcels, in accordance with the existing surface parcels. If required, it will be possible to consolidate the spatial sub-parcels, within a registration block, into one spatial parcel.

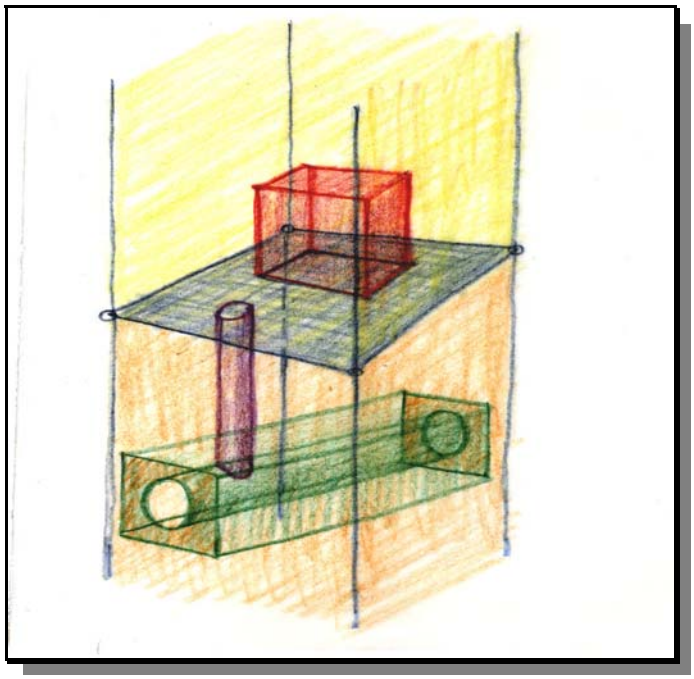

Figure 2: Spatial division into sub-parcels

- The Title Rights to the surface parcel will be preserved according to the existing definition of the surface parcel as extending infinitely above and below the surface. However, the spatial sub-parcel will be defined as a final volume object, subtracted from it.
- The spatial sub-parcel will be included in the existing registration block as a part of the surface parcel. The existence of spatial sub-parcel will be noted also in the Title Register. The Register will include the 3D definition of the spatial sub-parcel. In the case of consolidation of several spatial sub-parcels into one spatial parcel, this spatial parcel will be registered separately in the Register and in the registration block.

The proposed solution for the cadastral spatial registration will be realized on the basis of the following recommendations of the R&D team:

- Preservation of the Rights of Property: No infringement of the rights to property, except for proper purposes and limited to the minimal required extent.
- Setting off Distances: The stability of the existing structures built on the surface of the earth, will be achieved by setting off distances to them and to the spatial sub-parcel as well, imposed by engineering considerations.
- Continuity of the Existing Registration Method: Allowing extension and adaptation of the existing registration system to the new spatial cadastral reality without infringement upon the system itself. Necessary amendments will be made in the Land Law, Planning and Construction Law and the Survey Ordinance.
- Subterranean Registration Following Construction: In many cases, the underground construction does not conform exactly to the planning, especially in cases of unexpected technical difficulties. Therefore, the final registration of the subterranean sub-parcels will usually be made only after the project has been completed, measured "as-made" and registered accordingly. During the planning and construction stages only a warning note will be registered.
- GIS Land Management: The future cadastre will be incorporated into the national GIS system and will be managed by GIS means. This will result in a more efficient planning, exploitation and management of all three spaces of the land.
- A Soft Copy Combined with a Hard Copy: All maps and plans will be based on a digital database, as vectors, GIS and digital maps. The spatial activities will be shown three-dimensionally (perspective and sections) in a plane projection on the computers monitor. A plotted map (hard copy) will also be produced in the format similar to a regular block registration map, on which the spatial activities will be detailed on separate plans at different levels, with the aid of colors and conventional signs, similarly to the maps presently in use. The existing surface division will be displayed as a background to the spatial subdivision.
- The Spatial Geodetic Technology Feasibility: The state of the art methods (Laser scanning) and existing geodetic technologies have been experimented in the Tel-Aviv, in Modi'in and in Acre sites, and have been found feasible for application in the production of registration plans both below and above the surface.

5. VISUALISATION AND 3D CADASTRAL MAPPING

The delineation of surface parcels, spatial sub-parcels and spatial parcels that are vertically layered, requires a spatial description, including data defining the horizontal and vertical boundaries between these units. The ability to present spatial characteristics of land parcels will permit a better definition of cadastral spatial subdivision. The three dimensional presentation will provide better means for inspection and analysis of data, than the existing 2D one.
Presentation of spatial data in a digital map (2D and 3D) makes it necessary to use graphical tools, which would facilitate the perception of the 3D reality *(Benhamu and Doytsher, 2003)*. Subsequent to the examination of a number of options, the following techniques were selected:

- Graphic Symbolization: The application of graphic tools (color, type of line, conventional signs etc.), which permit discerning objects belonging to different space layers.
- Multi-Windows: Presentation of information about spatial activities in different windows/screens displays.
- Transparency: Display of the spatial activities against a high degree of brightens background of the surface reality.
- Perspective Presentation: A 3D perspective of the object, from different angles of view.
- Varying Resolution: Focusing on surface attached object with the accompanying detailed data on the spatial activity.
- Multimedia: Virtual reality, spatial flight and other modern 3D techniques.

The Israeli Evidence Law does not accept a digital document as conclusive evidence in a court of law, unless accompanied by an original hardcopy. Therefore, it is recommended that the future 3D digital map be projected onto a plane and a paper copy plotted. The R&D project examines the two following alternatives:

- A 2D graphical document along the lines of the existing cadastral map, showing the three spaces: surface attached, subterranean and aerial.
- A conventional cadastral map, to which will be attached a plotted appendix, relating to the subterranean and aerial spaces, as the case may be. In addition, to the future cadastral map will be attached also vertical cross-sections and perspectives views.

The R&D team recommended the second alternative, as the alternative to be chosen in order to represent the spatial reality in 2D.

The majority of CAD software's on the market include advanced tools for presentation of information and it's editing *(Benhamu and Doytsher, 2001)*. They lack, however, the GIS functions, which handle queries and spatial analysis of information. On the contrary, the majority of GIS software's on the market are 2D, developed for management, presentation and analysis of data, essentially 2D in character. During the last few years, several GIS extensions were developed in order to represent a 3D model, such as digital terrain elevations, a 3D presentation of objects, preserving the elevations as object characteristics. However, no 3D GIS software has been yet developed, based on 3D topology. Therefore, it is

necessary to develop an interface between the GIS and the CAD software's, in order to achieve a 3D capability of representation, computation and analysis.

6. THE ENGINEERING ASPECTS – "DISPLACEMENT DISTANCES"

In accordance with the proposed solution, a spatial sub-parcels, defined stereometrically, as simply as possible, will delineate every project established in the subterranean or aerial spaces. The definition of the outer envelope of the spatial sub-parcel will be based on survey data of the spatial project, combined with planning data and the displacement distances creating the required boundaries, in accordance with engineering considerations.

The "displacement distances" are defined as the distances between the project itself and the outer envelope, displaced from the project, because of engineering stability, safety and ecological considerations. These "displacement distances" will be specified by a planning authority in a document describing the relationships between the project and its environment as far as the influence of the project and its operation is concerned. The "displacement distances" will minimize the environmental negative influence of the spatial project.
Other aspects for the delineation of the spatial sub-parcel boundary (the outer envelop) are:

- Delineation of the spatial envelope by a simple stereometric definition, in such a manner, that the spatial sub-parcel will be defined by 3D coordinates (in the New Israeli Grid and the vertical component), thus permitting easy computation of the parcel's volume.
- In the areas, in which spatial projects are planned, a temporarily spatial subdivision of the subterranean and/or aerial space will be made. After the construction is completed, a more precise subdivision will be made with accordance to an "as–made" survey, followed by the registration of rights.

7. SPATIAL REGISTRATION PLAN

In the land registration practiced in Israel, the registration plan is an integral part of the register and it serves as geodetic component of the register and its revisions *(Benhamu and Doytsher, 1997)*. The accurate registration plans are an important factor in keeping the records up to date and contribute to the reliability of the land register. The 2D registration plan presents the existing surface subdivision as well as the new one, the areas of the parcels, their shape and precise location. The current registration plans, do not include altimetric information at all. The registration plan does include information on surface attached details, such as buildings, fences, roads etc.

In the 3D cadastre, the registration plan will be digital, 3D and multi-spaced. Its production will involve advanced technology (GIS, CAD, INTERNET etc.) and the results will be included in the National Digital Information System.

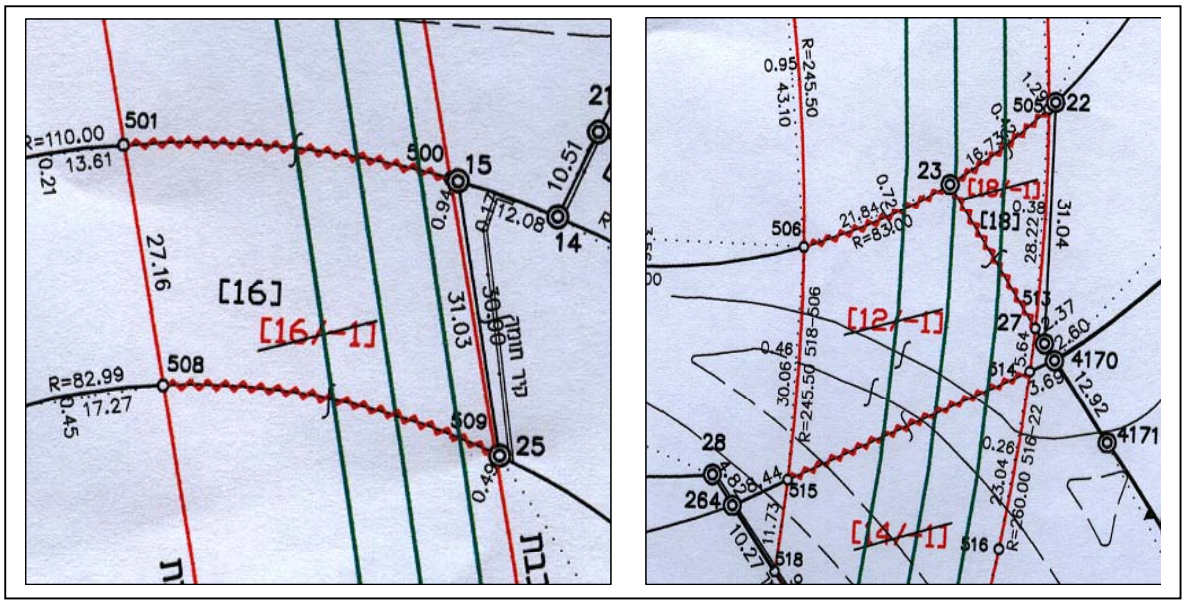

Figure 3: Spatial subdivision against the background of surface subdivision

The 2D presentation of the spatial registration plan will bear the following characteristics:

- Presentation of a mutation for one space and one level only as a one-registration plan. The whole mutation will include a number of spaces and a number of levels, composed of a number of 2D registration plans.
- Presentation of the surface land subdivision, as a background to spatial mutations. Colors and different types of line symbols will be used, in order to differentiate between different objects from different spaces (see fig. 3).
- Various formats of presentation will be included: sections and perspective views.
- Notes will be included pertaining to the definition of the outer envelopes of spatial sub-parcels.
- The table of mutations will include data relating to the space, area, and percentage of horizontal overlap, volume and minimal and maximal elevation.

8. COMPUTERISED PROTOTYPE FOR SPATIAL CADASTRE

0ne of the tasks of the R&D project is the development of an active, computerized prototype of the Registration of Rights in space, in a GIS environment. The prototype of the GIS system is applied to the management of spatial cadastral database and will facilitate queries, visualization, production of reports and maps. The prototype will support testing and demonstration of the solution recommended by the R&D team.

The development of the prototype includes specification of the future GIS for the registration of spatial rights, as well as the development of a number of examples of application in order to demonstrate a routine use of the spatial cadastral information (see fig. 4).

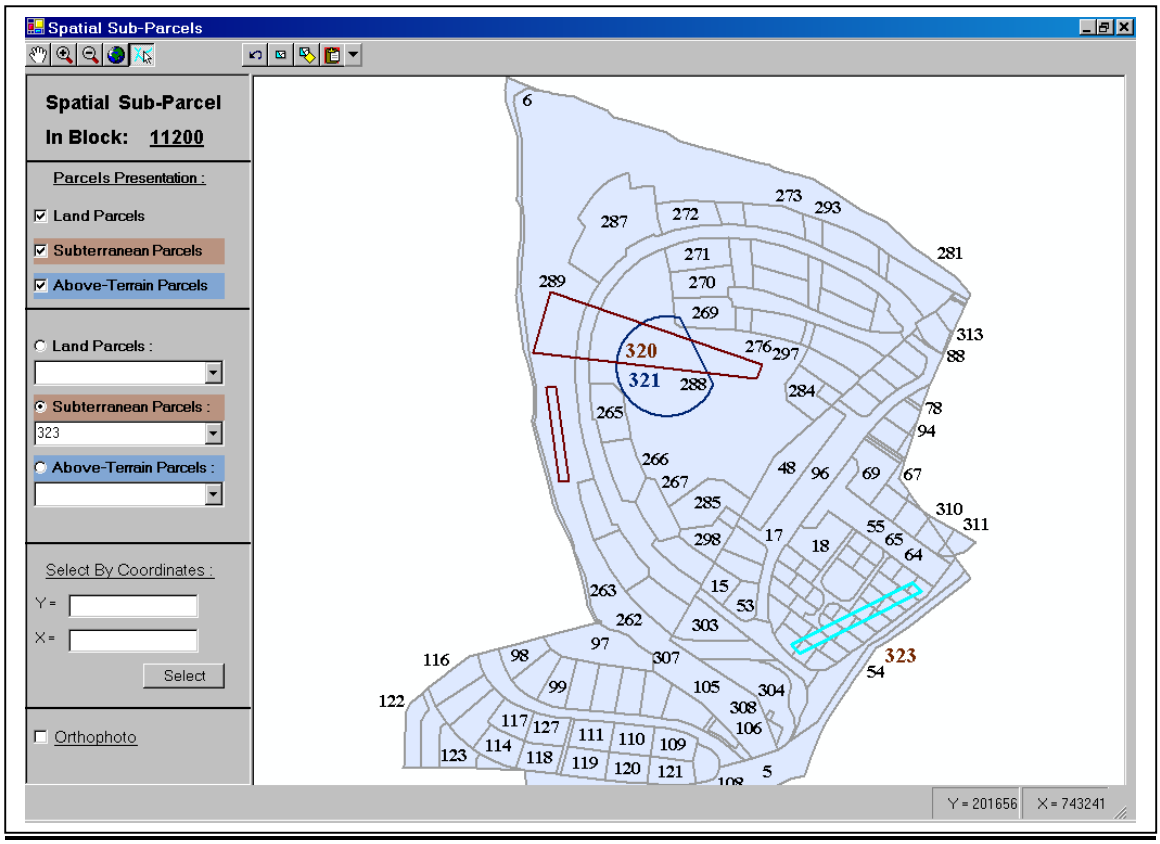

Figure 4: A display of spatial activity within a registration block

These applications include amongst others: production of alphanumeric information pertaining to a surface parcel, a spatial sub-parcel, a spatial parcel and a registration block. Similarly, a two and three dimensional display of all spatial sub-parcels existing within the space related to a surface parcel, and a graphical display of the original surface parcels with their appropriate spatial parcels (see fig. 5), etc.

9. THE EXPERIMENTAL PROJECTS

Within the framework of the R&D project, four experimental projects were carried out:

- A multistory building in the center of Tel-Aviv and includes subterranean parking on several levels, which extends in the space of several parcels belonging to different owners.
- The main town center, under construction, in the new town of Modi'in and includes four subterranean levels with different ownerships and planned for different purposes (a railway station, public park, bus terminal and a principal road).
- Two antiquity complexes (a Templar's tunnel and St. Andreas church), in the ancient town of Acre.
- A subterranean antiquity complex the "Knight Halls" located in a crypt in the ancient town of Acre.

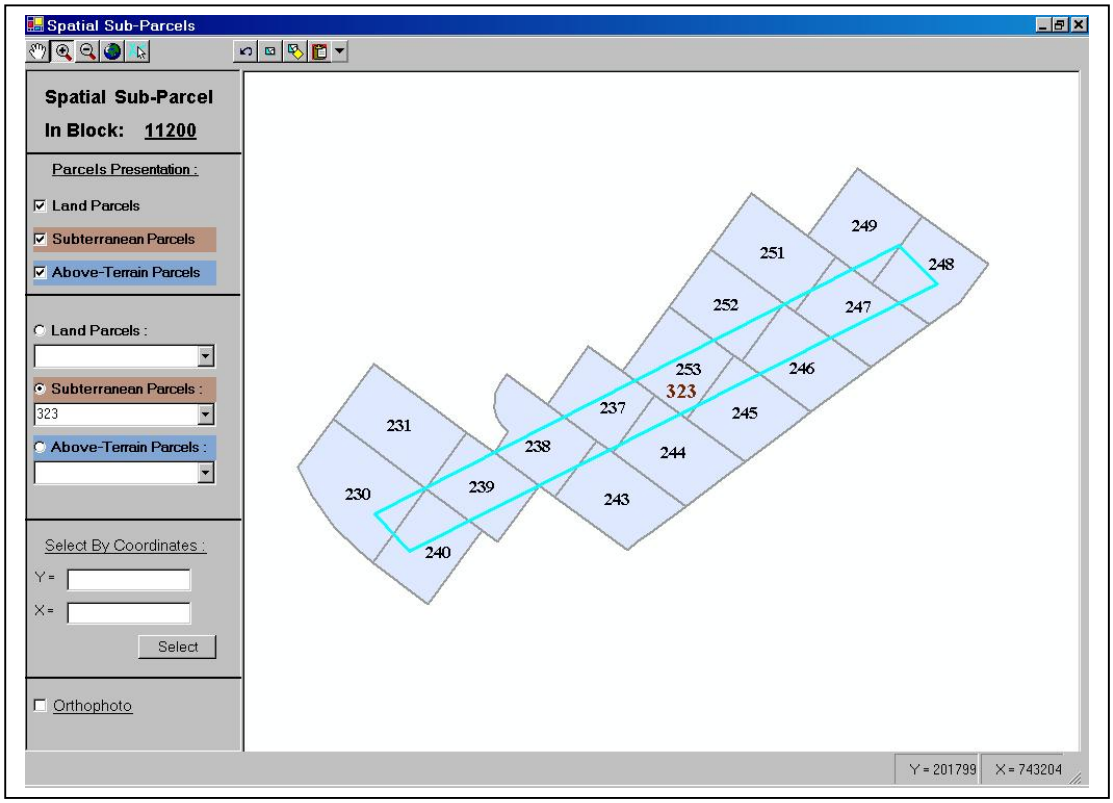

Figure 5: The original surface parcels regarding to the spatial parcel

The principal objective of these projects is the registration of rights to land in a complex composed of a number of structures, below and above the surface. This principal objective includes also several secondary objectives:

- Construction of 3D models of the surface and the subterranean reality.
- Definition of the spatial sub-parcels which envelope the physical objects in subterranean space.
- Integration of spatial sub-parcels, in order to produce a "spatial parcel" within the boundaries of the existing registration block.
- Production of a spatial registration plan and also of a land settlement plan in areas which did not undergo yet a settlement process (such as the ancient town of Acre).
- Examination of the solution proposed by the R&D team, drawing final conclusions and updating the recommendations pertaining to the spatial registration process.

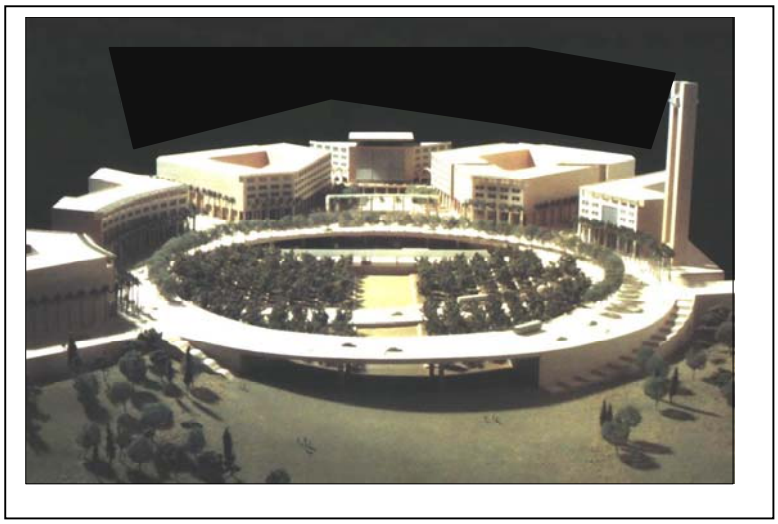

Figure 6: A model of the town center of Modi'in

The town center of Modi'in is a planned complex, which will include a modern transportation terminal of trains and buses and a number of additional municipal functions *(Grinstein, 2003)*. This multilayer complex was chosen because it is obligated to register the spatial rights, which are not necessarily functionally connected and belong to different owners. For example: a subterranean train terminal above which there is a bus terminal, parking spaces for buses and a main road, with a secondary road above it and a public park. Above them, buildings of varying heights designed for commercial, residential and public purposes. Between the various functional spaces, there are inter space passages (see fig. 6).

Some 12 years ago, a process of exposing a subterranean Crusader's town began in the ancient town of Acre. The town being exposed extends below large parts of the upper ancient town (the Mameluk town). Up to the present, only approximately 1.2 hectares out of 36 hectares has been exposed. The subterranean reality is very close to the surface; the buildings exposed are only 0.3-meter to 1.5-meter bellow the surface. In some places, the subterranean reality is even tangent to the surface (see fig. 7).

Figure 7: the Templer's Tunnel – a vertical cross section

The Israeli Land Authority administers most of the land and some of it belongs to or administered by the Moslem Religious Authority and/or by the Christian Religious Authority. The subterranean reality does not coincide with the existing buildings, built according to the description in the existing Taxation Blocks (see fig. 8).

Figure 8: The Templer's Tunnel – spatial sub-parcels on the background of land parcels

In all the pilot projects, the R&D team has prepared plans for 3D registration purposes, in accordance with the recommendations stated above. All these plans will serve as examples for 3D registration in the future.

10. SUMMARY

Most of the existing cadastral systems are 2D and deals only with properties on the surface of the land. The existing cadastral systems, due to being surface and 2D, are unsuitable, as is, for the multilayer reality that has evolved in recent decades. In order to facilitate the continued establishment of engineering projects below and above the surface, and particularly to enable the registration of properties that are not on the surface, it is necessary to amend the legislation and define a new multilayer and 3D cadastral model.
A number of actions have been initiated in Israel in preparation for the 3D cadastre, including the government financed R&D project, which is the subject of this paper. It is worthy to note, that this R&D project is one of the first of its kind, both in Israel and worldwide. The final results of the R&D project, due in August 2004, will hopefully lead to the realization of the 3D cadastre in Israel and will assist the authorities in the transition period. The R&D team has already formulated number of recommendations for the transition steps, some of them described in this paper.

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APPENDIX

Time / Disciplines	1 - 6	7 - 12	12 – 18	18 - 24
Cadastre expert	Standards for surveying and mapping, processing and managing of digital data in 2D and 3D, as preparation for Modi'in pilot project. **Product:** Initial 3DCad database.	Completion of Modi'in pilot project (including surveying, data processing and mapping). Input of the data to the 3Dcad database. **Product:** Real 3D Cad data in 3DCad database.	Adjustment between existing 2D and planned 3D cadastral data in Modi'in. Managing the data in the 3DCad database. Elaboration of the main principles of property registration in starta. **Products:** Operational 3Dcad database and proposals for its further improvement; initial proposal to spatial property registration procedure.	Final revision of all previous standards; fixing principles and technical details (hardware, software, instructions, documentation, etc.) of the registration procedure. **Products:** Final version of proposal of standards and instructions, both of standards and instructions, both for 3DCad activity and registration procedure.
GIS expert	Integration of 3D data within GIS Cadastral Database. Establishment of 3D cad database. **Products:** Initial 3DCad database.		Improvement of the 3DCad database according to the above proposals. Visualization of the database content. **Products:** Improved 3DCad database; operational module of visualization.	
Lawyer – real estate expert	Study of the necessary changes in the existing surveying regulations with introducing the third dimension. **Product:** Proposal for changes of regulations.	Study of problems, which have arisen during Modi'in pilot project; Judicial/ Planning/ Engineering answers. **Product:** an improved version of all previous products.	Support to elaboration of the principals of property. Registration procedure in strata, including documentation, information for costumers, etc. **Product:** Continuous advising.	Support to the final revision of previous standards and to the determination of the registration procedure. **Product:** Continuous advising.

Time Disciplines	1 - 6	6 - 12	12 - 18	18 - 24
Soil engineer and Geology expert	Study of engineering constraints, determination of standards. **Product:** An expert system, instructing the user according to designation, status, etc. of the spatial land property.			
Urban Planning and Construction expert	Study of planning constraints, determination of standards. **Products:** An expert system, instructing the user according to the designation, status, etc. of spatial land property.			