

The New Israeli Survey Regulations

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ABSTRACT

The new Survey Regulations of the state of Israel have been published this year. The Survey Regulations is the principal document that standardizes the professional activities in four key areas- geodetic control, mapping, cadastre and Geographic information systems. Licensed Surveyors and mapping professionals in Israel are required to work according to those regulations. The development of the regulations followed a long process of research and investigation into new technologies in geomatics. These new technologies include the emergence of advanced Global Navigation Satellite Systems, National Spatial Databases and Geographical Information Systems, Digital Photogrammetry and Laser Scanning and Remote Sensing technologies. These technologies have changed the core principles and working procedures of geomatics professionals. For this reason, surveying and mapping regulations, standards and specifications should be updated to reflect these changes. The regulations include major changes in the following fields:

In the Geodesy chapter, horizontal control is officially based on the Israeli network of Continuously Operating GNSS Reference Stations (CORS). The regulations were phrased in a manner that will allow minor datum changes to the CORS stations due to Earth Crustal Movements. Moreover, the regulations permit the use of GNSS for low accuracy height measurements. In additional new guidelines were developed for construction surveying. These describe all the surveying procedures in all the construction phases (foundation layout and marking, building columns positioning and marking, first floor approval, to the as-build map submission).

In the Cadastre chapter, the most critical change is the move to Coordinate Based Cadastre (CBC). Each parcel corner point is ranked according to its quality (accuracy and clarity of definition). The highest ranking for a parcel corner is 1. A point with a rank of 1 is defined by its coordinates alone. Any other contradicting evidence is inferior to the coordinate's values (Barazani and Felus, 2017). Cadastral Information is stored and managed via the National Cadastral Databases.

In the Mapping and GIS chapter, digital maps or spatial databases replace the traditional paper maps (ranked by scale). These spatial databases are ranked by their quality level. Quality level is determined (similar to the ISO19157 Standard) by logical consistency, completeness, positional accuracy, attribute accuracy, temporal accuracy and usability.

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Metadata is another critical component of any spatial database. Every component in a map should have a metadata identification, even if the map was compiled from multiple resources. The regulations permit the use of advanced sensors and mapping techniques including LIDAR and digital cameras that have been certified and meet the defined criteria. The article reviews these new regulations and the process that led to their development.

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INTRODUCTION

The geomatics profession has been regulated in Israel since 1929 when the British Mandate enacted the Survey Ordinance of 1929. According to the Ordinance "No person shall engage in the surveying profession unless he holds a license". The Ordinance also states that "Any map, chart or diagram of land shall not be accepted by the Register Office or approved as an evidence in any court, unless prepared and signed by a licensed surveyor". The strong statements of the Ordinance requires proper definition the surveying profession, its work, and the appropriate standards that surveyors should follow.

The Survey Regulations is the official document that defines and regulates the surveying work in Israel. The regulations are signed by the Minister of Housing and Construction following a comprehensive legal and procedural review.

While, the Survey Regulations defines the basic principles and quality requirements of surveying and mapping work, it is the Director General Instructions that provide the technical details about the methodology and technologies.

The Survey Regulations are being updated once in about a decade to meet the new technological, legal, and administrative changes and developments. The update is made according to the following principles:

- New regulations are developed as a joint cooperation between the Survey of Israel, Government Offices, public agencies, academy, surveying companies and the private sector.
- The new regulations require high quality but at the same time promote efficient processes that maximize the utilization of technologies. The regulations should place emphasis on critical requirements and "separate the wheat from the chaff" to expedite cadastral work (one of the national goals).
- The new regulations should create uniformity in the requirements across different governmental offices and districts in the approval process of mapping and cadastral documents
- The new regulations should be simple, easy to understand and follow standard working procedures in surveying and engineering.
- The new regulations strengthen the link between planning processes, development and building permits, surveying and cadastre, and land registration.

In the following sections, we will describe the three chapters of the Survey Regulations, namely; the Geodesy, Cadastre, and Mapping and Geospatial Information chapters.

REGULATIONS IN GEODESY

The Geodetic chapter includes the basic definitions for horizontal and vertical control networks. The principles and definitions of horizontal control have greatly changed with the adoption of Continuously Operating GNSS Reference Stations (CORS) based networks (Steinberg G. and Even-Tzur G., 2005, Establishment of National Grid Based on Permanent GPS Stations in Israel. Surveying and Land Information Sciences, 65(1): 47-52). The primary horizontal control in Israel is a network of 22 CORS named G1 and shown in Figure 1. Two additional networks exists that are based on the traditional setting of a static (established by surveyed monuments) network of points these are named G1 and G2 (Srebro, 2009). The accuracies of these national networks are described in Table 1. The accuracy measures that were used in the regulations (and in the tables) are:

- CEP 95 - Circular Error Probable, a measure for the accuracy of horizontal coordinates. The radius of a circle centered on the measured coordinates that contains the most probable location with a probability of 95%.
- LEP 95- Linear Error Probable, a measure for the accuracy of a linear measurement (height, length, etc). Half of the interval that is center on a measured linear value and contain the most probable value with a probability of 95%.

Table 1: Accuracy classes for horizontal control network surveyed by the Survey of Israel

Class	Control type	Number of points in the network	Horizontal accuracy CEP 95 (mm)	Vertical (ellipsoidal height) accuracy LEP 95 (mm)
G0	National CORS, Primary geodetic control	22	3	5
G1	Secondary geodetic control	150	6	10
G2	Tertiary geodetic control	1500	15	20

The new regulations have set uniform and countrywide accuracy requirements for all survey work as listed in Tables 2.

Table 2: Accuracy classes for horizontal control network surveyed by private surveyors or by the Survey of Israel

Class	Control type	Surveying method	Horizontal accuracy CEP 95 (mm)	Vertical (ellipsoidal height) accuracy LEP 95 (mm)
S0	Private CORS	GNSS	15	20
S1	-	GNSS	25	60
S2	-	GNSS or using a	35	None

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		total station		
S3	Not for boundary points determination	GNSS or using a total station	70	None



Figure 1: The primary horizontal control in Israel is a network of 22 CORS

Further details about occupation time, difference between survey stations and so on are provided by the Director General Instructions, these are comparable to Caltrans 2012.

Unlike the horizontal network, the principles of the vertical network have not been changed. Initially, it was proposed that the vertical network should be based on the CORS network along with an official geoid model (Steinberg and Even-Tzur, 2006). Nonetheless, while it was agreed that in the future, the vertical network will be based on GNSS technology, it seemed that the currently GNSS technology with geoid undulation modeling does not meet accuracy standards for construction and civil engineering. Thus, the national vertical control is a network with two classes, which was surveyed by geometric leveling with Closure error requirements (relative accuracy) as listed in Table 3.

Table 4 provides criteria for the maximum length of a leveling segment and the minimum length of the leveling loop. The regulations permit the use of GNSS technology for the surveying of low

accuracy orthometric height. The orthometric height is calculated from an ellipsoidal height with the specified accuracy and the national geoid model.

Table 3: Accuracy classes for national vertical control network surveyed by the Survey of Israel

Class	Surveying method	Maximum length of Leveling loop (km)	Maximum closure error (mm)
H1	Geometric or trigonometric leveling	NA	$2*\sqrt{L}$
H2		60	$3*\sqrt{L}$

Lower level vertical networks are divided into 4 classes as listed in Table 4.

Table 4: Accuracy classes for vertical control network surveyed by private surveyors and by the Survey of Israel

Class	Surveying method	Leveling			GNSS Ellipsoidal height accuracy LEP95 (mm)
		Maximum leveling segment length(km)	Maximum leveling loop length (km)	Maximum closure error (mm)	
H3	Geometric or trigonometric leveling	2	24	$10*\sqrt{L}$	NA
H4	Geometric or trigonometric leveling or using GNSS technology	2	10	$20*\sqrt{L}$	10
H5		2	5	$30*\sqrt{L}$	20
H6		1	4	$60*\sqrt{L}$	40

2.1. Guidelines for construction surveying

As mentioned in the introduction chapter, the new published regulations are followed by the Director General Instructions. These instructions are considered as the guidelines for the Licensed surveyor and designed specify the technical details. Their purpose is to describe all necessary technical information required for the surveyor to successfully complete the job.

The instructions cover aspects such as the technologies allowed and the methodologies to implement, in order to meet the requirements set out by the regulations. Each guideline covers different surveying products produced by a Licensed Surveyor or mapping professional.

A significant subject which was described in the Israeli Surveying Regulations for the first time is Construction Methods, technologies and the required accuracies for surveys conducted at construction sites and engineering projects are specified.

According to the Israeli Planning and construction Law and regulations there are 4 steps in the construction process which requires the involvement of a licensed surveyor.

Those steps are:

1. Preparing a map for building g permit: Collecting topographic data, measuring trees, adding cadastral information and adding underground infrastructure data.

2. Preparing a stakeout plan: determine of the coordinates of marker to stake out markers for foundation, building columns, property corners and construction limits. This includes methodologies for applying the stake out survey for the markers and the methods for quality control of the procedure.
3. Stakeout approval plan – Following the stake-out
4. Ground floor plan - surveying the concrete molds for casting, and monitoring the location on the ground floor
5. Conducting an As-Built survey and preparing as-built map for submission

Each step requires the surveyor to supply a survey map for validation and approval. All survey maps for construction surveying must apply computer and cartographic format, logical format and layer structure set out by the Director General. The Director General instructions also serve as a supplement for syllabus being taught in the academy.

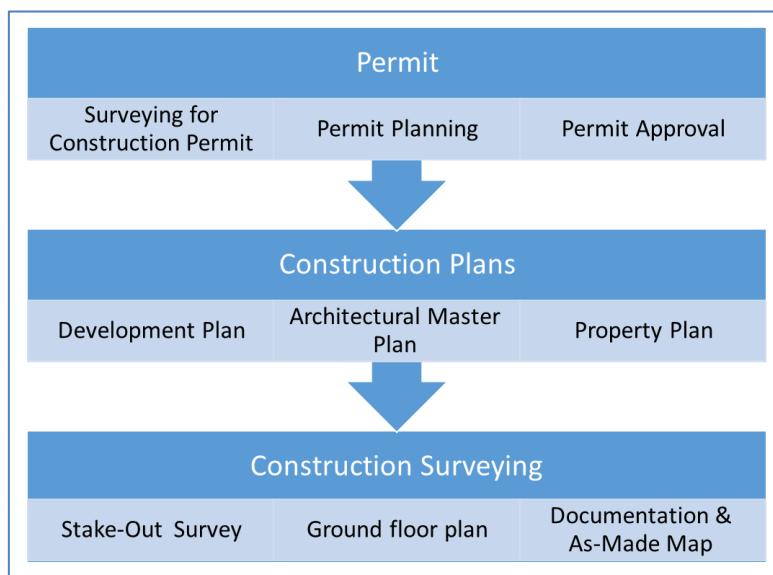


Figure 2: Construction surveying steps

CADASTRAL REGULATIONS

The current cadastral system in Israel was established in 1926 by the British mandate of Palestine, and is based on the Torrens principles (registration of titles). The country's registered area, which includes 21,000 square km (about 3% of the area still is not registered), was divided into approximately 16,000 registration blocks; each contains an average of 50 parcels (about 800,000 parcels). Each block was assigned a unique number and was surveyed and drawn on a parcel map, along with a table of areas and parcel numbers. Surveying measurements and field notes were generally recorded in field books. The methods and the accuracies in which the boundaries were defined were heterogeneous. In some areas the boundaries are accurate to within a few centimeters but in some areas the boundaries are poorly defined and can be estimated to five meters accuracy.

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Thus, every modification of land division (cadastre) requires massive amount of work that include the search and identification of the original boundary monuments, the reconstruction of the obliterated monuments, the establishment of the correct boundary lines, the design of the new division and the submission of a subdivision (mutation) plan. Since there are about 1400 land modification (subdivision plans) every year, this process had to be improved.

The new Survey Regulations aim at improving the cadastral process by the following means:

1. Transform the Cadastral process **from a paper based** and manual one **to a digital workflow** enhanced by internet technologies (Felus et. al 2013). The new regulations do not require the submission of paper maps, paper field books but prefer digital maps signed digitally using digital signature technology and electronic field books and calculations submitted using electronic portal according to standard computer formats and protocols.
2. Accurate and country wide consistent **surveying procedures, which are based on GNSS technology**. The new regulations require that boundary point coordinates will be determined to an accuracy of 7 cm (CEP 95) using the Israel CORS network (G0, as shown in Table 1).
3. **Developing the Boundary Documentation Map (BDM)**, an instrument that will provide planners, architects and designers with accurate boundary coordinates. The BDP coordinates will be served as an accurate framework to support modern design procedures. Moreover, since the new planning zones will be based on approved and accurate boundaries, the conversion of the planning zones to subdivision plans is direct which will expedite registration.
4. Defining the **National Cadastral Database (NCDB) as the dominant source of Cadastral information**, this NCDB will be the only source in the future. Currently, Cadastral information is retrieved from a variety of heterogeneous resources including Block maps, field book, technical description, subdivision plats, existing monuments, land surveying etc.
5. **Setting the principles of Coordinate Based Cadastre (CBC)**. The concept of CBC was developed by Steinberg (2001) and was implemented in Singapore in 2004 (Andreasson 2006). Nevertheless, the complex setting Israeli Cadastral system (as presented in Klebanov 2009) required a more sophisticated solution. This solution that was developed is a new classification system for boundary points, which ranks them by quality and by their legal status. The new ranking is listed in Table 5 and is described in detailed by the Director General Instructions.

Table 5: Boundary point ranking

Point Ranking	Range of accuracy, meters (CEP 95)	Type
1	"0"	A statutory point approved by the SOI Director General as a Coordinate based point. The location of this point is determined by its coordinates alone.
2	0.07	A boundary point found in the field. The point was determined to be authentic and was surveyed with GNSS at an accuracy of 7 cm (CEP95)
3	0.07 – 0.2	Obliterated point, which was calculated from all the available cadastral information at an accuracy of 5 to 20 cm (CEP 95)
4	0.2 – 1.0	Obliterated point, which was calculated from all the

		available cadastral information at an accuracy of 20 cm to 1 meter (CEP 95)
5	Accuracy of digitization process	Obliterated point, which can only be derived by digitizing Cadastral block maps (has no field surveying measurements). The accuracy of the point is derived from the accuracy of the block map
6	N/A	Point coordinates were calculated from all the available cadastral information alone. No attempt was made to find the point in the field.
7	N/A	Point coordinates were calculated only from the original cadastral document. No attempt was made to find the point in the field.
8	Accuracy of digitization process	Point coordinates were derived by digitizing Cadastral block maps. No attempt was made to find the point in the field.
9	>1	Point coordinates have an error and are incorrect.

This new ranking allows efficient management of cadastral data at boundary point's level resolution. It also allows using different measures to treat boundary points with different quality. The key concept underlying the table is that a point at rank 1 are legally determined by its coordinates alone. Any other contradicting evidence is inferior to the coordinate values. These regulations presents a major step towards Coordinate Based Cadastre, which will pave the way to a multi-dimensional cadastre, and to an overall more efficient Cadastre.

MAPPING AND GEOSPATIAL INFORMATION REGULATIONS

The field of mapping and Geospatial Information is consistently changing with new concepts and technologies making it impossible to set comprehensive regulations that will be valid for long time. Thus it was decided that the regulations will cover the basic definitions of mapping products and principal quality requirement and will not describe the details of the technological procedures. The Director General Instructions are more dynamic and will be modified to follow technological changes. The three most important concepts that set the framework for the new regulations in mapping and Geospatial Information were: digital environment and metadata, sound quality control procedures and enabling emerging technologies and advanced mapping products.

1.1 Digital environment and metadata

The new regulations recognize the need to move away from paper maps with legend and specified scale to a digital spatial database (map) with metadata and specified quality parameters. Each digital spatial database should be provided according to the Director General Instructions, which specify the layer structure, attributes fields, table relationships etc. and with a Metadata file. The Metadata file structure is specified in the Director General Instructions which are comparable to the ISO19115 standard.

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1.2 Quality control procedures

The new regulations puts emphasis on modern quality control procedures, which are based on the ISO19157 principles and quality components. The six quality components are: logical consistency, positional accuracy, completeness, thematic accuracy, temporal accuracy, and usability. The Survey Regulation describe the detail requirements for the first four quality components, the last two components are used only rarely for unique projects.

- A. Logical consistency – describe the fidelity of the relationships in the data set and the level of conformance to the required computer format. The dataset is automatically tested to see that it meets the computer format, otherwise it is rejected. In addition, automated software checks are carried out to evaluate the logical consistency parameter, for example:
 - Within a thematic layer - topological rules (e.g., search for overshoots or undershoots)
 - Domain rules for database fields and attributes (e.g., elevations cannot be smaller than - 1000 m)
 - Between proper thematic layers (e.g., unreasonable intersection of building layer with road layer)
- B. Positional accuracy - an assessment of the accuracy of the coordinates of spatial objects. The required accuracy is a function of the map level (scale) and similar to the ASPRS (1989) and the old regulation is specified using the root mean square error (RMSE) and the CEP 95. The two tables that summarize the requirements are Table 6 and 7.

Table 6: Accuracy levels for mapping (horizontal)

Accuracy level	RMSE in Easting or Northing (m)	CEP 95 (m)	Largest scale
1	0.01	0.03	1:50
2	0.03	0.08	1:100
3	0.06	0.15	1:250
4	0.13	0.32	1:500
5	0.25	0.62	1:1,000
6	0.30	0.74	1:1,250
7	0.63	1.55	1:2,500
8	1.25	3.06	1:5,000
9	2.50	6.12	1:10,000
10	6.25	15.30	1:25,000
11	12.50	30.60	1:50,000

Table 7: Accuracy levels for mapping (vertical)

Accuracy level	Spot height		Elevation at well-defined point		Contour line interval (m)
	RMSE	LEP95	RMSE	LEP95	

	(m)	(m)	(m)	(m)	
1	0.01	0.02	0.02	0.04	0.05
2	0.02	0.04	0.03	0.06	0.10
3	0.05	0.10	0.08	0.15	0.25
4	0.10	0.20	0.15	0.30	0.50
5	0.20	0.40	0.30	0.60	1.00
6	0.25	0.50	0.38	0.75	1.25
7	0.50	1.00	0.75	1.50	2.50
8	1.00	2.00	1.50	3.00	5.00
9	2.00	4.00	3.00	6.00	10.00
10	5.00	10.00	7.50	15.00	25.00
11	10.00	20.00	15.00	30.00	50.00

Table 8: Ground resolution for digital images (used in mapping and for ortho imagery)

Accuracy level	3	4	5	6	7	8	9
Maximal pixel size in cm	2.5	5.0	7.5	10.0	12.5	25.0	50.0

C. Completeness – Is information about omissions, commissions and selection criteria within the data set.

The new regulations specify the exact ground resolution of images and orthophotographs used for mapping at different levels, see Table 8.

With this limiting resolution, the regulations specify two selection criteria for the completeness parameter:

- Every permanent object, which cover an area greater than 36 time the ground resolution (at Table 7), should be mapped as a matter of routine.
- The Digital Terrain Model should include a breakline in every surface alteration larger than half the contour interval specified in Table 6

Tests for to evaluate completeness are specified in the Director General Instruction and are carried out either by performing duplicate surveys by two different mapping organizations or by superimposition of the vector map on the screen with the raster image of the aerial photograph. Results will be reported in the same manner specified by ISO 19157

D. Attribute Accuracy – is an assessment of the accuracy of the identification of entities and the assignment of attribute values in the data set.

This parameter is highly coupled with attribute accuracy because they have similar tests. Results will be reported in the same manner specified by ISO 19157

1.3 Enabling emerging technologies and advanced mapping products

One of the goals of the new regulations is to encourage the use of more efficient mapping procedures and technologies to produce more advanced mapping products.

Some of the latest mapping technologies include digital cameras (on satellites, aerial, on UAV's or on terrestrial systems), LIDAR, radar, mobile mapping systems. The regulations permit the use of any technology given that it was certified by the SOI as one that meets the quality requirements of a specific mapping level. Thus the regulations require that the SOI set up a certification program to test different sensors, and different combinations of integrated mapping platforms.

The regulation aims also at defining advanced mapping products that will be used to facilitate varying business activities (planning, design, construction, facility management, and more). Some of these include traditional products such as:

- Digital Elevation Model (DEM) - a regular grid of ground points with spot heights, with density as described in table 9.
- Digital Terrain Model (DTM) – a DEM with natural and artificial breaklines of the ground
- Digital Surface Model (DSM) – a DTM with spot heights, elevation and breakline of earth's surface with all objects on it properly represented (building will have a rooftop breaklines as well as ground footprint breaklines).

Table 9: Density of a DEM

Mapping level (vertical)	Minimum number of points in 1000 m ²	Distance between points on a regular grid
1	62	4
2	28	6
3	16	8
4	10	10
5	7	12
6	3	20
7	2.5 (5 point for 2000 m ²)	20
8	1	30
9	0.5 (1 point for 2000 m ²)	50

Moreover, the regulations define a 3D models as a mapping product, and specify it very similar to the OGC 2008 standard.

5. CONCLUSIONS AND FURTHER WORK

The new Survey Regulations form the framework for more efficient geodetic, cadastral, mapping and GIS working procedures in Israel. This framework will be used as the basis for the Director General Instructions, for guidelines to certify surveying and mapping equipment, for specifications in geo-information projects and so on. It is just the beginning.

In addition to publishing the regulations, the SOI is planning to develop a training campaign to make sure that every professional understand the regulations and how to implement them.

Finally these regulation instigates the development of computer systems to support the new quality control requirement, and the development of regulations in related professional fields for example civil engineering, planning, valuation etc.

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BIOGRAPHICAL NOTES

Eng. Vadim Fishbein, holds a BSc IN Geo-Information from the Technion (2014). He is a Licensed Surveyor in Israel Since 2017. Currently he is Senior Coordinator for Geodetic Mapping Technologies at the Survey of Israel.

Prof. Yaron A. Felus holds a BS from Ben-Gurion University, Israel (Electrical and Computer Engineering), a M.S. from the International Institute for Geo-Information Science and Earth Observation, Netherlands (Geomatics), and both M.S. and Ph.D. from the Ohio State University (geodetic science). He is a Professional Surveyor in Michigan, USA and a Licensed Surveyor in Israel. He is currently the Chief Scietist and head of the R&D division of the Survey of Israel.

Eng. Shimon Barazani graduated from the Technion Haifa, Israel with a BSc. in Geodesy (1995), and Civil engineering (1994). He is a Licensed Surveyor in Israel Since 1997.

He was a Department Head in D.E.L , a private surveying and engineering company. A Section Head of Surveying in the Ministry of Construction & Housing of Israel, a Director of Mapping Technologies In The Survey of Israel and currently he is the Deputy Director General for Cadaster in the Survey of Israel.

Eng. Ronen Regev, holds a BSc IN Geo-Information from the Technion. He is a Licensed Surveyor in Israel. He has worked for many years in the private sector managing surveying projects at different positions. Currently, he is the Director General of the Survey of Israel.

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