

# Permanent GPS Network-based Measurement Practice in Israel

**Joseph FORRAI, Israel**



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## **OUTLINE**

- 1. INTRODUCTION**
- 2. THE "EVOLUTION" OF THE PERMANENT GPS STATION NETWORK**
- 3. THE IMPACT OF PERMANENT STATIONS ON GEODETIC MEASUREMENTS**
- 4. THE IMPACT OF APN ON CADASTRAL MEASUREMENTS**
- 5. THE NEW SURVEYING REGULATIONS**
- 6. CONSEQUENCIES**

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# 1.INTRODUCTION

- **The Survey of Israel (SOI).**
- **SOI responsible, among others, for geodetic infrastructure.**
- **The permanent GPS (GNSS) network has a central role in it.**

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# OUTLINE

## 1. INTRODUCTION

## 2. THE "EVOLUTION" OF THE PERMANENT GPS STATION NETWORK

- 2.1. The Classical Control Networks
- 2.2. Eastern Mediterranean Tectonics
- 2.3. The "Short History" of the GPS-GNSS in Israel
- 2.4. Current APN Configuration, Main Services
- 2.5. Geodetic Datum, Projection and Grid in GPS Era
- 2.6. Israel Forum of Infrastructure

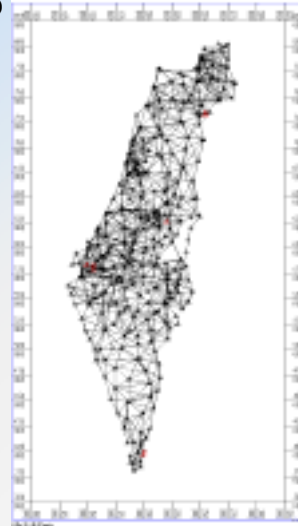
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## 2. THE "EVOLUTION" OF THE PERMANENT GPS STATION NETWORK

### 2.1 The Classical Control Network

- A triangulation-trilateration network.
- 3 parts per million.
- Proper for construction, development and cadastre, insufficient for geodynamics.



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### 2.2. Eastern Mediterranean Tectonics

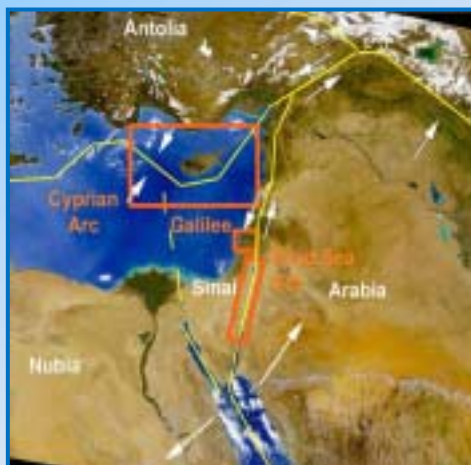


Figure 1. A meeting place of three major tectonic plates: Arabia, Nubia and Eurasia, and of two sub-plates: Anatolia and Sinai

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- **The eastern Mediterranean tectonics is a challenging one.**
- **Before the end of the eighties: precise EDM and precise leveling were feasible.**
- **Limited extension.**

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• **And then,  
the GPS  
arose as a  
meteor,  
becoming  
more and  
more  
feasible for  
geodynamic  
research.**



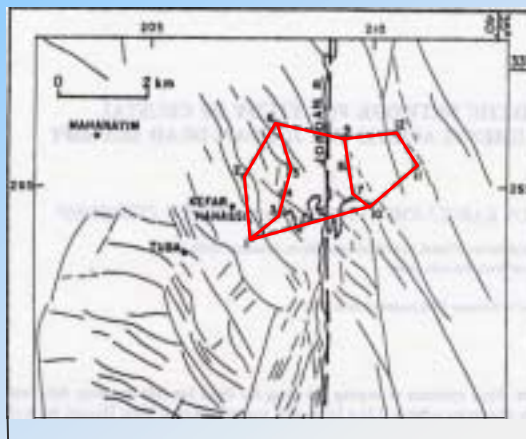
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### 2.3. The "Short History"

- The scientific intellect acted as a main driving force for GPS applications.

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The "Kfar Hanassi" network: dedicated to monitoring relative crustal movement in a small size area of the Dead Sea Fault (DSF).

Figure.2. Kfar Hanassi Monitoring Network

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•(The "**Kfar Hanassi**" monitoring network) was...

- Measured by: EDM (Tellurometer MA 100, Geodimeter AGA 114, Mekometer 5000) and precise leveling before 1990
- Cooperation : Geological Survey of Israel, SOI, TU Karlsruhe, TU Hannover
- Sponsored by the German-Israel Fund

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The Kfar Hanassi network was extended to the "**Galil-Golan network**" (21 sites). Measured with 10 geodetic GPS receivers in 1990, and later in 1991, 1992 and 1993 (GIF consortium)

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Figure 4. G1 Network

The next stage:  
a country-size  
geodetic-  
geodynamic  
network called  
**G1.**

160, specially  
monumented  
control points.  
Measured, for  
the first time, in  
1996-1997, incl.  
2-3 permanent  
stations.

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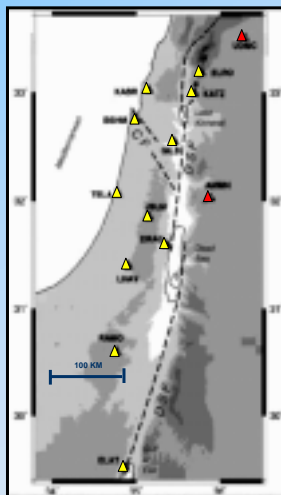


Figure 5. GIL Network (yellow marks), with a Syrian and a Jordanian permanent station (red marks) which were included in a crustal movement research.

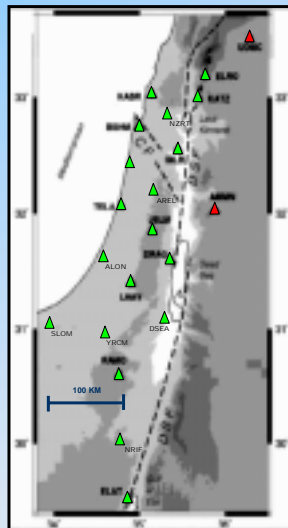
The G1 network has  
become gradually  
accomplished with  
permanent GPS stations  
forming the **GIL**  
network, applied to  
continuous monitoring  
as well as to geodetic  
and geophysical  
applications.

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## 2.4. The Current Active Permanent Station Network (APN) Configuration and Main Services

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•At present, the GNSS permanent station network of Israel, called Active Permanent Station Network (APN) numbers 19 stations.

Figure 6. APN, (green marks), with a Syrian and a Jordanian station (red marks) which were included in a crustal movement research.

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## **APN:**

- **14 of them receive both GPS and GLONASS.**
- **Operated and maintained by SOI through a private geodetic company (GSM).**
- **1 second epoch interval.**
- **GPS data can be downloaded by the user.**

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## **APN:**

- **Supports RTK and VRS applications.**
- **98% reliability level.**
- **A number of APN stations are involved in international frames (IGS, GIBS, SOPAC).**
  
- **211 APN users are registered: 137 RTK users, 144 download data for Post Processing.**

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- **Number of RTK-users:**
  - 33 in 2006**
  - 75 in 2007**
  - 137 in 2008 (15,000 "service hours")**
  
- **PP users downloaded 15,800 hours of data in 2008.**
  
- **The total income:**
  - 450,000 NIS in 2006**
  - 700,000 NIS in 2007**
  - 900,000 NIS in 2008 (more than 200,000 US \$)**

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## **2.5. Geodetic Datum, Projection and Grid in GPS Era**

- **The "New Israel Grid", NIG 1998. *Aided by GPS.* (GRS80, Israeli Transverse Mercator.)**
  
- **The NIG brought a new standard of quality, accuracy and homogeneity.**

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- **"Israel 2005 Grid", IG05: a new, "APN- ruled" geodetic datum and grid, introduced in 2007.**
- **Users should carry out all new tasks in "Israel 2005 Grid".**
- **APN + IG05 = a strong booster for GPS\GNSS geodetic practice.**

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## **2.6. Israel Forum of Infrastructure (IFI)**

- **APN was established through joint contribution of geologists, geophysicists and geodesists.**
- **The Treasury and Israel Space Agency – supported.**
- **An interdisciplinary, inter-ministry committee (IFI) was formed in 1995, for scientific and management cooperation.**

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- Geological Survey of Israel
- Geophysical Institute of Israel
- Israel Oceanographic and Limnological Inst.
- Israel Space Agency
- Survey of Israel

**The Forum has been confirmed by all responsible ministers.**

- Its objective is: to propose solutions to problems at national level.

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### **3. THE IMPACT OF PERMANENT STATIONS ON GEODETIC MEASUREMENTS**

- 3.1. Measurements for Scientific Purposes**
- 3.2. Horizontal Control Network, Densification**
- 3.3. Vertical Control**

### **4. THE IMPACT OF APN ON CADASTRAL MEASUREMENTS**

- 4.1. The Cadastre in Israel**
- 4.2. Geodetic Control Points for Cadastral mapping**
- 4.3. Cadastral Boundary Point Measurements**
- 4.4. Coordinate Based Cadastre**
- 4.5. Three Dimensional Cadastre**
- 4.6. Dynamic Cadastre**

### **5. THE NEW SURVEYING REGULATIONS**

### **6. CONSEQUENCIES**

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## **3. THE IMPACT OF GPS PERMANENT STATIONS ON GEODETIC MEASUREMENTS**

### **3.1. Measurements for Scientific Purposes**

- **The G1 network has been measured three times (1996-1997, 2001-2002, 2008). The 3-epoch analysis will refine our geodynamic knowledge.**

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- **The permanent station observations of GIL network stations and one Syrian and one Jordanian permanent station data enabled us to analyze the crustal movements along the DSF.**

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- **1.7-2.8 mm/year northward motion of Arabia with respect to Sinai.**



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### **3.2. Horizontal Control Network and Its Densification**

- **Seven classes of horizontal control points.**
- **Higher classes - responsibility of the SOI.**
- **Lower class points - by private surveyors (supervised by the SOI).**
- **Final coordinates are included in the National Geodetic Database (NGDB).**

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- **APN, Israel 2005 Datum and Grid practically changed the geodetic reality and practice.**

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- I. class: G0 network - 19 permanent GNSS stations**
- II. class: G1 network points (150, measured and computed relatively to the G0)**
- III. class: G2 network points (1200, "good, stable points", measured and computed relatively to G0 and G1.**

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- **G0, G1 and G2 – SOI are the responsibility.**
- **S1 (by GNSS only) and S2 (either by GNSS or by Total Station) – private surveyors, supervised by the SOI.**
- **S1 and S2 final coordinates are also included in the NGDB.**



### **3.3. Vertical Control Measurements**

- **The idea: involvement of ellipsoidal heights in a vertical control system.**
- **Steinberg and Even-Tzur suggested: "the first objective of a primary leveling system can be ... achieved ... with reasonable accuracy on nationwide basis, by a combination of ellipsoidal vertical control ... and Official Geoid Undulations Model, OGUM".**





- **High quality ellipsoidal vertical control is available with the use of the APN.**
- **Since May 2007, lower classes of vertical control points allowed to be defined by orthometric heights, using GNSS and statutory OGUM.**

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**Moreover:**

- **Orthometric height of each geodetic control point can be easily computed with this method.**
- **Geodetic control network is gradually becoming three dimensional, including both ellipsoidal and orthometric heights.**

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### **3. THE IMPACT OF PERMANENT STATIONS ON GEODETIC MEASUREMENTS**

**3.1. Measurements for Scientific Purposes**

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### **4. THE IMPACT OF APN ON CADASTRAL MEASUREMENTS**

**4.1. The Cadastre in Israel**

**4.2. Geodetic Control Points for Cadastral mapping**

**4.3. Cadastral Boundary Point Measurements**

**4.4. Coordinate Based Cadastre**

**4.5. Three Dimensional Cadastre**

**4.6. Dynamic Cadastre**

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### **6.3 CONSEQUENCIES**

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## **4. CADASTRAL MEASUREMENTS**

### **4.1. The Cadastre in Israel**

- **Torrens Principles (Registration of Titles).**
- **The State is responsible for parcels' boundaries as registered in the Land Registry Office.**

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- **The subject of registration is the land parcel.  
Boundaries and details are surveyed.**
- **Any change in the original settlement of land rights  
has to be carried out by means of **mutation plans**.**

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- **The **mutation plan**:**
  - prepared by a private surveyor
  - supervised by a supervising surveyor / SOI
  - approved for registration by SOI
  - registered by the Land Registry Office

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## 4.2. Geodetic Control Points for Cadastral mapping

- APN based GNSS control points as a basis for "local" traverses, or *instead* of them.

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## 4.3. Cadastral Boundary Point Measurements

- Technical instructions (SOI, 2007) permit the use of GPS RTK based on APN, for *direct measurement of cadastral boundary points* and detail elements.
- This possibility was significantly increased by the use of GNSS.

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## •Total Station Measurements

**2006: 405 projects**

**2008: 278 projects (a decrease of 31%)**

## GNSS Measurements

**2006: 706 projects**

**2008: 934 projects (an increase of 32%).**

**2008: 77% of the cadastre related geodetic projects were completed with APN related GPS technology.**

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- **2003 - 60 geodetic GPS receivers in Israel.**
- **2008 - 220, owned by some 150 companies**

**2009: technical instructions gave legitimacy to GPS RTK based on an appropriate IG05 control point. This opportunity certainly will make the use of GPS RTK even more popular.**

- **GPS RTK is frequently used also for reinstating parcel boundaries.**

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#### **4.4. Coordinate Based Cadastre**

- **In the future, cadastral boundaries should be defined by coordinates (instead of physically established marks).**
- **The goal: 5 cm accuracy at 95% confidence level.**
- **Two main problems:**
  - **appropriate technical infrastructure**
  - **legislation of a legal background**

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- **APN + IG05 make the coordinate based cadastre feasible.**
- **Legislation will hopefully be completed soon, within the scope of the new surveying regulations.**
- **3 "pilot projects" have been completed, consisting of 141 cadastral blocks in total, for proving the technical feasibility.**

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- **The idea: to transform traditional cadastral data from formerly used coordinate systems to IG05, on the basis of old and current measurements and computed coordinates of "authentic points".**
- **In 2009, a half-country size project was started, aiming at the establishment of coordinate based cadastre over the Negev desert.**

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- **GPS RTK, based on APN stations.**
- **Different kinds of software have been developed.**
- **Further development of National GIS has started, for enhancing coordinate based cadastral data.**

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## 4.5. Three Dimensional Cadastre

- **The relationship between the 3DCad and the APN is indirect, through the coordinate based cadastre.**

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## 4.6. Dynamic Cadastre

- **Relative (yearly) movement of millimeters between two sides of an active rift.**
- **The accumulation of such a movement can displace cadastral borders.**
- **A "dynamic cadastre" approach is necessary (Jarroush and Even-Tzur, 2006).**

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#### **6.3 CONSEQUENCIES**

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### **5. THE NEW SURVEYING REGULATIONS**

- They are expected to be published within a year and a half.
- They will "rectify" the present situation, in which the lower rank technical instructions precede the more "senior" legislation level of regulations.
- Important, APN based national extent applications will be established.

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#### **6.3 CONSEQUENCIES**

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#### **6. CONSEQUENCIES**

- **GPS\GNSS permanent station network and APN in Israel have a considerable and positive effect on the measurement practice.**
- **New standards of accuracy, homogeneity, reliability and work-schedules are applied, contributing to the success of surveyors' activity in everyday tasks of accelerated development.**

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- **For geo-scientists, APN network is considered and used as a basic, sophisticated and indispensable scientific infrastructure, contributing to their multilateral research activity.**

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## **ACKNOWLEDGEMENT**

**Special thanks to Dr. Ron Adler, former Director General of the Survey of Israel, Dr. Gershon Steinberg, Chief Scientist and Deputy DG for Geodesy of SOI, Dr. Gilad Even-Tzur, Senior Lecturer, Head of the Division of Mapping and Geo-information of the Israel Institute of Technology (Technion), Ms. Einat Salmon, Head, Division of Field Geodetic Control of SOI and Mr. Yossi Melzer, Head, Dept. of Research of SOI for their constructive comments which resulted in the improvement of this paper.**

**Author thanks for their contribution to Mr. Moshe Rozenbloom, Ms. Marina Kozakov, Dr. Yaakov Tuchin, Mr. Samuel Grosman, Mr. Jad Jarroush, Prof. Shimon Wdowinski, Ms. Noa Ben Yosef and Mr. Ofer Angert.**

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## WARNING

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...set your dress-code as a surveyor did in the past centuries,...



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...even if you have a muddy job. And,  
in any case...



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INSTRUMENTATION!!!**

**...and**

**thank You**

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