Permanent GNSS Networks and Official Geoid Undulations Model as a Substitute for Orthometric Control

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INTRODUCTION

Vertical control: provide a framework on which topographers and engineers can base and adjust their heights with the expectation that its errors will be less than theirs. (Bomford 1970, 1980).

- In the pre-GPS era this objective could be achieved by precise leveling only.
- The goal of achieving a dense nation-wide accurate and consistent orthometric control network by precise leveling is “Sisyphus work" and is practical impossible.
- We do not really need a nation-wide accurate orthometric control network.

VERTICAL ELLIPSOIDAL CONTROL

- Ellipsoidal Control is the imminent replacement for the orthometric control.
- Vertical Ellipsoidal (Geometric) Control should be based on Permanent GNSS Network as one part of the 3D Geodetic Control.
- The Permanent GNSS Network is the first order of the 3D Control.
- It is recommended to densify the first-order control by more orders, according to actual needs.

THE ELLIPSOIDAL ALTERNATIVE

Can Ellipsoidal Height Control Networks replace the Orthometric ones?

- There is no more room for new country-wide Vertical Geodetic Control based on precise leveling!
- However there are needs for orthometric heights and for Orthometric Control networks.
- Those networks can be of local nature (“Orthometric Islands”).
- In order to tie the local networks to the country-wide control, we can use the vertical ellipsoidal control & geoid undulations model.

ACCURATE GEOID UNDULATIONS MODELS

- Enormous efforts are undertaken in order to achieve cm-level geoid models with which one can get orthometric heights by GPS.
- The usual attitude is that you can't use GPS measurements in order to achieve this goal unless you have a higher-accuracy geoid model.
- The effort to improve the geoid-undulations model to accuracy of one cm-level in any place over a whole country, might be endless.

THE IDEA OF OFFICIAL GEOID UNDULATIONS MODEL (OGUM) AS A SUBSTITUTE FOR ORTHOMETRIC CONTROL

- A very important objective of the leveling network is to bring consistent identical heights by every surveyor.
- There is no need to wait for the "perfect" geoid model.
- We suggest declaring the best available Geoid Undulations Model as an Official Model (OGUM).
- The combination of OGUM with vertical Ellipsoidal Control based on CORS, produces a practical country-wide network of Orthometric Height Control, appropriate for most of the geodetic/surveying needs.

EXPERIMENTS IN ISRAEL

Goal: To examine the accuracy of orthometric height differences based on GPS measurements and OGUM in different locations in Israel.

Two alternatives for OGUM:

1. **ILUM1.0** - Israeli Undulations Model, Based on 750 Benchmarks.
2. **GPM98B**- Global Geopotential Model (Wenzel), contains few gravity data from Israel.

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EXPERIMENTS IN ISRAEL (2)

- Six height-differences (between 4 adjacent benchmarks) were measured simultaneously by GPS (40 minutes' sessions).
- The relative accuracy of the known orthometric height -differences, as well as the measured ellipsoidal height- differences, is 1-2cm.

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EXPERIMENTS IN ISRAEL (3)

- Eight locations where the OGUM experiment was held in Israel.
- The numbers denote the place's name as appears in the next table.

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EXPERIMENTS - RESULTS

- The RMS and the mean PPM values of the differences between the known orthometric height-differences and the orthometric height-differences obtained by GPS and the two alternatives for the OGUM.

			ILUM1.0		GPM98B	
Place	Min. distance [km]	Max. distance [km]	RMS [cm]	[ppm]	RMS [cm]	[ppm]
1. Eilat	1.4	4.5	5.0	14	18.5	61
2. Hazeva	2.9	5.6	5.2	11	6.7	15
3. Nitzana	1.8	4.5	3.9	11	3.2	12
4. Mizpe-Ramon	0.6	3.3	1.0	8	3.1	25
5. Beer-Sheva	1.3	4.8	3.8	10	1.4	8
6. Jerusalem	1.0	4.1	2.4	9	1.2	5
7. Tel-Aviv	1.8	7.6	1.9	4	1.7	3
8. Kiryat-Shmona	0.3	1.8	4.0	27	2.5	20

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DISCUSSION

For a reasonable orthometric control we actually need a height-differences accuracy of 25mm for benchmarks 1km apart: (25PPM).

- We achieved this goal in all our experiments with the temporary Israeli OGUM. It was achieved also using the Global model, except for Eilat.
- The results demonstrate the capability of the idea, for most of the engineering works.
- Not instead of existing good networks.
- A special benefit for areas were establishing a leveling network is practically impossible.

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CONCLUSION

- Following the idea of Vertical Ellipsoidal Control, and understanding that some kind of National Orthometric Control is still necessary, the suggested idea is a proper substitute to the traditional National Leveling Network.
- The big advantage of the OGUM is its consistency (can be regarded as "errorless").
- The idea is especially recommended for undeveloped areas, far from existing benchmarks (determine official datum for "Orthometric-Islands").

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CONCLUSION (2)

- The experiments in Israel proved the ideas' efficiency for most of the surveyors' needs.
- The ideas may contribute mainly to countries which can't afford the luxury of establishing and maintaining dense leveling networks. (Isn't it every where?).
- The users of this idea can gain a lot, but they must be aware to its limitations.

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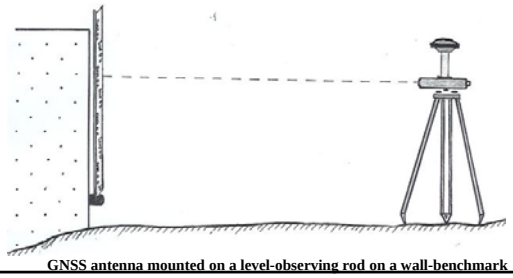
AND ANOTHER PROPOSAL

We urge instrument developers to enable GNSS antennas to be mounted on levels.



GNSS antenna mounted on a level-observing rod on a wall-benchmark

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MANY THANKS FOR YOUR PATIENCE

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