THREE-DIMENSIONAL DIGITAL PHOTOGRAMMETRIC UPDATE OF THE ISRAELI NATIONAL-GIS DATA BASE

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Working Group IV/3

KEY WORDS: GIS, Updating, 3-D, Digital Photogrammetric Workstations.

ABSTRACT

The Israeli National GIS project, carried out by the Survey of Israel since 1991, has entered the updating phase at the beginning of 1996. The paper will discuss, briefly, the test cases, the results, the experience gained during an evaluation process, ended in 1998. These experiments include: (1) Different photogrammetric instruments; (2) Various spatial models (2-D, 2.5-D and 3-D); (3) Effects of the updated units, in terms of size; and (4) Optional updating protocols. Also presented are the recommendations for the chosen updating process of a "full" 3-Dimensional Digital Photogrammetric Updating Environment. In addition, the paper is presenting the Digital Updating Pilot Project which will serve as the basis for future updating efforts. Presented also, is the resulted "6-step updating process" of the National GIS data base: (1) Data extraction from the 2.5-Dimensional GIS data base (in Arc/Info environment); (2) Quality control, including automatic corrections and tagging of erroneous data; (3) Transformation of data into a 3-Dimensional model; (4) PC-based digital photogrammetry updating; (5) Automatic quality control, and (6) Conversion data into the 2.5-Dimensional model of the Arc/Info based National GIS.

1 INTRODUCTION

In 1990 the Government of Israel resolved that the Survey of Israel would be in charge of the National GIS. At the end of 1990, the Survey concluded The guidelines for the new and most challenging mapping project: (a) The new National GIS data base will be established by remapping the country rather than digitizing old existing maps; (b) The remapping will be based on photogrammetric mapping of 1:40,000-scale airphotographs by 1st and 2nd class photogrammetric stereoplotters; (c) The planimetric and altimetric accuracy of the mapping will be ± 2 meters, suitable to the 1:5,000-scale traditional mapping; (d) Level of mapped details will be according to regional mapping of 1:10,000-scale; (e) A 50 meter resolution measured DEM will compliment height observation of the measured features, spot heights and topographic break lines. These guidelines were used to develop the schema and conceptual model of the new GIS data base. Based on the schema, the Survey developed, in 1991 [Peled et al., 1991], the instruments to launch the remapping project and the generation of the National GIS: (a) The basic layers of the data base; (b) Unified and unique feature digital coding system; (c) Specifications for data acquisition from the 1:40,000-scale photographs; (d) Standard for digital data transfer and exchange format; (e) Quality control procedures and protocols; (f) time schedule and framework for mapping units.

The actual remapping, started at 1992. Today, eight years after, the basic remapping project is near completion (see figure 1). In its current stage, the GIS project yielded already, over 15 million NIS in total. In conclusion, the basic phase of establishing the National GIS of Israel by remapping the country has proved to be a most successful and promising scientific and professional effort [Peled, Raizman, 1997].

2 UPDATING EXPERIMENTS

The updating and completion of the spatial and non-spatial information of the National GIS data bases is evolving to be the most important task of the Survey [Peled, 1994; 1996]. Without the completion phase the data base will not earn, rightfully, it's National credibility. Without updating protocols and easily effected procedures, the whole project will collapse and the mere existence of the National GIS data base as a national source for spatial data is doomed. As successful as the remapping project is considered now, the real success of the GIS project lies within the establishment of a sound, ongoing, updating effort [Peled and Raizman, 1997].

As part of the preparation to the updating project, the Survey developed an updating cycle criteria: (a) Every area will be updated, within a 5 years cycle; (b) Any area that will undergo many changes, due to rapid development, will be updated, regardless of the planned schedule for updating; and (c) Area that is commissioned for mapping by any Government ministry or even private entrepreneur will be updated, charging the initiator and not the Survey's budget [Peled and Raizman, 1997].

2.1 Ongoing Updating

Quiet early into the remapping project, the Survey started to experiment with updating procedures. The first experiment focused on updating of digital data, before it even went through all the quality control procedures, at the Survey. As it happened, it takes about 12 months from the date of the air photography mission, until the digital data is stored in the National GIS data base. In 1994, the Ministry of Housing requested digital spatial data of an area (Benei Ayish) that was photographed just a year ago and the mapping data was just supplied to the Survey by the private photogrammetric vendor. The updating procedure was carried out at the Survey, using 1:12,500-scale air photographs that were taken at the 1994 all-country coverage campaign of 1994. This is a bi-annual photography mission that is carried out by the Survey of Israel, on a regular basis for many years now. The new digital GIS data served for the establishment of geo-referencing and photogrammetric control. The updating was done by analytic stereo-plotters with no superimposition ability. As time was the major parameter, only new developments were updated. Thus, it concentrated only on specific parts of the new stereo-models. As a whole, this was a very preliminary effort that proved, only, the ability of a quick updating procedure, using off-the-shelf photographs without special preparations. The ability of geo-referencing single stereo-models, using the digital GIS data, lead to a new option of effecting quick map updating by orthophoto. These are generated be geo-referencing single photos, based on the existing GIS hypsographic and topographic data

2.2 Large-scale Updating

Encouraged by the first experiment, the Survey issued a larger-scale updating at the vicinity of Be'er sheva. This is a city in the northern Negev Desert, and is on the route to the southern part of Israel. The updating area, 200 sq. km in terms of size, was given to a private photogrammetric company, according to the policy of involving the private sector in the making of the Israeli National GIS. As is done in the remapping project, aero-triangulation was carried out be the Survey. The private vendor was given all existing digital GIS data, supplied by another vendor; newly developed specifications for the updating; and the 1:20,000-scale air photographs, chosen for the updating, as part of the experimentation. At this time, the digital GIS data came directly from the National GIS. Thus, each of the features had several attributes: Unique-id number, source-code, type-code (class) and many other physical attributes. The specifications dealt also with the new issue of preserving the existing attributes, especially the Unique-id. The private vendor was restricted to finish the work within 2 months. Among other, the vendor had to establish a defined protocol for the updating work process and computer applications which will enable to preserve the topology and the attributes, attached to each feature.

The results of this experiment proved how difficult it is to effect an updating procedure of GIS data. The experiment failed, totally, on the issue of preserving the attributes, topology and any other non-spatial data, correlated with the spatial features. In addition, it was proven that the specifications should be more detailed and more "digital-domain-specific". Also, it was obvious that some preliminary photointerpretation is needed. When given "freely" to the private vendor, a tendency of generalization, and incompleteness of the updating occurred. These raised many rejections at the QC step. The actual updating was carried by analytic photogrammetric stereo-plotters with no superimposition ability. The latter issue proved, again, to be crucial as many of the vectors, although connected in the

horizontal (x,y) plane, were not connected in space (different z value, at nodes). This generated many problems in the DEM generation, Physical attributes inaccuracies and spatial topology inadequacies.

2.3 Small-scale Digital Updating

As one of the issues, raised in the previous experiments was the spatial topology, it was concluded that this issue should be dealt as a major factor of the planned updating process. Thus, the next three experiments were carried out at the Survey, using a digital photogrammetric station, with superimposition option, of course. These were specific experiments, testing one issue or two, at most. Thus, there was no need for large-scale updating, in terms of area size. All existing ("old") data were extracted from the National GIS data base. Data ere translated, directly into the specific digital photogrammetric software format used at the Survey. All attributes and other administrative items and parameters, were kept intact. These experiments enabled to define the needed standard and format translation procedures. Also, at this stage some general principles of the future updating process were formed.

2.3.1 Lod. The first of the 3 "digital" experiments was carried out at an area near Lod Airport. The updating was based on 1:20,000-scale photographs that were geo-referenced by using the GIS as the geodetic control source. The area was divided into small units 1.5 km. X 3.5 km, in size. The process of transforming the symbolization, as was needed for the digital photogrammetric software, deleted the attributes. The conclusion from this experiment were: (1) There is a need for a special set of software routines and applications in order to process the data for the updating project; (2) Using small updating units. In terms of size, brings about many problems of connecting the vectors into the seamless data base; and (3) The use of 1:20,000-scale photographs manifested with a "super-flux" of data and caused many photo-interpretation for the photogrammetric operators.

2.3.2 Jerusalem. The second experiment, in the vicinity of Jerusalem was based on 1:40,000-scale photographs. This time an area of 10 km. X 10 km. was extracted and processed as one unit. The work on such large updating unit, did overcame the issue of connecting data from the different stereo-models. Yet, the quality control step was affected and it was uncomfortable to process the relatively large amount of data by the GIS software. Many logical QC steps could not be effected and viewing the results became a time-consuming step.

2.3.3 Ashkelon. The third and last of these "digital specific" experiments, was carried at an area near the city of Ashkelon, on the Mediterranean Sea. Again, the updating was based on 1:40,000-scale photographs. This time, the updating units were 7 km. X 3 km. In size. This is a typical 1:40,000-scale model size. This size was found to satisfy all needs, even at the updating stage. Yet, the problem raised here was, again, the continuity problem between stereo-models. This meant, of course, that the size of 20-25 sq. km.-updating units is suitable but those should not trace the stereo-models' borders. Also, at this time the difference between the two aero-triangulations was analyzed.

2.4 Updating Guidelines

As a result of the above mentioned experiments, a set of conclusions and guidelines were drawn for the upcoming large scale updating pilot project:

1. The remapping effort should be carried out over existing 3-D information (2.5-D model) and should not be regarded as a new mapping (remapping) effort. Thus, it is important to carry out the updating, using digital (softcopy) photogrammetric systems that will allow stereoscopic vision and superimposition of the existing 3-D vector data that exist already in the existing GIS data bases. The use of such system was found not only crucial to smooth and easily effected updating procedures but also very constructive in finding inadequacies, still embedded, in the existing data.

2. The updating will be based on 1:40,000-scale air photographs. Exactly as for the original remapping effort.

3. Updating units (tiles) of 5km.X5km. This, size is suitable to all existing processes and software routines. Also, the fixed size and geographic position, enables effective management and solved the continuity problem. This is due to the simple fact that the private vendors are forced to connect the edges of the stereo-models (at the middle of the tiles).

4. There is a need to develop a unified set of computer routines for processing the updated data, according to the newly developed specifications. This unified set will be used by all vendors and will support more homogeneity of the data.

5. It is mandatory to analyze the effect of the two different aero-triangulations. If severe, it should be taken into consideration. This, both in software development and in the updating process itself.

In addition to these important conclusions and guidelines, the experimentation with many issues of the updating resulted with additional benefits: (1) Studying the problems, and into the updating pilot project, a set of additional QC steps were defined. This was adopted for the ongoing remapping project. In addition, many QC automatic processes were applied to the existing data in the National GIS data base. This resulted with better information even before the actual updating had begun; (2) Managing and defining the updating steps, became clearer; and (3) Development of protocols for extracting data from the National GIS data base, for updating, and the introduction of newly updated data, back to the National GIS data base.

3 UPDATING PILOT PROJECT

The idea of the updating pilot project, stems from the understanding that the updating process should be regarded not as a “routine” digital mapping step. It was obvious, when analyzing the results and experience gained by the updating experiments that the specifications developed for the remapping project will not suffice. Updating spatial data bases in the GIS domain, requires special treatment and considerations. In addition, it became clear that the GIS data base should be enhanced into a level of a full 3-D topological compliance.

3.1 Goals and Considerations

The digital updating project pilot was devised under the guidelines described in section 2.4. In addition, some considerations, concerning specific oriented characteristics of the existing National GIS data base, formed some of the goals that are specific to this particular updating project. The goals of the pilot project were defined as a result of a discussion and evaluation analyses step, of the updating experiments' results and the findings concerning inadequacies found in the National GIS data base:

1. Development of the digital updating processes and protocols.

2. Generation of specification for the digital updating project of the national GIS data base, by private photogrammetric companies.

3. Development of easily effected computer procedures for the various steps in the updating process. This procedures should cover issues such as: administration and project management; data format translations; automatic QC and data enhancement; etc.

The basic idea and goal was to develop a sort of “turnkey” project for the Survey and for the private photogrammetric companies, as well. Using all the tools developed in the pilot project, it is envisaged that the private photogrammetric companies will be able to start the work immediately. Thus, the learning curve will be steep and short. The results and experience gained by the digital pilot project effort will be open for any vendor who will participate in future updating efforts. A secondary goal would be the homogeneity of the results. One of the findings of the GIS data base evaluation were the differences of “style” between different vendors. The rational of having everybody using the same QC and digital topological treatment procedures is, among other things, to result with a homogeneous digital spatial data base, as much as possible. Another issue of developing a “common” QC process was to apply the best ideas given by professionals that otherwise are not connected with the private vendors. As a parallel research effort all the QC and other special spatial and non-spatial data treatments will be translated into effective computer procedures and will be open for use by the private vendors.

As mentioned above, one of the major considerations was the level of homogeneity and compliance with the GIS specifications. Thus, it was concluded that area which will be selected for the digital updating project should be diverse both in it’s “content” and the source data (original private vendor). Another consideration was that the area should be

minimal yet it should be large enough in order to simulate "real" work conditions. This was important, as it was crucial to develop the procedures and protocols along with the actual updating of the pilot area. Thus, the Survey will gain not only the "turnkey" capability of an immediate continued updating but also the updated data that may replace the existing GIS data base. As a result of these considerations the Survey selected an updating unit of 1600 sq.km., in size, at the northern part of the country, between Haifa, on the Mediterranean Sea and Tiberias, on the Sea of Galilee. This is a diverse area in terms of terrain, man made features and the source of data. In addition, this was an area that was important to update in terms of completeness, due to the rapid development.

3.2 Status

The pilot project is entering its final phase. As planned, the National GIS management module was enhanced, with minimal effort is operable to process both the remapping data and the new influx of updated data. Two 1:25,000-scale quads (300 sq.km. in size) were replaced already by February 2000. The third quad was processed in April. The final 600 sq. km. will be processed by the end of July. Any data extraction from the National GIS data base is controlled by the Management Module and is supervised until the final processing of replacing the old data.

3.2.1 Additional Benefits. In addition to the administrative measures, taken in order to facilitate smooth transformation to the updating era, the Survey gained several more benefits. Data extracted for the digital updating pilot project, went through several QC processes. As mentioned above, this is a result of the cooperation between the pilot project operators and the research liaison professionals from the Survey of Israel. These QC rules that were devised to check the existing data, before the updating, were embedded into the QC procedure of the Survey. The idea is to tag all features that are suspected to carry inaccuracies in their related non-spatial attributes or that their physical (spatial) information does not cohere with the expected value range. These features are to be re-measured by the private vendor. Again, this was motivated by umbrella rational of unified processes for better homogeneity of the resulted spatial data base. At the interim phase, until the data will be updated, several correction processes were effected to enhance the data that are distributed to the customers.

3.2.2 Updating Protocol. The general framework of the updating process was established based on experience gained as the pilot project progressed. This is, again, the result of the cooperation and close working relations between the pilot operators and the liaisons from the Photogrammetry Division and the Computer Applications Section at the Survey. This would be the basis for the digital updating project that is envisaged for the next ten years (two cycles of updating): **(1)** Data extraction from the National GIS data base, in tiles (5 X 5 sq.km.), activating the Management Module; **(2)** Activating QC processes, tagging erroneous data; **(3)** Mirroring of extracted data for the updating procedures (including the transformation to the needed exchange format), allowing continuation of data dissemination; **(4)** Updating procedures at the private vendors: (a) Aero-triangulation analyses; (b) Vertical datum transformation; (c) DEM analysis, correction if needed; (d) Correction of tagged features; (e) Digital updating; (f) Polygonal topology reconstruction; (g) Spatial QC; (h) Attributes re-installation; (i) Final QC; (j) Format transformation; **(5)** Spatial QC at the Survey; **(6)** Inserting data into the National GIS data base.

3.3 Products

The digital updating project produced a variety of benefits to the survey: (1) Digital updating protocol and specifications which includes many operational recommendations based on an ISO-9002 procedure; (2) Computer procedures and routines for managing the updating at the level of the private vendor; (3) Recommendations related to the usage of digital work stations and photogrammetric software; (4) Computer procedures and routines for data format translation and quality control; (5) Recommendations related to the aero-triangulation, concerning the amount of geodetic control and the quality of the ground control points; (6) Algorithms and complimenting software for datum transformation of different data layers and coverages from different epochs; (7) Work procedures and protocols at the Survey level; (8) Quality control algorithms and procedures for assessing , tagging and enhancing existing data within the National GIS data base; (9) Definition of Final stage QC procedures and protocols of the updated data, at the Survey level.

As mentioned above, the updating pilot project is the culmination of 5 years of experiments and research. Thus, the updating protocols are characterized both in terms of theoretical solutions and professional know how. The basic idea of effecting the updating project using a 3-D model and using only digital photogrammetric work stations, has proved to be a success. It was also found that preliminary photointerpretation expedites the updating pace and brings about more homogeneity in the resulted data. Yet, it was found that preliminary corrections of the "old" data based on findings gained during the interpretation step, do not justify the effort. The administrative division of the country into updating units (tiles) of 5 X 5 sq.km., was found most constructive: (a) Breakdown of the stereo-models by the updating tiles, forcing the vendors to connect neighboring features was very effective in achieving the desired seamless spatial data base; (b) Easily effected processes dealing with suitable units, in terms of size; (c) Flexibility on one hand and order on the other hand. The updating may take place over any area size (even one tile only) as long as the area is combined from a set of these predefined tiles.

The digital updating pilot project will come to an end on August 2000. By this time, all updated data should be inserted into the National GIS data base and the QC and other procedures will be tested at the Survey. The new air photography mission and the aero-triangulation processing should be carried out during the third quarter of the year 2000. Bids for the first updating by private photogrammetric firms should be effected, parallel to these efforts. Thus, the actual updating is planned to start at September or October 2000. By the end of this year, the basic remapping project will come to it's end, as well. At this envisaged pace, when 3-4 private vendors could participate in the updating project, the Survey will achieve it's goal of 4-5 years updating cycle, at the end of 2001.

ACKNOWLEDGEMENTS

The project was funded by a grant of the Survey of Israel, Ministry of Housing. The authors wishes to thank Mr. Oren Nachshon and Dr. Anatoly Socharevsky, at the Survey of Israel and Mrs. Tatyana Bulichev of Pelled GIS Mapping Ltd., for their contribution to the success of the project.

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