A Radical Solution for the Cadastre Problem in Egypt Using Integrated GPS-GIS System

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Key words:

ABSTRACT

During the period 1897-1907 the cadastral surveying of Egypt was established. The increase in the total area of cultivated land and the rapid escalating need for planning of national projects, highways, canals as well as updating land information require non-traditional solution of such large-scale maps.

The Egyptian Survey Authority (ESA) started developing cadastre since 1988, using the total station technique. About 1.2 million feddans of total nine million feddans were covered by cadastre maps. The shortcoming digital maps with no attribute data have been produced.

A multi-purpose cadastre system for Egypt, which is feasible to solve the Egyptian conditions, has to be developed. Obviously, An extended know-how technique with regard to the existing procedure and regulations is utilized.

An integrated RTK-GPS system and designed GIS modules for full data acquisition, as well as immediate quality control and quality assurance was proposed. This paper focuses on the proposed system, which automates the parcel transactions and preserves any update information in both spatial and attributes data. An applied test has been carried out in Beheira Governorate to assess the system performance. The results indicated that the system can cancel 70% of the field and office works and can finish rural cadastre of Egypt in two years. According to the analysis of results, the research adds a significant social economic developing that presented in the processes of feasibility study, future planning of national projects and lands property withdraw.

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1. INTRODUCTION

Proper cadastral mapping in Egypt began in 1897 at the time when the Egyptian Survey Authority (ESA) was established. By the end of the year 1907 all the cultivated area in Egypt (about 6 million feddans) was covered with cadastral maps of scale 1:2500. [1 feddan =4200.83sqm].

At that time, the cadastral survey was executed by using the system of theodolite traversing controlled by triangulation points, the plotting of holdings in the field, the calculation of the area of each holding for the map sheets, and the compilation of the land- registers on certain forms.

The increase in the total area of the cultivated land to about 9 million feddans and the rapidly escalating need for updated and reliable land information by both public and private use institutions has forced ESA to look for non – traditional procedures for cadastral mapping. This was accomplished by the development of modern equipment, digital theodolites, electronic distance measuring equipment, and lastly total stations.

A leading Egyptian - American project which started in 1989 produced cadastral maps for the Egyptian Governorates using GPS and Photogrammetry, yet the project had to use terrestrial total stations and traditional methods for demarcation of land boundaries and recommended to use Photogrammetry for planning of large new areas.

The Photogrammetric department in the Egyptian Survey Authority (ESA) produces 1:2500base maps and conveys them to the Survey Bureaus in the Governorates to accomplish the cadastral work. The maps are produced from aerial photography with scale 1:10000 and 13000 feet flying height. The main irrigation system, bridges, roads, tracks and urban blocks are well identified in these maps.

Different studies show that the cadastre in Egypt needs integration between different techniques to put the suitable system for each of land use category concerning value, size, area and social issues. It is a must to set the specification of cadastre map production determining the needed accuracy for each category and how the survey will be done by suitable technique.

The use of digital equipment accelerates the production rates, yet many technical requirements are needed to overcome some major obstacles. Among these the huge number of traverse stations that must have intervisibility, and also the large number of traverse points required to cover a limited area (one point per fifty feddans), in addition to the destruction of about 50% of them by the people and farming machines. Also, we have no kind of quality checks and quality control, because we just measure a ray from the traverse point to the prism in its position. Again, in total station surveys it is essential to number all boundaries on survey sketches before surveying. One more team in the office has to edit and link the separate points to form the polygon then the resultant form is a closed line not identified area features. The output of all these production phases is a survey map but with nothing about the ownership and registration information. The collection of the attribute data is treated in many other long stages. Yet, we still have all the defects mentioned above.

The proposed Real Time Kinematic system (RTK) is the solution for all the problems mentioned. RTK-GPS will speed-up the work considerably and facilitates data acquisition and transfer. The best benefit of the system is that we can survey more than 10.000 feddans from one base, so the traverse stages including reconnaissance, demarcation, establishment, observations and adjustment are escaped entirely. Consequently, we get a reduction of about 50% of the job time when compared with the traditional method. Moreover, the quality of positioning and area computation is displayed in the field with position accuracy of ± 1cm, area accuracy±2 cm^2 that is quite equivalent to control point's accuracy. Also, the orientation and numbering of all boundary marks no longer delay the production in the field. Accordingly, 20 feddans per hour are surveyed in small (two to three feddans) and wet parcels. This number will be raised to 40 feddans per hour if the areas are larger (fifteen to twenty feddans)

Concerning the data management, the RTK system with the GIS data-logger record the features as topology features, (point, line, and area) accompanied with the related land information. The designed data dictionary fields are fed during the surveying then the observation files will be transferred to the GIS software as graphic and connected tabular data.

The destruction of landmarks problem will be solved completely, because the coordinates of the landmarks will be stored digitally. Accordingly, it will be easy to stake out these points, then the transactions will be performed very accurate and so easy. As, we survey the parcel with accuracy ±2cm^2 in area computations and all data are stored in digital form, problems of **boundary disputes** and all setting out problems will **diminish.** Also, the local bureau of surveying in different Governorates can use the terrestrial total stations for updating and register of transactions.

2. RURAL CADASTRE SYSTEM IN EGYPT

The country is divided into 27 governorates, which can be either a big city like Cairo and Alexandria, or towns and rural areas as the case with the rest of governorates. The second level of hierarchy is the district in rural area and urban area. The third level is the village in rural area and the municipality in urban area. The next hierarchy level is a block in rural area and a street neighborhood in urban area.

A rural block forms convenient subdivisions of the village and it is usually considered as one cadastral section. The boundary of a rural block is usually based on topographic features such as road or canal.

Recently, final digital cadastral maps (in few governorates) have been produced. The addition of other ownership parcel information is a completely separate process. Generally, there is no relation between the spatial and attribute data of the parcel. Due to this problem, the transactions of the parcel are done manually on hard copy maps and on transactions document papers. The deed plan certificate, which is used in registration of the parcel is also done manually, which leads to delays in process and increase the chance of errors. It also means that after a few years the cadastre map and its attribute become out-of-date and obsolete.

Cadastral system in Egypt consists of two parts, the Surveying and Mapping department and the Land Information System department. The first department is responsible for producing digital cadastral maps and the main task of the second one is to collect the attributes related to the parcels and owners in database files. In each province there is a local bureau of surveying that is responsible for making all kinds of parcels transactions. Also, the bureau produces the deed plan certificate belonging to each parcel from the hard copy cadastral maps and from the printed documents to use it in the registration of the parcel. The legal registration is the responsibility of the Ministry of Justice.

3. THE RTK TECHNIQUE

GPS is competing with traditional surveying techniques in almost all fields of geodesy and surveying. However for the system to be successful in cadastral surveying there are some remaining problems to be solved. Cadastre surveying cannot be realized until real time measurement at the cm level is possible both in the horizontal and the vertical for ranges up to say, 5Km. Several manufacturers now offer GPS receivers with this capability, but some practical problems remain, such as rapid ambiguity resolution in urban and some environment, where cycle slips and multipath effects are likely to occur frequently. Also, height determination requires that geoidal information is available in one way or another.

Real Time GPS surveying requires an important step called initialization. This procedure must occur before the system can provide baselines accuracy at the centimeter level. The introduction of the GPS Total Station in 1994, the dual frequency version of this survey system is capable of fully automatic initialization, irrespective of whether the roving unit is stationary or moving. Passing under a bridge for example no longer requires the surveyor to occupy a known survey mark to repeat the initialization. The reliability of the initialization process has received much attention.

There are two essential items in this respect: the initialization reliability and time to initialize. It should come as no surprise that there is a direct correlation between these parameters and the quality of the satellite measurements made by the GPS receivers. In turn, this quality is dictated by a source of measurement error, external to the receiver, known as multipath.

A dominant error source on satellite measurements is caused by multipath. This is the same effect that causes ghosting on a TV screen, a signal reflection is superimposed on the desired direct signal, causing distortion. In fact, for short baseline lengths, multipath is the only relevant signal propagation error affecting GPS receiver performance.

Trimble navigation has introduced Everest, a new digital signal processing technology designed to substantially reduce the errors associated with multipath reflections, and enhance field performance.

Cadastre surveying includes detailed measurements and setting out. The survey area is usually small; within, say, 5*5 km^2. The detailed measurement can be performed in rapid static or stop-and-go kinematic mode, and the data processing can usually be hand held separately after data collection. However setting out requires that a roving receiver have an on-line connection to a reference receiver placed on a known point. This task implies real-time surveying, where instantaneous position data are transferred from the reference station to the roving receiver in order to provide the coordinates of the roving receiver with respect to those of the stationary receiver with, say, cm accuracy.

4. DATABASE DESIGN

A prime motivation for powerful multi purpose cadastral system is to support an efficient information management system, by means of which a massive quantity of property maps, and precise survey data in highways, public works, and other agencies can be integrated.

The design of database involves defining how data will be captured, how relationships will be built, how graphics will be presented and symbolized, how graphic files will be structured, how tabular attribute files will be structured, how file directories will be organized and how files will be named. Many other subjects are investigated such as the geographical subdivision of the project area, the processing of the GIS products, and the security restrictions of the data.

Many phases are accomplished to setup the required system:

- The selection of the entity source and attribute in the Entity relationship design.
- Definition of the procedures for converting data from source media to the database.
- The managing and maintaining the database.

The main building of topology for features coverage is performed in Geomedia-Pro. V.3.00from Intergraph. The conversion of data from the source media to the database, the automation of parcel transactions, and design of deed plan certificate are programmed in Microsoft Visual Basic v.6, then customized in the Geomedia-Pro software as additional modules.

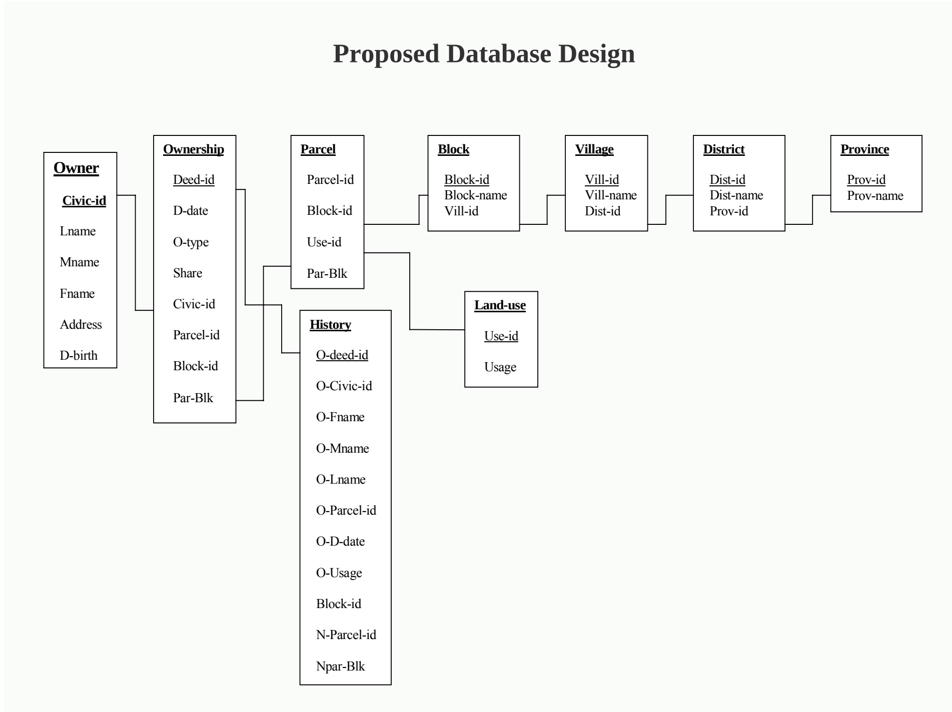

Figure No.1proposed Database design

5. PROPOSED SURVEY SYSTEM

Automating parcel transactions and developing fully attributed cadastral maps are the main objectives in the proposed cadastral system in Egypt. This proposed system preserves any update information in both spatial and attribute data. Also it helps to achieve the user requirements for the cadastral system quickly and efficiently.

An integrated GPS-GIS system allows the pre-designed features to be uploaded as a data dictionary file. The required features are categorized geometrically, (point, line, area) together with the related attributes for each feature.

The designed database is imported to the GIS System; the main obligation in this design is to be capable for extension and always ready for continuous feeding. The distribution of the picked features through the designed database is programmed using V.B.V.6. Additional codes are written for parcel transactions, (selling, splitting, aggregation), and design of instantaneous deed plan certificate are developed. The programs are fed into the Geomedia-pro and treated as a separate customized module

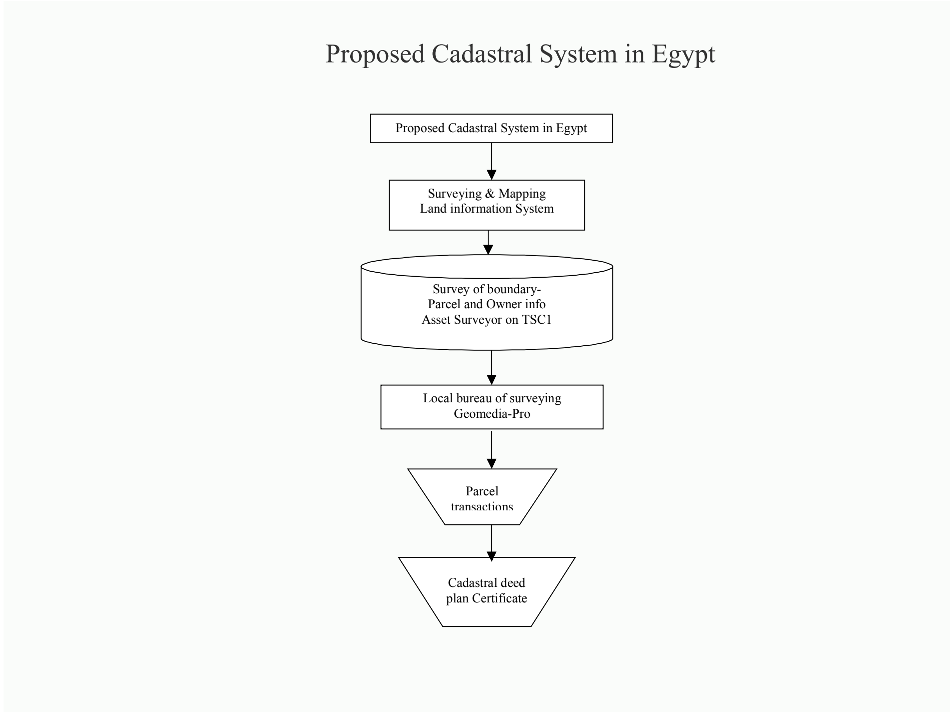

Figure No.2 Proposed Cadastral System in Egypt

The collected features (position &attributes) are exported in GIS format to the Geomedia-pro for revising, editing, and analyzing the captured data. A complete presentation of spatial and attribute data is available, also, spatial and attributes queries can be easily performed. The parcel transaction modules are executed for continuos updating and accurate data recording.

6. THE PILOT PROJECT IN BEHEIRA

The pilot project in a small village in Beheira Governorate was implemented to develop new procedures always with regard to existing procedures and regulations. The selection of Beheira was based on essential considerations. It has original cadastre survey1937, base map produced from aerial photography1991, modern cadastre survey1992. Additionally the village has many tall crops rice and corn, which were a challenge to use the GPS technique.

El -Zahra El-Bahareia village was chosen to investigate the possibility of using the proposed system in Egypt. This village has the following characteristics.

1. The total area was about 712 feddans, divided into 5 hods. The area of each was 100 - 150 fed. Each hod was divided into 40-60 plots.
2. It has a great number of topographical features such as roads, canals, drains, etc.
3. The parcels contained a great number of palm trees, which formed a great obstacle to the survey work but was easily overcome by a good planning and using the system capability.
4. The village has maps for all the stages of old and modern cadastre systems, more over the base maps, which were produced from aerial photography in 1992.

5. The total station survey including the traverse observations, computations, boundaries survey, editing and plotting is existing.

Therefore, the choice of this village with all these characteristics was supposed to give a good example of what a surveyor faces in rural areas of Egypt.

There are three critical phases in the planning of this project;

- Organize feature and attribute information using a data dictionary editor in Pathfinder Office software. A data dictionary is a description of the objects to be collected for a particular project. It is used in the field to control the collection of these objects and information about them. The element of data dictionary can include point, line, and area features.
- Feeding the TSC1 data logger with boundary corners coordinates, lengths and areas from the digital maps, this were surveyed by the electronic total stations (the reference system).
- Configure the data logger in the office; datum, coordinate system, zones, height reference, geoid model, measurement tolerances and data collection criteria. This defines the method of data acquisition and saves time in the field.

5.1 The Field Stage

This stage included preparing sketches, observing and measuring the existing control points and picking up all detail points. The work was arranged as follows:

- A static session was performed using five GPS receivers. Two GPS receivers occupied two stations of the Egyptian national net. The occupation of the control stations was to connect the project to the national net.
- Three of the traverse stations that established during the implementation of American-Egyptian project in 1992 were found and checked using the RTK system.
- Picking up detail points: initially for this technique, it is required to have one control point to cover a circular area of radius 10 km. The extra control points in the area of interest these were used as checkpoints. Old maps were used as a guide sketches to simplify the surveying process. Coordinates of the boundary corners were loaded-up into the data logger, from digital file of Total Station survey, this process is greatly recommended in the re-survey work and parcel transactions.

Attributes data for the parcels were collected according to the designed database during the survey from the deeds or the old records of the Egyptian Survey Authority (ESA).

5.2 The Office Stage

- Data transfer: Data was transferred from the data logger into Pathfinder Office software.

- Revising the collected data; GPS data acquisition criteria, precision, and attributes were accurately executed.

- The system provides data editing tools, often used to clean data before exporting.

- During data revising and quality control phase; deleting individual positions or blocks of positions, modifying attributes, and adds offset values were performed in many data files.

- The digital maps of the Total Station survey were displayed as a background file to measure the difference in positions, lengths, and areas between the two techniques.

- Data files were exported in the shape files format. This format deals with the graphic and attribute data as well and it’s a common format suitable for importing into the Geo-Media professional software.

- On the Geomedia-pro software, the coordinate system file was created before importing the data. Then the data were connected with the predesigned database. Geometry validation and connectivity validation firstly executed to ensure identified intersection and vertices. Consequently, the fixations of geometry and connection errors were done using the Geomedia-pro commands.

- Revising of database feeding and record distribution on the table was very easy (just by clicking the feature).

- Queries is the most essential module on the Software, it is available to have enough information about the selected area or single feature by the owner name, parcel-id, and selected geometry properties.

- The designed database is capable to join additional database. Many authorities could have access to the cadastral system and use it to strength their GIS system.

- Hence, we have all the cadastre system in digital form, the updated maps will be conveyed to the interested authorities through a computer net.

- The owner will have a deed certificate indicate the exact location of the parcel and his neighbors, accompanied with a complete information of the ownership and history of the parcel transactions.

6. RESULTS

Using the RTK system for survey of boundary marks gave a high accuracy. At each mark the surveyor can check the accuracy before recording the position. Applying the standard specifications for RTK observations and set the tolerance in horizontal and vertical direction. Since the data are processed instantaneously using the phase and code data of the base receiver, a complete statistic analysis can be obtained. The error ellipse is the graphic presentation of errors in north and east direction, the size of the ellipse is an indication of errors in both directions. The lengths of major and minor axes of the ellipse represent the error of each direction. The following are the average error values that obtained at each boundary corner:

At 95% confidence level

-Northing σ = 10mm - Easting σ = 8mm

-Ellipse of error major axis 15mm - Ellipse of error minor axis 3mm

See table No.1&2.

6.1 Achievement Obtained Through the Field and Office Work

Since the Asset-Surveyor software survey the parcel as an area feature identified by its marks, the parcel is automatically recorded as a closed polygon. The position at each corner in plotting stage has the same accuracy in observation stage. Using this facility, no confusion in numbering and no overlapped areas were detected during the survey.

- As we survey the parcels as independent lots (not individual points), no errors in numbering or mistakes in attribute recording were occurred.

- The line features like canals, roads, railways and bridges since they were surveyed as line features with full identification in the field if they were arcs or straight and the capability to divide them in many segments in the field. This option reduces a tedious work in linking points to form the line features.

- The cartographic work was almost diminished in this system. Each feature class in the used data dictionary was distinguished. The features have definite layer, definite colors and definite symbols. For example, the canals have two-line feature in left and right sides, both banks of the canal surveyed as a line feature in many segments as continuous line. In Pathfinder Office software the setup is to draw this feature in blue continuos line with thickness 0.2mm. When the data-logger file is transferred, the canal will appear on the screen as a two blue continuous lines with connected with designed attribute data; id, name, width, bank status and required remarks.

- Editing in offset measurements is performed in the office, where exists, the actual position will be changed automatically.

- It was useful to use any background file, Orthophotos or maps to verify the relative positions between different features.

6.2 Rate of Work

For estimating the rate of work using the RTK system, an area of 350 fed. Was considered. The time required to produce a cadastral map for this area was found to be 3 days /crew. (Crew has two RTK surveyors for fieldwork and one technician for office work).

The 3 days were distributed as follows:

1. 20 working hours/crew for fieldwork that comprises preparing the base station, preparing the sketches, and surveying the parcels.
2. Just 3 hours for office work which comprises; Files transfer, clean up and editing.

While the time required to produce cadastral maps for the area using the traditional total-station is 21 working days /crew. (Crew has two surveyors and two prism-men for fieldwork, also, two surveyors and two assistants for office work).

The 21 days were distributed as follows:

1. 14 days/crew for field work that comprises;
   Preparing the sketches, constructing and observing the traverse (7 stations) and picking up all detail points.
2. 7 days/crew for office work for office work which comprises;

Traverse computation and adjustment, computing the coordinates of detail points, the lengths and areas of the plots, also plotting and drawing the map.

7. RECOMMENDATIONS

- Using the RTK system accompanied with GIS data-logger reduces the time andcost and cancels many stages in cadastre production.
- Physical survey of properties on the ground is still necessary for legal description and records.
- The RTK system will be so helpful in future planning of the national projects. Spatial and attribute queries can be executed to give accurate geometrical and attribute information. A prime motivation for revised cadastral mapping is to support an efficient **information management system**, by means of which the massive volume of registered property maps, and precise survey data in highway, public works, and other departments can be integrated.

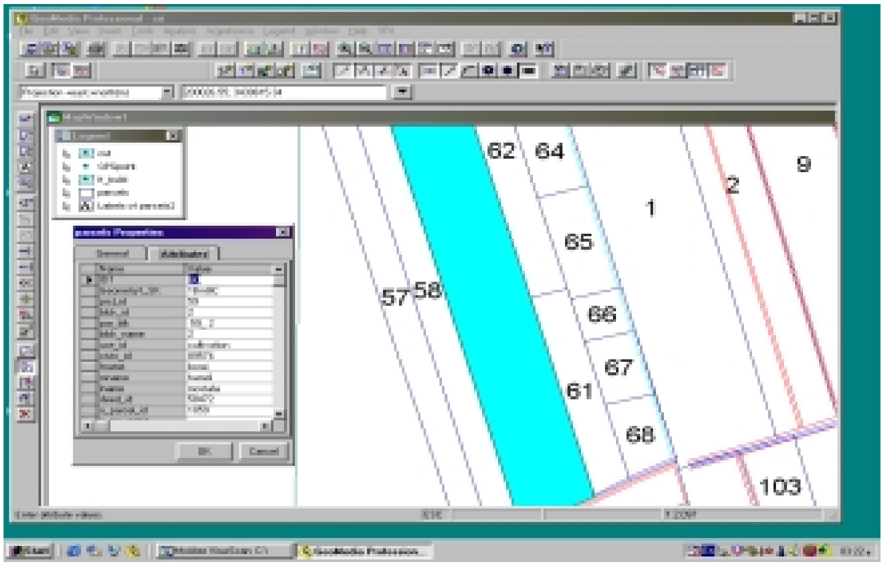

Figure No. 3 Produced Cadastre Maps

Table No. (1) shows the precision of sample positions that obtained at boundary corners of

Id	σNorth m	σEast m	Major axis m	Minor axis m	Orientation degree
62	0.005	0.005	0.006	0.006	188
63	0.0006	0.014	0.017	0.007	11.0
65	0.004	0.004	0.006	0.004	91.6
66	0.014	0.011	0.018	0.013	299.6
67	0.010	0.009	0.014	0.010	348.4
68	0.023	0.020	0.032	0.020	54.1
62	0.015	0.031	0.039	0.017	315.2
61	0.008	0.008	0.011	0.009	52.8
60	0.008	0.016	0.021	0.008	321.7
59	0.018	0.015	0.025	0.015	168.7
58	0.010	0.007	0.013	0.009	178
57	0.005	0.004	0.007	0.004	191.5
10	0.009	0.005	0.012	0.007	229.6
69	0.013	0.008	0.017	0.009	200.6

Table No.(2)Comparison Between Area Computations in the Current and Proposed Systems

Parcel_id	Areas computed from total station survey m2	Areas computed from the proposed system m2
1	26496.07973	26497.50463
2	16490.64888	16491.93055
11	7821.342998	7823.482352
59	12376.54297	12377.89718
60	5801.597828	5801.362874
60	7726.255416	7725.309313
61	3879.620428	3880.179273
62	5661.455285	5661.842542

– In short, a two years plan to finish the cadastre mapping in Egypt is outlined below:

Area category	Area in million fed.	Proposed time	Cost in million LE
New reclaimed areas	1.6	Three months 2crew/ governorate	9million equipment 1million software 5million wages
Old cadastre	7.1	800 working days 60 crews for all Egypt	
Automated cadastre	1.2	One year in the office parallel to the previous stages	1.5 million wages

The previous plan needs to be executed in perfect scientific management of the field and office work in each Governorate. In order to achieve this task by the previous cost the two rovers unit should be use the same base. This operation system will reduce the cost of equipment by twenty five percent.

– Each base station will be located and connected to the national 2nd order geodetic net. The Egyptian Survey Authority (ESA) established this net especially for cadastre work with base lines about 25 kilometers. To intensify the control points, static sessions will be performed for 90 minutes including the new base station and two points of the net. About five hundred control points are required with average cost 1000 LE for each. To cover the whole country.