MODERNIZING EGYPT'S LAND INFORMATION SYSTEM

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ABSTRACT:

Among the many problems faced by developing countries is the maintenance of a current, accurate and complete land information system. The integration of digital surveying and mapping with information systems technology offers developing nations a method for preparing and maintaining a comprehensive land information system. However, the effort and skill required to use these new technologies is widely misunderstood and the cost is frequently underestimated.

This paper details the approach that Geonex International's Technical Assistance Team has adopted in assisting the Egyptian Survey Authority (ESA) move its land information system from the 19th to the 21st century. Discussed are: the composition, equipping and training of cadastral survey crews; the automation of existing land registers; the construction of digital basemaps and cadastral maps; and the development of an integrated Land Information System covering agricultural lands for ESA .

The experiences related in this paper are based on 30 months of day-to-day interaction among the members of Geonex's TA staff and their ESA counterparts. The lessons learned are pragmatic, practical and transferable to other developing countries faced with the requirement to modernize their land records system. The project is funded by a $28.5 million grant from USAID to the Government of Egypt's Ministry of Public Works and Water Resources for the modernization of the Egyptian Survey Authority.

KEY WORDS: Land Applications, System Design, Integrated System, Survey, Cadastral, Mapping, Developing Country.

INTRODUCTION

The creation and maintenance of an accurate and current inventory of land, as well as the maintenance of a record of its use and ownership is a principal function of government. In its capacity as the national surveying and mapping agency of Egypt, The Egyptian Survey Authority (ESA) has been tasked to produce and maintain basemaps upon which the national land inventory can be depicted. The Authority has also been assigned responsibility for conducting the detailed cadastral surveys required to accurately map land ownership and administrative and political boundaries.

As an adjunct to its mapping responsibilities, ESA is charged with collecting selected items of information describing land ownership and use. In this capacity, ESA serves as a data collection agent for both the Ministry of Justice (land registration) and the Tax Office (land use and area calculation).

The rapid growth of the Egyptian population and the concomitant migration of large numbers of people makes it impractical, if not impossible, for ESA to develop and maintain the national cadaster using its tried and true manual techniques. As a result ESA requested and received a grant from USAID for modernizing its surveying and map production systems. The grant is in the form of a Host Country Contract with Geonex International. Among the sub–projects within the Surveying and Mapping Component of the greater Irrigation Management Systems (IMS) Project is one designed to explore the feasibility and practicality of establishing an automated Land Information System (LIS) for the Authority.

CONCEPTUAL DESIGN

Because ESA's current procedures for the production of cadastral maps and land register information are not automated, the primary focus of the LIS pilot has been the development of techniques for automating the collection, compilation and presentation of cadastral information. A set of standard tools for data analysis is also included. ESA's LIS consists of four discrete but related modules. They are:

The Map Production Module. This module automates the production of 1:2,5000 scale topographic maps and 1:1,000 scale town plans. The data items maintained within this cartographic database are those depicting the topographic and cultural features appropriate to the scale of the maps being produced. These features are normally collected using photogrammetric techniques. Where topographic and cultural features cannot be collected using photogrammetric techniques, they are collected using electronic surveying techniques.

The Cadastral Overlay Production Module. This module automates the production of the information needed to produce the cadastral layer for ESA's 1:2,500 scale cadastral map series. The data items maintained within this module are those needed to depict parcel, administrative and political boundaries on the 1:2,500 map series. These data are collected in the field using Total Stations equipped with magnetic data collectors to permit automated downloading of survey data for subsequent processing.

The Land Records Production Module. This module automates the production of the many forms used by ESA to collect, compile and distribute the information needed to produce the Siguel El Aine. These data items are collected by culling existing records and, where necessary, by interviewing land owners. They are maintained in a relational database management system for easy expansion and modification as the need arises. This standalone

relational database is referred to the Land Records Management System (LRMS).

The LIS Applications Module. The purposes of this module are data conflation, exception processing, cartographic presentation, and spatial analysis. Data conflation is the cross indexing of the graphic information contained in the cartographic database with the data items contained in the LRMS database. Exception processing is the processing of data which failed to conflate during normal processing due to inconstancies in the disparate data sources. Spatial analysis and cartographic presentation is the interactive query and ad hoc reporting of LRMS data using the online graphic interface provided by the module's geographic information system software.

MAP PRODUCTION MODULE

Data Sources

The primary source of data for ESA's cartographic database is aerial photography augmented with control surveys, aerial triangulation and field verification surveys, as required. The following photo scales are used for the production of the map series indicated.

- 1:2,500 Map Series – 1:10,000 scale aerial photography.
- 1:1,000 Town Plan Series – 1:5,000 scale aerial photography.

Cartographic Database

The data items in ESA's cartographic database are those necessary for producing ESA's standard series of 1:2,500 scale maps and 1:1,000 scale town plans. Approximately 130 feature codes are currently used to describe the planimetric and cartographic features of interest to ESA. They are stored in *ARC/Info* format.

Quality Control

Field verification and visual editing procedures are used to assess the esthetic quality, adherence to cartographic specifications and completeness of content of plotted maps. Spatial topology is verified and maintained through the use of *ARC/Info*'s built in utilities for cleaning the topology of graphic files. Specialized proof plots with temporary symbols are to verify database attributes and spatial integrity.

Configuration

This module consists of two networked systems.

Data Collection System. This system controls the collection of topographic and planimetric features from aerial photography. The primary data collection instruments are nine Zeiss P3 analytical plotters. Six Kern PG2 stereoplotters equipped with encoders are also used for data capture. All photogrammetric workstations are on a Novell Network. The software employed for data capture is the Kork Digital Mapping System. These compiled data are converted to *DFX* format before being passed to the Map Publishing System.

Map Publishing System. This system controls the translation of graphic data from *DFX* to *ARC/Info* format, the editing and cartographic finishing of data collected with the data collection system as well as data collected during the field verification of compilation manuscripts and cadastral surveys. This system controls the preparation of check plots as well as the production of camera ready film positives of each map sheet.

Its primary production instruments are 16 DEC 5000 Unix workstation running *ARC/Info* software. Other tools include electrostatic and drum plotters. All cartographic workstations are on a Unix Network. Arabic calligraphy is added to maps and managed by the *JoGraph* Arabization routines within *ARC/Info*.

System Administration

Administration of this module is the responsibility of the Aerial Survey Department (ASD) Systems Manager. He establishes backup schedules, oversees weekly off-site archiving of the cartographic database, and controls access to the databases. He is also responsible for maintaining the integrity of the cartographic database, ensuring that changes are not made to its structure without his concurrence and documenting all authorized changes.

Under his direction, the Systems Support and Development Department is responsible for the maintenance of the Novell and Unix networks as well as for hardware and software maintenance. Software development, currently the job of the Geonex Photogrammetric and Cartographic Advisors, will in time be shifted to ASD's Systems Support and Development Department.

Final Products

This module produces:

- Camera ready film positives of 1:2,500 scale topographic and planimetric maps.
- Camera ready film positives of 1:2,500 scale cadastral maps.
- Camera ready film positives of 1:1,000 scale town plans.
- Camera ready film positives of customized topographic, planimetric and cadastral maps at scales between 1:10,000 and 1:1,000 and containing selective features from ESA's cartographic database.
- Digital files containing the topographic, cultural and cadastral features contained in the cartographic database and suitable for use by outside agencies requiring such information.

CADASTRAL OVERLAY PRODUCTION MODULE

Data Sources

The primary source of the parcel, administrative and political boundary data items needed for the production of cadastral maps are cadastral surveys conducted by ESA's Cadastral Survey Department using Total Stations. Additional sources include:

- GPS surveys for placing cadastral surveys in the same coordinate system as the maps produced using photogrammetric techniques.
- "Project Maps" for locating canal and road easements and rights-of-way.

Cadastral Features

Parcel, administrative and political boundary data items needed for the production of cadastral maps will be permanently stored in ESA's cartographic database in *ARC/Info* format. Currently they are being maintained in *AutoCAD's DRG* format for use in an interim cadastral map publishing system. Approximately five additional feature codes are currently used to describe the cadastral and other boundary features of interest to ESA.

Data used in the interim cadastral map production system is archived at the cadastral field office producing it. A copy of these data is periodically sent to ASD's digital cartography department in Cairo, in *DFX* format, for conversion to *ARC/Info* format and spatial adjustment by the Map Production Module's map publish-

ing system. Eventually these data will be inserted into the cartographic database and used for producing cadastral maps.

Quality Control

Field verification and visual editing procedures are used to assess the esthetic quality, adherence to cartographic specifications and completeness of content of plotted overlays before shipment to Cairo for translation to *ARC/Info* format. Spatial topology is verified and maintained through the use of *ARC/Info*'s built in utilities for cleaning the topology of graphic files after translation. Specialized proof plots with temporary symbols which will be used to verify database attributes and spatial integrity.

Configuration

The Cadastral Overlay Production Module consists of the following systems.

- *Data Collection System* – This system controls the collection of parcel, administrative and political boundary features as well as the supplemental topographic and cultural features needed for the production of cadastral maps. The primary data collection instrument is the SOKKIA Set 3 Total Station equipped with magnetic data collectors. Thirty three of these instruments have been acquired for the project's use.

- *Data Processing System* – This system controls the editing and plotting of the data collected with the Total Stations. It consists of networked printers, plotters and IBM–compatible computers equipped with graphic accelerators and capable of running *AutoCAD* software. The network is managed with Novell's NetWare.

Cadastral Map Publishing System

The unavailability of the Map Production Module at the start of the project necessitated the development of a complete, but temporary, *Cadastral Map Publishing System* in each governorate cadastral field office. This system permits the preparation of:

- Camera ready film positives of 1:2,500 scale cadastral maps.

- Camera ready film positives of 1:1,000 plats of built-up areas.

It consists of additional printers, plotters and IBM–compatible computers equipped with graphic accelerators and running *AutoCAD* software. Cadastral map production is accomplished with *AutoCAD*. Arabic calligraphy is placed on the maps with *X–fonts* software.

System Administration

Administration of this module is also the responsibility of the ASD Systems Manager. He establishes backup schedules for governorate cadastral offices and oversees weekly off-site archiving of all collected cadastral data. Under his direction, the Systems Support and Development Department is responsible for hardware maintenance at outlying cadastral offices and the operation and maintenance of their Novell networks. Software development, currently the job of the Geonex Cadastral Data Processing Advisors, will in time be shifted to ASD's Systems Support and Development Department.

Final Products

This module produces:

- Digital files containing the parcel, administrative and political boundary data which when overlaid on selected planimetric features enable the publication of 1:2,500 scale cadastral maps. The supplemental planimetric data required for the production of 1:1,000 scale cadastral plats of built up areas are also included.

Eventually, camera ready film positives of 1:2,500 scale cadastral maps and 1:1,000 scale plats of built up areas will be produced in the map publishing system of the Map Production Module. In the interim, they are being produced with the cadastral map publishing system.

LAND RECORDS PRODUCTION MODULE

Data Sources

The primary sources of the information needed to populate the land records database are contracts of sale and existing tax and cadastral records. New data collection forms, *LRMS DC Forms*, have been designed for this task. When completed by ESA's data collection and scrubbing teams, the information contained on the forms is keyed into formatted *Paradox* screens corresponding to the *LRMS DC Forms*.

Land Records Database

Data items needed for the production of the Siguel El Aine and related reports and forms are contained in the LRMS database. These data are compiled, stored and managed by *Paradox* which has been front-ended by *Sharouk*, a locally produced Arabization utility, to allow users of the Land Records Production Module to work in Arabic. Current LRMS data items are listed in Figure 2 which shows the system table to which each data item has been assigned.

Quality Control

LRMS data entry forms are visually checked against the data collection forms before being entered into the database. Data items requiring standardization such as governorate, district and village names, nationality, and religion are controlled by internal tables accessed by a series of data codes. After keying, data entered into the database are printed out and independently checked against the data entry forms. Needed corrections are made using the appropriate data entry screen.

Database integrity is verified at each stage by the database management team. Once the data are accepted as correct, the integrity of the database becomes the responsibility of the LRMS database administrator.

Configuration

This module consists of three systems.

- *Data Collection and Standardization System* – This system controls the collection of the data items needed to populate the land records database. It is a manual system. Data collection currently requires from 45 to 60 minutes per record.

- *Data Entry and Verification System* – This system controls the population of the land records database. It consists of networked printers, IBM–compatible PCs running *Paradox* and a file server. The network is managed with Novell's NetWare.

- *Report and Form Production System* – This system controls the production of reports and forms as well as ad hoc queries of the database. It consists of networked printers and IBM–compatible computers running *Paradox*.

System Administration

Administration of the Land Records Production Module is the responsibility of the ESA Land Records Manager. She establishes backup schedules, oversees weekly off-site archiving of the land records database, and controls access to the database. She is also responsible for maintaining the integrity of the LRMS database,

ensuring that changes are not made to its structure without her concurrence and thoroughly documenting all authorized changes.

The Systems Support and Development Department is responsible for hardware, software and network maintenance. Responsibility for software development, currently the job of the Geonex LIS Advisor, will in time be shifted to the Land Records Department Manager.

Final Products

This module produces:

- All reports currently produced by ESA for the Ministry of Justice and the Tax Office.
- All forms currently in use by ESA for the collection, compilation and dissemination of cadastral information.
- Customized reports to the extent provided for by *Paradox*.
- Ad hoc queries of the LRMS database.

LIS APPLICATIONS MODULE

Data Sources

Data used within the LIS Applications Module (LISAM) come from either the cartographic or LRMS data base.

Cross Indexed Database

The data in the cartographic and LRMS databases are conflated through the use of a parcel identifier which is included in both databases. The parcel identifier, or PID, is a unique data string which serves to positively identify a specific parcel in the LRMS.

In some cases, the PID is predictably assembled from records simultaneously and independently maintained in the cartographic and LRMS databases. In other cases, the PID is newly assigned in the cartographic database first, then added to the LRMS database. Portions of the LRMS database are then ported to the platform of the cartographic database where the relational database capabilities within *ARC/Info* are used to affect parcel polygon conflation.

The relational characteristics of both *Paradox* and *ARC/Info* facilitate the expansion and modification of the cross indexed database as the need arises.

Quality Control

As all data used in LISAM come from either the cartographic or LRMS database, the maintenance of the quality and integrity of those data is carried out under the modules used to produce those databases. Quality control procedures within LISAM focus on exceptions identified following the conflation of the graphic information contained in the cartographic database with the items in the LRMS database.

Data which fails to conflate due to inconstancies in the disparate data sources are sorted into three cases.

1) *Empty Polygon*– No LRMS record exists for the the graphic parcel polygon.

2) *Orphan PID*– No graphic parcel polygon exists for the LRMS record.

3) *Bad PID*– PID is mis-coded in the LRMS record or the graphic parcel polygon.

Corrective action for cases 1) and 2) are delegated to the next round of map maintenance involving the mobilization of field crews. Corrective action for case 3) is normally possible within the LISAM work group. The strategy of exception processing is, therefore, to find as many occurrences of case 3) as possible from symptoms which show up originally as case 1) and 2).

PID strings are printed out in *Empty Polygon Reports* and *Orphan PID reports*, then researched in the office to verify that the PID strings are correctly assembled from the various sub-fields (Governorate code, District code, Village code, etc.).

A record of bad PID formation is maintained by the LISAM work group to provide timely feedback to the quality control sections of the Map and Land Records Production Modules.

Configuration

This module consists of the following systems.

- *Data Conflation System* – This system controls the cross indexing of parcel boundaries in the cartographic database with the parcel table in the LRMS database. This task is carried out on DEC 5000 workstations in the map publishing system of the Map Production Module.
- *Exception Processing System* –This system provides support for exception processing.
- *Applications System* –This system controls the creation and production of special purpose maps and customized reports from the cross indexed databases. Ad hoc inquiries of the cross referenced databases using the tools for spatial analysis contained within *ARC/Info* are also made from this module. This task is carried out on DEC 5000 workstations assigned to the Land Records Department which is also responsible for the development of specialized applications and customized reports.

System Administration

Administration for the *Data Conflation System* is the responsibility of the ASD Systems Manager. Administration for the *Exception Processing and Applications System* is the responsibility of the ESA Land Records Manager. Upon Authority-wide implementation of LISAM, she will be responsible for providing users of the LISAM module with periodic updates of the cross-indexed cartographic and LRMS databases.

The ASD Systems Support and Development Department is responsible for hardware, and software maintenance. Responsibility for application software development, currently the job of the Geonex LIS Supervisor, will in time be shifted to the the Land Records Department Manager.

Final Products

This module produces:

- *Special-purpose maps* – As standardized map series are produced in the Map Production Module, these have not been defined for LISAM. However, special purpose maps at various scales will be generated by LISAM on demand to demonstrate land ownership demographics and taxation attributes.
- *Ad hoc queries* – Tabular reports of the cross-indexed databases are produced, taking full advantage of the topological attributes maintained by *ARC/Info*. For example, reports can be generated listing all parcels within a specified search radius of a particular point of interest, or lists may be produced of land owners who hold property at elevations below a specified elevation.

DEVELOPMENT APPROACH

As with any development effort, the procedures used for the development of the LIS pilot have varied greatly from its eventual use. Practical considerations such as local priorities, equipment and personal availability and the requirement to analyze ESA's current operating procedures and future requirements have controlled the approach used. Briefly, the approach chosen for the LIS Pilot has been as follows:

- Development of a temporary, but complete, cadastral map production system based on 100 percent field collection of the topographic and cadastral data needed to produce cadastral maps.

- Design and development of the Land Records Production Module.

- Collection of ownership information related to both the new and existing cadastral maps in Beheira governorate.

- Experimentation with the digitizing of property, administrative and political boundaries from existing cadastral maps.

- Production of planimetric basemaps in Beheira governorate to provide a base for testing the fit of both newly surveyed and existing cadastral boundaries to the digital base maps.

- Merger of the data from the other production modules in the LIS Applications Module.

STATUS

This approach was adopted to provide ESA with a quick start on the production of cadastral maps. It has done that. By mid-May 92, more than 279 1:2,500 scale cadastral maps had been turned over to ESA's cadastral edit section for final review. See Figure 1 for a segment of one of the cadastral maps produced with the interim Cadastral Map Production System.

In mid-May 92, the operational status of each modules was as follows:

- *Map Production Module.* Equipment received; installation and training in progress. Production scheduled to commence in Sep 92. Digital mapping specifications nearing completion. *DFX* to *ARC/Info* translation procedures under development. When fully operational, the Map Production Module should a two shift output of between 150 and 200 1:2,500 scale basemaps per month.

- *Cadastral Overlay Production Module.* Fully operational. Governorate Cadastral Survey Groups are organized and equipped as depicted in Figure 3.

In Beheira the cadastral survey group is fully staffed and trained except for a second data processing shift which is being added to reduce a growing backlog of digital survey data. After an average of 12 months of on-the-job training, field survey crews are averaging approximately 151 rod shots per total station per day with each feddan requiring 5.9 rod shots. After an average of 14 months of on-the-job training, computational personnel are producing approximately 30 cadastral maps per month—60 percent the output required to keep up with the field crews.

In Sharquiya the field team is approximately 75 percent staffed. The computational section is at 20 percent strength with additional personnel being added monthly as individuals gain experience in the field and complete the project's computer training program. After an average of 6 months of on-the-job training, field survey crews are averaging 80 rod shots per total station per day with each feddan requiring 4.2 rod shots. After an average of 2 months of on-the-job training, the understaffed computational sedction is producing approximately 11 cadastral maps per month.

- *Land Records Production Module.* Equipment received. Database design, data collection form and entry screens completed. Data collection was just beginning.

- *LIS Applications Module.* Equipment received. Installation in progress.

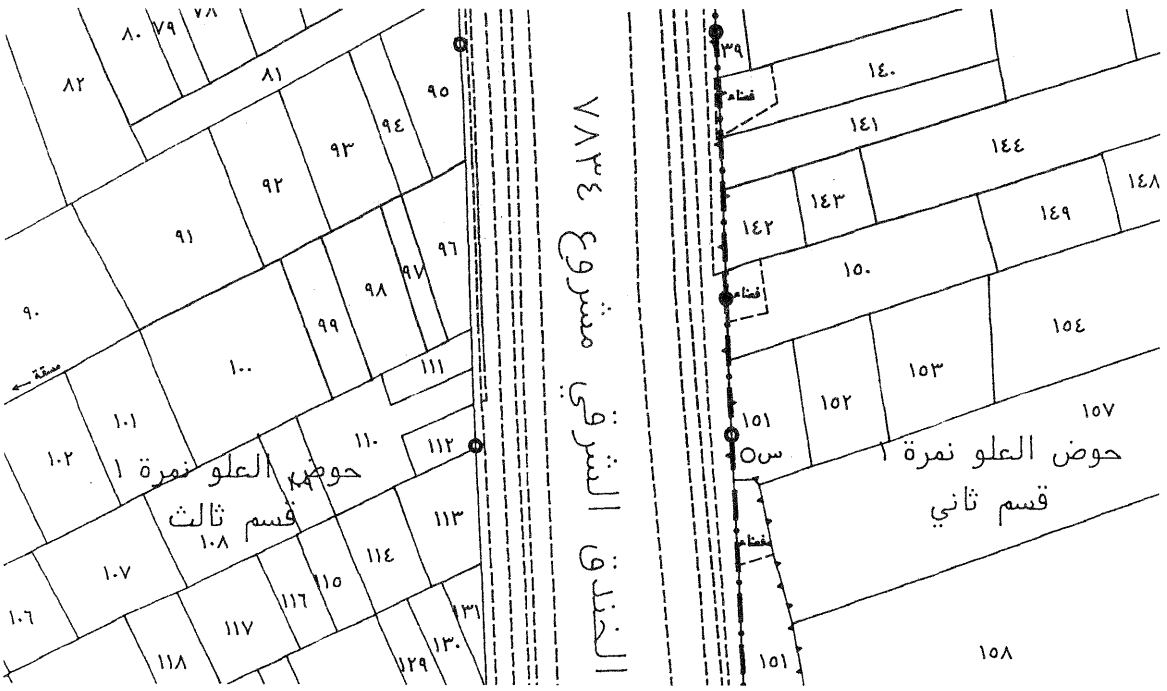

Figure 1 -- Segment of a 1:2,500 scale Cadastral Map

		Data Items vis-á-vis System Table Number													
No.	*LRMS Data Items*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Application number												✍		
2.	Application date												✍		
3.	Application time												✍		
4.	Beneficiary names									✍					
5.	Beneficary number									✍					
6.	Change form number								✍				✍		
7.	Comment								✍	✍			✍		
8.	Crop code	✍							✍						
9.	Crop	✍													
10.	District code		✍												
11.	District		✍												
12.	Duplicate indicator								✍		✍		✍		
13.	Fractional interest										✍		✍		
14.	Governorate code			✍											
15.	Governorate			✍											
16.	Hod code				✍				✍		✍		✍		
17.	Hod name				✍										
18.	Land code					✍			✍						
19.	Land type					✍									
20.	Owner address									✍					
21.	Date of birth									✍					
22.	Date of death									✍					
23.	Federal ID number									✍					
24.	Owner muklafa number										✍				
25.	Owner name									✍					
26.	Nationality code						✍			✍					
27.	Nationality						✍								
28.	Religion											✍			
29.	Religion code									✍		✍			
30.	Owner system key									✍	✍		✍		
31.	Map number 1000								✍						
32.	Map revision date								✍						
33.	Map number 2500								✍						
34.	Calculated area								✍						
35.	Area calculation date								✍						
36.	Mukalafa area								✍						
37.	Parcel number								✍		✍		✍		
38.	Area description								✍						
39.	Grantee system key									✍			✍		

Figure 2 — LRMS System Tables

		Data Items vis-á-vis System Table Number													
No.	*LRMS Data Items*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
40.	Record Status										✍		✍		
41.	Occupation code							✍			✍				
42.	Occupation type							✍							
43.	Grantor system key									✍			✍		
44.	Survey office								✍				✍		
45.	Survey date								✍		✍		✍		
46.	Tax rate				✍										
47.	Tax rate year				✍										
48.	Fractional tax liability										✍				
49.	Transaction code												✍	✍	
50.	Transaction type													✍	
51.	Village code									✍					✍
52.	Village														✍
53.	Contract date										✍		✍		
54.	Contract number										✍		✍		
55.	Ohmda														✍
56.	Land class					✍									
57.	not used at this time														
58.	Special fractional tax								✍						
59.	Temporary fractional tax								✍						
60.	General fractional tax								✍						
61.	Engineer		✍												

Table Name	No.	Table Name	No.	Table Name	No.
Cropcode	1.	National	6.	Religion	11.
District	2.	Occupatn	7.	Transact	12.
Govenor	3.	Parcel	8.	Trancode	13.
Hod	4.	People	9.	Village	14.
Landcode	5.	Ownershp	10.		

Figure 2 — LRMS System Tables

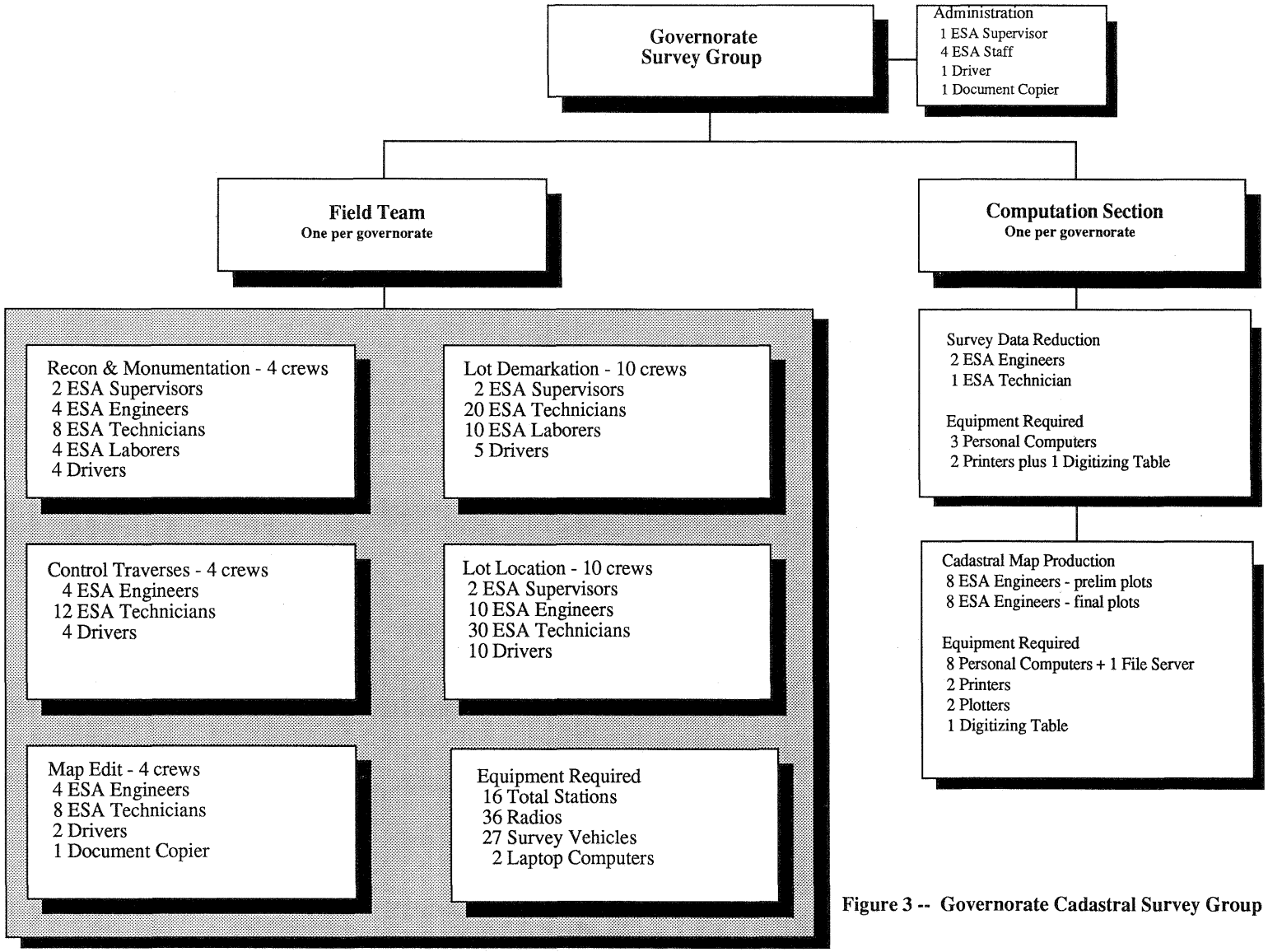

Figure 3 -- Governorate Cadastral Survey Group