EJIDAL MAPPING INFORMATION SYSTEM*

ABSTRACT

Given the most recent changes to the Article 27th of the Mexican Constitution, made to offer juridical certainty in land tenancy for approximately 3.5 million of mainly rural land usufructuaries (called ejidatarios), which accounts for 25 percent of Mexico's population, the Government created the PROGRAM FOR CERTIFICATION OF EJIDO'S RIGHTS AND TITLING OF URBAN PLOTS (PROCEDE).

Several government agencies are involved in this project. The challenge is to survey more than one hundred million hectares, (about 50 percent of the Mexican territory), as well as to produce cartography, with initial volumes of more than 10 million maps in scales ranging from 1:100 to 1:200 000. For this purpose, the National Institute of Statistics, Geography and Informatics (INEGI) created the Ejidal Mapping Information System (SICE) to control the automated process of transforming the information obtained in the field, to produce the maps required in this program.
SICE is integrated with 6 modules, the first step to start the process is the data reception coming from several sources such as DXF, CGP, photogrammetric data files, field information (draws made by hand and notes), photomaps, documentation maps of the ejidos and lists with the names of the ejidatarios who have rights over the land. Afterwards, new data are processed, arranged and validated through different processes, in other words, such data is generated to create proper conditions to respond to data requirements. Finally, as a result of the use of data base, SICE obtains the mapping products which are then delivered to the other areas involved.

INTRODUCTION

The modernization process taking place in Mexico is facing the challenge of reactivating its agrarian area, which since several decades has been left behind the rest of the productive structure. The last modifications to the Article 27 of the Political Constitution of the United Mexican States and its law, *without a doubt is assisting in the purpose of setting up legal bases to end with vicious practices* given in the past, and above all to offer juridical certainty in the land tenancy, which was not possible to have before. All of the above is going to increase the capital in the countryside as well as in the agricultural production, also it is going to protect the ejidal and common life of people wishing to continue this kind of social organization.

In this context, the Mexican Government has created the Program for Certification of Ejidos' Rights and Titling of Urban Plots (in spanish, PROCEDE), which goal is to give the rights over tenancy land to all people that integrate the ejidos of the country.

*** GEOG. CARLOS A. GUERRERO ELEMEN**
DIRECTOR OF CARTOGRAPHY AND AUTOMATIZATION
NATIONAL INSTITUTE OF STATISTICS, GEOGRAPHY AND INFORMATICS
MEXICO

INTERINSTITUTIONAL PARTICIPATION

The public institutions involved directly in the fulfilment of PROCEDE are the following:
The Agrarian Attorney's General Office (PA), the National Agrarian Registry (RAN), and the National Institute of Statistics, Geography and Informatics (INEGI). INEGI is in charge of carry out the technical-operative work leading to the identification, precise geographic location and mesurement of the ejidos land's boundaries.

POTENTIAL COVERAGE

In principle, the Program of Ejidos' Rights Certification and Urban Lands Entitlement is guided to all ejidos that ask for it through their Assembley.
In the country there are more than 29 thousand ejidos[1] and agrarian communities, this at the same time groups 3.5 million of ejidatarios and communers, they count with 4.6 million of parcels and 4.3 million of urban plots. The overall ejido surface represents 50% of the National Territory, and its number of inhabitants is a little more than 25% of Mexico's population.

CHARACTERISTICS OF THE CARTOGRAPHIC PRODUCTS

The cartographic products required by PROCEDE are de following:

- *Internal map of the ejido*
- Map of Common Use Lands
- Map of Community Working Lands
- Map of Human Settlements
- Map of Individual Parcel
- Map of Individual Urban Plot

See figures 1, 2 and 3

GETTING THE INFORMATION

To get information field exists a National Operative Work with 11 000 persons working on it. Two surveying methods will be applied:

Geodesic Topographic Method. Through a physical walk by the ejido's perimeter, each one of the vertexes are located in a precise manner. Subsequently, the ejido's interior is walked down, is there where the exat principal vertexes coordinates are obtained through Total Stations[2] and GPS's[3]. From these vertexes, location, distance and surface's calculations of the ejidal lands are generated in an automatized way.

Aerophotogrammetric Method. It is based on the use of photogrammetric products on detailed scale. This method implicates to go through the ejido's perimeter and to the interior of parcels, communal use lands and human settlement lands. To locate each one of the vertexes[4] , these photogrammetric products are pricked with a needle. The coordinates could be obtained by diverse alternative processes.

An important support in these activities is a new information source, the Active National Geodesic Network (RGNA), which through 14 Fix GPS Stations set in a strategic way, allows to cover totaly data, continually 24 hours per day over 365 days per year. RGNA is a frame in the Mexican Territory where the surveying work of the ejidal lands are related.

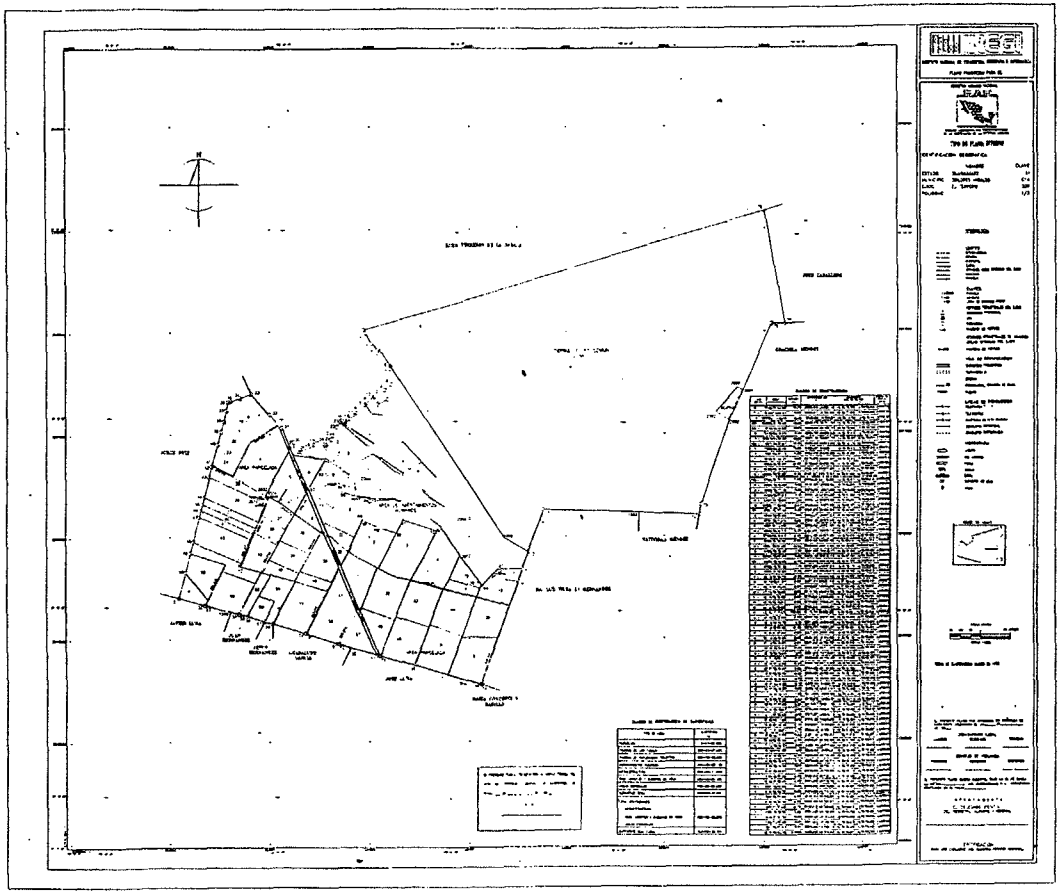


FIGURE 1 INTERNAL MAP OF THE EJIDO

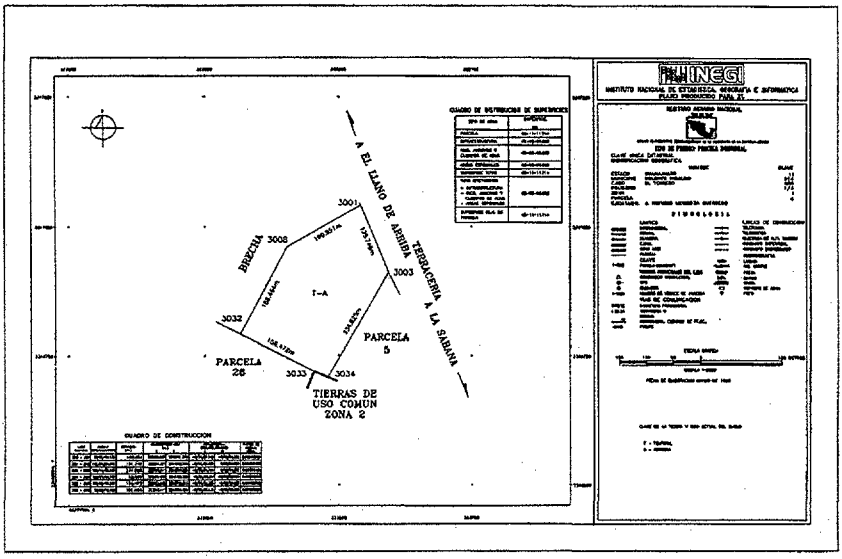


FIGURE 2 MAP OF INDIVIDUAL PARCEL

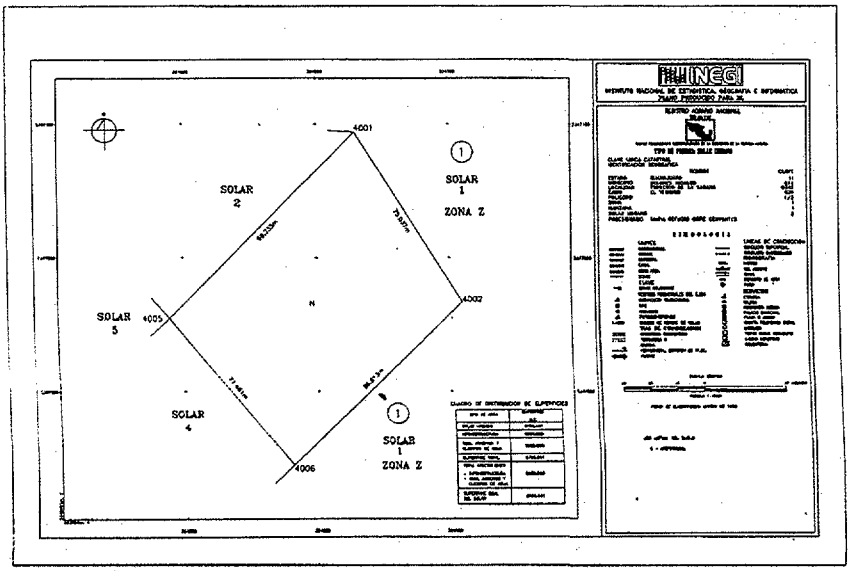


FIGURE 3 MAP OF INDIVIDUAL URBAN PLOT

This new information source means, in the other hand, the transition of the mexican cartography, from the NAD 27[5] system to the ITRF 92.0[6].
Addicionally to the topographic-geodesic data obtained, information about each goedesic vertex and each type of land. (human settlement area, urban plot, parcelled area, working common area, etc.) is collected. The instruments to reach this information are the 12 information sheets applied in the field during the surveying period.

EJIDAL MAPPING INFORMATION SYSTEM (SICE)

The Direction of Cartography and Automatization at INEGI has designed and implemented the Ejidal Mapping Information System (SICE) to ensure and control an automated proceeding to produce the maps required by PROCEDE to the certification and titling of the ejidal rights. In this proyect several important efforts in programming have been combined, due to the complexity that in the national context represents the systematization of the diverse phenomenon and characteristics into each ejidal unit.

The SICE includes the following purposes:

- Establishing a system that allows to register, control and preserve the information collected in the surveying activities.
- Controlling properly the processing of each ejidal unit with the purpose of taking track of the production advances, to make possible a best distribution of the charges.
- Appling a strict quality control (presentation-content) in the production of cartographic products.
- Establishing effective mechanisms to back up the generated information.

HUMAN RESOURCES

At a national level, the Cartography and Automatization area has 2 400 employees; 1 700 are technicians who work in the production of ejidal cartographic products, 176 work in the cartography quality control, 250 in the documents control, 206 in the administration of the calculation network, there also are 40 secretaries and 28 technicians working full time in the designing and the development of the geographic information system.

To improve our procedure on the generation of the cartographic products, now we are reviewing our design and particulary the GIS programming so we will develop a new version that probably will change the meaning of what we have explained here.

TECHNOLOGICAL INFRASTRUCTURE

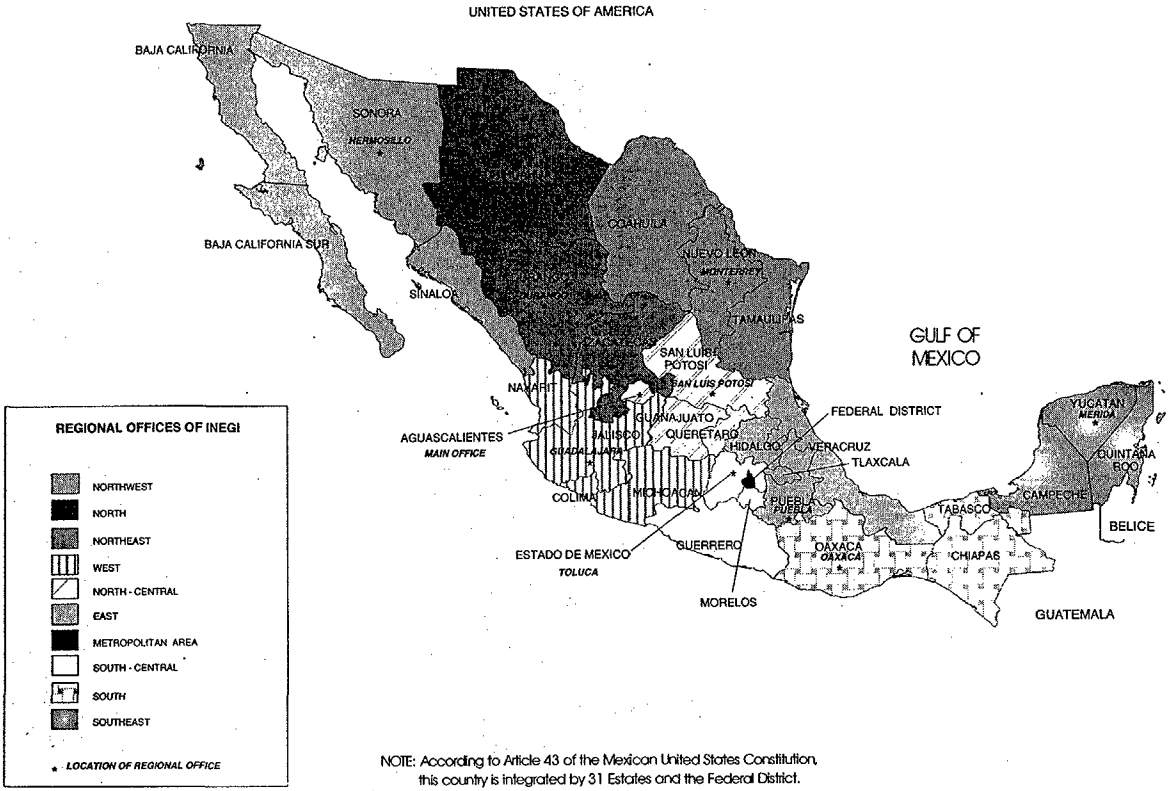
Because of the great amount of field information to process as well as the cartographic material required for the PROCEDE program, INEGI has set up 33 Automatized Cartography Centers (CENCA): one main center and 11 other distributed along the country, plus 22 more established in the capitals of the other mexican states (see maps 1 and 2).

To carry out its activities, the Centers CENCA have a configuration made by:

- A high capacity main server with 4-50 Mhz processors and 1 Mb Cache memory, with posibilities of growing possibility to 6 processors), a disc storage capacity of 10 Gigabytes (Gb) expandable to one Terabyte, and 640 Mb of main memory, expandable to 2 Gb.

Map 1
MEXICO
POLITICAL DIVISION

REGIONAL OFFICES OF INEGI



NOTE: According to Article 43 of the Mexican United States Constitution, this country is integrated by 31 Estates and the Federal District.

Map 2
MEXICO
CENCA GEOGRAPHICAL DISTRIBUTION

Regional CENCA	Name	Languaje	Meaning
Northwest	Tetamai	Opata-Cahita	Limit pointed whith a stone
North	Huanko	Tarahumara	Map
Northeast	Amoxtlalli	Náhuatl	Field codex
West	Mexicaltzingo	Náhuatl	On the mexicans house
North-Central	Tampatal	Huasteco	Everybody's place
South-Central	Tlaltica	Náhuatl	On the labor land
East	Amoxtli	Náhuatl	Geographic data record
South	Tlalpohua	Náhuatl	Land measurenment
	Layu	Zapoteca	Cultivation land
Southeast	P'is K'as	Maya	Measuring the land
Mean Office	Nocuen	Náhuatl	My land

- Advanced WorkStations with 30 Mhz RISC processors with 102 million instructions per second (MIPS), with support to Ethernet 10 baseT network, 65 Mb RAM of expandible to 512 Mb, with 2.47 Gb of hard disc storage, a color stereographic monitor 1 800 x 1 600, 24 bits.
- WorkStations with 50 Mhz RISC processors, 6 Kb Cache memory at 59 MIPS. 24 Mb RAM expandible to 96 Mb; 1 Gb Hard Disk expandible to 20 Gb, 19 inches color monitor with a 1 280 x 1 024 resolution, 8 bits.
- PC 486-33 Mhz with 16 Mb RAM, 200 Mb hard disk, network card monitor SVGA, 14 inches, color.
- Input devices, such as digitillzing tables with an active area of 90 x 120 cm, and 0.002 cm resolution, and scanners with 400 dpi resolution.
- Output devices: 300 dpi laser printers, 17 pages per minute. Eight-pen plotters, with automatic paper cutting, 88 x 106 cms format. Ink-Jet plotter, 400 dpi, automatic paper cutting, 88 x 106 cms format.
- Communication equipment, such as:routers, modems, etc.

Every CENCA has its own UPS unit, Emergency Energy Plant and Air Conditioning System, to ensure an interruption-free production environment.

Optimal Use of computing resources is achieved through a CENCA's Local Area Network ,which permits information and software sharing. This connectivity and overall redundancy permits continuous operation, even in the case of one of more workstations failure.
All of the CENCA's are linked together in a WAN, using the facilities of the INEGI's Satellite and terrestrial communication infrastructure.

The CENCA software is composed of a Geographic Information System package, a Data Base Manager, Information Backup Utilities, Languages such as C and Fortran, all under UNIX Operating System. For Office Automation, Word Processor and Worksheet packages are included.

SICE OVERVIEW

Fig. 4 shows a global view of the SICE design, as follows:

Input. The system accepts data in DXF[7] and CGP[8] format from the GPS and Total Stations, Photogrammetrically-produced digital data, field documents (sketches and surveying records), photomaps, ancillary data for each plot, and tenant information.

Processing. All of the input information is validated and assembled, creating the required Databases for all legal and technical aspects of land adjunction and registration.

Output. The information obtained is composed of a series of Cadastral Maps, several types of graphical and numerical products, both for the associated agencies, and for internal project control.

In the following sections, each of these components is described in detail.

SICE MODULES

With the field information as a starting point, the sequence of input control and result production begins (see fig. 5), which is composed of the following stages:

1.-Data Inventory Control.
2.-Development of Spatial and Numerical Data.

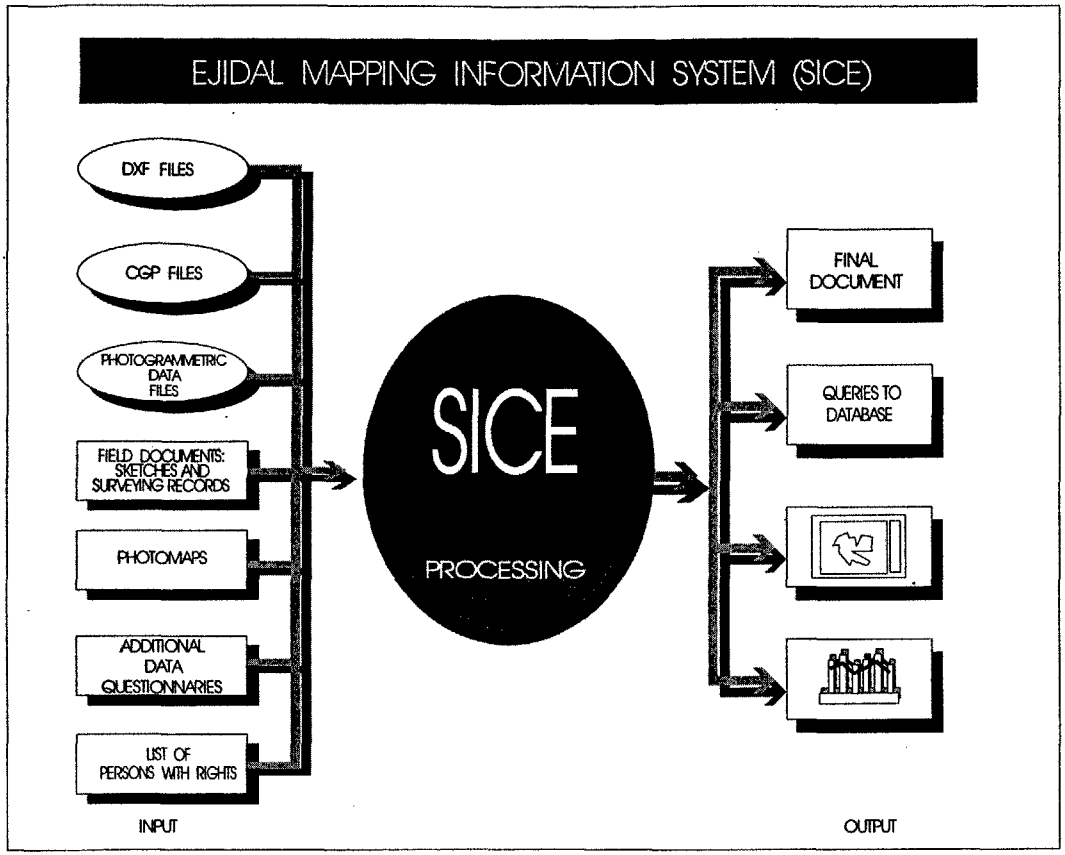


FIGURE 4 EJIDAL MAPPING INFORMATION SISTEM (SICE)

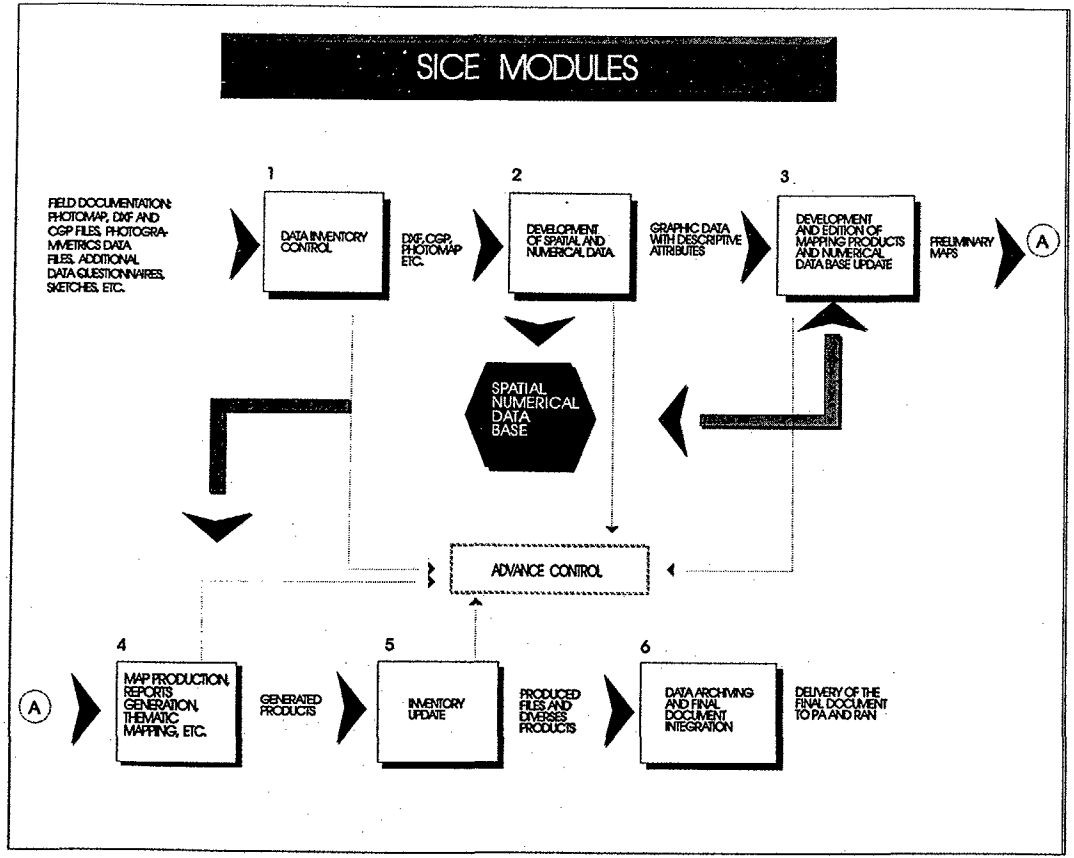


FIGURE 5 SICE MODULES

3.-Development and edition of Mapping Products and Numerical Database Update.
4.-Map Production, Report Generation, Thematic Mapping, etc.
5.-Inventory Update.
6.-Data Archiving and Final Document Integration.

1.-Data Inventory Control.

In this stage, data collected in the field is validated, classified and inventored. This activity is part of the Documentation Center duties.

2.-Development of Spatial and Numerical Data.

The purpose of this module is to extract spatial and numerical data from source documents and capture it into the corresponding database. Is composed for the following activities:

- Spatial data collection and classification.
- Numerical data capture and validation.
- Spatial-Numerical data correlation.
- Data correction.

3.-Development and edition of Mapping Products and Numerical Database Update.

Here, cartographic data is produced, based on coverages and descriptive attributes. The activities involved are:

- Topologic validation of spatial data.
- Complementary information production (control grids, graphic scale, azimuthal and distances tables) are built.
- Preliminary map drawing.
- Quality control
- Materials generation for land tenants assembly.

Integrated in this module there are several data verification stages, oriented to check the consistency of the integrated cartographic data. Every step checks de validity of its previous data. At the end, cartographic data should be error-free.

4.-Map Production, Reports Generation, Thematic Mapping, etc.

This module generate the final plots and data reports. Is composed of:

- Final map plotting.
- Generation of several reports an tables.
- Diverse database queries.

5.-Inventory Update.

This module is the production process control and is composed of the following activities:

- Map and documental completion checking.
- Input and output data comparison, and differences record.
- Generation of inventory and inconsistencies reports.

6.-Data Archiving and Final Document Integration.

This activity is related to the control of the source and materials production. Is mainly performed by the Documentation Center, and makes sure that the final document is completed and turned to the corresponding agencies. It is composed by:

- Information backup
- Data labeling
- Final document integration.
- Final data shipment control for PA and RAN Agencies.

CONCLUSIONS

Facing the magnitude of the job represented by PROCEDE, SICE consolidates itself as the ideal system to process great data volumes and make cartographic transformation.

SICE is a system that has been enriched with daily experiences and the continuous appearing of unforeseen situations. During 3 years with SICE we have obtained a total of 1'821 564 maps which correspond to 7 690 ejidos (May 15th, 1995), this represents an area of 19' 283,881.738 hectares, the 22.7% of the great total, and all this is equal to the areas of Belgium, Cuba and Costa Rica all togheter.

All of the above has led to the certification of the ejidal lands and has benefited directly more than 780 000 ejidatarios.

As a changeable, SICE in its first stage system has required a great designing and developing effort. The GIS has been expressed on 40 thousand code program lines. To improve our procedure on the generation of mapping products, now we are reviewing our design and particulary the GIS programming so we will develop a new version that probably will chage the meaning of what we have explained here.

NOTES:

[1] Ejido is an area (land, water, forest, etc.) assigned by generic law (January 6th, 1917) for the use of a defined social group.

[2] Total Station.- High presicion topographic instrument composed of a two-second accuracy theodolite, a distanciometer, a sensor, everything under control of a microprocessor capable of measure vertical and horizontal angles as well as distances. INEGI has 687 devices like this, operated by 4 people each.

[3] GPS (Global Positioning System).- Electronical device which determines the position of itself over the earth surface, processing designals recived from 21 artificial satellite constellation (NAV-STAR). INEGI has 131 of them, and the team who operates it is composed of 7 people.

[4] For PROCEDE, a special program for aerophotography was developed. It reached in two years, 1'048,799 km² as well as 3 465 photomaps, which cover 167,252 km² more, 62 per cent of the country size. There are 570 photoidentification teams, with two people each.

[5] NAD27 (North American Datum of 1927).- Geodetic system defined over parameters such as geodetic position, geoid highs, etc. Its origen is located in Meades Ranch, Kansas, USA, taking espheroidal size and shape from Clarke, 1866.

[6] ITRF92.0 (International Terrestrial Reference Frame of 1992, epoch 0).- Geocentrical dinamically defined system which taking physical constant creates uniquelly a mathematical frame which determines size and shape of the earth. Is referred to the GRS80 spheroid. Its origen is the earth center by this reason is linked to a particular date and time.

[7] DXF (Drawing Exchange Format).- ASCII file format designed to contain graphical information.

[8] CGP (Coordinate Geographic Points) ASCII file format containing coordenates of points included in the DXF.