

BRAZILIAN CARTOGRAPHY

Jose Kleber Fialho
Brazilian Institute of Geography and Statistics

THE BRAZILIAN CARTOGRAPHIC SYSTEM

Owing to continental dimensions of the country, about 8,511,965 sq km, and due to the fact that its territorial expansion and regional development have evolved somewhat unevenly, Brazil has considered it essential to conduct meticulous surveys which, when translated into charts and maps, depict not only the physical aspects of its territory but also the geographical occurrence of its natural resources.

To harmonize the growing demand for charts and maps and other cartographic documents with available resources, the government was led to combine these activities and to create one sole cartographic system, encompassing all governmental and private entities, in order to ensure the proper conditions of efficiency and rationality.

Cartographic activities thus constitute a huge undertaking which demands the use of specialized personnel and equipment. The proper planning and implementation of these activities requires not only the consolidation of efforts and funds of all our domestic cartographic organizations, but also their centralization and coordination.

The cartographic activities of the Brazilian Institute of Geography and Statistics ("Instituto Brasileiro de Geografia e Estatística," or IBGE) are regulated by Law 5878 of 11th May 1973.

This law establishes the fundamental activities of IBGE which are contained in Article 2, which translates as follows:

Article 2 -- It is a basic goal of IBGE to provide necessary information and studies of a statistical, geographic, cartographic and demographic character for the knowledge of the physical, economic and social conditions of the country, its particular purpose being the establishment of economic and social plans and the benefit of national security.

Editor's Note: This paper is based on information supplied by the Superintendency of Cartography and elaborated by the Department of Cartography.

The goal described above is further embodied in the article immediately following which reads:

Article 3 -- For the fulfillment of the basic goal prescribed in Article 2, IBGE will act chiefly in the following areas...

III - surveys, analyses and studies in the fields of statistics, demography, geodetics and cartography;

IV - geodetic and topographic surveys, mapping and other cartographic activities.

Within these guidelines, IBGE participates in the national effort covering research and cartographic production which, according to the established laws, follows a course of natural development.

THE NATIONAL CARTOGRAPHIC SYSTEM

Cartographic activities in Brazil are consistent with one single system -- the National Cartographic System -- which unites all public and private entities whose purpose is the execution of cartographic works or other similar activities which are necessary for the socioeconomic development of the country and the national security.

Mapping in its various forms is processed through the leading cartographic organs of the national system.

a) National Cartographic Organizations:

IBGE - Instituto Brasileiro de Geografia e Estatistica
(Brazilian Institute of Geography and Statistics
of the Planning Office of the Presidencia)

DSG - Directoria do Servico Geografico (The Geographic Service
Administration of the Ministry of the Army)

DHN - Directoria de Hidrografia e Navegacao (Hydrographic and
Navigation Administration of the Naval Ministry)

DEPV - Directoria de Eletronica e Protecao ao Voo (Electronics
and Flight Protection Administration of the Air Force
Ministry)

DNER - Departamento Nacional de Estradas de Rodagem (National
Highways Department of the Transportation Ministry)

DNPM - Departamento Nacional de Producao Mineral (National
Department of Mineral Production of the Ministry of
Mines and Energy)

b) Regional Cartographic Organizations:

- SUDENE - Superintendencia do Desenvolvimento do Nordeste
(Superintendency for the Development of the North-east)
- SUVALE - Superintendencia de Desenvolvimento do Vale do Sao Francisco (Superintendency for the Development of the Sao Francisco Valley)
- SUDAM - Superintendencia de Desenvolvimento da Amazonia
(Superintendency for the Development of Amazonia)
- SUDECO - Superintendencia de Desenvolvimento do Centro-Oeste (Superintendency for the Development of the Center-West)
- SUDESUL - Superintendencia de Desenvolvimento da Regiao Sul
(Superintendency for the Development of the South)

These latter organizations participate on a contractual basis in mapping work in accordance with their regional interests.

- c) State organizations which take care of the major cartographic necessities within each State.
- d) Private Organizations: Enterprises engaged in cartographic projects and similar activities make up the Associacao Nacional de Empresas de Aerofotogrametria - ANEA (National Association of Enterprises engaged in Aerophotogrammetry).

THE CARTOGRAPHIC COMMISSION

Mapping in Brazil is subject to a policy of development, to a basic plan and to permanent coordination.

With this purpose in mind, Decree-Law no. 243 of 28th February 1967 created the Comissao de Cartografia - COCAR (Cartographic Commission) for the purpose of providing this coordination.

COCAR is composed of representatives of official and private organizations. Its function is the coordinated implementation of the plans and projects of the Brazilian Cartographic System. It is accountable to the entities that comprise the National Cartographic System.

THE REPRESENTATION OF THE BRAZILIAN TERRITORIAL SPACE

Brazil uses the following classifications for the plane, graphical and conventional representation of its territory:

1. With respect to the dimensional representation:
 - a) planimetrics
 - b) plane-altimetrics

2. With respect to the informative character:
 - a) general, when they provide regular information
 - b) special, when they record information that is particularly aimed at a single class of users
 - c) thematic, when they present one or more specific phenomena; the dimensional representation serves then to situate the theme

Besides these, other cartographic documents such as photo-mosaics, photomaps and orthophotomaps may be presented in conventional form, pictorial map or shaded relief.

Regarding the essentially dynamic aspect of planning and, in order to accompany the technological evolution of cartography, technical norms are developed by the respective official agencies which aim to attain the best standards of precision in the corresponding field of application.

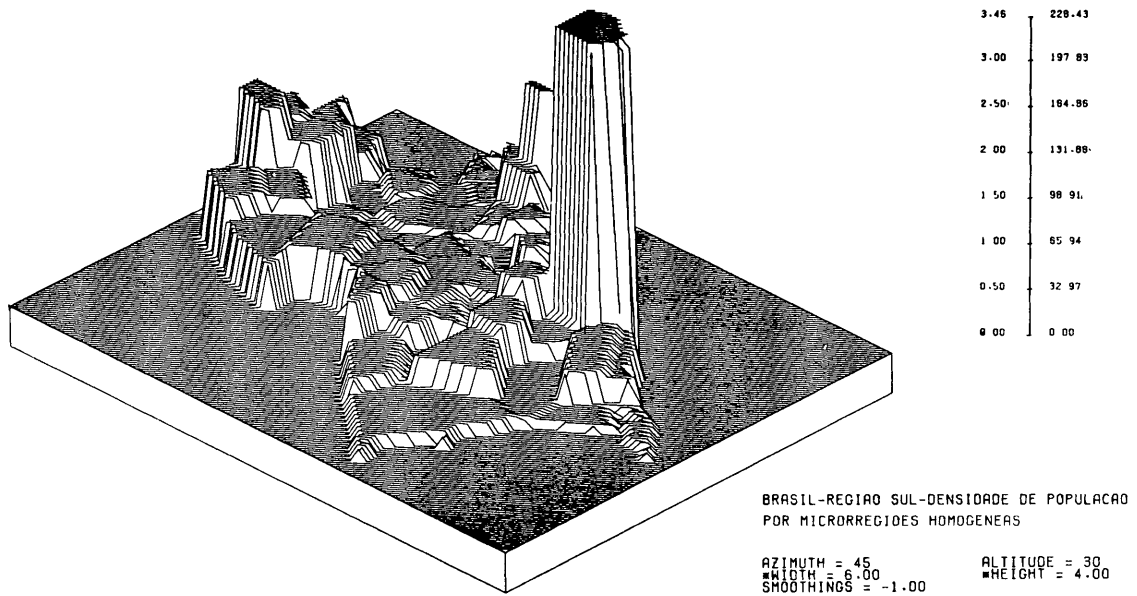
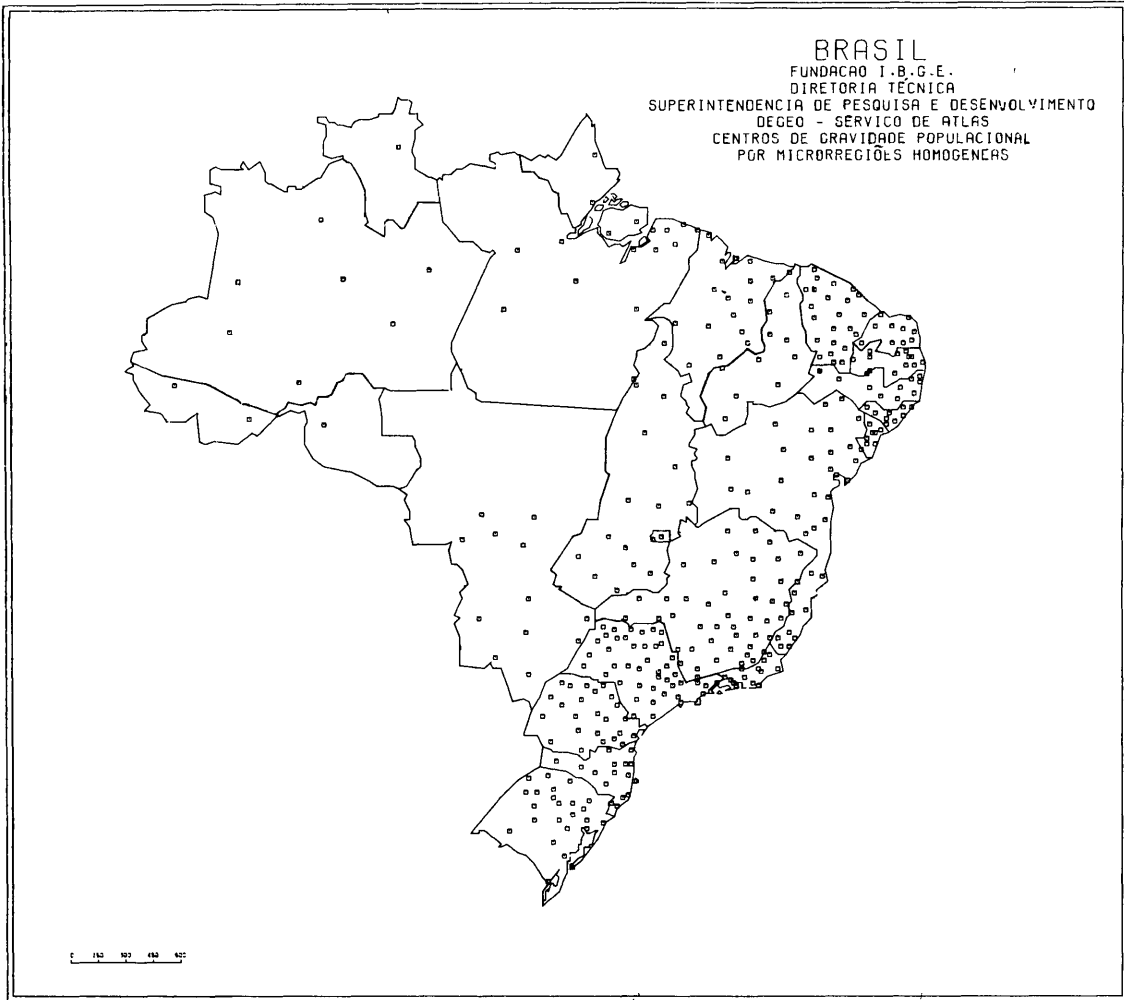
In this respect IBGE establishes the norms pertaining to the Fundamental Geodetic Network, upon which all the cartographic activities of the country are based, as well as those norms which pertain to general maps of scales under 1: 250 000; the Geographic Service Administration, an agency of the Ministry of the Army, is responsible for the norms which regulate the production of the General Maps series, with 1: 250 000 to 1: 25 000 scales; the Hydrographic and Navigation Administration, an agency of the Naval Ministry, is in charge of all nautical charts regardless of scale; and it is the duty of the Electronics and Flight Protection Administration of the Air Force Ministry to establish norms for aeronautical charts.

Such norms were elaborated in accordance with international agreements and conventions ratified by the Brazilian Government.

THE PRESENT SITUATION OF BRAZILIAN CARTOGRAPHY

The cartographic infrastructure of Brazil is a concern of both official and private enterprises; it is the responsibility of IBGE, through the Superintendency of Cartography, in its turn responsible for the Geodetic Plane-Altmetric System of Basic Support.

Our country has a vast geodetic network which covers a considerable area of its territory, extending to the Brazilian frontiers with Uruguay, Argentina, Paraguay, Bolivia, Venezuela, the Guyanas and Surinam where it is connected with the Inter-American Geodetic Network.



As to these geodetic plane-altimetric first order surveys, up to December 1974 the total extension of the triangulation network amounted to 28,780 kilometers with 2,952 established vertices; the polygonals comprised 4,379 kilometers with 183 stations and the trilateral, 26 HIRAN and 31 SHIRAN stations, besides the setting up of 31 satellite geodetic stations.

MAPPING

Until a few years ago, Brazil had urgent need of cartographic documentation.

With the growth of a national interest in providing elements that enable planning in the various sectors, and thanks to the evolution of operational techniques, the capability of producing charts and maps has developed considerably in the country. Present map availability is as follows.

MAP SERIES 1: 1 000 000

This series aims to provide a cartographic basis for geographical studies, for economic planning and for the transportation routes in general. It is a document of general use that gives an overall view of considerable areas of our territory. It constitutes, furthermore, a fundamental element for proper execution of studies and analyses and the background for the preparation of various special thematic maps. Another very important application of the series is its use in the development of the Aeronautical Chart of Brazil.

The development of International Maps of the World at 1: 1 000 000, meets standards and agrees with the international conventions established by the United Nations Conference that took place in Bonn.

All mapping up to now has been done at this scale. The series is composed of 46 sheets which were published in 1971/1972 - 2nd edition. Some of them have already been republished, after due updating by means of ERTS and RADAR pictures or by topographic mapping of demographic information, the highway and railway systems, places worthy of records, and man-made works that have been constructed.

GENERAL MAP SERIES

Government and public interests in general have brought about a demand for maps of the various States of Brazil.

In drawing up these maps, norms and specifications are applied in accordance with the interests and the aspects that have to be emphasized, also the scale and the projection are maintained, consistent with the cartographic representation of the area.

According to the particular necessities of each of the 21 States and 4 territories, various scales have been used.

SPECIAL AND THEMATIC MAP SERIES

The Brazilian Government is committed to the task of providing the necessary means for setting up a process of spatial organization of its territory, in order that conditions may exist for its rational occupancy.

Special attention is therefore given to technical and scientific research which supports these specific studies.

The Brazilian Cartographic System cooperates by supplying the bases for the thematic studies utilizing multi-spectral ERTS and RADAR pictures for research work on oceanography, hydrology, geology, soils, etc.

MAP SERIES OF BRAZIL

This item refers to the issue of a series of maps of Brazil composed of: Brazil and its schools, of purely didactical character; Brazil -- physical and political, at 1: 5 000 000 scale; and political maps with basic colors at 1: 2 500 000 scale -- providing an overview of specific aspects of each cartographic element, featuring hydrographic basins, relief units and the artificial works at their updated stage, as well as functional urban regions.

VARIOUS MAP SERIES

Many entities also publish maps for tourism and atlases of many kinds such as general, regional or of a specific State, etc.

The range of cartographic documents described above fulfills the assistance requirements for general needs and for specific planning in the various sectors.

TOPOGRAPHIC MAPPING

The extent of mapped areas in Brazil at 1: 50 000 and 1: 100 000 scales grew to approximately 2,916,750 sq km in December 1974, corresponding to 34.03 percent to its territory. Currently work is being done on about 2,205,000 sq km, 25.7 percent of our territory.

These data are indeed remarkable if the large expanse of territory is taken into consideration.

1. Map Series at 1: 250 000 Scale

Due to occupancy characteristics and development in the Amazon area, mapping at 1: 250 000 is being considered, however, there are no plans for larger scale mapping in the near future.

2. Map Series at 1: 100 000 Scale
The goal of this series is to reach areas of average population size where natural resources may need research and exploration. Execution is based on aerophotogrammetric surveys with plane-altimetric terrestrial control, permitting complementary geological studies, land use, etc.
3. Map Series at 1: 50 000 Scale
This series shows densely populated areas, with a high level of socio-economic development. Its development is based on the same methods used for the 1: 100 000 scale maps.

DATA PROCESSING IN BRAZILIAN CARTOGRAPHY

The considerable progress made in the field of electronic data processing has enabled public and private corporations to participate in this technical-scientific field and introduce the use of computers in their organizations.

This use is not restricted only to the establishment of new equipment but, as a matter of fact, it implies the rationalization of methods and processes put into practice and, thus, the introduction of mechanization or automation must be preceded by feasibility studies that define the targets to be reached and enable the degree of economy attained by its use to be verified.

Brazil, as well as the entities that compose the National Cartographic System, have been making continuous progress in data processing.

In the field of cartography, Brazil has been developing and implementing software projects dealing with aerotriangulation adjustment; it has been processing data obtained in the field for automatic correction and weighting and producing information with far greater speed and accuracy.

The electronic data processing done in cartographic work and in similar activities is utilized by the principal official agencies, such as IBGE, the Geographic Service Administration of the Army, the Electronics and Flight Protection Administration of the Air Force, and private enterprises affiliated with the National Association of Enterprises and engaged in aerophotogrammetry.

We shall focus below on the principal projects, uses and versions developed in the field of Brazilian cartography.

THE PLANNING OFFICE OF THE PRESIDENCY - IBGE

With due consideration given to the functions of the IBGE -- which operates in the fields of geodetics and topography, cartography and geography -- data processing is being put into practice at the level of field and office operations not only for general cartography, but also for thematic purposes.

As to geodetics and topography, the programs are carried out so as to provide Brazil with fundamental geodetic support, especially where priority plans have been established.

THE SPATIAL GEODETIC PROJECT

The spatial geodetic project makes use of four programs: one deals with estimates used in tracking satellites; the other three deal with the reduction of data collection at the stations by the geociever, which supplies the values of λ and H of these stations.

1. Estimates are provided through the calculation of the time of passage (hours and minutes) of the satellite, its angles of elevation, propagation and delay of the transmissions, etc. These data are calculated for each satellite in a single operation. This program allows the calculation of 90 day estimates for six stations and up to nine satellites.
2. The Program for Reduction of Doppler Data (consisting of three programs).
 - a) The first has as its end reformulating the precise ephemerides received at the NWL, in such a manner that they are compatible with the Solution Program (see below).
 - b) The second is for the purpose of converting the collected data in separate blocks per passage (orbit) to be used as input in the Solution Program.
 - c) The third is the Solution Program which is designed to execute the mathematic processing necessary to calculate the coordinates of the stations in order to transform them into the reference system for our use. These programs were supplied by the U.S. Defense Mapping Agency Topographic Center (DMATC), having been converted from the UNIVAC 1108 system to our IBM/370 system by technicians of both DMATC and IBGE.

3. The program of Geometric Geodetics performs the planimetric adjustment of first order triangulation nets and polygonal geodetic lines. It is the outcome of the original HAVOC program, converted into the IBM/370 system. This program performs, by means of coordinates, block adjustment of the hook-up and triangulation net, as well as of the polygonal lines, in separate jobs.

In the area of geography, the programs have been developed along lines that help forming a data deck by means of processing of statistical, geographic and cartographic data; the aim is to use this data deck for the preparation of digitized cartographic bases for the Nation, for micro and macro regions, States and provinces in spatial programs of thematic geographic cartography.

Another objective is the utilization of the transformation of geographic coordinates into systems of appropriate projections, contour points, cities, geographic centers, centers of gravitation of the population of the above mentioned territorial units and, furthermore, the amplification of automated cartographic equipment, for digitization of geocartographic data and the execution of plotter outputs, directly for reproduction, by the system of separation of colors, recording in scribecoats and peel coats.

PROJECTS OF THEMATIC AND STATISTICAL MAPS, CARTOGRAMS AND GRAPHICS

Four programs are utilized.

1. SYMAP version 5 (Laboratory for Computer Graphics and Spatial Analysis, Harvard University) for studies and analyses of spatial facts and phenomena and related qualitative and quantitative data.
2. SYMVU version 1 (from the same source) for the production of tridimensional plots for studies of geography and the computation of quantitative facts based on statistical data.
3. BASIC SOFTWARE (from California Computer) utilized for subroutines of control of the Calcomp Graphic System.
4. FUNCTIONAL SOFTWARE (from the same company) for the making of graphs, cartograms and all types of unidimensional plots.

A Calcomp Plotter is used for automated cartography with a 7,000 system. Cartographic programs are being developed in aerotriangulation adjustment; the following have already been installed:

1. The transformation of coordinates and inverse - DECART (Jozias Ribamar) which enables geographic or planorectangle networks to be calculated at the desired scale.
2. Timebelt Change - DECART (Jozias Ribamar) permits the noting of sheets with meridians of distinct origin and in opposite directions.
3. Convergence Calculation - DECART (Jozias Ribamar) is used in subsidiary calculations intended for the elaboration of topographic sheets.
4. Condensation and confirmation of models - DECART (Jozias Ribamar) used to check instrumental and calculated coordinates in photogrammetric models.
5. Band adjustment (Coast and Geodetic Surveys, Schut, Ackerman) allows the calculation of aerotriangulation by polynomial, iterative methods, etc., without conditioning the number of bands of models or the quantity and the positioning of points of support.
6. Definition of the perspective centers (Inter American Geodetic Survey, Santoro, McKenzie, Ackerman) using methods of intersection, direct measuring of photogrammetric models for the determination of the perspective centers.
7. Semi-analytic triangulation (McKenzie, Ackerman) a process on a fixed basis, either variable or an oscillating perspective center.
8. Block adjustment (Inter American Geodetic Survey, Schut, McKenzie, Ackerman) with versions that permit the adjustment of large blocks of aerotriangulation with even over 1,500 models.
9. Analytic aerotriangulation (Coast and Geodetic Survey, Schut, McKenzie) for the orientation, formation and the calculation and the connecting of photogrammetric models.
10. Calculation of Projections - DECART (Jozias Ribamar) for generating network of UTM, LAMBERT, Polyconic and Geocentric coordinates.

THE AIR FORCE MINISTRY: ELECTRONICS AND FLIGHT PROTECTION ADMINISTRATION

This agency concentrates on the installation and development of programs that furnish precise and trustworthy data of great importance for aeronautical charts such as: radio-navigation charts; maps of the terminal area; charts for instrument landing approach, landing charts; traffic charts; charts for radar landing approach; climb charts; obstacles charts, and aeronautical charts at 1: 1 000 000 scale.

Secondly, this agency serves the Brazilian cartographic community in such areas as aeronautical information as well as general cartographic information.

The projects already set up and in process of development comprise:

The Cartographic Cadaster - TRC-03 for the purpose of giving access, in simple and practical form, to pertinent information, available not only for airfields and radio-aids, but also any geographic and geodetic cartographic points which may interest flight protection.

1. Transformation of the TM (UTM, LTM, GAUSS - TARDI, GAUSS - KRUEGER) coordinates into geographic-TR-01.
2. The generation of TM coordinate tables in any subsystem (UTM, LTM, etc.) serving for the supply of coordinates for the corners of the TRC-02 map sheets.
3. Systematic articulation of the map sheets beginning at the "millionth" (1: 1 000 000) and going to the "half-millionth" (1: 500 000) in multiple divisions of 9 inches (sheet 1: 500) -- subroutine AIDT.
4. The generation of tables of plane coordinates for plotting the projection coordinatography following Lambert, with two standard-parallels at any scale and magnitude - TRC-04.
5. Computation of airways, terminal areas, coordinates of position controls and flight procedure, following normal geodetic behavior (great circle sailing) MAP.
6. Distribution of issues of all publications with computerized addressing, AIS.
7. Polygonal calculation in geodetic long lines, in accordance with the Sodano and Rainsford formulas - TOP.
8. Doppler positioning calculation by means of instruments such as: MARCONI and MAGNAVOX 702 - HP - DOPSAT.
9. Calculation of Datum Shifts parameters.
10. Aerotriangulation with independent models - Schut OSU - McKenzie and Ackerman adapted to the /360-40.

Currently under development are the following:

1. The Cadaster of Computerized Airfields.
2. The generating of punched tape for the printing of publications by photocomposer.

3. The edition of the booklet "MANAE" -- (Manual of Assistance to Aerial Navigation - ENROUTE), elements provided by the Cadaster of Airfields through punched tape for printing in photocomposer.
4. Multipurpose technical integrated Cadaster of airfields and vicinities.
5. Aerosurvey Data Deck comprising: the Cadaster of Airfields and the Cadaster of Aerophotography.

THE NATIONAL ASSOCIATION OF ENTERPRISES ENGAGED IN AEROPHOTOGRAMMETRY (ANEA)

Our purpose here is to describe the principal applications of the electronic data processing now in current use among the enterprises affiliated to the ANEA and applied to cartographic works and similar activities.

Considering the large number of enterprises and the diversity of projects currently being undertaken, the subjects will be discussed in general.

BAND AND BLOCK AEROTRIANGULATION

Programs installed in data processing centers which serve the enterprises:

1. Determination of perspective centers (McKenzie).
2. Band and block adjustment (McKenzie).
3. Band formation with independent models (Schut).
4. Band formation with independent photos (Schut).
5. Band and block adjustment, with analogically, semi-analytically and analytically formed bands (Schut).
6. Block formation and adjustment with independent models (Ackerman).

HIGHWAY PROJECTS

Programs installed in data processing companies or in engineering consultant firms:

1. Directrix calculation, plane and profile.
2. Transverse section calculation, digitized in restituting apparatus.
3. Volume calculation of excavated cuts and fill-ups.
4. Land distribution calculation by the Broockner method.
5. Projected highway costs calculation.
6. Offsets calculation covering also other elements for highway locating.

URBAN AND RURAL, TECHNICAL AND FISCAL CADASTER

Programs installed in data processing firms:

1. The calculation of thoroughfare sections facing buildings and real properties, starting with the digitization of stereoscopic models of existing maps or of orthophotomaps.
2. Automatic plotting of property boundaries and any other visible element which can be identified in the stereoscopic models.
3. Field complementary data collecting directly in the form of punched cards for use by automatic plotters.
4. Calculation of the sale value of properties and the cost of public utilities for establishing rate and tax values.

HORIZONTAL AND VERTICAL, GEODETIC AND TOPOGRAPHIC NETWORKS

Programs set up in firms engaged in data processing or in table computers which belong to the aerophotogrammatic and topographic firms themselves.

1. Compensation calculation of trilateral, polygonal and triangulation networks.
2. Rear and forward intersections calculation, as well as of excentric sightings in order to determine the supplementary points of support.
3. Compensation calculation of the geometric leveling networks.
4. Trigonometric levelings calculation.
5. Barometric levelings calculation.
6. Ellipsoidal coordinates calculation, of the tracking satellite stations by geodetic receivers exploring the Doppler effect.