JUBILEE 2000 PROJECT: THE EXPERIENCE OF BUILDING DB25 AT THE I.G.M.I., THE ITALIAN LAND MAPPING AGENCY

Antonio ARRIGHI
Istituto Geografico Militare, Servizio Fotogrammetrico, Florence, Italy
igmiced@fi.nettuno.it

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ABSTRACT

The Italian Land Mapping Agency (I.G.M.I.) has promoted the identification of operative methodologies in digital form in order to build a geographic database, structured as an informative system, whose content globally corresponds to the topographic map at scale 1:25000.
The original project began under the "Jubilee 2000 Project" for the city of Rome and its neighboring area.
The project was organized according to the following methodological division: photogrammetric data capture, data processing, implementation of the database and exchange format, data layout and lithographic preparation.
The implementation of the DB25 was developed throught a topological environment and the exchange format was referred to a neutral model for digital geographic data which allows maximum flexibility to access data, guarantying continuity of topological relationships.
The present paper documents the established procedure for realization of the project over that last two years, preceded by a brief description of the design that makes up the basic structure of the innovative productive system at I.G.M.I..

1 INTRODUCTION

After more than 10 years of map making experience at a scale of 1:25000 through numerical procedures aimed at cartography automation (digitalization from stereoscopic model, interactive cartography processing, automatic plotting of topographic maps), the I.G.M.I., the Italian Land Mapping Agency, has promoted the identification of operative methodologies in digital form in order to build a geographic database, structured as an informative system whose content globally corresponds to the topographic map at scale of 1:25000. Its accuracy is comparable to a scale of 1:15000 and makes possible, through extraction of information from the database, the paper version of the map at scale of 1:25000.
The original project began under the "Jubilee 2000 Project" for the city of Rome and its neighboring area in light of geoinformation demands required by the upcoming Jubilee event and its worldwide importance (Fig.1).

2 THE DB25 PROJECT

The project was organized according to the following methodological division of four principal steps:
-*Topographic data capture* (from stereoscopic model and field completion);
-*Data processing* (standardization of data with different formats for import to Microstation, object coding and geometric congruence inspection, geographic name placement);
-*Data layout* [tabular data organization according to a standardized model (captured data conversion to transfer format, further transformation to intermediate format), final conversion to store and exchange format];
-*Lithographic preparation* for cartography printing at scale of 1:25000 (data layout for border and neat lines, cartographic grid and marginal information, vector file rasterization and transformation into final lithographic format).
The main features of DB25 and its related

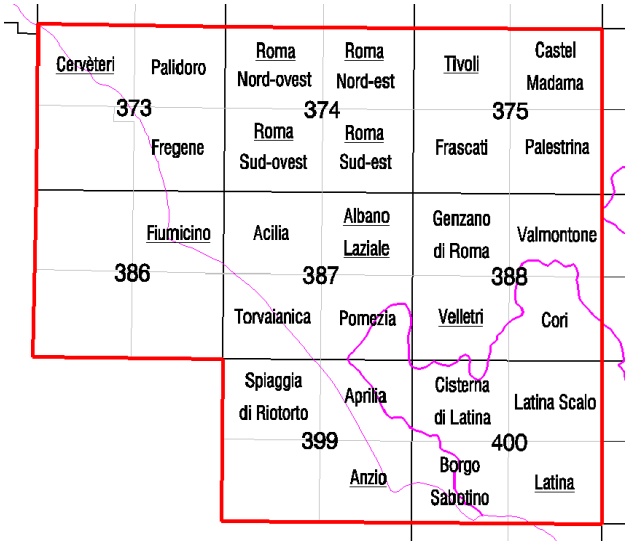

Figure 1

cartography are as follows:
-*Informative content* . essentially identical to IGM cartography at scale of 1:25000, subdivided into eleven thematic layers (administrative boundaries and generic delimitations, morphology, elevation, hydrography, vegetation, built-up areas, industrial settlements, technical facilities, transportation, names and quality);
-*Geometric data structure* - vector format represented by point, line and area components corresponding to a total of 128 features;
-*Descriptive data structure* - with three components represented by simple objects and qualifying attributes for 392 objects overall, provided by topological relationships;
-*Geodetic reference system* - planimetric, WGS84-ETRF89 ; altrimetric, IGM high precision geometric leveling net;
-*Cartographic reference system* - for data capture, UTM-WGS84 grid; for DB25 storing and exchange format, WGS84-ETRF89 graticule;
-*Quality indicators* - characterized by position accuracy (circular and linear error with degree of reliability in %), semantic accuracy and thoroughness (error rate and exhaustivity) and geometrical and logical consistency (presence and correctness of topological relationships, respect for selection criteria);
-*Coding system* - primary code for topographical feature identification and as many attribute codes as descriptive features according to the "Feature Attribute Coding Catalog" (FACC) provided by the Digital Geographic Information Exchange Standard (DIGEST);
-*Archiving and exchange format* - conforming to "Vector Product Format" (VPF) according to DIGEST standard;
-*Geographic tile and cartographic grid* - the geographic tile (10' X 6') is temporarily referred to as the E.D.50 system; a final solution would be to refer to the same geographic tile as the WGS84-ETRF89 system ; the cartographic grid conforms to the UTM-WGS84 system.

3 THE PHOTOGRAMMETRIC METHOD

Numerical restitution is at the heart of photogrammetric method through which it is possible to carry out data capture by digitalization of stereoscopic models (b/w frames at a mean scale of about 1:30000).
Generally, varying land details are obtained from three basic geometric components: point, line, area. Quite functional alfanumerical codes (I.G.M.I. format) were assigned to each one which make it possible to easily manage data. Required geometric congruencies are assured so that the "*chain-node*" structure is respected.
Restitution is integrated with a data processing phase. Data stemming from different restitution systems are normalized by transformation of a new "neutral" format, named *SAF* (Simple ASCII File) (Fig. 2), initial quality inspection of coding and geometric congruence, the insertion of toponymy from I.G.M.I.'s model database (DBTOP25) and from the latest ISTAT database (ISTAT-91).
Data acquisition is completed by field complition. Reviewed, corresponding geometric and semantic findings, between resulting details and those seen on the terrain, are reported by a surveyior on a worksheet.
Information are gathered and documented on paper allowing correction of original graphic files.

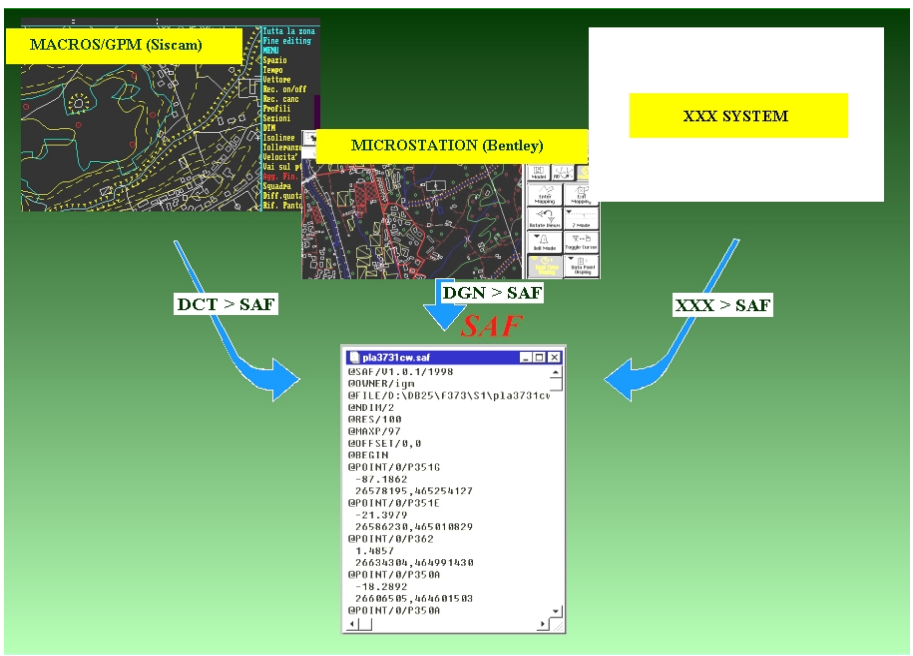

Figure 2

The conclusive phases are represented by the organization of information according to a standardized scheme of database (DB25 loading): automatic generation of links between graphic primitives and related database tables with conversion of alfanumerical codes into a "passage" format (DGN-dBASE); successive interactive integration of DB tables with captured data and subsequent conversion of the same tables into an "intermediate" format (ASCII), named RISDUMP, rendered legible by MGE software (DGN-MGE); lithographic preparation where data are laid out for border and neat lines, cartographic grid, marginal information and the numerical cutting of objects straddling between adjacent cartographic units as well as vector file rasterization and transfer to final lithographic format (LSR). Quality inspection of both maps and the DB are carried out during these phases. In brief, work flow is made possible with the support of the following hardware/software configuration:

• for numerical restitution

-analogue stereoplotters stereosimplex G7 digitalized with encoders combined, through electronic interfacing, to WS IP 2020 with 16 MB RAM, s.o. CLIX (UNIX), sw for restitution Microstation 5.0, SPI/M and PandEF (generated integrative program, at I.G.M.I., in MDL language for codified unit acquisition and modification);

-analogue stereoplotters stereosimplex G7 digitalized with encoders combined, through electronic interfacing, to PC 486 with 16 MB RAM, s.o. MS DOS, sw for restitution MACROS/GPM and MACROS-Utilities (series of generated programs at I.G.M.I. in Visual Basic language to verify and check acquired data and for format conversion);

-analytical stereoplotters stereosimplex III transformed into analytic interfaced with PC Pentium MMX 333-96MB RAM, s.o. Windows NT 4.0, sw for restitution Microstation 95, SVKitA2T and PandEF;

-analytical stereoplotters digicart 40 interfaced with PC 486 with 16 MB RAM, s.o. MS DOS, sw for restitution MACROS/GPM and MACROS–Utilities;

• for data processing, DB loading and lithographic preparation

-TDZ2000 workstations, single/double Pentium 500 Xeon - 512 MB RAM, s.o. Windows NT 4.0, sw for data processing Microstation 95, PandEF, MRCFClean, MRFFlas, wGeos (generated program container, at I.G.M.I., in C^{++} to carry out inspection, transformation of coordinates and conversion of format data as well cartographic processing and automatic graphic files plotting), MACROS-Utilities, SAFImp (generated integrative program, at I.G.M.I., MDL language for transferring SAF files to Microstation), IPLOT, IRASB, Map Publisher;

• for automatic graphic files plotting

on paper: plotter A0format, HP Design ink jet 3500CP;

on film: high precision laser plotter OPTRONICS.

Aerial triangulation activity is carried out in preparation for numerical restitution. Hw/sw configuration used for this operation is represented by a first level digital system made up of a DSW 300 frames (Helava scanner and ws SUN Ultra 30 Creator on Solaris platform with sw SCAN) and by a DPW 700 stereorestitution station (ws SUN Ultra 30 3D Creator on SOLARIS platform and SOCET SET+ HATS with NuVision Percepiva 21 MX monitor for stereoscopic vision through passive eyeglasses).

The activities that have been described are carried out by four offices named "sections":

The 1st, 2nd and 3rd Topographical Sections have in charge data capture and processing for the building of DB25 and related cartography; this is realized by four numerical stereorestoration instruments as well as editing workstations. This work organization, based on parallel, autonomous operative units, aims at drastically improving on productivity by reducing lost time between one phase and another, inherent of successive organizational work procedures directed at map automation;

The Numerical Restitution Section, responsible for digitalization of aerial photos and aerial triangulation with automatic printing of monographs of ground control points required for absolute orientation. The role of the section is not limited, however, to georeference aerial photos. Indeed, the digital photogrammetric system is integrated with national database construction activity through regular automatic/interactive sampling of land surface (DTM generation with sw TERRAIN) and related visualization of contour lines in order to satisfy the need for tridimensionality of DB25 and to represent altitude on the map at scale of 1:25000.

4 IMPLEMENTATION OF THE DATABASE AND EXCHANGE FORMAT

Data to be elaborated for building DB25 are provided in ASCII and DGN formats so they could be imported to MGE.

Through Modular GIS Environment it is possible to develop consecutive elaboration of a topological environment through DYNAMO software and create format for exchange and storing data through VPF Bundle software.

Construction activity of the DB25, where original subdivision of graphic files and database files are forfeited so the final DB contains only one file for both graphic structure and related characteristic information, is generated in DYNAMO where binary files are drawn up according to project specifications.

These files are characterized by:

-parameters which allow identification of features, related qualities and possible values, indexes of linking between tables, the structure of database elements, qualified thematic nature and METADATA as well as validating final data;

-dictionaries which represent instruments of analysis for verification and interactive modification of graphic and informative components of topological DB (FACS dictionary - semiautomatically generated from RISDUMP data, allows transfer from MGE to DYNAMO where it is possible to blend graphic files and databases into one file; FACC

dictionary - interactively generated, contains a description of all objects of DB25; FACV dictionary - defined by DB25 structural parameters, makes possible name changing of original objects grouped according to class whose denomination is conceived in such a way that the final letter identifies the primary geometric associated type, with theintention of simplifying and therefore accelerating loading operations, research and data analysis by DB geographic visualizer);
scheme-mapping table which convert files from one dictionary to another so that it is possible to retrace one's steps, regenerating MGE and recreating DGN files and related databases;
Tileref, which defines the portions of database clippings according to criteria of subdivision by the World Geographic Reference System (WGRF), and Libref, which corresponds to the coupling of tiles; both Tileref and Libref allow for the explicit topological relationship between the varying tiles so that every database element is matched to a corresponding one, leading to continuity between the varying components of subdivision and to management of the geographical environment in a joint manner;
In this context, VPF, the exchange format, has been adopted to fully analyze the DB. VPF is a neutral model for digital geographic data which allows maximum flexibility to access data, guarantying continuity of topological relationships even in the presence of subdivided data banks.
Work flow for exchange format and archiving was articulated into the following phases:
-conversion of DGN files and related databases from MGE to DYNAMO by the FACS dictionary;
-vertical integration, the combination of informatic themes into one file;
-spatial analysis for areal and linear sharing check-up and eventual interactive correction;
-transformation of coordinates from cartesian UTM-WGS84 to geographical WGS84-ETRF89;
-geometrical inspection and interactive elimination of overshoots, undershoot, node mismatches, slivers, kinks, loops and kick backs;
-passage to FACC and inspection of continuity of attributes (features belonging to adjacent tiles are matched through reciprocal pointers at initial points of their graphic primitives);
-horizontal integration to match more portions of the DB to realize the dimension of the planned tile (such procedure is necessary when the cartographic clipping is different than what is forecasted for the DB in VPF format);
-linear and areal features matching which share common nodes and identical attributes to manage relative memorization of space (such procedure happens automatically through software that uses two files: one that contains data which identifies features to be matched and the other, which specifies conditions for the realization of the operation);
-elaboration of texts with interactive examination of each place name assigned to its correspondent theme, with character attribution in relation to the typology and classification of the specific topographic object that it refers to;
-interactive connection between adjacent tiles;
-passage to FACV;
-interactive inspection of correspondence of attributes of FACV structure;
-thematic separation;
-translation of Tileref and Libref data to VPF format;
-metadata creation through tables writing which contain structural pathways of the VPF-DB25 product;
-validation of structural data by means of interactive inspection of completeness, quality correctness and the relationships between tiles in VPF format (eventual errors, summarized in a specific list, are resolved in DYNAMO, translated again to VPF and submitted to new validation);
-archiving on CD ROM according to ISO 9660.
The office responsible for the above outlined activity is Section DB25 that uses five TDZ2000 workstations, double Pentium III 350/550 Xeon.512MB RAM, s.o. Windows NT 4.0. Software configuration is like the one previously described.

5 MAP DELIVERY AT SCALE 1:25000

The laying out of the map at scale of 1:25000 is organized according to the following phases:
-realization of the border line and grid in SAF format through the wGeos program;
-creation of cover and marginal infomation in SAF format by the wGeos program;
-combination of two SAF files and consecutive rototranslations of the second, in respect to the first, for the correct correspondence and conversion into DGN through SAFImp;
-rasterization of DGN files in RLE format through IPLOT;
-composition of raster files in a CRL file in assembled colors through MapPublisher to accurately check for thickness, symbology and masking through visualization by means of quick plotting or video by IRAS/B;
-generation of 4 separate LSR files through MapPublisher to plot film mirror reverse to layout printing plates for four colors separation in order to automate, to the best extent possible, the simbolization phase of the database for map production (Fig. 3).

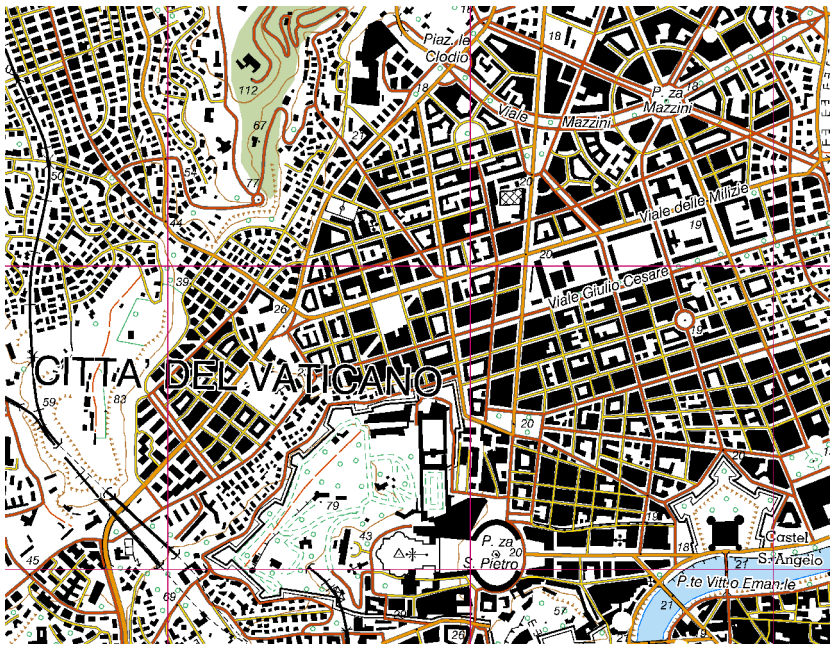

Figure 3

6 RESULTS AND CONCLUSIONS

The "Jubilee 2000 Project" achieved, among other things, three fundamental results:
-rendered DB25 independent of capture data photogrammetric systems and surveying data coding criteria;
-modification of map symbols for cartography at scale 1:25000, preserving projection of plotted topographical objects to the greatest degree in actual size so as to obtain remarkable reduction in editing;
-integration of digital photogrammetry into that of tradictional character;
-reorganization of the production process according to integral operational modules, thereby significantly improving on productivity.
In summary, the construction of DB25 (MGE intermediate format) for a tile covering 150 km^2 at scale 1:25000 and cartography preparation took 2000 working hours (14 months/man). The following is a sample of the statistical data obtained with the aid of DB25 for the city of Rome: 97.093 buildings, 2464 factories, 347 churches, 144 chapels/oratories, 229 sport fields, 115 swimming pools.

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