THE CADASTRAL MAP AS BASIC CARTOGRAPHY LAYER FOR LAND INFORMATION SYSTEMS: THE EXPERIENCE OF THE CITY OF MODENA.

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GENERAL ASPECTS

The need for modern management of activities and services has stressed the importance of a system capable to provide a synthetic and punctual representation of phenomena and their territorial distribution.

Studies and researches from Government, Public and private Organizations, conducted in the respective area of competence, have shown the following common facts:

- the need for setting up a large scale cartographiuc support system where the main requirement is to have maps with good geometric characteristics;
- the need to have a basic cartographic layer where it is possible to superimpose other features in order to obtain a Land Information System describing properties: an indispensable prerequisite to formulate plans and operative projects about the territory.

The plurality of different Organizations requiring cartographic supports has led to produce basic maps covering the same area of territory. That has not always been appropriate and justified.

This situation has also led to a non-homogeneous production of cartographic maps from the point of view of metric quality. This was caused by different technical and economic capabilities of the Organizations involved in producing maps.

It is becoming increasingly evident the need for proper coordinationfor the achievement of uniform results.

It would be highly desiderable to obtain the representation of the territory according to standard geometric characteristics.

Coordination has been found to be particularly important for establishing a rational implementation of both economic and human resources. These resources can be redistributed to cover a wider range of activities with a marked improvement in the efficiency of services offered to users.

As far as the strictly technical aspect is concerned, there is a growing awareness for a homogeneous cartographic representation of the entire national territory that could be used a basic strata for other thematic layers, to be superimposed according to the needs.

As a result, the idea of implementing a large scale "basic cartographic layer" was put forward. This would be used as a support for subsequent processing, where uniformity of the "basic cartographic representation" could be a determining factor since the transfer of information is becoming more rapid, automated and without the critical verification by operators.

It is proposed with more evidence the importance of establishing a Governing Body with the authority to produce large scale cartographic maps, able to safeguard the operative conditions of this particular sector according to the above mentioned needs.

Such a task in Italy finds its natural solution within Cadastre. As a matter of fact, according to the law n. 3682 of March 1st 1886, the Italian Cadastre must keep and verify the records of the geometry describing the boundary of the land properties, the ownership, all the variations and mutations through history. In other words Cadastre is the inventory of all existing real estate properties existing on the national territory.

The second paragraph of the above mentioned law prescribes:
"to survey the shape and the extent of each individual property and to represent them on planimetric maps with geographic references".

The representation scale of the maps are mainly 1:4000; 1:2000; 1:1000; 1:500 that is according to the density of properties for a given area.

Aerofotogrammetry has opened new possibilities for updating and integrating maps with altimetry. According to the law n. 1043 of August 8th 1941 Cadastre was given the task to make maps that would have altimetry.

This makes possible to use cadastral maps, obtained with rigorous geometric specifications, for civil engineering applications.

With the law n. 62 of February 2nd 1962 Cadastre has been officially appointed as one of the five Italian State Government Cartographic Istitute.

Cadastre's long standing authority in the area of producing and updating large scale cartographic maps makes this Organization a reliable reference for all the other Public Organizations that have started projects on large scale maps following the proper needs of evolution for a modern Society that requires a rational development plan spread out all over the national territory.

Cadastre is often engaged to give techical cooperation for implementation of the most important large scale cartographic projects concerning Territorial Authorities (Regions, Provinces, Municipalities).

Furthermore the creation of new maps, updated by new features,may represent an exchange and an integration of information between cadastral maps and other level of geometric information proper of the local territorial Administration.

This exchange of information, that implies a significant commitment between Cadastre and other Organizations, can be more efficently done if the implementation of new cartography is standardized to exiting cadastral maps.

It is auspicable and convinient from the technical-economic point of view to update existing cadastral maps and to superimpose other thematic layers instead of other Organizations thinking of remake ex-novo maps to their needs.

The process of converting paper Cadastre maps into digital form is alive and priority has been given to the territorial areas where the paper support has adeguate characteristics and good geometrical qualities.

For the maps where these characteristics are satisfied, it was proved

to be possible the use of digitalization to obtain a good geometric data base where it is kept the accuracy of the land's boundaries. It has become reality to update,digital maps representing the territory, though computerized systems using graphic interactive stations.

Geometric updating of cadastral maps can be done substantially in two different ways:

- the first involves ground survey which is used mainly for updating limited areas;
- the second, based on aereophotogrammetry, is convenient for large areas.

The use of the latter method requires that certain preliminary conditions be met. We will illustrate these conditions, making reference to the project thate Cadastre is currently conducting with the Municipality of Modena.

The preliminary feasability study was begun in 1980 when the City of Modena felt the necessity to have a basic cartographic support, to be used as starting point for establishing a city-wide Land Information System.

It was decided to use Cadastre's maps as basic cartographic support because these maps were recent and also because it was possible to obtain related alphanumeric information by the computerized Cadastre Office of Modena. Between other things this Office was one of the first to use a diistributed cadastral information system.

The project was centered on areas characterized by a high level of urbanization and covering approximately 3.200 Ha, that were represented on 133 cadastral maps (scale 1:1000).

The updating and the integration by aerophotogrametrics technology required the definition of operational methods, and the choise of selected ground control points.

OPERATIONAL PHASES OF THE PROJECT

It followes a description of main operational phases.

A - Verification of the geometry of the maps.

In order to verify the metric precision of all maps it was taken a rappresentative simple consisting of 15 maps out of 133. For each sampled map were taken 50 ground measurements on materialized elements (buildings) where the distance from one element to the other was from tens of meters to hundreds of meters.

These verifications pointed up that the differences between the distances measured on the maps and those taken on the ground were in the order of centimeters, and that only a few differences were greater than 0.50 m.

The distribution of the differences found is shown in Table 1.

This table shows that to the increase of distances between verified elements corresponds an increasing number of measurements that have greater errors.

This was found to be related to the methods and instruments used when the maps were originally made(1960).

Figures 1-2-3 show the distribution of the measurements into graphic

form in relation to deviations and to the distance intervals between verified points.

B - Orientation of the stereoscopic models

On the base of the results obtained it was decided to use, as ground control points for the orientation of the stereoscopic models,corners of buildings univocally identified on the photogram and also represented on the original cadastral map. The coordinates values used were those red directly from the map through digitalization. That allows compensation of problems derived by paper stretch.

The purpose of this operation was to create an homogeneous reference system between the original map and the stereoscopic models in order to obtain the best fitting for the geometrical elements to by updated without decreasing the geometric quality of the final representation.

For elevation ground control points it was used the method of technical levelling done by the City of Modena: the height values of approximately 200 ground control points were determined.

The updated maps, compared to the original, pointed out the need to riexamine about 6200 new buildings derived by photogrammetrical updating.

Cadastre Office of Modena had official documents for 4210 of them.

Administrative cadastral files had been updated but was clearly missing yet the update of the relative geometry on the maps.

For the remaining 1990 buildings, it was discovered that about 1250 had been built according to law but not yet officially declared to Cadastre, while 740 had been built not in accordance with the law and not declared.

C- Implementation of the digital data base

Aerophotogrammetrical updating of the original maps was done using traditional analog instruments. The final cartographic product was then digitalized for further processing by the cadastral system and the land information system of the City of Modena.

For digital representation cadastral geometric data structure was used. The basic cadastral data structure was integrated with other layers proper of municipality features.

The schematic structure of the resulting geometric data base is shown in the seguent page.

Within the geometrical data base the parcel (land properties) represents the basic unit to which is possible to link associated information.

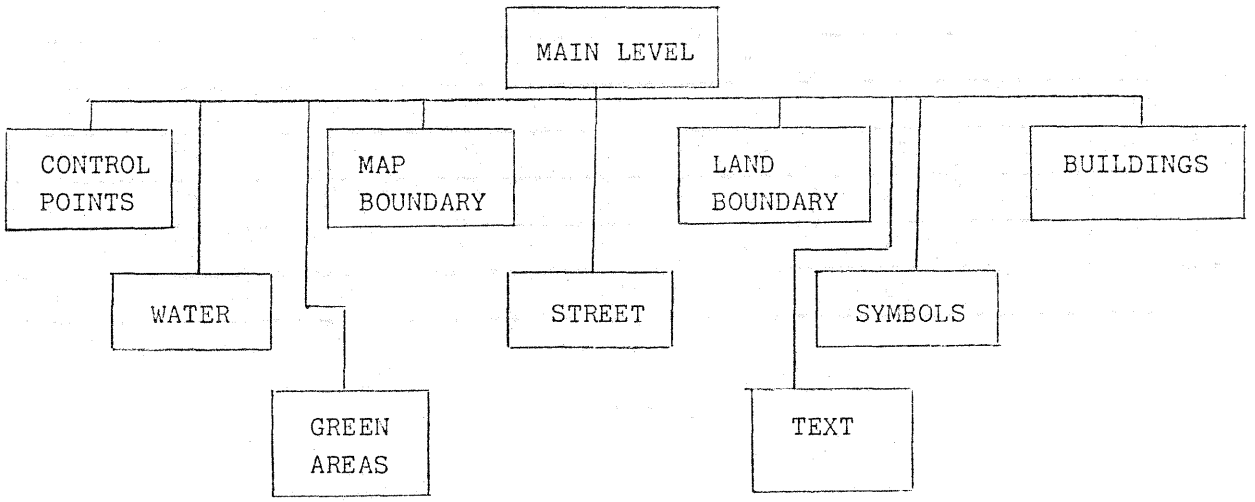
The final digital archive took about 70 Mbyte.

D - Geometric Updating of the new cartography

Keeping in mind that the two Organizations had a different hardware-software architectures, it was decided to use a standard transfer file to exchange data (National Transfer Format - NTF).

In this way, each Organization can be autonomous for managing the geometric data base that is institutionally of its own competence.

GEOMETRIC DATA STRUCTURE



CONCLUSIONS

Cadastral maps are suitable to be used as basic cartographic representations for land information systems.

The final cartographic product, eventually updated and integrated is homogeneous and geometrically accurate such that can satisfy the requirements and the needs connected with the planning of the territory.

Beyond the economic advantages associated with using an already existing official cartography,it is also opend the way to a real possibility of keeping the cartography constantly updated.

The exchange of files through network between the two Organizations allowes to keep both data bases constantly updated. This reduces the number of manual procedures and lower costs.

It should be pointed out that while Cadastre has the task of keeping updated the existing real estate properties all over the National territory, on the other hand Municipalities, Provinces and Regions directly manage the territory of their competence through infrastructures, civil and technological services in a more dynamic way.

In conclusion it is a fact that almost all activities concerning civil engineering projects on the territory are faced with problems related to land properties.. It is then clear the need for close ties and cooperation between Cadastre and all other Organizations involved in territorial planning.

range of deviation (mt)	range of ground distances (mt)						
	0 ÷ 100	100 ÷ 200	200 ÷ 300	300 ÷ 400	400 ÷ 500	500 ÷ 600	total
< 0.50	3	0	6	9	5	4	27
0.40 ÷ 0.50	4	4	37	33	42	56	176
0.30 ÷ 0.40	24	37	45	45	35	35	221
0.20 ÷ 0.30	37	43	40	35	33	20	208
0.10 ÷ 0.20	8	10	12	20	15	10	75
0.00 ÷ 0.10	4	6	10	8	10	5	43
total	80	100	150	150	140	130	750

Table 1

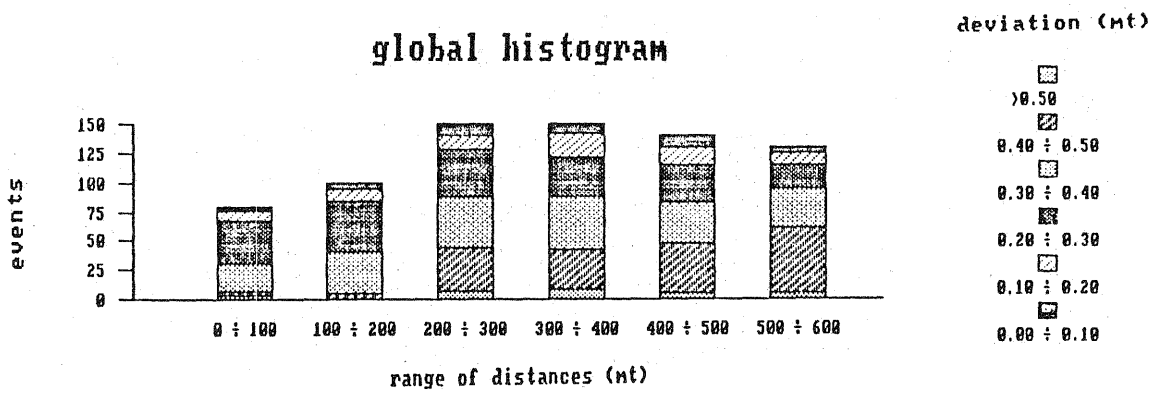


Fig. 1

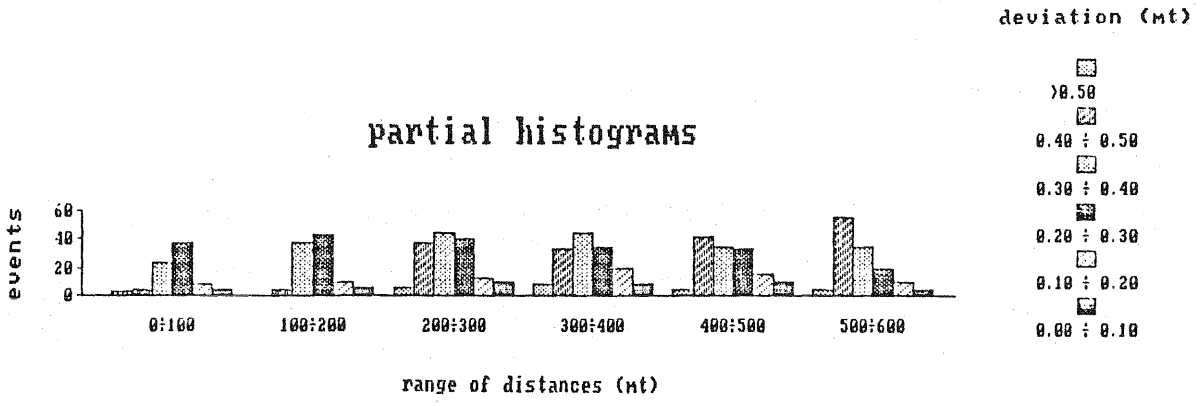

deviation (mt)
>0.50
0.40 ÷ 0.50
0.30 ÷ 0.40
0.20 ÷ 0.30
0.10 ÷ 0.20
0.00 ÷ 0.10
partial histograms
events
60
40
20
0
0÷100
100÷200
200÷300
300÷400
400÷500
500÷600
range of distances (mt)

Fig. 2

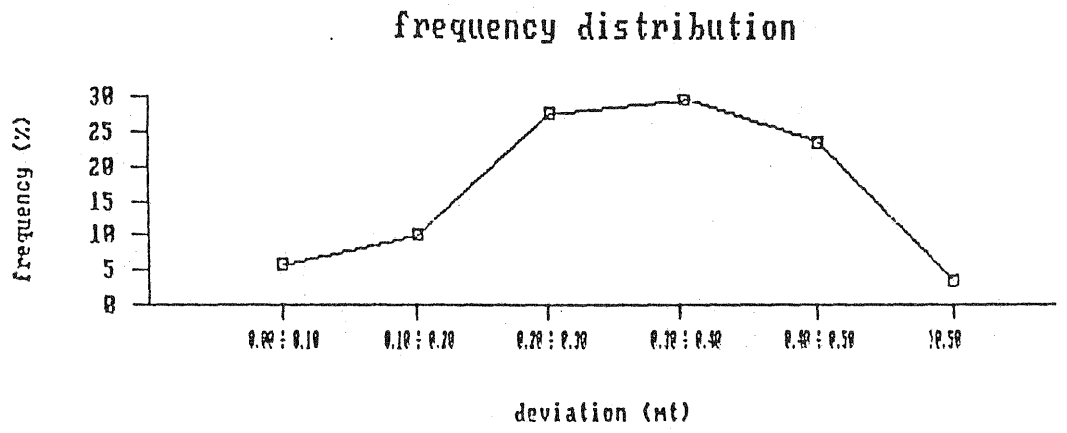

frequency distribution
frequency (%)
30
25
20
15
10
5
0
0.00 ÷ 0.10
0.10 ÷ 0.20
0.20 ÷ 0.30
0.30 ÷ 0.40
0.40 ÷ 0.50
>0.50
deviation (mt)

Fig. 3