SAMPLE CARTOGRAPHIC PROBLEMS FROM SMALL TO LARGE SCALE AND GIS APPLICATIONS

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ABSTRACT

Cartographic detailed knowledge and description of the territory are always more requested to support data acquisition and Management, correlation between human activity and available resources, govern of change and forecast, to guaranty the quality of the environmental policy and sustainable intervention. Different surveying methodologies and different cartographic representations from small to large scale need to be strictly related: the logical connections between themselves oblige to not separately treat cartographic information and require an effort to build congruent description in open systems. For decision makers it's important to use organized information in suitable Temporal GIS.

Three topics: the new frontiers of the digital photogrammetry, the GPS diffused employment, the knowledge of the territory through the Cadastral Mapping.

1. INTRODUCTION

I'm very pleased to take the floor, also on behalf of my colleague Raffaella Brumana, invited by the Prof. Luigi Mussio, excellent host of this Committee together with the Prof. M. Sara De Torres Curth, about a general subject quit improvised since expected only inside the Poster Section. From the oral presentation which took place in these days by Argentine and South American colleagues it's clear the interest for three main topics: the new frontiers of the digital photogrammetry, the GPS diffused employment, the knowledge of the territory through the Cadastral Mapping. These three subjects can be strictly related inside the Geographic Information Systems.

I'll try to make a synthesis, like requested, on the state of art in Italy in these fields. On the first subject the Prof. Forlani has already taken an exhaustive speech.

1.1 GIS and GPS: Present situation and Prospects

GPS is developing world wide tank to the different applications, but it opens also lot of problems: the satellite observations cannot be confused with the real co-ordinates of the points. The last one are the result of complex stochastic models of processing data. The efforts of our disciplines to obtain precision of some centimetres are directed to reach always more approximate degree, economically sustainable, optimizing measure, analysis and modelling methodology. But I would be constructively critic. Shape and dimension of the Earth have occupied famous scientists in the past, together with the movement of the Poles and the gravimetric anomaly: GPS give the possibility to connect long distance points. But Russian scientist with high effort measured between 1816 and 1855 the Latitude arc (25°, 25'), about 2820 km, between the mouth of the Danube and the Isle of Fuglenacs in the Arctic Sea, through a network of 258 triangles, with an error not greater than 12 m (Struwe).

The problems about the Earth are complex and every time we think to reach the best level we discover other field of research!. It's the case of the Geoid (Fig.1). The Earth is not a rigid structure because of the phenomena (earthquakes, etc.) which move the masses; the rotation terrestrial axis moves itself (i.e. S.L.A.R. methods have specified the aspects of the problem); luckily the real important thing is the symmetry of dynamic effects. The contribution to the research in the field of the study of the Geoid was very important from the expedition to the Peru' (1735-1741) of La Condamine and Buguer, and to Lapponia of Maupertuis and Cleraut (1736-1737). From that century it has been made measure of the deviation.

When we'll have the knowledge of the Geid with some centimetre precision, we'll use the GPS such a level! Only at that time we'll have the 3D knowledge of points determined on the terrain. There are some areas in the Earth in which we know the Geoid with the precision of the order of 10 cm. In Italy we have a new network determined with GPS distributed on the territory with a good density of points (one for 300 km), with an uncertainty of the cm order: it allows to use this network

THE EARTH GRAVITY MODEL: EGM96

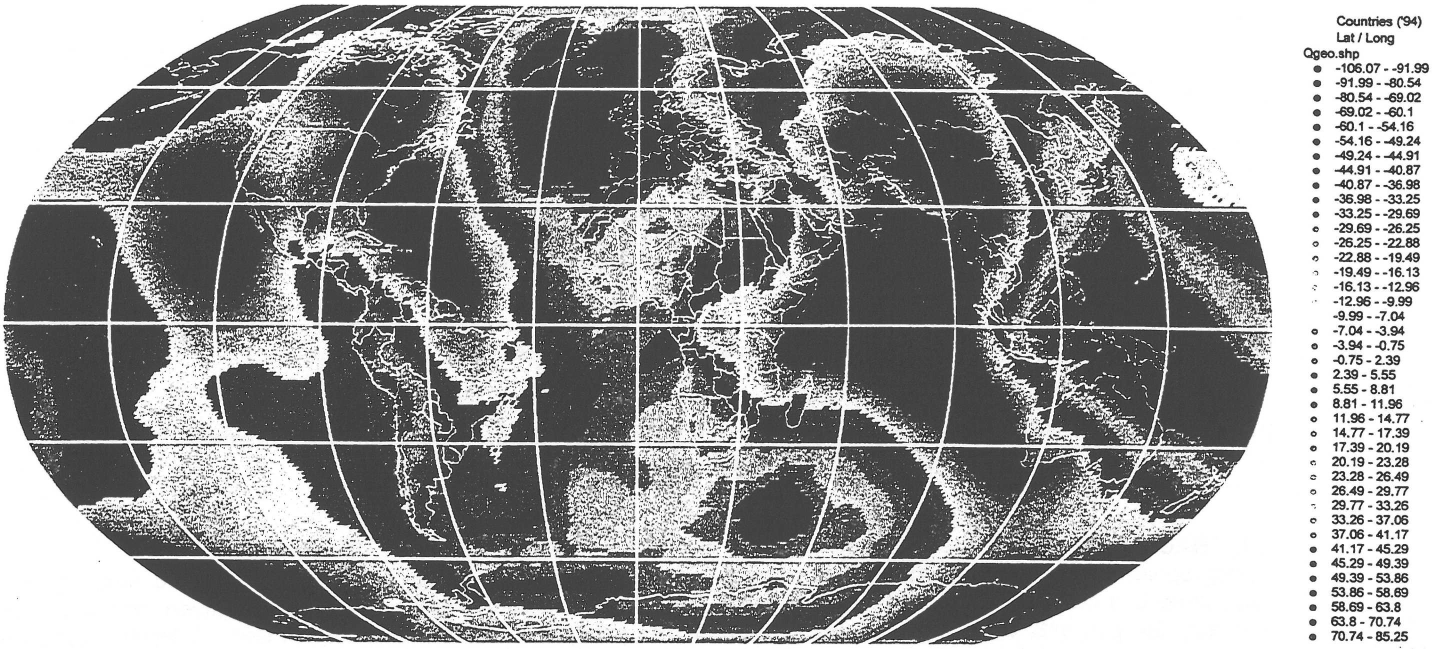


Fig. 1 Map projection of the EGM96 obtained on the 64800 values referred to the geographic coordinates and managed with ArcInfo

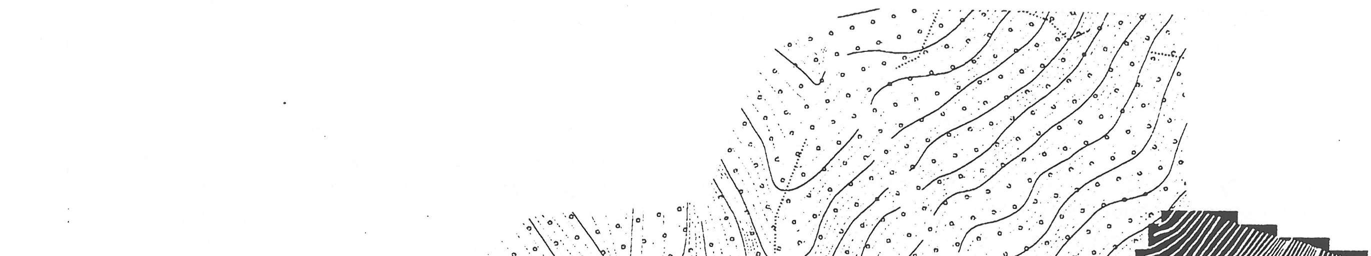


Fig.2 An example of the Numerical Cartography of the Commune of "Olgiate Molgora" at the scale 1:2000 with the cover organization (soils use, rivers, streets, buildings, administrative limits, etc.) managed to support the urban planning (PRG) and administration. It has been superimposed a raster representation using GRID tools of the Analyst Module of ArcView 3.0 of the altimetric shape of the terrain obtained by the "Elevation" attribute table of the contour lines. The integration between the Local Government, the Register Office and the Land Register and Cadastral Office will request in the next future to integrate in such a GIS also the Cadastral Maps with the related table of attributes (the "property", the "parcel number" and the "covered surface).

to support the production of technical cartography at scale 1:10000, 1:5000 and at the large scale too. The last one are necessary to support the urban planning and management and now they'll become the natural referent for the Cadastral Cartography and related data (Fig.2).

1.2 Present situation and Prospects in Italian Cadastral Cartography

The beginning of the Italian Land Register and its activities can be divided into two distinct periods. The first includes the constitution or formation of the New Land Register which was set-up with the Land Register Law of 1886 and ended in 1956 and the second followed with activities concerning the conservation and updating of the Land Register. The realisation of an autonomous trigonometric network was programmed right from the beginning, supported by the national geodetic network, (set up by the Military Geographic Institute (IGM) after the Italian unification), and connected to the network's first three orders. The Land Registration Network is also organised in four orders, in similarity to the IGM network which is less numerous in terms of vertices.
The survey of the land register maps was mainly based, from the start, on the revolutionary technique of the tachometric or celerimensura surveying, so that in the original formation, the result being that 83% of the maps are surveyed with this method, 13% with the so called lining up method, 3% with the photogrammetric method and only 1% with the plane table. We have to recognise the fact that the Italian Land Register was the first in the world to introduce, as early as 1934, the photogrammetric method as a current surveying practice in well determined situations. In fact, before the Second World War, two entire provinces had already been surveyed using this technique, as well as a few towns in other provinces such as Rome.
Statistically, the Land Register includes 310,000 maps of various scales, with 70 million particles, for 17 million owners. With the word 'particle' we mean to specify a plot of land situated in the same town and registered in the name of the same owner, with the same cultivated unit, and with the same quantity and class.
At present the Land Register belongs to the Territory Department, which is one of the three departments where the Ministry of Finance has been restructured. This department has a reference role in the technical, legal and fiscal activities concerning public and private real estate situated in the national territory. Leaving out the various tasks that the department is appointed to do and limiting ourselves to the description of the subjects concerning the constant revaluation of the cartographic land register document (the basis of the majority of the above mentioned activities), it is necessary to underline the technical and economic relevance that this revaluation has, in two particular instances:

- The role of support and topographical & geometric identification of the real estate, connected to the descriptive files of the registry of land, buildings, conservatory and state property.
- The role of support which is socially correct for imposing property tax and the potentially fundamental role that this updated cartography and integrated altimetrically could have, in an informative territorial system on a town basis or/and on a wider basis.

These considerations imply a revision of the informative contents of the maps and the necessity of starting update processes in terms of contents and accuracy in order to fulfil correctly the aims that have to be reached. It is clear that this subject also depends on a context of costs which are all but without important and that obviously condition the technical choices available.
The Land Register administration has been running, for some years, the formation of the geometric numeric Land Register using two different methods:

- The formation of new cartography directly in numeric form using land surveys or by aerophotogrammetry.
- The numeration of the existing maps either automatically or by manual digitisation.

It is evident that choosing one method or another implies different time periods, accuracy and costs. It is easy to observe that the first solution, certainly the best for accuracy and contents, clashes with the times for realisation and above all with the costs that it implies. This is why the largely practised solution was and still is the digitisation of existing maps.
Comparing the two operative choices for their time periods and costs on the basis of a large sample taken on a national territory, one can estimate the following:

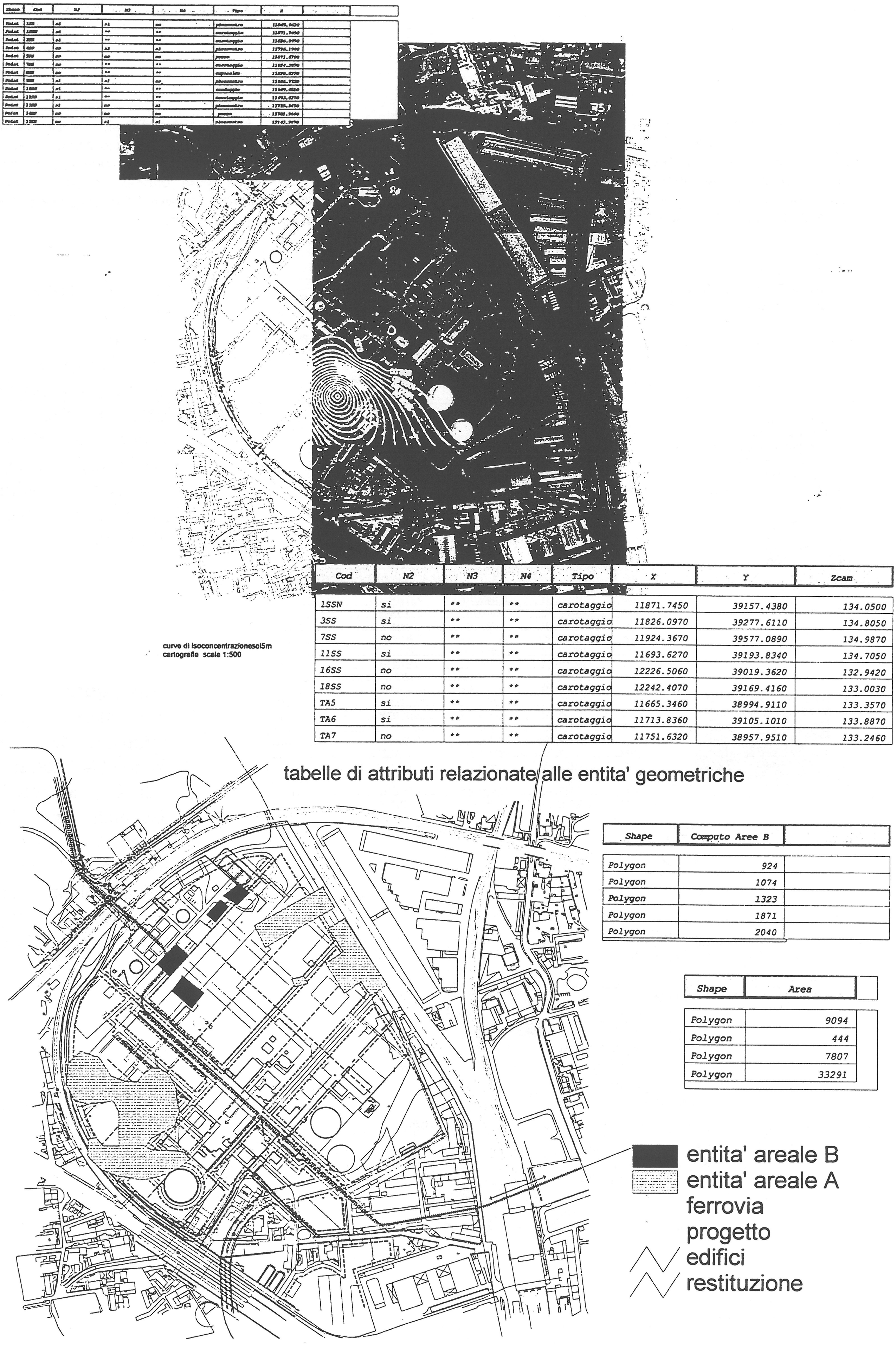
- In the case of a single survey ex novo using the aerophotogrammetric method one can realise a cost of approximately 14 million lire per map sheet (1:1000 scale), with a unitary cost of 400,000 lira/ha and a production rate of 1.5 ha/hour. An average sheet consists of 35 ha and contains around 400 particles.
- Likewise the second would cost approximately double (1:2000 scale), where one could realise a production of 3/4 ha/hour. The cost per particle in this case varies from 35,000 lira (1:1000 scale) to 140.000 lira (1:2000 scale), where the number of particles is on average 200 on a 120 ha surface.

The planimetric and altimetric accuracy are 40 and 5Ocm, 80 and 100 cm, respectively for the two scales. Traditional costs (for the two scales) show a doubling in production (ha/hour) with a reduction of 20 to 30 % in costs. The digitisation of existing maps requires roughly identical production times to those obtainable using the photogrammetric method, but the cost is drastically reduced if the digitisation is done using semiautomatic techniques. Naturally, in this case the accuracy depends wholly on the method used, but in any case the qualitative and geometric errors found in the maps always remain. In economic terms, the reduction value varies from 1/8 to 1/2 of the costs, for the realisation of cartography ex-novo. In the Italian case, the number of maps which were considered acceptable for use with a manual or semiautomatic digitisation techniques were estimated at roughly 270,000. Whilst the remainder would have to be redone from scratch. From 1988 (when the digitisation project began) until 1992, approximately 90,000 map sheets were processed. A third of the specified total. It is foreseen that the project will be concluded in around 7 to 8 years, using the available financial resources. Due to territorial alterations and updating difficulties, a remaining 40,000 maps (approximately) have to be completely redone, using either the photogrammetric method or by carrying out terrain surveys using electronic celerimensura.
From 1987, legislation has been brought into action for the revision of the procedures in the drawing up and in the geometric acts of updating. These acts refer to variations concerning limited territorial areas but involve a

myriad of sparse zones within the national territory The new legislation proposes to set in motion a substitution of digitised information in numerical maps replacing them with more precise information derived from direct topographic surveys of land. Specified check-points are set out by the administration, for each map, and their co-ordinates and inaccuracies are also noted down. Those who compile the fractionating and subdivisioning plans have to connect to these check-points and strictly follow the written procedures using modern instruments and compensate these measures with a program supplied by the cadastral administration called PREGEO.
In this way it will be possible to give to professional the task of measuring the particles to be updated with reference to the network of points chosen, measurements carried out according to precise rules and methods and provided by the administration on computer support, while to the latter the task of management of the measurements of existing maps is assigned.
The result is a cartographic recomposition and the recovery of the characteristics of accuracy that the map must have for its correct use.
This operation obtains the immediate effect of redefining the form and dimensions of the particles involved in the updates (boundary lines, new buildings, new manufacturers, etc) and then getting the cartographic reconfiguration ready in well determined situations, cartographic reconfiguration obtained by means of local rototranslations based on cheek-points inserted in the networks used for the determination of the above mentioned elements.
After 7 years of experimentation one can say that this procedure has obtained important results. 1.7 million updating acts have so far been carried out, acquired in numerical form; more than 4 million particles have been re-determined in form and consistency; more than 1 million check-points have been used in updating surveys and have been entered into a cadastral network database. This large operation was made possible thanks to a collaboration among all those working in the sector who had to adapt themselves in a short period of time to a modem methodology and new instruments. This has led to a notable development in rigorous compensation methods and data management through PC technology.
As pointed out earlier on in the discussion, it is important to look upon the numerical cadastral maps as only part of a territorial information system (SIT or GIS or LIS). It is therefore necessary to have in hand the altimetry of the same maps, a characteristic not typical of cadastral maps. In the light of this discussion one must recognise the fact that it is necessary to create a database of trigonometric vertices which are the same for all public and private institutions operating in the territory.
Given the extraordinary number of particles in Italy, approximately 70 million, and the consequent difficulty in the management of such a large number of data and information connected with it, the opportunity to modify the concept of particle itself is understandable, connecting it to a geometry of possession and propriety, no longer to the type of cultivation which at that moment is extremely variable, also in relation to community politics and the relative contributions.
An estimation of classification of the particles according to the geometry of possession reduces their number to little more than 1/3. But if on the one hand we recognise the necessity of revising the rules which are typical of our land register, which moreover date back to more than a hundred years ago during the reunification of Italy and have a wellrooted historical tradition (i.e. the land register of Carlo VI and Maria Teresa of Austria for the Lombardo-Veneto realm, the land register of the Repubblica Veneta, the land register of the Pontifical and even further back in time that of the Roman Empire), on the other hand then we must recognise that it is compulsory to take speedy choices for the updating of the cadastral cartography. Among these the techniques of photo identification by means of digitised photo grams, straightened and superimposed on rasterised or vectored maps.
We saw how superimposing permits a fast identification of the elements of updating present on the photo gram and not represented on the map. The current hardware and software systems that run the superimposition allows one to shift the information in raster or vector format from one support to another, i.e. from a photo gram to a map. This implies, of course, a series of procedures that can be summarised as follows:

- Digital raster acquisition (approximately 1000 dpi) of the photo grams with a 23 x 23 cm square format of the areas involved in the updating. We saw that even photo grams on a 1:2000 scale, equivalent in as much as representation of a surface of about 7/10 map sheets, are enough for the aim mentioned above.
- Digital raster acquisition of map sheets (approximately 150 dpi)
- Superimposition of the map sheet images of the map sheets and of the corresponding photo gram, both raster or the first in vector format. This super-imposition is done via software singling out corresponding points easily traceable on both images (ground control points).
- Photo identification of buildings not counted in the census or elements that have changed over time.

This speedy procedure is certainly not comparable for its accuracy with an updating carried out aerophoto-graphically or using land topographic surveying, as the scale of the map sheets are generally 1000 or 2000. However, it is a great help in adding to our knowledge of the territory and of the changes that modified it.
We can see that a single way of proceeding does not exist but a series of procedures that can and have to integrate with each other in such a way as to obtain a satisfactory product in terms of time and costs. This type of procedure aims at the constitution of a database which includes metric contents of the represented elements, altimetry included; the chronological contents (the history of the acquired elements and updating); valid qualitative contents; and administrative contents which permit connections to other census data to be made.
Summarising what has been discussed, we see that the effort which is being carried on in Italy is comprehensive. We can also sec, though, that cadastral cartography, recovering that quality that should be intrinsic in it, is assuming a fundamental function for the knowledge of a territory and its estate changes, so that it can represent one of the basic elements of an informative territorial system.
The representation scales 1:1000 and 1:2000 have a great metric content in an ex-novo cartography and have uncertainties that, as we know, are limited to very small values, i.e. a few decimetres at the most.
It is evident that recovering the accuracy in the maps means also recovering and reorganising all of the framed



Cod	N2	N3	N4	Tipo	X	Y	Zcam
1SSN	si	**	**	carotaggio	11871.7450	39157.4380	134.0500
3SS	si	**	**	carotaggio	11826.0970	39277.6110	134.8050
7SS	no	**	**	carotaggio	11924.3670	39577.0890	134.9870
11SS	si	**	**	carotaggio	11693.6270	39193.8340	134.7050
16SS	no	**	**	carotaggio	12226.5060	39019.3620	132.9420
18SS	no	**	**	carotaggio	12242.4070	39169.4160	133.0030
TA5	si	**	**	carotaggio	11665.3460	38994.9110	133.3570
TA6	si	**	**	carotaggio	11713.8360	39105.1010	133.8870
TA7	no	**	**	carotaggio	11751.6320	38957.9510	133.2460

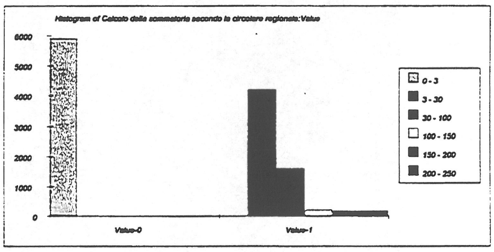
Shape	Computo Aree B
Polygon	924
Polygon	1074
Polygon	1323
Polygon	1871
Polygon	2040

Shape	Area
Polygon	9094
Polygon	444
Polygon	7807
Polygon	33291

Fig.3 GIS to support the analysis of environmental characterization in polluted areas, intervention policies, sustainable intervention and risk analysis: "The old industrial disused area of the Bovisa".
The superimposition of the rectified image of the area georeferenced to the photogrammetric restitution allows to related the green area to the isoconcentration model of the different substances, obtained through SQL connections to the Data Bank in order to support decision of the environmental experts about the choice of the methodology of intervention.

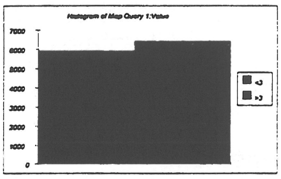
Fig.4 Data Management: simple or complex relationships, dynamic and cinematic models of the diffusion of the substances, related to the state of art of the physical characteristics of the subsoil (such as porosity, hydraulic barriers, waterproof artificial manufacts, presence of ground water tables, etc.) can be traduced by algorithmic functions developed inside the query process. In the tables are related the positions of the logs with an ID-Code to the different depths at which the sample analysis were made: it has been drew up samples in order to punctually survey the level of underground water and soil pollution due to compare the degree of pollution with the values admitted by the current laws.

Map Query:
comparazione di dati rilevati con valori ammessi dalle normative
(es. estrazione dei valori <3)



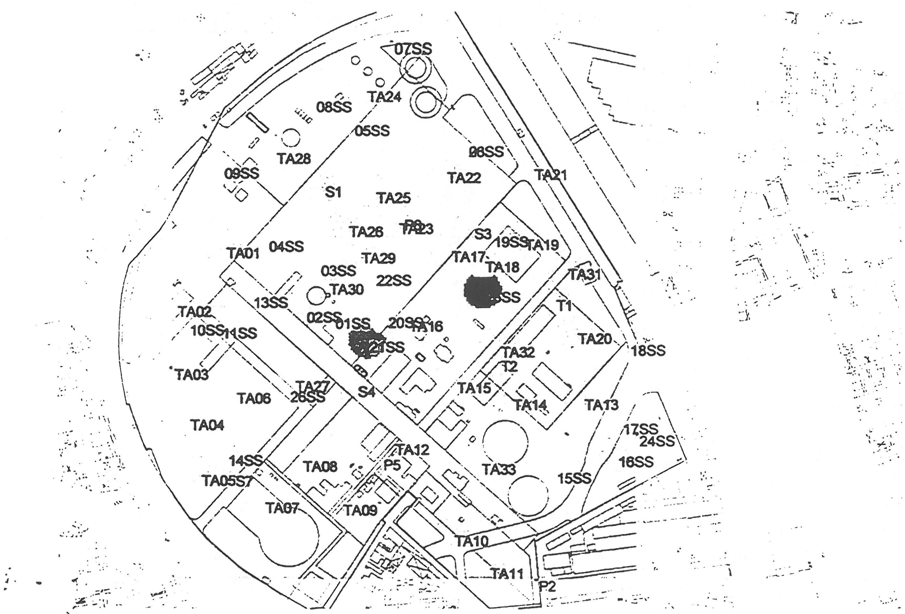
Isoconcentration model of the polluting substances obtained interpolating data of the samples acquired at the different depths in the terrain (the attributes are topological related to the ID_COD with the coordinates of the points of survey) .

ril-vasche
ril-recinzione
prog-aree-sup-fond
rilievo fabbricati
aem-edifici
Calcolo della sommatoria secondo la circolare regionale
0 - 3
3 - 30
30 - 100
100 - 150
150 - 200
200 - 250
No Data
Talq1.shp



COD	X	Y	Total Of Ccalc/Cli	1-2-4-TRIMETILBENZENE
01SS	1511845,962	5039206,741	2,15959008	
03SS	1511826,097	5039277,61	2,36549344	
04SS	1511756,194	5039310,911	3,06040752	
05SS	1511871,681	5039467,226	2,36367648	
08SS	1511820,831	5039499,969	3,27770064	
09SS	1511696,775	5039409,017	2,51291856	
10SS	1511649,399	5039197,652	2,18469408	
11SS	1511693,625	5039193,833	159,2587219	
13SS	1511735,346	5039234,307	39,33597472	0,5456
14SS	1511701,555	5039021,959	32,0764264	
15SS	1512143,955	5038997,317	2,7194064	
18SS	1512242,401	5039169,397	5,83265168	
1SSN	1511871,744	5039157,432	164,17776	
20SS	1511916,164	5039207,56	2,07469712	
21SS	1511891,046	5039174,402	470,7612168	
22SS	1511900,212	5039264,529	3,06363248	
23SS	1512025,925	5039438,412	1,8505168	

Map query: through map query it has been compared data surveyed from the terrain with values admitted by Regional and National laws (i.e. an extraction of the data with index < 3 in green colour and the chromatic scale of values > 3 on the fixed range)



networks of the maps themselves and particularly through the insertion of check-points in a context of a univocal network of high precision organised on a hierarchical scale. Therefore the administration foresaw the survey using electro-optical instruments, with GPS instruments, with aerial triangulation from stereoscopic models of a new network in which the previously mentioned check-points are framed and divided into two levels of numerosity and different accuracies. A principal net with a vertex every 10 km square, with a diversified uncertainty for urban expansion areas, for agricultural areas and mountainous areas, or areas covered with wild vegetation. This uncertainty varies between 10 and 30 cm for the planimetry and double for the altimetry. A secondary net with a vertex every 10/25 has double the uncertainties in comparison with the above-mentioned ones. This network which will be supported by the IGM 95 one, surveyed *ex novo* with GPS over the entire national territory (about 1000 points), will result in the determination of 30,000 new vertices, in a period of a few years.

In conclusion one can say that the most consistent procedure in the production of cadastral cartography on a large scale is the photogrammetric method, which allows besides a high level of accuracy also a direct knowledge of the territory given by the aerial photographs but it is costly and requires time periods which are relatively long. The direct land survey by means of electronic celerimensura is very accurate and less costly than the photogrammetric one, but it does not benefit from the continuous knowledge of the territory which the other method, on the contrary, does. Having, on the other hand, a complete map covering of the territory, as in the Italian case, even if with very different characteristics of quality, updating, and accuracy and due to the urgency of having an informatised cartographic instrument, I believe that the choice taken by the land register administration is the correct one, even with its previously mentioned limitations and difficulties.

1.3 Applications. GIS to support the analysis of environmental characterization : "The Bovisa area"

Environmental risk information, Data acquisition and Management, correlation between human activity and available resources, govern of change and forecast are some of the basic topics to guaranty the quality of a complex project.

For the Public Administration it's mandatory to use geographic information for the description of possible dangerous events, natural phenomena, degree of the pollution levels, related to human risks and to economic development of disused areas.

Therefore for decision makers it's important to use organized information in a suitable GIS.

Such a GIS operates in geographic domain and has to be able to acquire, handle, produce georeferenced data, that is the Numerical Cartography with all the linked data.

Inside the Department of DIIAR between the section "Rilevamento" and the section "Ambientale" it has been developed a GIS application on a polluted industrial area in order to support the analysis of environmental characterisation. The Bovisa area is in part a disused industrial area: two hundred years ago it took place the most important national chemical and petrochemical industry. Now the are the gasometers of the AEM, the Municipalized Agency of the gas supply of all the city of Milan. In this area there will be build up the Second faculty of Architecture and the second faculty of Engineering of the Politecnico of Milan. This complex area has to be put on safety and reclaimed: it has been study an hypothesis of GIS in order to support the environmental policies of intervention, sustainable intervention, and the risk analysis (Fig.3).

Data Management: the first step is to build and organize the GIS Model through logical relations between the tables of attributes (DATA). The relations can be traduced by simple or complex algorithmic functions developed inside the query process. In the tables are related the position of the logs with the ID-Code to the different depths at which the sample analysis were made in order to punctually survey the level of underground water and soil pollution and the concentration of the different dangerous substances (Fig.4). The one to many typology of data organization allows to relate to the single position of the wells the different deeps at which the sample were drawn out.

The superimposition of the rectified image of the area georeferenced to the photogrammetric restitution allows to related the green area to the isoconcentration model of the different substances in order to support decision of the environmental experts about the choice of the methodology of intervention. Perhaps it is possible to quantify the volume of polluted soil to be reclaimed through the TIN model built on the topographic and GPS survey; it's possible to manage the TIN model related to the volumetric model of the buildings; it allows to evaluate how it could be possible to reclaim area and to guarantee people use and access to the green area; this complex 3D temporal GIS model become an instrument to support decisions, perhaps if it's better to take away the volume to be washed or if it's necessary to put in safety the area through hydraulic barriers, etc.

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