Altimetric and Tridimensional Aspects for the Updating of Cadastral Archives

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Key words: Digital cadastre, altimetry, GPS, 3D objects.

SUMMARY

The innovations made in the Italian "Pregeo 8" specifications and, particularly, the adoption of the G. P. S. system, with the introduction of altimetric information, would enable the possibility to use the cadastral data-base as basic support for the development of GIS at local scale. Some problems would arise if the uncertainty connected to coordinates of fiducial points is not overcome, with the consequent risk of invalidating all the updating process.
In a first phase, this study refers to some experiences in compliance to new realized dispositions, with the aim to contribute in using of cadastral archives, indispensable for property definition and correct territory management.
As the current cadastre systems are based on 2D parcels, the physical 3D objects cannot be defined as cadastral objects and there are limitations in representing the complex internal structure of the buildings on geometric and thematic dimensions in the 3D entity levels.
In the last phase, this paper contains some reflections on 3D cadastre, with the aims of analysing the current Italian situation and seeking to define some recommendations regarding future developments in three-dimensional and spatial cadastre, that will replace the existing two-dimensional graphical surface cadastre.

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1. INTRODUCTION

With the legislative measure of 3th December 2003, the "Pregeo 8" procedure for the Italian cadastral updating, both in cartography and in altimetry, with GPS data processing has been approved.

Such innovations imply new future user skills in Geomatics disciplines. These last ones are in rapid evolution in connection with the progress of computer technology, both in measure operations and in next numeric treatment.

This procedure aims to the optimisation of updating process of administrative and real estate cadastral archives and introduce numerous innovative aspects compared with previous procedures. Some of these innovations regard managerial aspects, such as:

- issue of map extract in digital format;
- confirmation of digital map extract, prepared for digital updating by a professional worker;
- real time updating of cartographic and administrative census archives.
- Other innovations precisely regards the topographic aspect:
- the possibility to use GPS methodology in survey execution;
- obligation of altimetric data acquisition.

These last aspects have led us, in the first part of this study, to reply a cadastral updating by means of GPS instruments, already executed with a topographic total station.
In this way it is possible to make a technical and operative comparison between the two methodologies, by means direct experience on field, applying current techniques and instruments, not only for metric result, but for global consideration.

2. SURVEY OPERATIONS WITH "PREGEO 8" CADASTRAL PROCEDURE

In this study the comparison between conventional and GPS survey methodology for a map registration is executed on a parcel test that is part of the municipal district of Foggia in the Apulia region. All the vertexes and the fiducial points used for the grid were accessible with GPS, trying to avoid the use of out-centre stations.

The conventional survey was carried out with the Nikon DM 520 topographic total station and did not presented particular difficulty, except for the necessity to execute nearest stations, because buildings limited the visible field.

In order to execute the GPS survey, two TRIMBLE 4600 receivers and a GPS permanent station installed on the "Eugenio Masi" Technical School for differential corrections were used. This last station has worked since 1996 and became a vertex of IGMI '95 network.

On the fiducial and the parcel points the fast-static modality of receiver was practiced, with twenty-five minutes of permanence. The GPS methodology had offered the advantages to overcome scarce visibility of points, by avoiding polygonal measures for the link of fiducial points.

On the contrary, GPS accessibility was not always possible because of multipath effects and loss of useful satellites. The necessity to execute out-centre stations can usually make vain the utility of GPS survey.

FIDUCIAL POINTS	TOTAL STATION SURVEY	TAF	DIFFERENCES
PF04/127A/D643-PF19/1270/D643	233,348	258,073	-24,725
PF04/127A/D643-PF23/1270/D643	294,804	306,420	-11,616
PF19/1270/D643 - PF23/1270/D643	234,070	229,969	4,101

FIDUCIAL POINTS	GPS SURVEY	TAF	DIFFERENCES
PF04/127A/D643-PF19/1270/D643	233,268	258,073	-24,805
PF04/127A/D643-PF23/1270/D643	294,641	306,420	-11,779
PF19/1270/D643-PF23/1270/D643	234,080	229,969	4,111

Table 1: Distances between fiducial points (in meters)

The obtained accuracy in the determination of the coordinates of points is more then sufficient for the aims of our survey. Table 1 shows the calculated values obtained with PREGEO 8 processing.

While the distances measured by using a topographic total station differ from the distances measured by G.P.S. methodology of some centimetres, their difference, compared with the values of coordinates present in the archive of the fiducial points of the Agency of Territory, is in both cases of several metres up to reach the value of about 24 metres.

It is evident that the convergence of coordinate values was not verified because of reiterated calculations towards more reliable values. A suggestion could be the obligatory inclusion of permanent station data in survey.

By this time, the wide spread on territory and the reliability of data in a single reference system could make permanent stations a valid alternative to conventional methods, if they were introduced as vertex of I. G. M. I. '95 network. Moreover, we cannot overlook the close-meshed processing of the same network by many Institutions in order to use it as framing network also for cadastral survey.

A further consideration must be made on the altimetric reference. The possibility to use altimetric heights deduced from cartography at different scales can generate ambiguousness. As demonstrated in this study, it is evident the presence of various errors in the heights of fiducial points acquired in the Cadastral archives of Foggia. Particular importance is the fact that the heights are geodetic, while that ones provided by GPS system are notoriously referred to the ellipsoid. The value of the geoids undulation not always is known or easily determinable. In the territory of Foggia such undulation is nearly constant and the problem can be overcome by using known values (as permanent stations).

Elsewhere the problem is more complex when GPS observations are requested, since it would be necessary the link to levelling datum points. One solution could be the integration of cadastral cartography with vertexes of IGM fundamental geodetic network, with the necessary adoption of a unique reference system (UTM – WGS 84).

3. THE DECENTRALIZATION OF CADASTRE TO ITALIAN LOCAL AUTHORITIES

With the "Bassanini" legislative decree n. 112/1998, which appoints Municipality the functions of preservation, utilization and update of the Cadastre acts, starts the process of decentralization of Cadastre to local authorities. The effective phase of this decree begins three years later when the Official Gazette of 27 Feb. 2001 publishes the D.P.C.M. of 19 Dec. 2000. In the same decree the date 26 Feb. 2004 represents the extreme date to carry out the decentralization, while the following D.C.P.M. of 21 March 2001 states the financial resources and the necessary quota to fulfil the process.

The process of decentralization aims to better the technical-administrative integration between Municipality and Cadastre and the knowledge of real-estate and the process of imposition upon them as well as to favour the process of alignment between cadastral and municipal information; moreover it aims to give citizens a more functional and "closer" service.

The process of decentralization is directed and coordinated by the Agency of Territory which takes it upon itself to manage this passage and the transitional phase towards the new situation of the decentralized Cadastre. For this reason the real process of decentralization has been preceded by a procedure of experimentation which is still near completion. The decentralization of Cadastre to local authorities may be regarded as the chronological succession of these three following passages:

- definition of routes to be realized and of modalities of organization;
- experimentations on real cases and cognitive surveys;

- a proper decentralization on large scale.

The first phase has been already completed in the ministerial ambits and inside the Agency of Territory and has allowed both to outline the ways to fulfil the following phase of experimentation and to establish the guidelines to start and manage the whole decentralization.

At first the phase of experimentation has interested only some municipalities. In short, the aims of the phase of experimentation can be pointed out as follows:
- to simulate the possible paths of decentralization in order to have an accurate plan of process;
- to study the possibility of create inter-municipal cadastral poles for the management of the municipal activities on territory;
- to define the modalities of division of human and financial resources to transfer to Municipalities for the practice of cadastral functions;
- to study the role - in particular a technical-cadastral role- of the Agency of Territory once decentralization has been completed.

Beside the phase of experimentation in pilot areas, the Agency of Territory has also started a communicational action in order to survey the reactions and the wills of municipalities and of the technical personnel dealing with decentralization.

The model of decentralization which has been planned and to be fulfilled in the future is essentially based on the institution of the cadastral poles and on the duality between these ones and the offices of the Agency of Territory.

The process of decentralization will have an operative conclusion when the Agency of Territory will no longer deal with the cases which fall within the competence of the cadastral poles. To the operative conclusion will correspond a formal conclusion through a DPCM which will formalize the transfer of human, financial and instrumental resources from the Agency of Territory to Municipality.

The delay in the process of decentralization observed in the case has led to the need of extend for two years the deadline of such decentralization: with the DPCM of 22 July 2004, such a deadline has been updated to 26 Feb. 2006.

Moreover, in the course of 2004 people worked on the “flexible” decentralization: the cadastral functions would pass to Municipalities through “modules” of cadastral activities and services gradually assumed.

Flexibility would obviously concern the transfer of human, instrumental and financial resources in relationship with the really assumed cadastral activities and services and with criteria of division based on parameters of population, real estate registered in the cadastre and territorial surface.

The process would involve a further revision of the structure of the informative cadastral system in order to guarantee the interoperability of databases.

In spite of these efforts, troubles concerning decentralization remain and situation seems not to be completely defined.

In Italy, Cadastre derives from a multitude of cadastres preceding the unification of Italy and it is not consistent with any other Italian cartography.

Perhaps decentralization would have helped cadastre to redefine itself on the real exigencies of local authorities which do not lie in opening a decentralized desk at its own office but in integrating this thematic base with multi-scale topographic databases, basing itself on a unique system of coordinates compatible with the rest of Europe (Biallo, 2004)

This need is still further pointed out by the chance of utilization of the third dimension even for the archives of the Urban Cadastre which obviously foresee the planimetrical representation on a very big scale of the planimetry of single flats, that is of single living units.

The adoption of the third dimension introduces new problems, such as the height of buildings, numbers of floors, DTM of the surrounding ground etc, to be faced up to and solved in order to integrate the cadastral datum - inclusive of property, surfaces, fiscal data etc.- even in a GIS ambit for the knowledge, the development and monitoring of territory.

All these problems are difficult to register and to represent with the existing 2D databases.

In the last years, the scientific research in this field was fully oriented towards 3D dimension in GIS contexts, but for Cadastre aims some advance is still requested.

4. 3D DIMENSION IN TOPOGRAPHIC DATABASES

Currently, along with the development of computer technique, especially in 3D graphics and visualization, people have ability and deeply wish to increase 3D function in 2D GIS system in order to realize 3D display, manipulation and analysis for more and more application requirements. Also, 3D modelling and visualization are important techniques developed in recent years (Qingquan, Wenzhong, Bisheng, 1999).

Spatial data contains positional values and the attributes describe the kind of data and eventually the information of objects and their surrounding through spatial analysis operations. We would not be able to understand the objects fully if the analytical operations were not done in 3D space as we perceived in the real world (Rahman et al, 2002; Zlatanova et al., 2002).

The difficulties in realising 3D GIS or 3D topographic databases result from:

- Conceptual model: although there are several data structures available for the 2.5D and 3D data, each of them has its own strong and weak points in representing spatial objects. Spatial data can be modelled in different ways. The conceptual 3D model integrates information about semantics, 3D geometry and 3D spatial relationships (3D topology). The conceptual model provides the methods for describing real-world objects and spatial relationships between them. The design of a conceptual model is a subject of intensive investigations and several 3D models have already been reported.
- Data collection: Modelling in 3D drastically increases the cost of data acquisition, as compared with 2D. Despite the progress in automatic object detection and 3D reconstruction, the manual work is still predominant. Methods for constructing the model combining data from various sources, automatic techniques for data acquisition (geometry and images for texturing), rules and algorithms for ensuring consistency of data, algorithms for the automatic building of 3D topology, etc., are the widely discussed topics in literature.
- Spatial analysis: Whilst thematic analysis and 2D spatial analysis are well studied, research on 3D spatial analysis is still at an intensive stage. Spatial relationships are the fundament of a large group of operations to be performed in GIS, e.g. inclusion, adjacency, equality, direction, intersection, connectivity, and their appropriate description and maintenance is inevitable. Similar to 2D variants, 3D GIS should be capable to perform metric (distance, length, area, volume, etc), logic (intersection, union, difference), generalisation, buffering, network (shortest way) and merging operations. Except metric operations, most of them require knowledge about spatial relationships.
- Visualisation, navigation and user interface: Advances in the area of computer graphics have made visual media a major ingredient of the current interface and it is likely that graphics will play a dominant role in the communication and interaction with computers in the future. 3D visualisation within 3D GIS requires a number of specific issues to be investigated, e.g. appropriate means to visualise 3D spatial analysis result, tools to effortlessly explore and navigate through large models in real time, and texture the geometry. Observations on the demand for 3D City models show user preferences for photo-true texturing, due to improved model performance in terms of detail and orientation. Trading photo-true texture raises new topics for research, i.e. collection (methods, automation), storage (original images vs. separate pieces) and mapping onto the "geometry". Specific functions of objects modelled in VR systems, and referred to as behaviours, gain an increased popularity as tools for walking through the model, exploring particular phenomena and improving the cognitive perception.

In the field of 3D cadastral modelling an interesting study was made by Stoter et al. (2004). It describes the realization of a full 3D cadastre model with a prototype environment (based on Oracle spatial DBMS and ESRI and Bentley GIS/CAD software) which offers the possibility to query, analyse and visualise the true 3D situation of the properties. Such implementation could be verified also for the Italian case, even if some adaptations are requested.

5. CONCLUSIONS

The use of numeric archives and cadastral cartography, as a database useful to a correct management of the territory, can be made possible by means the introduction of the altimetry, but the removal of uncertainty connected to the coordinate of the fiducial points is requested, otherwise the updating project cannot be valid. The need of an omni comprehensive cartography and the lack of connection among various order networks and sub-network of geometric grid, as also the adoption of different origins, all will lead to a modest result.
The scientific discussion and skills are present for some time. There is an evident lack of political efforts in investments for a correct management of Italian territory, in order to realize a national topographic database (with metric elements and property indications in 3D space), based an unique coordinate system compatible at European level.

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BIOGRAPHICAL NOTES

Mauro Caprioli is Full Professor in "Topography and Cartography" (ICAR-06) at the Department of Roads and Transportation of the Polytechnic of Bari, in which he is also Responsible for the "Topography and Cartography" Laboratory.
From 1997 he is President of the Degree Course in Engineering of Infrastructures, Polytechnic of Bari.

Since 1985 he is coordinator of the researches carried out from the local unit of “Topography and Cartography” of the Polytechnic of Bari.
He is responsible of conventions of research with public agencies (ASI) and private companies in the field of the land survey also by means of GPS (Global Position System), of Photogrammetry and Remote Sensing aimed to the production of Cartography and GIS projects, of special surveys for environment and territory.
He is President of Bari section of S.I.F.E.T. - Italian Society of Photogrammetry and Topography, of which he is fellow of the National Directive.
He is Member of A.I.T. - Italian Association of Remote Sensing.
He is Member of the editorial board of the national scientific journal “Bollettino SIFET”.
He is Reference referee on behalf of the review ”Terra Nova - Blackwell Science”.
The scientific activity, testified from over 100 publications on national and international conferences and journals, has essentially been turned to the sectors: deformations control and monitoring, geodetic and navigational GPS, geodesy, treatment of the observations, applied photogrammetry, cartography, GIS and remote sensing.

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