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# The Venice Town Council Geographical Information System

*Issues of Methodology in the User Requirement Analysis (URA) and of Computer Assisted Urban Management*

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# Contents

# Preface

As can be inferred from the title, over the last two years I have had a close relationship with computers and computer programs. It has given me the opportunity to get to know many different types of computer, like the one I have at home or those at the University's EDP department, and programs, such as word processing and spreadsheet applications, widely-used and specialised CAD programs, as well as those for geographical data manipulation. I have learned that all have something in common which is often either ignored or however not given due consideration: both the machines (hardware) and applications (software) are designed and made by man and are not, therefore, ever able to do more than what in theory the specific engineer or analyst would be able to.

Above all, during the writing up of the material of this thesis — sitting here in front of a computer — it happened very often that I nearly lost patience when one or another text-formatting operation or spell checker (which I later gave up on) would not do what I wanted it to. One therefore arrives almost inevitably at considering the machine that one has before oneself something which, one tends to think, when it does not obey, is to be insulted in the hope that in this way the goals set may be reached. Obviously it does not work out this way, but what in this context gives cause for reflection is that one performs a highly dangerous mental operation: the object (computer) is made subject while the subject (user) becomes a sort of spare part, depending on the actions for which the machine has been conceived, that it to say he becomes object. I think the problem of this dilemma does not however lie in an unhealthy relationship that the user has with the machine, but in the way of handling the whole issue of information technology and thus in questions of basic structure and arrangement.

There are two fundamental aspects. On one side is the strong pressure that the market exerts on the choice of how one addresses real and potential users. Often in this context the functionality of a processor or program is sacrificed by trying to release it as quickly as possible, at least as far as the most widely used products are concerned. On the other — and this is what interests me more — during the development phase of software one does not pose the questions which regard the cognitive rather than the technological approach towards a certain topic, that is the capacity to translate the knowledge and specific techniques of a sector into a language that results as comprehensible to the computer in order to aid the activities of potential users. If this were the case, then also the automatic hyphenation program for Italian in my computer would succeed in dividing over two lines of text also those words that are connected by an apostrophe. Today I can instead only adapt, or forgo the hyphenation of a word like "l'amministrazione" or change my habits as a result of the needs of the machine by writing "la amministrazione".

By transferring these concepts into the area of dealing with geographical information — of Geographical Information Systems — the consequences of a possible adaptation to the needs of the machine would be much more serious. Writing a word that begins with a vowel detached from its definite article produces, at worst, a queer sound, but if within the rule of a town plan it is necessary to forgo the definition of the maximum height of a building according to a given road widthsimply because the software used is unable to establish proximity relationships, then I would say that computer assisted town planning instruments amount to a disastrous failure.

In a word this is the *reason* why I decided to address this topic. And the *technique* I went on to try and adopt in the most precise way possible is that of pursuing all the individual actions performed — often also unconsciously — when one carries out an activity that can be defined with the word "process". As will be easily seen, Regional and Urban Planning is such a process, and so are the ways in which certain *planning rules* affect the transformations of the region or the reasons that lead a planner to take certain decisions.

## The Subject of the Thesis

A definition of the precise subject aim of this thesis may not be classed as a *decision* taken at the same time, or shortly after, my decision to study how information technology deals with questions which generically regard the region. It was rather a *process* which, from an initial idea of looking into the Geographic Information Systems and their use in the field of regional and urban planning, has progressively led to this paper in its present format.

As well as the above, many other factors contributed to "modelling" the field in question, without doubt the most important consisting in the opportunity to take part in an implementation project of a *real* Geographical Information System, which did not entail having to falling back on an *imaginary* situation as so often occurs in undergraduate study. The project in question — the OPEN Project, commissioned by the Venice Municipal Administration and carried out in collaboration with the Venice Research Consortium and University of Architecture — undertook a preliminary *analysis* to gather and assess essential information to determine the characteristics and needs to be addressed by the Venice Town Council GIS. At that time, project implementation, under prototype form on a limited scale, was the second task.

Another factor was my personal interest — enhanced by the practical experience of OPEN — in investigating the nature of the planning instruments and the way they "work". Unlike other countries and the United States in particular, in Italy these take on very special features. I could also mention other events, such as the study of the "spatial thinking", which is a sort of key word among the Geographic Information Systems, the study of the concept of "real world" or my having "brushed up" again on those notions learned at university which, to some extent, were relegated to the byways of my knowledge. As often happens, however, it is not always possible to determine all the factors that have led to certain ways of acting and to preferring certain questions to others.

The subject of this work can thus be defined as:

1. The analysis, starting from the creation of an IT tool for managing processes of regional and urban planning, of the specific context in which work

is carried out, and the means available to the legislation for its control.
2. The appraisal of the study's results with a view to defining, with special reference to data processing techniques, a logical model which describes the components and processes characterising the activities of the above mentioned subject.
3. The proposal of a physical model that allows the application of the logical model as identified within the scope of current technology in managing geographical data.
4. The addressing of the above three questions through a consideration of the actual current Geographical Information System of the Venice Town Council, and their development so that they may be generalised.

## The Structure of the Thesis

On comparing the index of this thesis with the above four points it may appear that no correspondence exists between them other than the common presence of certain specific terms. However, in arranging the sequence with which to set out the results of my thoughts and proposals, I decided to distinguish as much as possible between the phase that deals with all those activities that are generally undertaken *before*, and those undertaken *during* the work of inputting and processing data into a GIS software. The contraposition is very similar to that encountered when defining *analysis* and *plan* in an urban plan. Here too it is not always possible to draw a clear line between the two phases since some ideas reflected in the former assume an already-defined idea of the plan, and some rules of the latter basically represent a summary of the analysis. When considering the group of topics to be addressed within the scope of the analyses and final design, one can note also how it proves sometimes difficult to split the two parts into logical groups which would instead be preferably documented according to topics.

However, some differences exist when compared to a GIS implementation project. On the one hand here too one may envisage dealing with each question by following it starting from its appearance in the preliminary studies through to the definition of all information management procedures. It is by following this logic that I present the four points above, which make up the subject of this thesis. On the other, however, the individual activities and reflections can be grouped according to the criterion that sees the beginning of the direct work with the computer as a watershed between *analysis* and *implementation*. Since in GISs it is not possible, as is sometimes the custom when drawing up urban plans, to address the two phases at the same time and then *present* them in separate chapters — here the "chapters" represent a temporal sequence — I have decided to adhere to this real state of the facts. The study of the nature of planning instruments does not therefore effectively belong to the analysis side, but to that of implementation. The same holds true, although to a lesser degree, for the data input plan: in theory, it could also belong to the preliminary studies, but many of its variables are only quantifiable from the moment in which one actually has the equipment and software, that is to say when, strictly speaking, the *implementation* phase is already underway.

I approach the questions as follows. In the first two short chapters of the first part, I attempt to identify, in the current political and legislative environment, the case of the OPEN Project, to obtain — or rather determine *ex post* — certain general characteristics of the system under study. The third chapter is devoted *User Requirement Analysis* and includes a descriptive excursus of the tangible experience of OPEN. Starting from experience I highlight some problems emerging to attempt to formulate a suitable methodology for all the preliminary phase of a generic GIS implementation project. The second and longest part of the thesis takes up again, in its two introductory chapters, the question of choosing software and drawing up the data input plan which, as mentioned above, straddle the phases of analysis and implementation. The third chapter of the second part deals in depth with the fundamental questions about base maps. Here too I review the digital map which was available in the OPEN Project. Greatest attention is however placed on the question of the radical changes which I think result from the appearance of *digital mapping* both in terms of information content and with reference to the ways in which this new instrument should be used. It is a necessary study if the general aim is one of dealing with the question of IT Management of Planning Instruments, which is my topic of discussion for the fourth and last chapter, where an X-ray of the planning system in Italy, and Veneto in particular, lays the foundation for determining and creation of its related logical model. In this context I have taken account both of the current debate in academic circles and the possibility of putting into practice the expressed concepts at the implementation stage of an operative GIS. Finally, I devote some pages to the outlook of future developments for further study, also in terms of the possibilities offered by technological evolution.

## Acknowledgements

In addition of course to Francesco Gosen, through whom also my participation in the OPEN Project was made possible, I would like to acknowledge those who have played an important part in my work on this thesis. Much of the knowledge I gained during the work and which proved indispensable for the completion of this study are due to the teaching of Alberto Giordano. I should also like to thank Alberta Bianchin, who was responsible for introducing me to the GISs, and also Francesco Contò, Massimo Mazzanti and Corrado Petrucco of CIDOC, who were always ready to answer my questions and to discuss in depth many of the questions which were brought up. Without Pietrangelo Pettenò I would never have understood a series of background questions concerning the Venice Municipal Administration, and solicitor Giuseppe Schiuma provided me with some valuable legal explanations that were indispensable to this study. I would also like to thank the colleagues of the CVR and all those I met and who, to a greater and lesser extent, are connected to this thesis. Naturally, a special thought goes to all my friends, my parents and, above all, my companion Donatella Schiuma, who in this last period have managed to put up with me.

# The Analysis

## Requests from the Council Administration

Before proceeding with a GIS implementation project, it is important to look at not only the specific requests by the Council Administration, but also the **assumptions** with reference to the political and institutional framework within which the activity operates (see also Eriksson 1987). With regard to the OPEN Project two features becomes particularly important. The first refers to the Special Laws for Venice which, since 1973, have been regulating **Save Venice,** a Plan that deals not merely with ecological issues but also which entails a series of initiatives aimed at preserving the socio-economical characteristics of both lagoon and mainland settlements. After the misuse in the Eighties of the funds allocated for these initiatives (*Venezia derubata*, 1993), it is probable that a more careful intervention of public authorities will take place in future.

The second feature is connected to the programme for **economic and environmental improvement of the Porto Marghera area**, which provides for the setting up of a Workgroup across different counsellorships to build up a database on Porto Marghera, to carry out a Revision to the General Urban Planning Programme, to prepare an Evacuation Plan for the urban area of Marghera and an Environmental Improvement Plan as well as to implement a **Geographic Information System for Porto Marghera**. At the same time the GIS should also act as a **pilot study** for a future GIS for the whole municipality area. This approach is certainly positive (Dale 1991). However its double nature — being both a pilot system as well as a system working for a specific area — creates several problems for the attainment of benefits able to compensate the costs. The carrying out of a preliminary study has therefore constituted the main objective while at the same time great attention was paid to problems regarding Porto Marghera industrial area.

In consideration of the specific **aims** set, it can be maintained that the GIS shall be highly functional, not imply any restriction as to the way in which the various data formats will be dealt with and provide for a wide range of conversion filters. The hope to be able to use information technology also for the drawing of urban plans and such like implies the setting up of ad hoc applications which take account of the specific territorial sciences involved.

A further important element is the conception of the future GIS as an open system to which much attention is paid also by the GIS software developers and producers (Dangermond, 1991). An open system is represented on the one hand by a structure which is not tied to a specific institutional body but rather to a specific area and, on the other, by the sharing of resources both in terms of equipment and, above all, data. It is therefore necessary to develop also a **new organisational and IT-based model**.

## The System's General Features

Before moving to its carrying out in a truly inter-institutional way, the open system issue presents repercussions also within Venice Municipal Administration. At the start up of the OPEN Project, some organisations are present which avail themselves of GIS software for specific purposes. These organisations must therefore be integrated with the new system. We chose to build up a system which provides for the setting up of a specific structure — the GIS Office — which shall supervise the updating activities as well as quality and documentation of the data available. Other municipal structures are instead given the task of acting as Peripheral Offices, which enactthe principle of a single data possession, that is its collection, updating and transmission to the GIS Office. The GIS Office will deal with the IT-data processing for those structures which do not possess any GIS technology, while the specific office will deal with the non-IT processing.

## The User Requirement Analysis (URA)

In English literature (Dale 1991, Dangermond 1990), the *User Requirement Analysis (URA)* indicates the part of preliminary analyses of a GIS implementation project having the aim of determining the requirements of the future or potential users of the system. During the OPEN Project and more generally in this study, the term has been used with a slightly different meaning. It includes the requirements of not only the users, but also of those from which one cannot (whether for technical or structural reasons) or does not want to (whether for previously set choices) detract. The term has thus been translated into Italian with the expression Analisi dei Requisiti Informativi (literally "Information Requirement Analysis").

With reference to the user requirements, **questionnaire** was chosen which, in most cases was completed together with the managers contacted who belonged to the sectors of the Municipal Administration. The first question emerging in this context was of **who the questionnaire should be given to**. The whole administrative structure was involved, with particular attention given to those sub-structures which are distinct from the one to which they bureaucratically belong for their particular field of application. The second question regarded **the way in which to pose the questions**. Here, the main difficulty was how to not blind the respondents with information technology jargon, while succeeding in getting across the concepts and obtaining the necessary information. This operation did not prove successful in all situations. **The order with which to proceed** with the questions started from those which were, as expectable, closest to the topics treated daily, to progressively move towards those pertaining to the GISs. After some practical experience, the **interviews were conducted** in such a way as to address from the outset those questions which would probably have caused the greatest problems.

Among the **problems emerging**, worthy of mention are: the underestimation of the time needed for completing the analysis, the fact that it was impossible to complete the questionnaires for all the bodies contacted, and the reluctance on the part of some to collaborate with the Project. The causes were many, the main ones being the insufficient knowledge of the administrative contexts of the Venice Town Council (Comune di Venezia) — which can be considered highly complex — and the presence of conflictual situations the solutions of which remained beyond the scope of the external collaborators.

As to the **results of the analysis**, one aspect stood out above all others: the **highly fragmented structure** of the offices throughout the region, which led to the practical impossibility of building up an efficient internal administrative telematic network and the need to perform data exchange using magnetic tape and optical discs. Moving on to **data**, it should be noted that paper prevails. It was also noted how no organisation is in place for performing a systematic data transfer among the offices. Indeed, the same data is often reconstructed independently from in two different offices. The determining of the requirements took place on the basis of a classification and points system for each item which based itself on the questionnaire answers. Using a weighting system of these points and the aggregation of similar items, a table was constructed showing, in order of intensity of the requests, all the data available or requested in the Administration. The most requested data resulted as base maps. The nature of the data requested by the various offices and the administration as a whole had already predetermined all the **functionalities** to be implemented within the timescale available. The intensity of the **data exchange** resulted as rather poor due to their being no dedicated structure for this function. The need was therefore underlined, also under this viewpoint, for a Central GISs Office. **Information technology knowledge** among the personnel was not very well developed, due largely to the civil service's policy of not providing many training initiatives and to a generally **second rate IT infrastructure**. Among the offices contacted only eight had what could be described as advanced IT equipment such as software for GIS, CAD, data display and multimedia.

Particular significance is given to the **comments** (Maguire et al. 1991) on experiences which, in certain parts, resulted as problematic. In this context attention should be placed on the fact pilot projects can never be expected to produce benefits (*Nordisk Kvantif* 1987). The statements and official documentation must therefore be very clear on this point, to avoid possible unrealistic expectations from turning into suspicion towards the GIS tool. With reference to the analysis of requirements, it should be noted that in many situations the questionnaire in the form of *switchboard* has proven unsuited and that often it would have been better to proceed using less formal interviews.

The **method** proposed provides for certain modification with respect to the procedures adopted during the OPEN Project. The acknowledgement of the importance of the **knowing one's working context** requires that, before any study aimed at the individual offices, there be a **study phase** of the situation based on the official documentation on questions of politics, organisation and studies already performed by others. Of particular importance are also the continuous checks with the administrators to reach a harmonisation of the objectives and methods. The **survey** should then be carefully drawn up and be completed within reasonable timescales (three months as a working guideline). It is helpful to differentiate the structures according to whether they are involved in transformation activities of the territory. For all the other structures it is more useful to simply conduct informal interviews and then possibly go into greater depth at a later date. The analysis of the answers should however be completed in a short period (say one month). With reference to **handling the collected information**, it should be noted that the schematic questions should only regard the territorial location of the offices, the sector activities, and the IT soft and hardware resources. All other information should be obtained by informal questioning. The assessment of the answers becomes more efficient if a software is used that is developed especially for these aims, which allows the processing of the individual answers by interactive user interface. This software should also allow the possibility of making queries in *SQL-like* mode.

## Implementation

### Some Preliminary Comments on Software

The preliminary studies indicate that the software for the Central Office of the GIS should be implemented on a workstation with a multiuser operating system. Its characteristics should allow the treatment of all fields of activity, the management of all data formats and should feature a high number of functions. As to the recommendations for the peripheral units, these should be equipped with software compatible for use on a desktop PC. Here too, the characteristics should however support the treatment of all fields of activity, the management of the most common types of data, have a more restricted number of functions than the central system, as well as a user friendly interface. For the central system the **Arc/Info** software is recommended, while for the peripheral systems **Apic** or **MapInfo**.

### The Data Input Plan

In the design of the input plan, in addition to the need emerging during the preliminary analyses, we also took account of the fact that there are some input sequences which are pre-set by the fundamental management rules of a geographic database. In this context it is necessary that, before any other data is brought in, the base map be imported. Then, within the individual data categories, similar objective priorities exist requiring that — for example, in the case of planning instruments — digitizing takes place before the zoning data and that one should proceed only after the IT input of the rules or of locational data of the action plans. The general framework emerging reconfirms at the first place base cartography, followed by data on economic activities, plant at risk, land use, technological networks, transport conditions and routes, demography and — as a beginning of a second implementation phase — regional and urban planning.

## The Base Map

The **Base Map of the Venice Town Council** was obtained by a flight and analogical photogrammetric mapping processes carried out in 1983. The planimetric quality can be quantified with a positional error that does not normally exceed 0.80 metres. The error of the height component, instead, is greater: approximately 1.50 metres. The map corresponds overall to a map conceived for a 1:2.000 scale. Between 1983 and 1994 The Council *Planning* Department carried out various updating sessions which have however greatly altered the characteristics of the original map. From a quality viewpoint there is a certain increase in the positional error which is however difficult to quantify. From the point of view of data consistency instead, it is no longer possible today to determine exactly which objects have undergone changes over the last decade. At the base of this problem lies the concept of what a “building” is as adopted by the digital database: it cannot be compared to a building unit, but is much closer — especially in the highly built-up areas — to the building block. Thus a row of semi-detached family homes is considered as a single “building” and if it has undergone alterations, has been completely replaced in the archive.

The database is organised into layers whose function however is only one of graphic representation. Thus, the map’s **treatment in the OPEN Project** involved the complete reorganisation of the structure according to a treatment more suited to the real world. However, due to locational data consistency problems and the fact that many elements represented required interpretation, it was not possible to use automatic procedures to convert polylines which were not completely geometrically enclosed within polygons. Approximately five months were spent for the manual topological editing operations of the “building” layer, so subsequently only a transport network graph was made and other elements treated in order for them to be appropriately displayed. It was concluded that, in the medium term, it would be necessary to build up a new base map.

With reference instead to **base mapping in general**, the appearance of digital mapping makes necessary a reappraisal of the base map concept itself. The reasoning is built up starting from the definition of the five functions of base map (Biasini et al. 1988). Compared to the traditional maps, the problem arises that the digital maps are not characterised by a biunique relationship between **map scale** and information content. Although there are scientific methods for describing the quality of a digital map (Giordano/Veregin 1994), I propose to use the concept of scale as a sort of ‘measurement unit’ of the maps in general. This allows the classification of also the digital maps according to the usual types (Bezoari 1978, Biasini et al. 1988). Both in the traditional and digital maps, one can also find the **type** by distinguishing between drawn maps and orthophotographs. Information technology then introduces a last distinction according to the **format** of archiving of the digital map between raster, vector and, in considering the reflections on geometry (Laurini/Thompson 1992), topological. By combining among them the scale, the type and the format, thirty digitally-based maps can theoretically be obtained which, by eliminating the solutions which are technically and logically useless and by reducing the field to only the technical maps, we arrive at four fundamental map solutions: raster-designed, vector, topological and orthophotograph. Each of these solutions can be obtained directly by photogrammetric mapping. Subsequent operations of manual digitizing, automated digitizing, manual vectorizing, rasterizing or topological editing enable a specific solution to be obtained for **conversion**. In this way it is possible to define a tree structure of 23 solutions of digital maps.

The **raster solutions** of drawn maps have basically the same characteristics as the traditional maps except for some more marginal questions. Depending on the way the map is built up, the quality can be slightly better or worse than the traditional map. The **vector solutions** represent a first step towards transferring cartography interpretation operations from the operator to the computer (see also Zampieri 1994) since the possibility is provided of connecting the vectors to attribute data. A layered organisation allows the distinction among types of objects represented and also the creation of efficient display functions. The quality of these digital maps is generally better than the traditional paper ones. Finally, the **topological solutions** allow the archiving of not only metric information, but also information concerning the spatial relationships existing among multiple objects. In most cases, obtaining a topological map entails the carrying out of an editing session which, incidentally, has the advantage of not increasing positional error but even, in some circumstances, contributing to decreasing it. The **orthophotographic solutions** can represent an alternative to the use of a simple topological vector map since is possible to proceed with the digitalisation of the individual items depending on the circumstantial requirements (Cannistra/Godden 1994, Nale 1994, Hickey/Shillenn 1995). The quality tends to be better than that of the traditional map, but does not reach that of the vector solutions.

The **choosing of the best solution** for a specific situation is strictly connected to a very rigid **supply**. All the maps are obtained by air photos or derived from maps of this type. All other conversion process — with the exception of topological editing — introduce an additional positional error which causes a progressive lessening of the final product's overall **quality**. As to **cost**, this is very high in the case of direct hiring of a plane and its related mapping procedures. Also costly is the specialised personnel for those procedures requiring manual intervention. In the case of automatic procedures, it is more economical to buy the related technical equipment rather than hire the work. The **timescales** are very long when human intervention is required, and short in the case of automatic conversion. The flights and the air photos can technically be performed over a short time (Hickey/Shillenn 1995). The subsequent **conversions** possible (Ingersoll 1994a) or recommendable, the **contents**, the possibility of using the information of the map to build up **thematic maps** and the **hardware and software** configuration required basically depend on the type of the specific solution.

To divide the **request** it is first possible to use a distinction into **three conversion categories**: those pertaining to photogrammetry and topography, those which may be placed among the usual GIS functions and those relating to normal electronic data processing. As regards the **four distinct types of**

**maps**, one can say that it is always preferable to be equipped with a topological base map although, theoretically, one cannot necessarily talk of superior technology (Couclelis 1992, Worboys 1993) and although it is wholly inadvisable for a high-function GIS to preclude the integration between raster and vector (Hinton 1994). Finally, the **choice of the qualitative characteristics** can be made on the basis of the operations that one intends to perform: final designs, regional analyses or simply graphic representations of thematic maps. Two overview tables for deciding on the type of map according to the necessary conversions and the uses foreseen point to a restricted range of **recommended solutions**.

As many have found (cf. Giordano/Veregin 1994, Laurini/Thompson 1992, Berry 1993), the digital topographical maps are generally organised into thematic layers and then overlaid onto one another to display or build up information. However, I believe that these **overlay** procedures should be seen as characteristic of the present historical phase in the evolution of GISs and not as an always-valid axiom. I think that the concept is surviving in human minds due to the huge influence of the CAD software applications in GISs (Sinton 1991, Coppock/Rhind 1991, Clarke et al. 1993, van der Braak 1992). It is an influence that is often ignored (Laurini/Thompson 1992), to some extent disregarded (Scholten/Stillwell 1990) or presented under the form of hybrid systems that embrace the two technologies (Healey 1991, Schutzberg 1995, Kunze 1994). In addition to the question of error propagation during the polygon overlay procedures (Shepherd 1991, Giordano/Veregin 1994) and certain technological limitations which will be solved in the next few years (GIS World 4/1995), the real problem with overlay consists in its not amounting to a real-world construct due to unfortunate continuity interruptions (Pornon 1990) and redundant data. An alternative approach thus consists in overcoming the analytical treatment of materially perceivable space and in adopting the set-theoretical approach, which involves the building up of a locational database of information about a consequently **'total' topology**. The principle of this model is the archiving of data in the computer by imitating the perception of a human observer (Berry 1994). At an operational level it means designing the database starting from a line topology that represents real objects that delimit the polygons of a "pizza" model and the effect is one of removing the logical inconsistencies of the external polygon and dangling segments. Like in the real world, many of the materially perceivable characteristics can give rise to thematic information and therefore also the total topology model will be able to supply thematic maps on its own. The overlay operations will therefore be restricted to operations which deal with data belonging to incompatible two-dimensional Euclidean spaces, such as between base maps and data obtained from remote sensing procedures (Janssen et al. 1994), relating to underground an so on.

## Urban and Regional Plans

Before moving on to developing the physical model for the computer assisted management of the urban and regional plans, it is necessary also in this context to carry out an analysis on the nature of the objects dealt with and the management of a logical model which is independent from all characteristics of the system (Hargis 1992). The first question to address is therefore: **What are Urban and Regional Plans?** First and foremost, they are not mere graphic representations to be digitally archived, in which one can display the regulations. It is instead necessary to look into the processes that are directly tied to what, in reality, is done using the contents of an urban plan, that is to say the governing of the region's transformations. As to content, it should be noted that the elements and juridical principles take on a central — if not predominant — role in the description of the Italian urban and regional planning system. The analysis follows an order that first approaches the basic questions of the General Programme of Urban Planning, to move on to focus on regional planning, physical planning, as well as the other planning instruments.

**The General Programme of Urban Planning.** The only feasible statement at the beginning is that **zoning** will be represented as a *coverage*, meant as a data structure of the Arc/Info software. The division of the plan's rules and of the individual zones are then organised into a **hierarchy**. Some refer only to a single zone, as is represented in the *zoning map.* Others instead refer to groups of zones, so one may say that the relative *sub-zones* inherit the rules defined upstream in the hierarchy. The rules of an individual zone can however also modify an already-inherited rule, both by integrating it with other elements and by replacing individual elements or indeed the whole rule itself. In addition to this **inheritance**, the zoning hierarchy is thus also characterised by **integration** and **replacement**. These properties, and the provision for each zone of all levels on the hierarchy to independently define their own rules is termed **polymorphism** in IT. At the same time, it is also possible that **cross references** exist between rules that do not *descend* from the same *ancestor* or between one rule of the plan and rules of other planning instruments. In addition to the zoning, the General Programme of Urban Planning is made up of other structures. The **integrative rule sets** are those groups — whether hierarchically structured or not — which are applied to individual zones at all hierarchical levels of the main zoning. One example can be the plans for use which subdivide different zones into areas with pre-set uses. On the other hand, there are also the **complementary rule sets,** which refer to a locational database that is fully independent from main zoning one, and they are related to the main database only by way of standard procedures and **GIS functions** and the use of special pointers.

**Urban Legislation in Italy**. The urban and regional planning system in Italy is often described as having a 'cascade' structure. According to the Urban Planning Act ("Legge Urbanistica") of 1942, *regional planning* establish *a priori* certain characteristics of the *operational plans* which determine the contents of the *action plans*, which, in turn, discipline the issuance of building permission licences. At the top of this hierarchy are the rules which generally determine, as a sort of super-plan, the *urban legislation.* It is therefore correct to see the zoning of the General Programme of Urban Planning only as a part of an overall hierarchic structure. However, given that the two components are characterised by a greater and lesser autonomy, it is necessary that also a global

**validator** be conceived (the Republican Constitution) which, through a **global registry** (Official Register of Acts and Decrees) checks the conformity of the individual rules with the **legislation in force**. The rule according to which a law abolishing another law, which had in turn abolished a third law, makes the latter indirectly be reinstated, introduces the principle of restoration of (nearly) all rules, so no rule can be completely cancelled from the relative archives.

**Regional and Provincial Planning**. In Veneto, the Piano Territoriale di Coordinamento (PTC) — Regional Co-ordination Plan — set up under the 1942 Planning Act, is composed of two instruments: the Piano Territoriale Regionale di Coordinamento (PTRC) — Regional Co-ordination Plan —, which covers the whole Region, and the Piano Territoriale Provinciale (PTP), or Provincial Regional Plan. In some situations also the Area Plan is included, which is the responsibility of the Administrative Region. Unlike the General Programme of Urban Planning, these are **strategic (regional) plans** which do not indicate any zoning, and their attached maps have the aim of specifying the contents of certain rules referring to planning applications pertaining to lower-level planning or to certain rules which these later applications will acknowledge. Here too, the check of the conformity of an operational (and partly action) plan with these strategic (and partly operational) plans takes place through a validator which intervenes on rules and already-present delimitations and carries out spatial overlay and/or spatial query procedures. In many situations, the rules can also already **encapsulate** rules to be included in individual rule groups of subsequent planning instruments. By analysing the individual territorial plans of the Venice Municipality area, some elements emerge which point the implementation activities towards the following data structures and logical constructs.

- Rules and Plans can be organised into **objects**.
- Rule sets can be organised into **collections**.
- Individual rule elements and groups of rules can make up **constants**, **variables** or **quasi-variables** which are structured as variables, but whose components are all fixed constants.
- Individual objects can be redefined in a **redundant** way from descendent objects, to make them independent from possible modifications introduced at later dates by the ancestor objects.
- Individual rules can make up **conditional rules** which, depending on the occurrence of a specific situation, can provide for the application of a rule rather than another.
- Individual rules can previously set certain rule elements of subsequent plans, thereby giving rise to the **placeholders**.
- The relationships among rules, elements and groups of rules can be described with the aid of **set theory**.

**Revisions to the General Programme**. A distinction should be made between **real object** (the first draft of the General Programme of Urban Planning or individual Revisions) and **virtual object** (The General Programme of Urban Planning including also conditional expressions resulting from the Plan Revision). The nature of planning itself, with its acting when put before certain situations, makes it necessary to introduce such concepts as **event** and **result**. The actions of the plans can be described with the fundamental formula:

$$y = f(x, t, A)$$

where $y$ is the result of the of the plan's action, $x$ is the event to be managed, $t$ the event's time co-ordinate and $A$ the set of real objects making up the virtual object. The Revisions can be subdivided into three types: the 'normal' situation is given by the **'opaque' Revision** which finds its place within the hierarchical structure of the General Programme's Zoning and adds or replaces parts of the pre-existing programme. We have a **'transparent' Revision**, instead, when a Revision clearly replaces rules already existing before its introduction, rules which are however later removed by the virtual object through the introduction of a second Revision. In this case both the regulating elements introduced by the Revision and those of the original plan or other plan revisions — whose replacement can be considered as 'failed' — continue to exercise their action. There can however be an intermediate situation whereby some parts of a Plan Revision are characterised by 'normal' situations and others by 'extraordinary' ones. This type of Plan Revision can be called **'filtering' Revision**. The data structures and logical constructs necessary for managing these occurrences are:

— the **linkers** which replace the **static links** between the objects with **dynamic links**, both with reference to the relationships between **locational objects** and **attribute objects** and to the descent relationships and
— a **virtual method table** and **bypass** structures for managing **fields** and **methods** contained in **inactive descent** chains deriving from the introduction of a 'transparent' Revision.

The combined action between individual **real structures** (main zoning and integrative sub-zoning defined by integrative modules and non-hierarchy theoretical-sets defined by integrative module) of a real or virtual object leads to virtual structures which, in turn, can be subdivided into:

— **real integrative sub-zoning**, when a hierarchy integrative module is applied to a zone of the zoning map,
— **improper integrative sub-zoning** when a non-hierarchy integrative module is applied to a zone of the zoning map,
— **hereditary real (or improper) sub-zoning** when map a hierarchy or non-hierarchy integrative module is applied to a zone which is not found at the lowest hierarchical level of the zoning and
— **product integrative sub-zoning** when more than one hierarchy or non-hierarchy integrative modules are applied to a branch of the zoning map.

Finally, as to managing the events, the combined action of several real structures of a virtual structure requires the overcoming of the concept of **geometrical application field** which was introduced with the zoning of the General Urban Planning Programme and that a new concept, that of **event localisation**, be used instead. Since **event assessment** produces results in the form of

Boolean expressions it is possible to determine the overall result deriving from a virtual structure through **disaggregate determination** of partial results deriving from individual real structures.

**The Interim Issue.** The management of interim measures is implemented using as many temporary virtual structures as the Plan Revisions dealt with. The assessment of the events is carried out by determining the result on the basis of the virtual structure related to the Plan in force and by determining the results on the basis of the virtual structures of the individual Plan Revisions. The overall result is given by linking the individual results as if they were partial results of an individual virtual structure. Further, the presence appears necessary of a structure which we will call **time manager**, which checks and sets the values and deadlines for the administrative course of a Plan or Plan Revision.

**The Action Plans** are independent sets of rules which are related to real and virtual structures of general planning by simple cross references. The hybrid nature of almost all planning instruments requires a distinction between action and operational rules. The former can be found also in operational plans, thus giving rise to the possibility of direct intervention, while the latter also in action plans, giving rise to **virtual Plan Revisions** which are virtual in that as they can introduce modifications to the General Programme of Urban Planning.

**The Multiannual Action Programme and the Intervention Areas** constitute clear links between the general plan and action plans. Should these structures not be present — the former, however, being theoretically compulsory — their functions can be carried out by individual resolutions. The structure of the action planning framework returns as a **feed-back** in operational planning.

**Building Permissions**. Within the scope of a GIS, much in the same way as happens in the real world, the physical and functional transformation activities can be seen as a series of events (the application for permission to carry out a alteration) managed by processes (localisation and evaluation) which give a positive result (permission granted) or a negative result (permission denied). At a later stage the alteration will be acknowledged (updating of the database). The urban and regional planning shall therefore be simulated using an **executable program** written using **event-driven programming** techniques.

### The Logical Model

A logical consequence of the analysis of planning instrument nature is that an **object-oriented database** should be used. With regard to the concept in this context (Aybet 1994, Laurini/Thompson 1992, Worboys 1994, Milne et al. 1993), some modifications need be introduced at this juncture. The construction of an object does not take place on the basis of an object template (generally called *class*), but of a **genetic code** which is interactively defined by several actors. The concept of **type equality** refers to a set of objects which are compatible with reference to a certain method. The **class** is defined as a set of objects which are not related but having common characteristics. Static hierarchies apply only to real objects while, in other cases, **dynamic hierarchical**

**structures** are built up. A **global object register** must be prepared to manage the identity concept as well as some **global virtual structure registers** to avoid physically building them.

Within the scope of non-experimental GISs, it is not yet possible to move on to implementing an entirely object-oriented system (Worboys 1994, Pornon 1990, Milne et al. 1993, Strand 1994, Helokunnas 1994, Worboys et al. 1993). My proposal envisages a solution which can be defined as an extended **relational** (or field-oriented) **system** which exploits the UNIX file system properties and encapsulates data field access through procedures which can be written in the *Arc/Info Macro Language* (AML). The definition of rules relating to **file and directory names** takes on great importance: in this way it is possible to simulate the characteristics of virtual methods using **global procedures** which execute **systematic research** for methods and fields throughout the file system. Virtual structures are built creating **symbolic links** between the directories each representing a single object. Polymorphism can partly be managed by using fields containing **procedural variables** which, if run, execute procedures and return a value as if it were filed directly in the field itself. The general structure is built as any relational DBMS linked to locational data. With reference to the Arc/Info software, the following tables should therefore be prepared for managing hierarchical ruling structures.

- A **polygon attribute table** (PAT), whose name is made up of the directory name (*coverage*) and the `.pat` extension, this containing the polygon identifiers and the path name in the file system of the related zone.
- A **data table**, whose name differs from that of the PAT's by its `.dat` extension; this contains a list of the names of all zone paths and the path names for each hierarchical level present.
- A number of **level tables** equal to the number of hierarchical levels present, whose name differs from that of the PAT's by its `.lnn` extension, where `nn` corresponds to the ordinal number of each hierarchical level. These tables contain general information on the zones, as ordinal numbers, textual elements and so forth.
- In each directory referring to a zone, a **rule table** is found that is called `norme.nor`; its is made up of only one record, containing the data (alphanumerical values and procedural variables).

Finally, the **message loop** is an executable module which is regularly called by the user and for the assessment of the messages sent and written in specific files by the objects.

The issue of the juxtaposition between the object-oriented approach and field-oriented approach (traditional relational system) is parallel to that discussed in the chapter on base maps, between layer-oriented structure and total topology. A general controversy (Couclelis 1992) can be said to be present between the **analytical model** and **set-theoretical model**, the former closer to the nature of computers, the second corresponding rather to the real world entities (Thompson/Laurini 1992). Since physical planning is connected to the concept of **real world** as well as to that of **future world** (de Jong 1992), it is necessary to reflect on how to manage the time component within the scope of planning instruments: this, however, should not be confused with the fourth dimension discussion (see, for instance, Langran 1992) in GISs in general. I do not think that the definition of a point using four co-ordinates in space-time is suitable for a set-theoretical approach. The **spatio-temporal path** concept of a single object should instead be adopted in the same way as it is used in cosmology (Davies 1981). The fact that the future is unknown leads to imagining the world as a set of uncountable sets of spatio-temporal paths. It is therefore a model of the future with infinite scenarios, that is to say a spati**o-temporal model with infinite dimensions**. In this context, a re-thinking can prove useful of *Isolation of Dimensions and Elimination of Alternatives (IDEA) Method* and *Continuously Increasing Dimensionality (CID) Method*, which were developed in the Sixties (Doxiadis 1968). In addition to the future world, also the **legal world** issue is to be taken account of, this representing that part of the real world which cannot be materially perceived but rather defined only through legal instruments. A Plan is built by creating links to the individual 'worlds' described and integrating them with newly elements defined, the outcome amounting to a sort of **total spatio-temporal topology**. The approval of the Plan therefore corresponds to the creation of a copy of all the objects, the interruption of the links and thus the setting up of an own 'world'. The practical solution within today's two-dimensional GIS is nevertheless to be sought in the building of individual total topologies whose objects are linked to one another through the **identity** concept.

### Applications

Processes concerning urban and regional planning using IT can be grouped into four steps (Persson 1994) which, also in consideration of practical experiences (van der Braak 1992, Moore et al. 1995, Forcen/Torres 1994), correspond to the use of a **non-customised GIS**, the use of **CAD tools** in GIS environments, the use of **Spatial Decision Support System** (SDSS) and **Computer Assisted Planning** (see also Nijkamp/Scholten 1993). To these, a fifth function can be added which can be called **Computer Assisted Urban Management**.

To organise a "Urban and Regional Planning Module" within a GIS, the customised GIS functions and the work environment may be grouped, both providing the information necessary for decision making and, in this way, form a sub-system usually called **SDSS** (Fedra/Reitsma 1990, Densham 1991, Geoffrion 1983). This system is characterised also by the presence of logical constructs such as the **Inference Engine** (Leung/Leung 1993, Laurini/Thompson 1992) or the **endorsements** (Srinivasan/Richards 1993) as well as of **Knowledge-Based Techniques** (KBT). The following step envisages the use of information redirected from the SDSS into a further sub-system where interactive **Analytical Planning** takes place. This new system can be defined as **Spatial Planning Support System** (Wiggins/Ferreira jr. 1992) or SPSS for short. In this way, the SDSS and SPSS sub-systems form an application which can be called **Computer Assisted Planning** (CAP).

Under the operative viewpoint, it is a question of defining suitable work environments in the phases regarding the *discussion*, preparation of one or more *general hypotheses*, *public relations* (see also Cowen/Shirley 1991) and preparation or statement of the *final hypothesis*. Lastly, the issue is to be solved concerning the **raised seal** (Ayers/Kottman 1994). The resistance often found in using IT due to the prevalence of **pen and paper** requires a precise classification of **user groups** (Nijkamp/Scholten 1993) and the design of their related work environments.

Some experience and studies (Wood 1990, Joliveau et al. 1994, Drouet/Peyretti 1994) highlight the **Computer Assisted Urban Management** concept. They also prove that no applications exist which fully meet the requirements. Within the **general framework** of the "Urban and Regional Planning Module" a subdivision can be seen between CAP — which, in turn, is made up of SDSS and the SPSS — and Computer Assisted Urban Management.

For the future I foresee, for example, the development of a **rule translator** whose task will entail the translation between two intelligible languages: the human beings' and the computers'.

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