MASTER SCHEME FOR PLANNING, DESIGNING AND IMPLEMENTING A GIS FOR DRINKING WATER NETWORK IN QUITO-ECUADOR (SOUTH AMERICA)

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ABSTRACT

This paper concentrates in the master plan for drinking water, it contemplates the main components: data, human resources, hardware, software, and information. The data has to be gathered, modelled and stored in scale 1:1000 and comprises from the Geodetic control established for Quito in the WGS84 datum, passing for the cadastral base map, the vial map until reaches the drinking water network map. This set of maps has been organised vertically by themes and horizontally by administrative units. Here it is pointed out just the main problems and solutions on data gathering, modelling and storing it. The second component “human resources” deals with the MCSDW organizational changes and its capacity to support the disruption level provoked by the new information technology introduction, besides this, there is also a training plan for the operational, middle boss and managerial levels. This component also treats the different ways to keep the information users and managers involved in the process, maintaining their commitment and co-operation. The third component hardware concentrates in the server-client configuration of computers, plotters, network and their upgrades. The fourth component, the software has to deal with the specific software GIS, DBMS and CAD with the necessary number of licences to be purchased and the determination of operational sites with their functions. Finally the fifth component, the information is about the data enriched with specific meaning to the MCSDW, this information is sorted and correlated with all organisational departments so that the users, producers and who updates can be determined.

1 INTRODUCTION

The Metropolitan District of Quito the capital of Ecuador in South America comprises about 291000Ha and around 2’000 000 inhabitants, its overage altitude of 2800m over the sea has let it count with many natural resources of water, nevertheless, there is not a complete coverage of the drinking water demand. The main problems, which the Municipal Company of Sewage and Drinking Water–MCSDW faces in this matter, are the following:

- There are still 23% of inhabitants without service of drinking water. These inhabitants are located mainly above the allowed top (altitude) for building houses and they have a too rapid growth. Quito grows at 2.9% rate.
- Water no counted. The drinking water lose is around 32%, 20% of which is mainly because clandestine connections.
- The electoral interest of many politicians, who without care for technical designs, have offered and authorised to built networks of drinking water at levels even of “the heaven”, has produced many extra networks out of records and against the technical specifications. This situation does not allow the maintenance of some pipes since they are hard to be found. However they have to be updated somehow!
- The late starting maps automation and geographical data within a corporate approach have permitted the existence of many lost manual and digital archives through out all departments, so nobody knows where is the right information at the right time and suitable scales.

These problems have brought The MCSDW to a difficult situation of water networks design, operation control and maintenance, therefore a proposal of a corporate GIS for drinking water and sewage have been accepted and started to execute.

The main goal of this GIS has been written as the following: The corporate GIS will manage suitable data to allow the study, design, construction, operation and maintenance of drinkable water network and sewage to permit centralised information at frames of right times with distributed updating function.

From the strategic point of view it is noted also the obligatory coexistence of two systems: The first one that was the original with its patched solutions and puzzling development. This system has to continue working until the new corporate and structured system gets into operational mode and takes out the older one. The strategy can be appreciated also in the way, how each component of the information system is treated making priorities and study of early or late costs.

Everybody knows that any GIS project is a long term and as the MCSDW has been already working with GIS tools for about five years in just data gathering, it has been quite hard to keep the same support to the system as in the passed administrations was. With this fact in mind and cumulating the experience gained so far, the MCSDW has asked for a complete master plan for planning, designing and implementing a GIS for drinking water network and sewage in Quito, which could guide any organizational administration and implementation phase, through out the time.

2 "OPERATION CONTROL AND MAINTENANCE" DEPARTMENT-OCMD CURRENT SITUATION

There are three processes that the MCSDW does:

a) Client cadastral information and invoice delivering.

b) Drinking water and sewage network operation and control.

c) Drinking water and sewage network engineering designing

From the above list, only the client's cadastral information and drinking water will be developed in more detail in this paper. The drinking water network "Operation Control and Maintenance" Department - OCMD has to mainly care for: Water no counted because of leaks, tank's overflow and clandestine connections. Leaks are going to be solved by a better control and maintenance of pipes and valves, tank's overflow by level control valves implementation and monitoring, and clandestine connections through out a better control of connections! In short, the goal to the OCMD is to implement a better control. How to do that? If currently, there are:

2000Km of old/new pipes (60% steel, 30% PVC, and 10% cement) supporting 70PSI overage of water pressure, not known yet number of valves, fire hydrants, and tampons (these are called accessories) all lost in a pile of paper archives and few outdated digital files spread out all company wide. There is a need of a geographical information system, no doubt about! The goal for this module will be to automate the production of the "operative digital map" that allow to do the best field work of pipes and accessories maintenance and to keep updated information for mathematical modelling and simulations of drinkable water.

3 CURRENT SITUATION OF THE "CLIENT'S CADASTRAL INFORMATION AND BILL DELIVERING" DEPARTMENT – CCIBD

The CCIBD is currently working with digital clients recording together with their water accounts. The system has been implemented in the AS400 with 9406-170 processor model, Operative system OS400 V4R2M0 and DB2 as the relational data base management system. This client's textual database has around 400 entities of 270000 records each. It manages 40 transaction types with an overage of 17000 monthly calls. This is a good textual database but does not help routes drawing planning for measurer reading. Besides, the near future asks for quicker client attention and base on graphical display (maps) so that the client can locate its parcel on the map and start the process of water service contract. Therefore this department also needs the geographical information system tools as well. The goal for this module will be to display and query graphically the client's information currently stored in the AS400 under DB2, on line graphical update of connections implemented and requested, and automated graphical planning of routes for measurer reading.

4 HUMAN RESOURCES GIS COMPONENT

Within the corporate GIS vision, it is understood that there will be a core GIS and a desktop GISs so it is necessary to prepare and train three kinds of people: updating operators, administrators of systems, application developers and customising. The two later will work for the core GIS and the formal will do for the desktop GIS through which they will update the core geographical database. This project will start with a suggested incremental staff number you can see in the Table 1. The number of people has been established in order to end the project util its operation phase in a period of four years, the staff performance was calculated in base of passed experiences.

Use for		People for each use (number of sites for the client-server structure)				
	Clients	General Management	Planning and Development Management	Studies and Engineering Management	Client's Cadastral Information and Bill Delivering Management	Operation Control and Maintenance Management
Consults and queries	3	1	1	1	1	1
Networking design (water and sewage)				3		
Network operation control and maintenance (water and sewage). Data input and updating						4
Measurer readings and billing (routs designing)					3	
Geoprocessing and geo-database design and management			6			
Total = 24	3	1	7	4	4	5

Table 1. People and sites according to uses

4.1 Training.

Once specified the functions, the personnel choice, software, hardware, data models and database design, a good planned continuous training must start. Table 2 shows the training plan and its calculated cost.

Phase	Theme	Method	**Core GIS** Personnel	Time (weeks)	**Desktop GIS** Personnel	Time (weeks)	**Cost $**
Planning	The Company business (Client's information and water network)	Interviews/practical	2	3			3000
Designing	Georelational model Object Oriented model	Formal	3	0.2	8	0.2	2200
	GIS system administrator	Formal	1	1			500
	GIS network administrator	Formal	1	1			500
	DBMS administrator	Formal	1	1			500
Implementing	GIS global view	Formal	3	4	8	2	14000
	GIS specific module for water network.	Case studies	1	3			1500
	GIS specific module for cadaster	Case studies	1	3			1500
	GIS core application development	Case studies	2	2			2000
	GIS desktop application development	Case studies	3	1	2	2	3500
	GIS and orthophoto	Formal			3	1	1500
	Water network data loading	Tutored			5	2	5000
	Cadastral data loading	Tutored			3	2	3000
Management supporting (6 people 1 week)	GIS global view GIS products Economical analysis of the GIS project	Case studies Demonstrations Formal					3000
Total							41700

Table 2. Plan and costs for GIS training

4.2 Disruption level

For this component the disruption level is given by the following reasons: full decentralised and inconsistent replicated databases, low salaries, and personnel age over 37.

4.3 Organization.

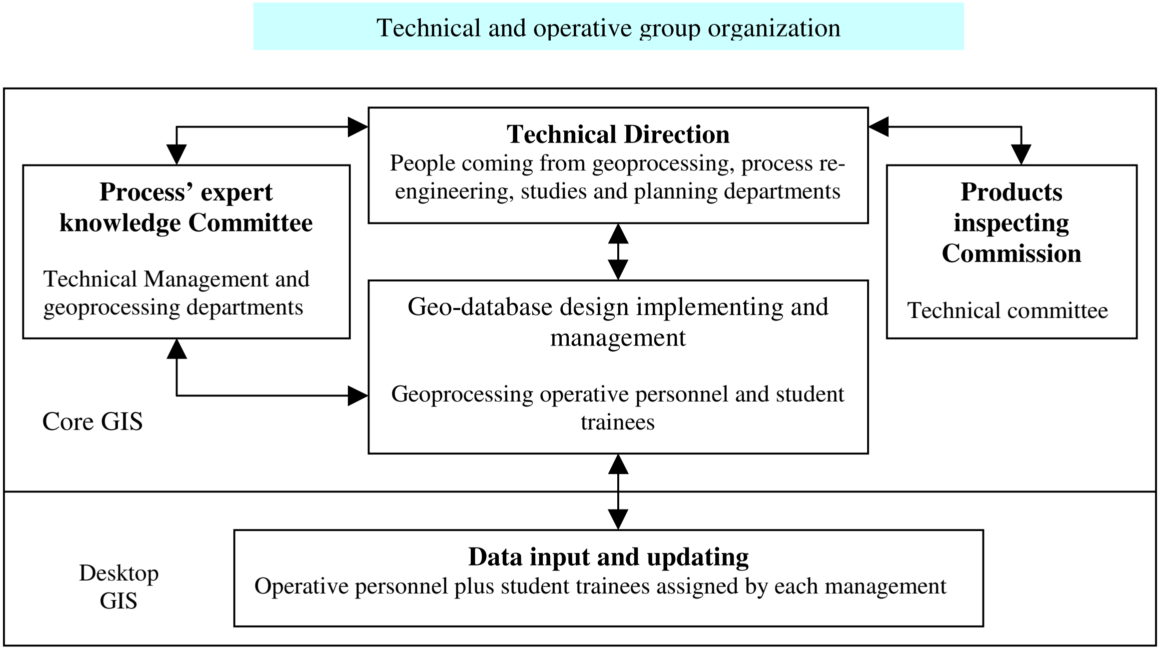

Figure 2. Technical and operative group organization

The Technical and operative group has direct interaction with Finances and Management group, the users group and the strategic policy group. This system is par t of one outer utilities system, which some day will just be the generalisation of the specific ones.

5 DATA GIS COMPONENT

The data needed to accomplish the GIS' goal is in accordance with the processes data need requirement. For CCIBD and OCMD the macro processes are:

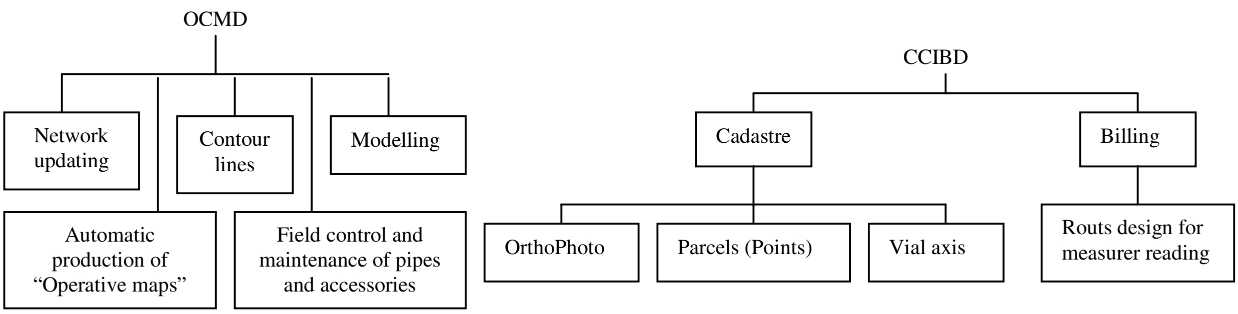

Figure 3. Operation Control and Maintenance macro processes. Client's cadastral information and billing macro processes

It has been defined three work scales: 1:1000, 1:2000, and 1:5000, the later is used for rural areas: So far, it has been working with the Provisional South American Datum from 1956 – PSAD56, which is a horizontal datum not suitable for scales greater than 1:10000. Therefore, this project has started to work with the World Geodetic System from 1984 geocentric datum, since June 1999, however most of the current digital cartography (95%) is in PSAD56, and this will continue until our WGS84 geodetic net and the "seven parameters" datum transformation will be ready. Consequently, we must continue establishing control points in WGS84 with precision valid for one thousand scales.

Since 1995 the project was devoted to mainly data gathering therefore it has already invest more than the 50% of the budget.

5.1 Disruption level

In MCSDW the data disruption level is given mainly by the still low orthophoto acceptance since –they say- it is not the goal for this water network company. This is true, but in the other way, although the MCSDW has money to buy that information, there is no secure and frequent source of supplying. At the end MCSDW is always paying to third companies to redo the cadastral digital information which results more expensive that keeping its own cadastral database for client's information. In fact there is already a textual cadastral database it needs the geographical related entity (drawn parcel or representative points).

5.2 Data Organization

The data models used will be the vectorial model for pipes, accessories and parcels. The raster model will be used for orthophoto. The database will follow the geo-relational model. The amount of digital data will be:

Theme	Administrative digital unit of information				Full size (GB)
	Raster	Vectorial feature	Name	Number	
Geodetic Network WGS84		Points	Cadastral sector	200	0.05
Orthophoto 1:1000	√		Cadastral sector mosaic	200	140
Cadastral sector (parcels)		Polygon	Cadastral sector	200	1
Parcels*		Points	Cadastral sector	200	0.2
Water network		Arcs	Hydrologic sector	300	0.3
Accessories		Points	Hydrologic sector	300	0.06
					141.61

Table 3. Data layers and administrative digital unit of information

*The parcel's points will be used on the orthophoto and linked to the client's database.

The data will be input to a central database in the core GIS and the updating will be distributed to each related management who does field work. In fact, there will be a Core GIS (centralised geo-database) and a desktop GIS with mainly data updating task.

6 INFORMATION GIS COMPONENT

Information is data enriched with specific meaning to the owner. The Information produced by the CCIBD and OCMD are:

Information produced by CCIBD		Information produced by CCIBD	
Data	Information	Data	Information
-Scanned aerial photographs 1:7000 -Geodetic network	-Cadastral sectors in Orthophoto 1:1000 mosaics -Client's textual information related to digital points representing the parcel's position. -Routs for water consumes measurer reading.	-Cadastral sectors in Orthophoto 1:1000 mosaics. -Pipes and accessories data gathering by fieldwork. -Pipes and accessories designed (drawing level) for specific projects. -Client's textual information related to digital points representing the parcel's position.	-Updated real drinkable water network. -Hydrologic sector. -Pressure modelled data for field operation control. -Operative maps for field operation control and maintenance. -Water clients consume information by hydrologic sector.

Table 4. Information produced by CCIBD and OCMD

The information produced, although is updated only for specific staffs, it has to be available to all departments and users all company wide. Therefore the information rights -in order to sell it- has to be established clearly. Besides, as orthophoto, automatic production of "operative maps" and contour lines are new processes for the MCSDW, the process reengineering has to be taken in account.

7 HARDWARE COMPONENT

The project is designed to have a centralised geo-database and a distributed updating process. Therefore we talk about a client-server architecture of one HP9000 server and 24 clients, 6 of which will be located in other buildings. This network is working as part of the general network installed in the company's building, see figure 4.

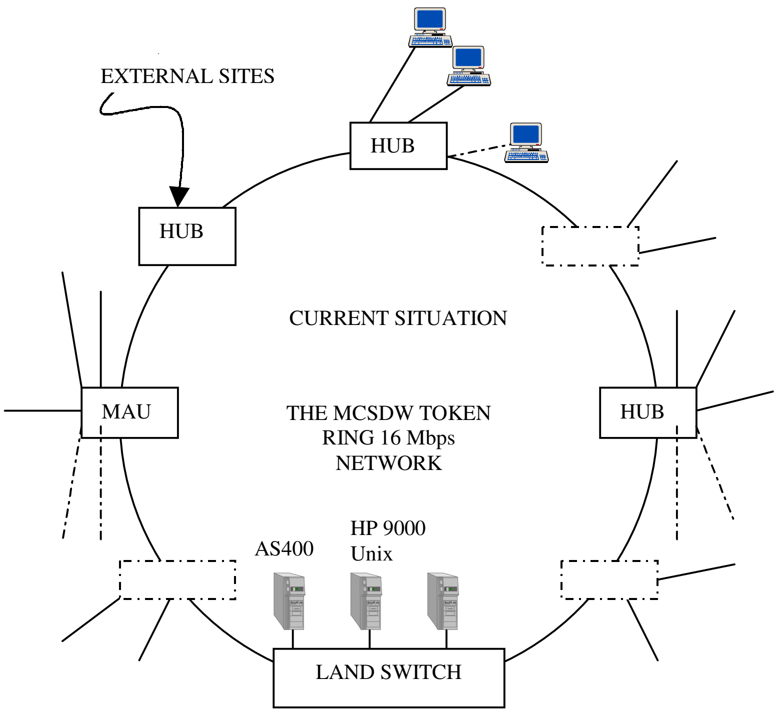

Figure 4. The current MCSDW token-ring 16 Mbps network

8 SOFTWARE COMPONENT

The order used to refer this component does not mean less importance. At the MCSDW, the software has been determined after the data and information was cleared see figure5.

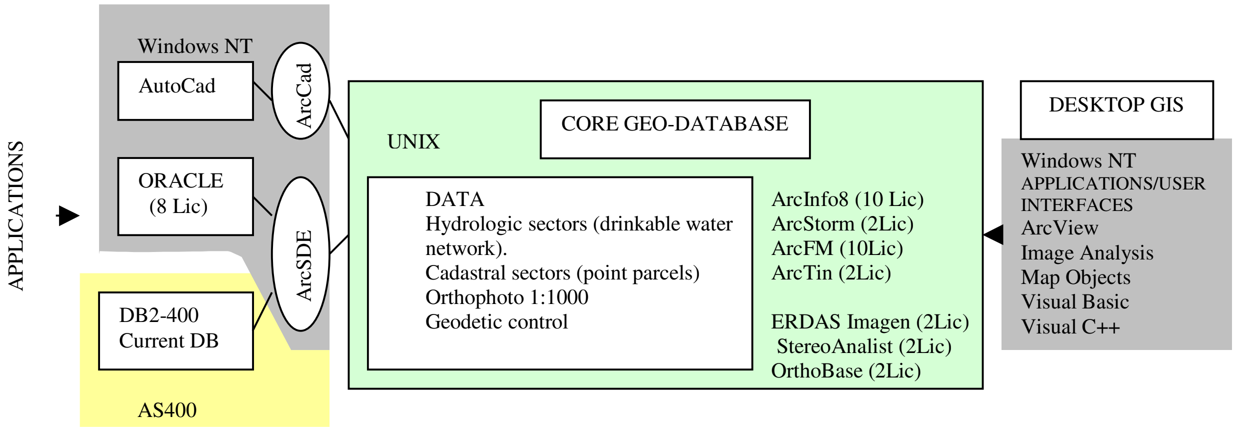

Figure 6. Software required for CCIBD and OCMD process

9 CONCLUSIONS

As this paper has shown some of the important points in planning a GIS project for drinkable water by using a components way, the conclusions will be presented for planning and implementing following the same components way.

9.1 Human Resources

9.1.1 The best GIS can be seen unsuccessfully implemented, if the system's human component was not properly enrolled in the project. It is wise to assign the task of keeping support to the project from the very beginning and constantly.

9.1.2 If the disruption level of staff and users of the system can be determined, strategies to change that level will be easier to develop

9.1.3 Start with formal levels of training is the best way to convince reluctant people and speed up the implementing process.

9.1.4 The GIS executive administration must be a top level if the project is going to affect all company departments. Otherwise the procedures to get approvals for process change, hardware buying, and contracts starting will remind backward.

9.2 Data Component

9.2.1 Data is the most expensive component of any GIS project.

9.2.2 Data requirements determine the project scope, so concrete specifications of data will reduce debates on themes that will never be implemented. But it should not be forgotten the current project insertion in a wider system which can be a national wide.

9.2.3 Besides the theme, it must be specified scale and accuracy required, because more accuracy implies more money and time!

9.2.4 Orthophoto is the best way to have updated cartography but is a process that can be developed or contracted, it depends on the circumstances. For MCSDW is better to develop the process and own the technology involved.

9.2.5 Vector and raster data models have to be integrated to get rapid drinkable water network digital information for operation control and maintenance. Vector for pipes and accessories information and raster for orthophoto.

9.2.6 Because of the physical area size, the digital information has to be managed by a stable "administrative digital unit of information". The MCSDW uses the cadastral sector for client's information and orthophoto base map, and the hydrologic sector for drinkable water network information. So we talk about a vertical sorted themes and horizontal area division.

9.2.7 Data can not be load at once; it needs to follow a priority plan under an overall design.

9.3 Information Component

9.3.1 Data enriched with specific meaning to the MCSDW represents information. In this paper the information produced is orthophoto base maps and operative maps for drinkable water network control operation and maintenance.

9.3.2 Information has to be seen for many departments no owners of it. Therefore, the information can be seen by authorised people but updated just by the owners.

9.4 Software Component

9.4.1 Software is more expensive than hardware.

9.4.2 Although every software package says to be compatible with the standards, it must be taken into account always an extra editing work when importing/exporting data from different packages. Consequently, a suitable family of software products must be selected from the very beginning although you are not going to buy them all at once, it is a process related to data loading and data analysis needs.

9.5 Hardware Component

9.5.1 It is the less important if we think that the suitable technology already exist. Therefore the hardware component can be seen just as the result of good planning on the above components.

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