Design Criteria in Government Institutional GIS (GIGIS)

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SUMMARY

Government institutional GIS (Asato et al, 1996) is all of those criteria that can be used in the design of an efficient and useful geoinformation framework in institutions that work with regional and environmental data.

As all environmental government agencies, National Geological Surveys supports as public good all of their territorial information. GIS and others computer methods are useful tools for archiving, analyzing and displaying resource information. Nevertheless there are some criteria that should be followed, in order to the successful management of the data:

- Standardized thematic and digital information which offers to users and developers a comprehensible data structure.
- General use oriented and open data structure design which facilitate the data integration -in thematic and logical terms- with other agencies or NSDI levels as well as specific projects.
- Use of legal or recognized data source which define the data quality, liability and reliability.
- Large database managing and operational capability that facilitates the access and management of the data.
- Use of a common Cartographic Index System in order to preserve the spatial consistence and promote the data sharing with other government agencies.
- Definition of Systematic Patterns for Data Entry and Productions Methods. A Institutional GIS infrastructure can be only made if all of the production processes and methods are well known.
- Metadata organized in a clearinghouse system

RESUMEN

Se define como SIG de Instituciones Gubernamentales (Asato et al, 1996) a “aquellos criterios que pueden ser utilizados para diseñar un Sistema Nacional de Datos Geológicos u otros sistemas nacionales o estatales de datos ambientales en instituciones basados en tecnología SIG”.

Las agencias de gobierno que manejan datos ambientales, entre las cuales se encuentran los Servicios Geológicos, tienen como una de sus funciones principales preservar y mantener como bien público, la información de su territorio en los temas que les competen. A pesar del gran potencial que los SIG y otras herramientas automatizadas de tecnología de información nos ofrecen para el almacenamiento, el análisis y el despliegue de la información, y la creación de productos específicos, existen algunos criterios que deben ser tenidos en cuenta para garantizar el éxito de un proyecto que contemple el diseño y la construcción de un Sistema de Infraestructura de Datos Geo-Espaciales en el ámbito de una institución de gobierno.

Estos criterios pueden ser organizados en siete puntos que se enumeran a continuación:

- **Se debe trabajar con información normalizada, tanto como desde el punto de vista temático como lógico** de forma tal que se pueda contar con una estructura de datos comprensible tanto para desarrolladores como para usuarios.
- **Los datos deben estar orientados al uso general y el diseño de su estructura debe ser abierto**, de manera que la integración de la información con otras agencias o niveles de la NSDI sea posible, así como también su expansión e integración en proyectos específicos.
- **Los Sistemas Institucionales deben utilizar datos de fuentes reconocidas**, tanto desde el punto de vista legal como temático, de manera de asegurar la calidad, disponibilidad y responsabilidades sobre los productos finales que se generen.
- **El sistema debe ser capaz de manejar y administrar grandes cantidades de datos**, de manera que se facilite el acceso y administración de la información
- **Los mapas (unidades de captura) deben estar referidos a una grilla índice nacional o patrón**, con el fin de facilitar el mantenimiento de la consistencia espacial y el intercambio de datos con otras agencias de gobierno.
- **La estructura de trabajo debe basarse en un sistema de entrada de datos y producción sistemática**, similares a los sistemas de producción industrial. Asimismo se asegurará que todos los procesos y métodos utilizados sean bien conocidos a través de la documentación de los mismos.
- **Los datos deben ser documentados en la forma de metadatos y los mismos organizados y administrados por un clearinghouse**.

INTRODUCTION

From a little more than a decade (1994 - 2005) the Geological and Mining Survey of Argentina (SEGEMAR) has been developing the “Government Institutional GIS” concept (Asato et al. 1996, Asato and Marín 1998, Asato 2001). Based on this concept, a series of criteria that provide a conceptual, functional and operative framework for the development of spatial infrastructure and production systems at national and state levels was defined. The same concepts and criteria, applied in the construction of the Regional Geology GIS System of SEGEMAR, provided the conceptual basement and basic tools in the design and management of different institutional projects.

"GIS is a system that can store, display, manage and analyze geographical information where computing systems, trained people and data analysis play an important role" (Burrough, 1986). Perhaps people that have never heard of GIS could find this concept a little strange, because GIS establishes a link between ideas and things. But people with experience in GIS understood that definition very well; because they found that it is very important to take in account into the GIS design all of the last enumerated elements. The success of a GIS project depends on how project designers evaluate the GIS components in the context of the project objectives.

At government level, the definition of GIS components depends on the role that the system plays in the organizational structure and the institutional role and responsibilities at the social and government context of the country.

Institutional GIS concept try to define a functional and operative framework facilitating the creation of a natural coordination between institutional spatial infrastructure, NDSI and special projects objectives. It also try to define a series of simple and basic guidelines for project coordination at different levels, between different working groups in the same institution or with other working groups in other institutions or agencies.

The coordination of efforts is made by establishing the objective convergence focusing the data management and integration problem at logical and thematic levels and through the establishment of a minimum set of cartographic and spatial consistency rules.

Institutional GIS may be understood as a special kind of Corporate GIS. As corporate GIS, institutional systems have to deal with similar resources and data management problems, as well as similar production methods. Main differences may be found in subjects related to the nature of data, production policy, and developed products. Institutional Systems should follow standards, directions and methods driven by public and social needs and also by geopolitical directions given by the government administration. On the other hand corporate systems are droved by business interest.

Institutional GIS concept is quite similar to Custodial GIS concept that Boham-Carter (1994) defined as “GIS developed and maintained in large organizations that have the responsibility of large database that are used by many users for extended periods of time”.

In several aspects Institutional GIS concept also have coincidence with the ideas about Infrastructure GIS defined by Murai (1999), Corporate GIS defined by Chan and Williamson (1999a) and the ideas about geological information publishing given by Bernkopf et al (1993), Schmidth (1995) and Cho (1995).

The following elements characterize the Government Institutional GIS:

- Standardized thematic and digital information which offers to users and developers a comprehensible data structure.

- General use oriented and open data structure design, which facilitate the data integration -in thematic and logical terms- with other agencies or NSDI levels as well as specific projects.
- Use of legal or recognized data source, which define the data quality, liability and reliability.
- Large database managing and operational capability that facilitates the access and management of the data.
- Use of a common Cartographic Index System in order to preserve the spatial consistence and promote the data sharing with other government agencies.
- Definition of Systematic Patterns for Data Entry and Productions Methods. A Institutional GIS infrastructure can be only made if all of the production processes and methods are well known.
- Metadata organized in a clearinghouse system

STANDARDIZED THEMATIC AND DIGITAL INFORMATION

Standards provide the basis for data definition and data structures, and promote data distribution, integrity and interoperability, and facilitate data use and exploitation (Asato 1995, Asato et al 1996, Burns and Glyn 1995, Bruce et al 1999, Cerdàn, 1993, Dozier et al. 2003, Murai, 1999, Schmidth 1995, etc.). Standards provide a common basic language for GIS developers and users.

GENERAL USE ORIENTED AND OPEN DATA STRUCTURE DESIGN

Institutional geospatial information not only could be stored as a series of geographical digital data. It also include a digital model or conception of different spatial phenomena reflecting their structure, organization and behavior. The Data model comprise a several geodata that could be included in other projects as framework information or as a part of NSDI core-data with different degrees of data generalization.

Data taken from institutions, as in the case of geological surveys, could be used in diverse projects by a variety of users or geoscience applications. The data structure and model generated in institutions must have a flexible design, so that external users can integrate the data in their own GIS projects (Asato et al 1995, Asato 2001, Murakami 2004).

In the context of this paper, open design not only has significance in terms of digital interoperatibility. It also is defined in terms of thematic and conceptual modeling, where geodata and their digital description should be modeled according to the institutional data rules (interactions) in the general geoinformation framework.

Thematic information not only should be supported by open systems and standards, it must be generalized and structured according its interactions with other data centers or systems in order to guarantee the correct use of the data.

The geodata interactions in different hierarchical organizations levels have been described by several authors. Asato et. al. (1995) analyzed the geodata interaction between three hierarchical levels, National Infrastructure GIS, Institutional GIS and Proyect GIS. Rajabifard and Williamsom (2000) also describe data interactions between different organization levels, from global to corporate, applying hierarchical spatial reasoning.

The definition of institutional data hierarchy and its interaction with the general geoinformation framework allow to define the levels of data generalization according to the requirements of other users and organizations.

The open data structure design must allow the use and integration of the data in different projects by data generalization and refinement. Open design also should promote the consistent use of the data maintaining the data lineage as far as possible.

USE OF LEGAL OR RECOGNIZED DATA SOURCE

Further on the quality or validity of geodata have been defined by metadata, the quality of information also must be supported by the quality of the institutions that generated it.

Institutions also must define the basis for the creation of standards and criteria of quality, based on the institutional knowledge and tradition about specific items and the know how supplied by universities or research centers.

The information not only must be controlled in terms of cartographic and thematic matters, but also in the possible legal aspects. Information or analysis generated by government institutions could not be recognized by courts if the geodata have not an adequate legal support and the institutional responsibilities are not well defined. In Argentina, official cartography has special regulations. Topographic maps are generated by IGM (Military Geographic Institute), and regulated by National Law n. 11.723. The Mining and Geological Survey of Argentina has responsibilities for the geological surveying of the national territory given by National Law n. 24.224.

The best way to assure the optimal thematic and legal conditions for geodata use and analyses it to warranty that this information are the best information available. In all of the cases, data should come or be certified from recognized institutions, which have the legal capability of certify the value and the data quality.

LARGE DATABASE MANAGING AND OPERATIONAL CAPABILITY

Institutional geoinformation may vary in volume, complexity and structure as well as the methods and the procedures required for data management, upgrade and production.

Hardware and software specifications depend on the area that the GIS has to cover, the working scales, the complexity of spatial formats to be included, the expected numbers of operators and users, and the production and data publishing policy. The operational problems were review by different authors as Murai (1999), who describe the condition of hardware and software in institutional infrastructure information systems focusing mainly the problem in data information sharing capabilities, networking and interoperable procedures capabilities.

In the case of the Geological Surveys, computer and software systems have special characteristics. Field samples, geological cartography, satellite images, geophysical data, and 3d seismic data, are some of the kinds of data that geologists have to manage. Because of the special characteristics of geodata, geologists need powerful computers, and special software that can handle a variety of spatial formats (p.e. arc-node, spagetti, TINs, binary and floating raster, quadtrees, octrees, etc.). Geological GIS software must be able to manage different kinds of vector and raster formats and should have database management capabilities. In addition, specific projects will need interoperable procedures with other applications such as statistical packages.

In government agencies GIS systems have to manage each sheet as a distinct cartographic unit, but also have to manage a series of maps covering a specific geographic area as one map. Analysis and dynamical displaying of geodata, among others procedures, may require to cross sheet boundaries. In this context, data storing, displaying and management is difficult. GIS software needs a special tools for geodata management as spatial index system, upgrade and versioning control applications, data compression tools, special display methods, spatial and thematic integrity tools, etc. Even though the system should made the geographical integration of different areas, it should be also prepared to integrate the information taken at different scales with different generalization levels.

Commercial software applications usually does not cover all of institutions necessities: this is the rule. Specific or scientific applications usually take a long time to be developed as commercial products. In this case, software should be customized using any programming language. Processes and production could be automated and special applications for users could be written.

Sometimes special applications requirements not only could be made by programming, but also be made by using other specific software packages by means of interoperable procedures. In this way, statistics packages, special analysis algorithms, database systems, etc. became interoperable and various disciplines could be integrated in the way of integrated geographic information system (Estes, 1992;Jaques L. 1992, Murai 1999, etc).

Also, operational capability is understood as the capability of the system to work in an adequate networking environment was geoinformation could be accessed and integrated by different systems.

Another important item is the hardware and software stability. Applications and equipment should be in condition to manage large data volumes. The System must be in a fit state to provide different information services in a quick, effective and flexible manner.

Since the institutional systems, by rule, should provide information services for a multiplicity of users, the used systems must be very stable even though under very high working pressure.

COMMON CARTOGRAPHIC INDEX SYSTEM

Standard or national grids are the most common and easiest methods for cartographic indexation and geographical dataset organization in catalogs. In the special case of institutional or regional GIS, cartographic grids, by definition, should cover all of the administrative areas.

Map sheets organized in cartographic grids, also have a lot of computing advantages:

- Provide the basic model for the arrangement of a geographic database space.
- Provide a basic model for rapid spatial data access, management and display by software processing throughout spatial index construction.
- Using the same geographical and projection definitions, agencies and institutions can share data easily.
- Provide a method for the management of mapping criteria and digitalizing conditions.

  In the continuous space concept, the tile or cell reflects the basic data. Use of capture units also implies the same mapping criteria and digitalizing conditions for the entire tile.

- Promote the spatial consistency.

Tiles or map boundaries may be used as spatial reference cover by the precise coordinate definition of boundary nodes. Map boundaries also could be used in automated process for the detection of geometrical or projection anomalies in geodata that correspond to this area.

- Grids self-similarity property could be used as a management tool where there are a lack of information exist.

Self-similarity means that grid and tiles can be decomposed in minor units with the same shape (Laurini, 1992). This property is a convenient method to organize the dataset and to integrate partial surveys in a spatial consistent manner because the area, surveying and digitalizing conditions are easy to preserve. The tile decomposition in smaller standard rectangular areas allow to play with the data as a regular puzzle and organize future survey for data completion.

Commercial advertisement usually point out that GIS can spatially integrate dataset with different boundaries; however the problem is that those final maps are not complete maps and analysis is only valid at superimposed areas. Using the tile decomposition in smaller units, where complete information is not available, may help the consistent integration and management of the geodata by the clear definition of the areas where data in not present.

DEFINITION OF SYSTEMATIC PATTERNS FOR DATA ENTRY AND PRODUCTION METHODS

The main reason to define a systematic production structure is to provide effective and constant services through time.

Although there are a lot of GIS applications developed at research level, is not easy to translate those developments to production environment. Effective information services and production systems could only be defined if fundamental necessities, systematic patterns, as well as practical solutions and products are recognized. This allows the development of systematic flow pattern from data surveying to final product generation.

Production systems comprising an Government Institutional GIS should mimic industrial production systems. All of the production processes have to be well known, well documented, and well tested. Working with industrial production systems, quality and production are guaranteed.

METADATA ORGANIZED IN A CLEARINGHOUSE SYSTEM

Metadata generation and management is one of the most important subject develop in the context of SDI development.

Most of the GIS producers agree that documented information promote the data use in future projects. Data plus documentation conform a set of information that could be used as valuable information.

Standard documentation methods support four mayor roles: locate, evaluate, extract and employ the data (Danko, 1997). Clearinghouse systems support the entire network framework of implemented metadata systems and try to minimize the duplicity efforts.

Recently, Taylor (2004) characterizes metadata by significant benefits to such asset management Metadata helps organize and maintain and organization’s investment in data and provides information about an organization’s data holdings in catalogue form.

- Coordinate metadata development avoids duplication of effort by ensuring the organization is aware of the existence of data sets.
- Users can locate all available geospatial and associated data relevant to an area of interest
- Collection of metadata builds upon and enhances the data management procedures of the geospatial community
- Reporting of descriptive metadata promotes the availability of geospatial data beyond the traditional geospatial community
- Data providers are able to advertise and promote the avaibility of their data and potentially link to on line services that relate to their specific data sets.

Due to the importance metadata in the management of geospatial information, institutions should promote the creation of metadata according international standards and support of a discovery and access service by clearinghouse systems (Nebert, 1996).

GOVERNMENT INSTITUTIONAL GIS AND ADMINISTRATIVE AND INSTITUTIONAL POLICY

Most of the subjects discussed in this paper describe the main conceptual and technical items that should be managed in order to design and create a GIGIS. Moreover, there are some other important subjects that have strong incidence in the development of institutional geoinformation framework related to administrative and institutional policy matters.

Those problems are far from the scope of this paper, but in few words it is possible to establish that the success of a GIGIS will depend on how the role of geoinformation technology in the organizational structure was defined and the awareness and benefits that other colleges and institutional managers perceive. The readers interested in this problems may referred to Asato, 2001; Chan and Williamson, 1999a and 1999b; Murai, 1999; Tateishi and Hastings, 2000; When de Montalvo, 2004.

In order to guarantee the success of a GIS project a clear administrative and institutional policy should be defined based on a careful analysis of financial support, production expectation, relationships with other institutions, and relationships and insertion in the hierarchy of national spatial data infrastructure.

CONCLUSIONS

The development of Government Institutional GIS (Asato et al. 1996), in geological surveys and other environmental agencies, has to be understood as a public service, and has to provide information for all of the administrative territory. The use of digital data has to be generalized, and the standards have to insure the quality and accessibility of the institutional data. Data model have to provide a comprehensive structure and reflect the organization and behavior of the modeled spatial phenomena. Open design criteria may allow the data integration by generalization or refinement in diverse projects. The production is insured by appropriate hardware and software selection and routines design. Good data structures and management systems designs facilitate the data use and exploitation.

As a general recommendation, the presented model is intended to be use in national or provincial agencies that work with regional and environmental data at scales between 1:500.000 and 1:50.000. The extrapolation of the presented criteria to more detailed information may imply an adjusting of the model.

Those criteria that conform the concept of Institutional Government GIS are general guidelines for the construction and development of a geoinformation framework at governmental institutions. They provided the conceptual basement and basic tools in the design and management of different institutional projects

The concept of Government Institutional GIS reflects the experience obtained in the construction of the SEGEMAR Regional Geology GIS and in the development of several institutional projects from a little more than a decade (1994-2005).

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