DESIGN, MODELING AND DATA PREPARATION OF MINES AND METALS GEOGRAPHICAL INFORMATION SYSTEM

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ABSTRACT

In September 2000 Ministry of Industry and Mines (MI&M), which is responsible for exploration, exploitation and management of mines as well as managing Industrial affairs in Iran, decided to build up a GIS in such a way to manage and control different tasks related to its Mines and Metals (M&M) Department. In November 2000, Department of Geodesy and Geomatics Engineering (GGE) of K.N.Toosi University of Technology has been selected to carry out this project. This project consists of two main stages. In the first stage a DBMS (DataBase Management System) is constructed and in the second stage applications of different parts of M&M Department will be added to it. This paper outlines the first stage with emphasizing on preparing and constructing the spatial database for M&M GIS, which is one of the fundamental requirements of MI&M.

1- INTRODUCTION

Before starting M&M GIS project a feasibility study was carried out to find the potential of MI&M for construction of a GIS. The results of this study showed that no powerful spatial DBMS for their appropriate spatial data infrastructure such as standard and specification for designing and implementing the system was available. So it was decided to carry out the project into two main phases.

The first phase involves standardization and preparing fundamental data, which is required for M&MGIS system, and building a DataBase Management System (DBMS). The result of this phase is a base GIS system containing those data and common GIS functionalities that almost all of the sections in the ministry need them.

The second phase involves adding required data and GIS functionalities of each section of the ministry into the DBMS. So applied GIS of each section of the ministry will be built separately based on prepared DBMS in the first phase. This paper outlines the first phase of the project.

In order to supervise the first phase of the project, the Steering Committee of Mines and Metals GIS (SCOMMG) consisting of GIS, mapping and geology experts was organized. For managing and carrying out the project better and more sophisticated, the SCOMMG broke the project into different subproject as follows:

- Recognition
- Conceptual modeling
- Selecting GIS environment
- Standardization
- Preparing methods and rules
- Logical modeling
- Physical modeling
- Designing user interface
- Data preparation and structuring
- Software development and implementing the system

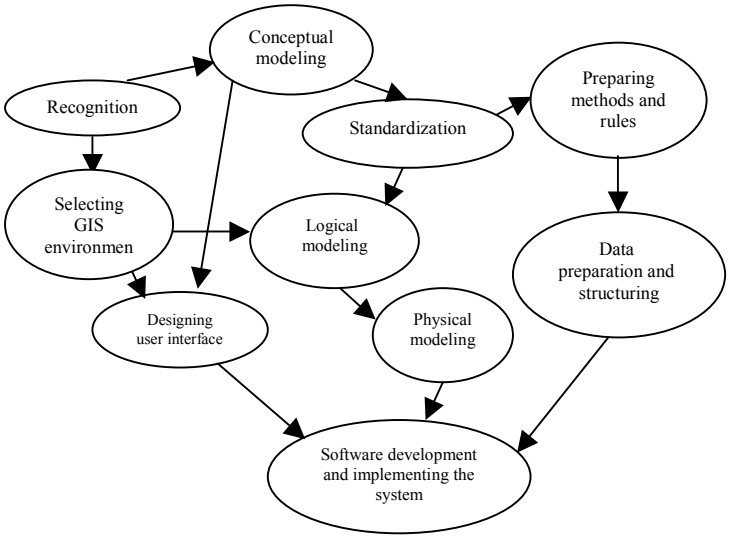

Figure 1: Relation between different sub-projects

2- RECOGNITION

This subproject includes recognition the availability of fundamental data in the ministry and other organization out of the ministry, in a GIS point of view.

The major departments of ministry dealing with spatial data such as the National Geological Survey Organization (NGSO), the Deputy of Exploitation, the Directorship of

Exploration, the Bureaus of Counties and etc. were visited. Different existing spatial data ranging maps, aerial photographs, satellite imageries as well as attribute data relating to spatial data were investigated. Also those range of requirements that a GIS can reply to each of the departments were investigated and documented.

Existing spatial data in different organizations, out of ministry, were also investigated and evaluated with respect to this project requirement. The main organizations include National Cartographic Center (NCC) which produces 1:25,000 scale topographic maps of whole Iran as well as 1:1,000,000 topographic database, National Geography Organization (NGO) which had produced 1:50,000 and 1:250,000 scale topographic map of the whole country, Iranian Remote Sensing Center (IRSC) which has updated some of the layers of 1:250,000 scale topographic maps using satellite imageries.

3- CONCEPTUAL MODELING

This stage consists of selection of appropriate scale (scales) of spatial data for storing in the system, compilation of the information framework, compilation of the information cycle and defining and representing the relation between entities.
For building a base GIS, one has to consider the potential sources of data and what data are available and can be used with minimum level of preparation and processing.

The most important factors that were considered in selecting the fundamental datasets were:

- Data should be available for entire country or at least major parts of the country.
- Data should be in suitable scales.
- Date of Production of data should be justified.
- The quality of data should meet the applications needs.
- Data should be available with reasonable cost and in certain amount of time.
- Data should not need much time and efforts to get ready to input into a known GIS software format.

SCOMMG investigated the results of the Recognition stage. Based on it, three scales of spatial data were identified as suitable sources to be utilized in the M&MGIS project. They are 1:1M, 1:250K and 1:25K digital maps of Iran. The first two items include both topographic and geologic-mining features, meaning that each of which are two separate datasets. The third item includes just National Topographic Database of Iran.

It was decided to use 1:25K and 1:1M topographic datasets that have been produced by NCC. Regarding 1:250K topographic datasets, it was decided to use those datasets that have been updated by IRSC. The NGSO was the only source of producing 1:250K and 1:1M geology-mining datasets so their datasets were selected for this project.

Based on the requirements of M&MGIS project the framework of information at each scale was compiled so the required features as well as their associated attributes were selected. The information cycle, which clarifies those departments that are responsible for producing, updating, storing and using of each of the features, was compiled.

At the end, the relationships between entities including spatial-topological relationships and spatial-non-topological relationships as well as non-spatial relationships were defined and represented in a network diagram.

4- SELECTING GIS ENVIRONMENT

An expert group evaluated different commercial GIS software under supervision of SCOMMG. Comparing the M&MGIS requirements and the capabilities and specifications of each of the evaluated software, Arc/Info was selected to be used as GIS environment. Also SQLServer was selected for storing attribute data, which will be linked to Arc/Info. It was decided to use Visual Basic for programming purposes.

5- STANDARDIZATION

The great efforts have been done for unification of data sets specifications. This was because of the project dealt with different data sets from different sources. The main issue in this regard was the adaptation of standards and specifications in such a way that one can relate between similar features in different scales and data sets without facing to any problem.
It was obviously easy to add extra layers to an existing data set with the same scale. But if one intends to mix several features in different scales, he or she may meet a lot of problems regarding logical consistency, different form of geometry, having the same features in more than one scale with different specifications (graphic symbology, definition, extents, etc) and so on.

For the project, first of all, a set of features in topography and each specific application in the Ministry, including geology survey, have been identified by SCOMMG. Two data sets, namely, 1:25K and 1:1M topographic databases had their own standards and specification. The rest did not have standards but there were a lot of documents concerning definitions, specifications, and symbology. Since 1:25K data set was accompanied by the most complete sets of standards and specification and it was the largest scale amongst the other, SCOMMG decided the standard set of 1:25K to be the basis for adapting and developing of the other specifications for the selected data sets. Subsequently, all the specifications were put together to develop a single set of standards, including all features in all categories, applications and scale. This set includes both topographic and mining features at the scale of 1:25K, 1:250K and 1:1M. Features are grouped into two main classes, namely, topography and mine & metals. The standards set also includes feature name, feature code, class and sub-class, geometry (the shape of feature), graphic symbology, and non-spatial attributes of each feature. The set is called “the Mines and Metals (M&M) GIS Standard”

6- PREPARING METHODS AND RULES

For producing, updating, storing, editing, structuring and quality control of spatial data as well as attribute data, required methods and rules were prepared and documented.

7- LOGICAL MODELING

In this stage, the conceptual model was documented in a manner to be implemented easily in the system. It contains

normalization and denormalization of tables, defining required tables and their associated fields, defining primitive keys and foreign keys as well as defining the domains of the fields in each scale separately.

8- PHYSICAL MODELING

In this sub-project the result of logical modeling was implemented in Arc/Info and SQLServer. It contains creating tables, associated fields with tables, primitive keys and foreign keys as well as linking tables together based on logical model in SQLServer.

9- DESIGNING USER INTERFACE

After holding several meetings and evaluating the requirements of ministry as well as the technical knowledge of GIS users in ministry it was decided to develop four software in one frame by customizing Arc/Info or developing software using Arc/Info functionalities. The first software, which was named General Mine GIS Software (GMGS), should have a user-friendly interface, which gives the users the capability of creating reports, doing required analysis easily as well as creating special thematic maps and so on. The other software will be used for storing and updating spatial data, storing and updating attribute data and creating backup.

In this sub-project appropriate user interfaces were designed for each of the software.

10- DATA PREPARATION AND STRUCTURING

As it was mentioned, different datasets from different organizations were used in this project in which each of the datasets had their own quality and structure. Data to be applied in any geographic database must be appraised in terms of quality. Quality comprises some components, namely, accuracy, logical consistency, resolution, completeness, time, lineage, and so on.

Various tests had been carried out by SCOMMG on the selected data sets to examine the quality parameters. For example, the date of production and the level of processing on digital maps were two important characteristics that had been assessed by SCOMMG.

1:1M and 1:25K topographic data sets had metadata and therefore evaluated easily. The 1:1M topographic maps fulfilled the conditions and were introduced as the suitable sets. 1:25K topographic data had some problems such as: existence of overshoots and undershoots in maps due to the specification and limitation of Microstation in removing these errors. Also no unique code is assigned to features, which have been continued in different map sheets. Specifying a separate database to each map sheet and etc were another problems.

1:250K geologic-mining maps had some problems too. Having no good geometric accuracy, difference in interpretation of geological features that lied in the edge of adjacent map sheets, using no standard in cartographic representation of features in different map sheets and so on were some of the problems of these maps.

1:250K topographic maps were the only set that did not come with any metadata or ancillary information. As it stated before, they have been produced several years ago just as paper map and for long time no updating has come to pass. The only thing that helped SCOMMG was list of map features and layers of digital maps. But since this set was the only set that could cover the entire country, SCOMMG decided to use the set with extra steps for processing and making them ready for adaptation to other sets and for being used in the project.

Except 1:1M scale topography and geology maps, the other datasets needed to be structured and ready for using in M&MGIS system.

In this stage, based on the prepared specifications, methods and rules, all of the datasets, which had not an appropriate structure, were edited and became ready for using in M&MGIS system.

11- SOFTWARE DEVELOPMENT AND IMPLEMENTING THE SYSTEM

Based on the designed user interfaces and functionalities, required software is now under customization and developing by a group of experts in software engineering. After that the prepared and structured data will be integrated with software. The prepared package will be tested and then will be installed in different departments of ministry.

12- FUTURE TRENDS

At the present time, the M&MGIS emphasizes mostly on mines and metals information. Based on the order of ministry the base data relating to industrial parts of ministry will be added to DBMS.

The second phase of the project concerning adding applied data and analysis of each of the sessions of ministry to DBMS will be started in near future.

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