A Centrally Managed GIS System for Protection of the Romanian Archaeological Sites and Historical Monuments

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1. INTRODUCTION

Archaeology and geography have much in common. Like geographers, archaeologists study places. They collect data in the field and map their findings at many different scales, from a square meter within an archaeological dig to regions covering half a continent. Since the discipline's beginnings in the nineteenth century, when researchers sketched artifacts and landscapes in pencil and watercolor, archaeologists have always interested to record and analyze this information. During the last decade, the GIS and GPS technology has been used to map sites with the new precision class and to predict where undiscovered sites of archaeological interest might be.

2. THE CHALLENGE

For over 4 years, the National Institute of the Historical Monuments (INMI) – Ministry of Culture and Religious Affairs has been in the process of capturing and maintaining a database of 23624 archaeological sites, called the official "List of Historical Monuments" (LHM 2004). In 2005, INMI decided to replace an existing tabular only system stored in Microsoft Access application with an advanced server based-applications of GIS technology. The lack of the national information system regarding to the national cultural heritage represent the main argument for the implementation of this centrally managed GIS system.

The main purpose of this project is to provide an coherent GIS system, in accordance with the actually legislation for cultural heritage resources, and to create a unique network between the following organizations: NIHM, INMI, Cultural Counties Direction, and the Direction for Historical Monuments from Ministry of Culture and Religious Affairs that are involved in the updating process of the national heritage resources inventory. This challenge allowed defining a strategy and better decisional support for the Ministry of Culture and Religious Affairs and making an easier access to the primary information related to the historical monuments, their unique code, locations, age determination, etc.

To accomplish this goal, ESRI Romania has built the Romanian Ar-

chaeological Sites and Historical monuments Inventory Application – *eGISpat*, to provide a centrally managed GIS system to maintain and advanced analysis a national-wide historical monuments geodatabase.

eGISpat was designed using a server based solution that provides a powerful, fully integrated, multi-user architecture leveraging the latest technology including ArcGIS Server 9.1, ArcSDE 9.1, ArcGIS Desktop 9.1, and Microsoft SQL Server. ArcGIS Server, ArcSDE and the geodatabase model provide a centralized multiuser mechanism for managing and sharing all the information related to the monuments and archaeological sites stored in Microsoft SQL Server.

3. COMPONENTS AND CAPABILITIES

3.1 The *eGISpat* architecture

The **eGISpat** represents a distributed archaeological GIS system, consisting of several components that can be distributed across multiple machines at the national level. The key components of the *eGISpat* application (Figure 1) can be summarized as:

- *ArcGIS server*: hosts and runs server objects. ArcGIS server consists of a server object manager and more server objects containers. – *Web server*: hosts the Web application and Web services that use the objects running in the GIS server.

- *Data server*: ArcSDE provides a gateway for using, managing and storing multiuser geodatabase in Microsoft SQL Server as database platform, for any client application. Spatial and tabular data are integrated in a common centralized relational database structure normalized through a geodatabase model.

- *Web browsers*: used to connect to the Web application - *eGISpat* Bucharest, running in the Web server.

- *Desktop applications*: ArcGIS Desktop 9.1 and a SOA client application – *eGISpat* Romania connect over HyperText Transfer Protocol (HTTP) to ArcGIS Web services running in the Webserver or connect directly to ArcGIS server over a LAN or WAN.

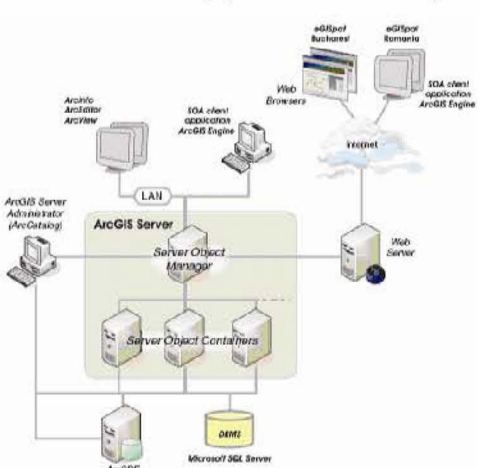

Figure 1. *The eGISpat architecture* – a centrally managed GIS system

3.1.1. Definitions and concepts

Before diving into the details, it's important to review some key terms and concepts that will be used throughout this paper: – *GIS server*: The GIS server is responsible for hosting and managing server objects. The GIS server is the set of objects, applications, and services that make it possible to run ArcObjects components on a server. The GIS server consists of a server object manager and one or more server object containers.

– *Server object manager (SOM)*: The SOM is a Windows service that manages the set of server objects that are distributed across one or more container machines. When an application makes a connection to an ArcGIS Server over a LAN, it is making a connection to the SOM.

– *Server object container (SOC)*: A SOC is a process in which one or more server objects is running. SOC processes are started and shut down by the SOM. The SOC processes run on the GIS server's container machines. Each container machine is capable of hosting multiple SOC processes.

– *Server object*: A server object is a coarse-grained ArcObjects component, that is, a high-level object that simplifies the programming model for doing certain operations and hides the fine-grained ArcObjects that do the work. Server objects support coarse-grained interfaces that have methods that do large units of work, such as "draw a map" or "geocode a set of addresses". Server objects also have SOAP interfaces, which make it possible to expose server objects as Web services that can be consumed by clients across the Internet.

– *Web server*: The Web server hosts Web applications and Web services written using the ArcGIS Server API. These Web applications use the ArcGIS Server API to connect to a SOM to make use of server objects and to create ArcObjects for use in their applications.

3.1.2 Geodatabase Model for management of the *eGISpat* application

The geodatabase model of the official LHM published in 2004 is under development to effectively manage these country-wide archaeological, architectural and historic resources. It is not intended to store all the information associated with a site. It identifies the following requirements: a) identify the location of the historic resources (historical monuments, archaeological sites and ensembles); b) identify internal data files of site data; and c) link detailed site records and other documents (i.e. photographs, scanned images, documents, text, video and so forth) to site locations. Analyzing the structure of the LHM, this includes 23.624 monuments, 18.516 monuments with national and international relevance and 5.108 positions representing monuments with local importance. From typological point of view, LHM includes 1.762 ensembles and 4.040 architectural and archaeological sites.

The *eGISpat* application contains information regarding archaeological

sites and historical monuments, classified as historical monuments, organized in three large categories, in accordance with the methodology regarding the inventory of the historial monuments, who established the principles of the listed/unlisted historical monuments as: monuments, assemblies and archaeological and architectural sites. In addition, in accordance with the Law no. 422/2001, the LHM are structured in four categories: archaeology, architecture, funerary- memorial architecture and public.

The geodatabase consists of a set of feature classes, related tables with defined relationships and domains and allows also business rules, relationships and behaviors to be associated with a combination of spatial and tabular data and administered through the same structure.

Figure 2 shows the structure of the archaeological sites and historical monuments geodatabase model designed for the *eGISpat* application.

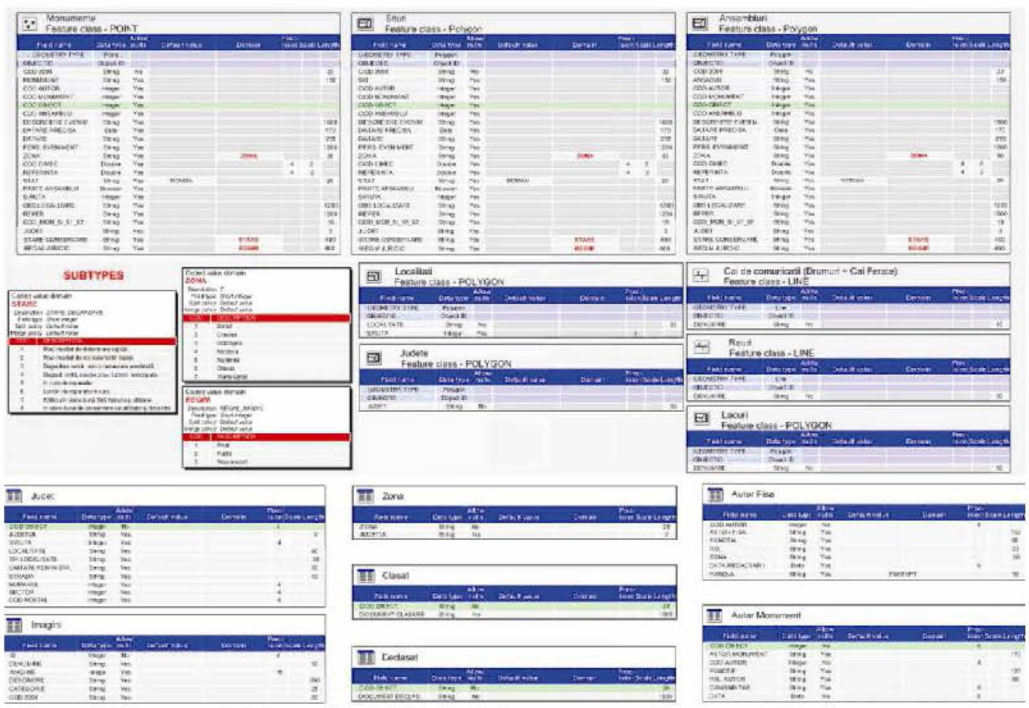

Figure 2. *The eGISpat geodatabase model* – work in progress

At this moment, the eGISpat geodatabase model contains the following feature classes:

- **Monumente:** a point feature class representing historical monuments as points.

- **Situri**: a polygon feature class including archaeological sites as polygons.
- **Ansambluri**: a polygon feature class identifying the extent of archaeological ensembles as polygons.
- **Localitati**: a polygon feature class representing the settlements (towns, villages, communes, Bucharest capital)
- **Judete**: a polygon feature class identifying the extent of the administrative limits (municipalities limits)
- **Drumuri**: a line feature class representing the road network
- **Cai ferate**: a line feature class representing the railroad network
- **Rauri**: a line and polygon feature class identifying the hydrographic network
- **Dunărea**: a polygon feature class representing the Danube Delta

Associated tables carry out most of the attribute information or identify links to site records and documents. The tables identify information about administrative units (called "județ"), geographical regions, historic monuments identifier, staff name, listed or unlisted sites, etc. Domains assist in standardizing sites information. The domains are based on definitions and the vocabulary in the LHM 2004 according to Romanian Law no. 422/2001 and include site condition, geographical zone and the jurisdiction.

3.1.3 eGISpat GIS Web services

For the purposes of this paper, Web services described are SOAP based. SOAP is the messaging framework that defines a suite of XML elements to communicate to arbitrary systems. Web services are discovered using Universal Description, Discovery, and Integration (UDDI). UDDI is a metadata structure that categorizes Web services. Once discovered, the Web Services Description Language (WSDL) is read to understand how to call and invoke services. The WSDL is simply a standards-based XML file readable across platforms.

The users are not allowed to directly connect to the server. Their access is restricted through a Web service catalog. A Web service catalog is a Web service that only exposes the subset of server objects that administrator chooses to expose. On the Web server, the Web service catalog is used also for publishing server objects as Web services over HTTP.

These GIS Web services implemented on the .NET Web server can be consumed also from a Java client.

The .NET GIS services (Figure 3) were developed using ASP.NET framework and could be consumed by the client application – *eGISpat Romania* to:

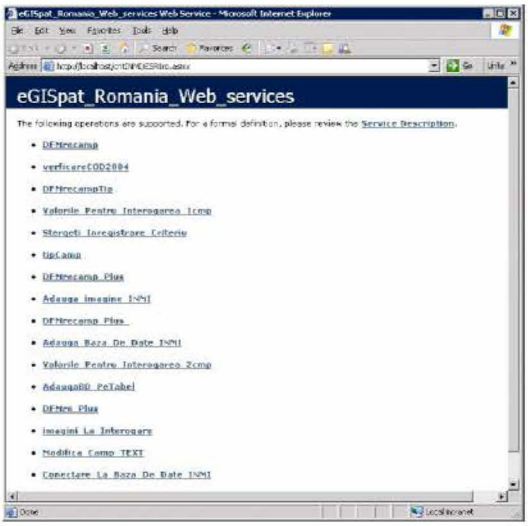

Figure 3. *eGISpat Romania – GIS Web services*

- Verify the uniqueness of COD2004 (according to Law no. 422/2001)
- Return data and the type of all column from a specified table
- Read data from one field
- Delete the records using a "where clause" criteria
- Return the field type for a specified table
- Add image files to geodatabase
- Create geographic features and their attributes
- Return an image according to the selection criteria
- Update attributes of the geographic features
- Perform geodatabase management tasks such as connect and release the connection.

This function could manage and authorize also the user/role and tasks, so Read, Insert, Update and Delete operations can be performed only after authentification process.

3.1.4 *eGISpat* Romania – Web service client application capabilities

The eGISpat Web services are a set of related application functions that could be programmatically invoked over the Internet. These application Web services are implemented using the native ASP.NET Web service framework and are called by the developed .NET client application – *eGISpat Romania*.

The available application's functionalities that can be consumed by the users that have access and know the URL to the Web service catalog are the

following:

- Display the map of the Romanian Archaeological Resources with multiple layers such as roads, streams, historical monuments, etc.
- Save a map document as raster files (JPEG, BMP, TIFF, WMF and so forth)
- Pan and zoom in, zoom out throughout the map
- Zoom to the full extent of the data
- Identify features on a map by pointing at them
- Search and find features on the map
- Display labels with text from field values
- Draw graphics features such as points, lines and polygons
- Draw descriptive text
- Select features by pointing at them
- Find and select features with a SQL (Structured Query Language) expression
- Transform the coordinate system of your map data
- Perform geometric operations on shapes to create buffers
- Perform advanced spatial and attribute queries
- Select features and generate reports related to one or more historical monuments

archaeological sites and ensembles

- Add and delete image files and geographic features to geodatabase
- Perform geodatabase management tasks
- Validate entering values during the create and update process
- Create and update geographic features and their attributes (Figure 4)

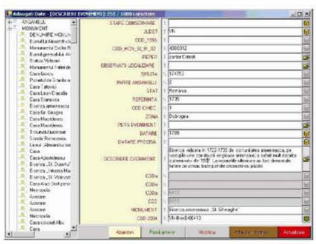

Figure 4. *eGISpat Romania* – the ability to create and update geographic features and their attributes

3.2 Web application of the Historical Centre of Bucharest

3.2.1 History

The historical centre of the city of Bucharest was determined and legally declared as a protected area in 2001, according to criteria corresponding to certain city planning process and architectural values.

The historic centre area contains archaeological monuments and sites dating back to the medieval age, among which we could mention the medieval ensemble "Curtea Veche" (representing *The Old Royal Court*), churches and inns built before the year 1800. Most monuments date back to the second half of the 19th century. They have been complemented by some of the most original monuments during the inter-war period. We should note that a great number of the historical monuments had been built on or include parts of cellars of the older constructions (dating from the 17th – 18th century).

The buildings inside the historical centre could be grouped in the following functional areas: *commercial area* (Lipscani and Calea Mosilor Streets), *functional area* (Calea Victoriei) and *residential area* (Stelea Spatarul and Radu Calomfirescu Streets). The archaeological monuments located in these areas present a large variety of architectural programs.

Firstly, there is a royal residence area called "*Curtea Veche*" that represents the main pole of the medieval town, around which had developed the town fair, churches (*Stavropoleos, Sf. Gheorghe Nou, Sf. Gheorghe Vechi, Coltea, Doamnei*), inns which proved for centuries to "live long" and be very expedient (*Hanul lui Manuc, Hanul cu Tei, Hanul Polonezilor, Hanul Patria)*, houses with shops at the ground floor and lodgings above (*Lipscani Street, Calea Mosilor, Selari and Smardan Streets)*, dwelling places (*the "round-windowed house" 15 Radu Calomfirescu Street)*, public and cultural institutions built-up between the second half of the 19th century and beginning of the 20th century, hospitals (*Coltea, PTTR-the hospital of the Romanian Postal Services)*, commercial arcades (*the Macca-Villacrosse arcades and the French passage way)*, and hotels (*Fieschi Hotel)*.

The built-on fund has been renewed in despite of severe damages (a great fire incident in 1847, several earthquakes) or due to new city planning and architectural programs requiring larger spaces. Curtea Veche exhibits the medieval construction system dating back to the 15th – 16th century, decorative elements from Brancovenian age and other representative monuments for the same age and the churches Coltea, Razvan and Stravopoleos, that are true architectural pearls.

3.2.2 Web GIS application of the Historical Centre – *eGISpat* Bucharest

INMI is currently involved in developing a GIS project for the Historical centre of Bucharest that will represent a planning tool to help planners and preservationists to better assess historical and cultural resources in Bucharest. The pilot project takes into consideration the applicability of GIS technol-

ogy for spatial data analysis and also for a better monitoring of the national LHM.

The technical team and ESRI Romania decided to build a web GIS application – *eGISpat Bucharest* (Figure 5) using ArcGIS Server technology and incorporate the historic resources geodatabase, a digital map scale 1:2.000, IKONOS satellite imagery courtesy of GeoEye, representative setting, registration files, plans photographs, building footprints, streets, sidewalks, rivers, etc.

3.2.3 *eGISpat* Bucharest capabilities

The developed Web application – *eGISpat Bucharest* allows user through a LAN or Internet connection to perform the following functions:

- Display the map of the Historical Centre of Bucharest with multiple layers such as
  roads, streams, historical monuments, archaeological sites, etc.
- Pan and zoom in, zoom out throughout the map
- Zoom to the full extent of the data
- Moving back or forward one display
- Identify features on a map by pointing at them
- Search and find features on the map
- Interactively toggle layers on and off

- Display labels with text from field values
- Draw image from satellite imagery
- Draw graphics features such as points, lines, circles and polygons
- Draw descriptive text
- Select features inside boxes, areas, polygons and circles
- Select features within a specified distance of other features
- Find and select features with a SQL (Structured Query Language) expression
- Find locations on a map from a street address or intersection you provide
- Transform the coordinate system of your map data
- Perform geometric operations on shapes to create buffers
- Perform advanced spatial and attribute queries
- Manipulate the shape or rotation of a map
- Select features and generate reports related to one or more historical monuments
  and archaeological sites
- Print maps in size A4

- Add and delete image files to geodatabase (Figure 6)

Figure 6. *eGISpat* Bucharest – the ability to add and delete image files to geodatabase

- Perform geodatabase management tasks
- Create and update geographic features and their attributes (Figure 7)

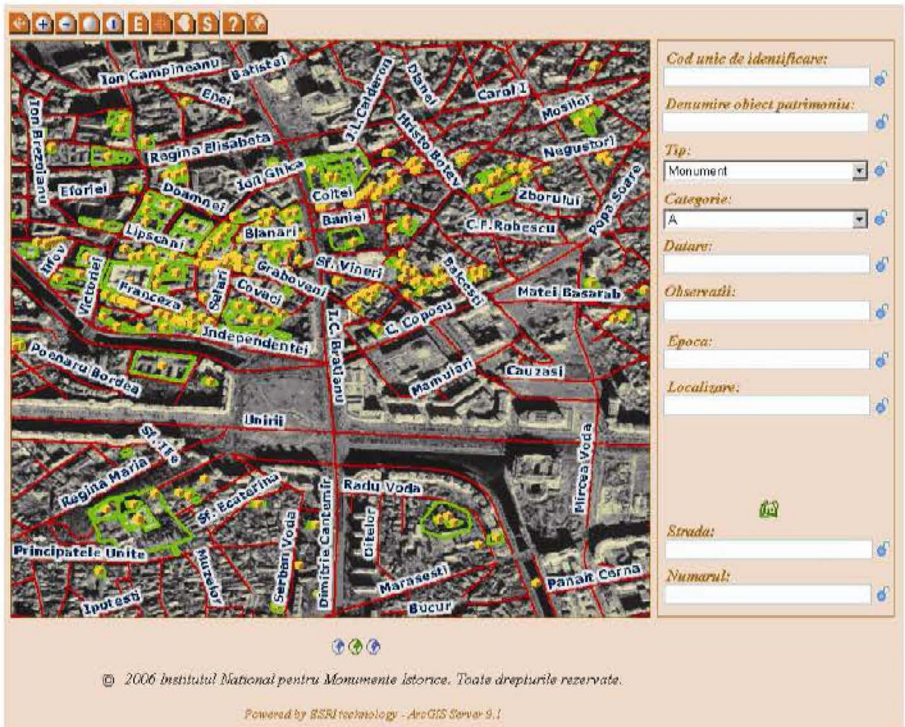

Figure 7. *eGISpat* Bucharest – Create geographic features and their attributes

4. CONCLUSIONS

This project represents the first phase, to create a centrally managed GIS system of the Romania's archaeological and historical resources. For the second phase, INMI will be applying for additional funding to field check the existing geodatabase information and to scan additional surveys. The last phase will involve additional archaeological sites using Trimble GeoExplorer GeoXT, GeoXH, Recon GPS Card and ArcPad application to complete the project.

"eGISpat application represents for INMI the first step to create and implement an enterprise GIS system that will be applied to the national historic resources inventory. Building a national network regarding to the cultural heritage is a stringent necessity and, in the same time a future desire for us. Using a geodatabase model will allow us a better management of the National Archaeologic Directory and also the List of the Historical Monuments.",

says Dr. Dana Mihai, Scientific Director, INMI.

The major benefits of the eGISpat application are described below:

- Significant operational and risk-cost reductions as compared to common practical experience where each user tends to have a "private" database that is not centralized and shared by other users within the organization.
- A centralized archaeological geodatabase allows users to modify the geodatabase schema, or to integrate new information according to their needs into the application. All their changes are simply documented in the UML diagram and the geodatabase is updated.
- Advanced ArcGIS users are able to directly access the eGISpat geodatabase for advanced spatial analysis and mapping. All non-GIS specialists are easily able to acces spatial data using the eGISpat interface.
- All departmental staff are able to work in a centrally managed GIS environment and fulfill business processes for multiuser editing, viewing and dissemination of cultural heritage resources in a timely way.
- Advanced GIS Web services are delivered throughout organizations (INMI, Cultural Counties Direction, and the Direction for Historical Monuments from Ministry of Culture and Religious Affairs).
- eGISpat is a performant tool for decision makers at the national level to eficiently manange the cultural heritage resources.
- Implementing a centralized management system using the state-of-art GIS technology will allow us to support also the geospatial specifications and standards required by European Community.
- The eGISpat Geodatabase Model offers a better support to take the right decisions to follow the administrative, rehabilitation and preservation tasks and also to promote our national cultural heritage resources.
- This enterprise GIS project will enable also the implementation of the sectorial policies and strategies in accordance to our specific requirements.

Such, eGISpat is a useful tool for research and planning purposes at a variety of scales. The eGISpat Geodatabase Model can provide practical benefits, including more efficient planning, and incorporation of cultural resources early in the local and country-wide planning process. The ultimate goal is to reduced disturbance of cultural resources and increases our knowledge of the past.

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Keywords: Geoinformation - GI, History, Real estate development, Spatial planning, Standards

SUMMARY

The Romanian Archaeological Sites and Historical Monuments Inventory Application - *eGISpat*, a centrally managed GIS system, was designed to provide the functionality to maintain and advanced analysis of the geospatial and parametric data, and to produce maps and reports using a national-wide archaeological and historical monuments geodatabase, known as the "List of the Historical Monuments" (LHM). This centrally managed web application was designed and built by ESRI Romania and the National Institute of the Historical Monuments – Ministry of Culture and Religious Affairs[1].

The purpose of the eGISpat is to facilitate the regional branches participation in and support of integrated resource planning at the district (called "judet") and local government level, and the maintenance of data on the historical record of archaeological work and historical monuments done in the districts.

The eGISpat take also in consideration the historical center of Bucharest that includes the archaeological sites (excavated during 1950 -2005) and historical monuments, and the digital map, scale 1:2.000, a satellite image and the historical records. All departmental staff are able to work in a Web integrated GIS environment and fulfill business processes for the entry, viewing and dissemination of information in a timely way. The National Institute of Historical Monuments continues to educate residents and promote also the preservation for future generations.

[1] This article was presented to the *XXIII FIG Congress Munich, Germany, in October 2006*