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CADASTRE AS A FOUNDATION OF MODERN GEOINFORMATION SYSTEMS AND SDI

Nowadays, modern GeoInformation Systems (GIS) are considered being an element of a much wider concept, namely Spatial Data Infrastructure (SDI). The paper starts with description of objectives and a vision of SDI and the role of GIS within the SDI. Then it describes technological requirements for modern GIS and SDI implementation, followed by articulation of benefits of deployment of GIS within a SDI context. Next, the paper analyses the GI data sets, which are required to achieve the benefits of the SDI and GIS deployment and draws attention to the importance of cadastral data within SDI. The final part of the paper discusses the significance of cadastre as a foundation of modern GIS and SDI and its essential role in achieving the most critical quantifiable benefits of GIS and SDI.

Modern GeoInformation Systems – Element of SDI

Until few years back there were many competing definitions and criteria for specifying what a modern GeoInformation System (GIS) is. Currently there is nearly universal consensus that a modern GIS must fulfil just one criterion: **it must be a fully compatible element of SDI – Spatial Data Infrastructure**. In addition, within Europe it must be compatible not only with national/regional SDI requirements but also with the European SDI (E-SDI) requirements.

The vision of E-SDI, in the form of the INSPIRE initiative of the European Commission, can be described through its objectives, principles and key components. The overall objective of INSPIRE is to make harmonised and high quality geographic information readily available for formulating, implementing, monitoring and evaluating policy both at the Community and Member State level, and for the citizen to access spatial information, whether local, regional, national or international. The six principles that govern the INSPIRE initiative are as follows:

- Data should be collected once and maintained at the level where this can be done most effectively.
- It should be possible to combine seamlessly spatial information from different sources across Europe and share it between many users and application.
- It should be possible for information collected at one level to be shared between all the different levels, detailed for detailed investigations, general for strategic purposes.
- Geographic information needed for good governance at all levels should be abundant under conditions that do not refrain its extensive use.
- It should be easy to discover which geographic information is available, fits the needs for a particular use and under which conditions it can be acquired and used.
- Geographic data should become easy to understand and interpret because it can be visualised within the appropriate context selected in a user-friendly way.

The four key components of INSPIRE, which are typical for any SDI, include:

(1) **Core reference and thematic data** – creating the main component of SDI,

(2) **Metadata** – ie. data that describes who has these resources, what are their characteristics, and the conditions for access and use,

(3) **A policy framework** – providing definition of the rules for access and sharing of data

(4) **Coordinating, operational and technology mechanisms** – to make sure that it all works.

Modern GeoInformation Systems (GIS) constitute the main element of the technology mechanisms within the component (4). The most important requirements for modern GIS are described below.

Technology for Implementation of Modern GeoInformation Systems and SDI

The technological requirements for modern GeoInformation Systems (GIS) can be grouped into four major categories: data and system standards, system and data integration mechanisms, data discovery mechanisms and data access and distribution services. Major features in these categories are as follows:

- **Data and system standards** are the most essential components of technology for implementation of modern GIS within the SDI context. They provide the "glue" to integrate the systems and the "lingua franca", ie. the common language to allow the systems to communicate. Currently, after an aborted attempt to create European level standards for GI and GIS, there is consensus that International Standards Organisation (ISO) and Open GIS Consortium (OGC) are developing the standards „to be followed" by all. The best examples of such standards are ISO/TC 211-19115 standard for metadata and OGC's GML standard for data transfer.
- **System and data integration mechanisms** are needed to unite distributed and disparate GI databases and GI Systems into one SDI environment. There are two basic options for implementation of these mechanisms. The first one, based on creating database repositories storing all data, incl. descriptive, geometric and image and multi-media data, replicated from their original source systems and then updated periodically, is easier to implement. The second option, which makes full use of the OGC interoperability standards such as Web Feature Server, GML and Catalogue Services, is more difficult and sometimes, due to inherent restrictions of existing "legacy GIS systems", may not be possible to implement. Therefore, in reality there are mixed schemas, such as, for example, mechanisms created for the Regional Spatial Information Project in Silesia in Poland illustrated in Fig. 1 below entitled "RSIP system architecture". These mechanisms should support both an object-oriented vector data model of GI (including its geometric and descriptive parts) and a raster data model. The vector data model, stored in the GI data repositories, as a minimum, should be compatible with the OGC's Simple Features Specification for SQL at the logical level. The raster data model, as a minimum, should support the TIFF geo-referenced files.
- **Data discovery mechanisms** should be based on the metadata and catalogue services covering both the replicated data in repositories and selected data in the source systems. As mentioned above, the standards adopted for metadata are usually based on the OGC's metadata model and ISO/TC 211-19115 standard. The metadata model should cover only a subset of the data specified in the standard to avoid difficulties in capturing and maintaining all the data required.

The recommended catalogue services model should be based on a concept of distributed metadata structures usually located on the same servers as the spatial data itself. The user should be able to traverse all the metadata servers searching for the required data starting from the root of the metadata tree, with the system automatically presenting him/her with a view of the consecutive branches of metadata and then leaves of the tree containing the data.

Data access and distribution services should cover, as a minimum, two basic categories of services. The first and the most common category of services provide the users with a highly interactive mode of work. Here the user views data and metadata through a standard Web browser environment using a Java applet similar in appearance to a GIS desktop environment. The user interface usually is based on a concept of manipulating layers (categories) of data combined with the mechanisms of data discovery described above. This allows the user to locate the required data within the repositories and then to define the scope, composition and spatial extent of the requested data to be displayed in the form of raster images. Then the user can query about any visible object or use the objects as reference points for more complex enquiries within the database.

The second basic category of data access and distribution service is addressing needs of users who need to receive the selected GI data in the form of a data file for further processing, eg by a more sophisticated GIS package. This service should be based on the appropriate OGC's reference models and specifications. In particular, the format of returned data should be compatible with XML/GML 3.0 and Web Feature Server model.

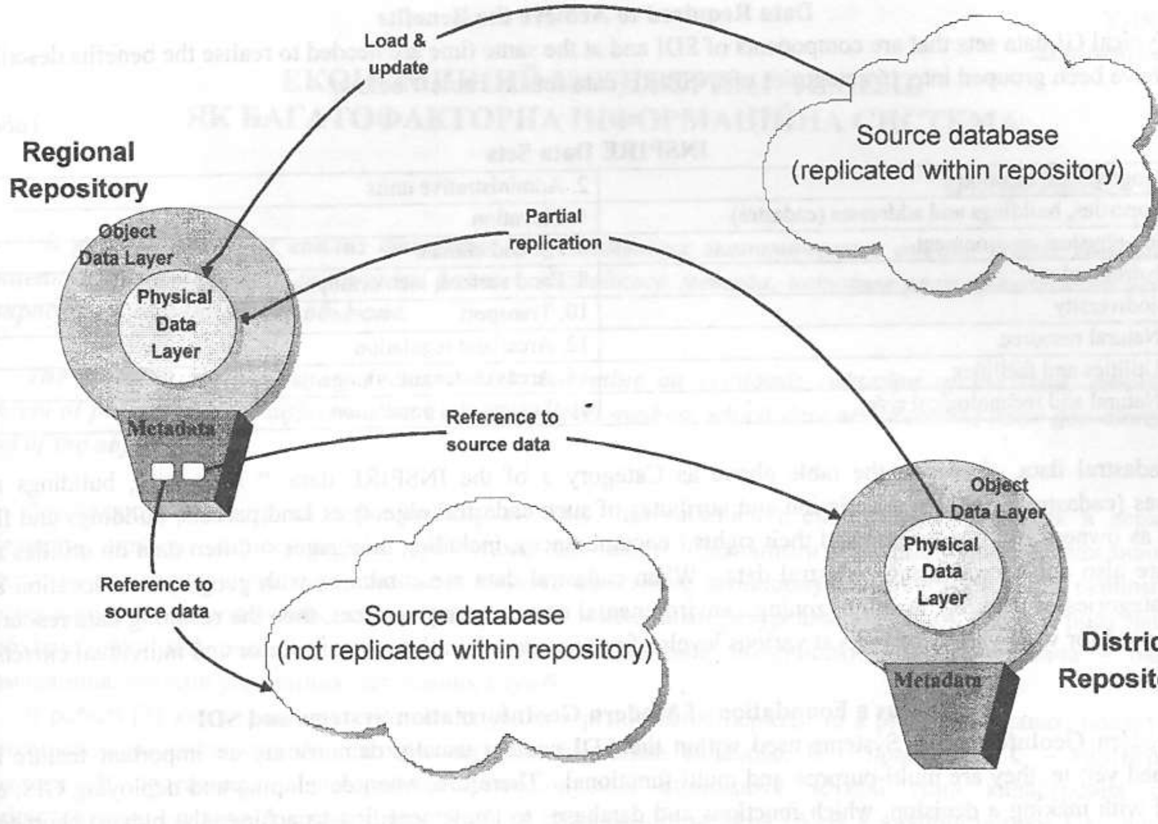

Fig.1 RSIP system architecture.

Benefits of Deployment of GeoInformation Systems within a SDI context

There are two basic categories of benefits of using Geographical Information (GI) and deploying GeoInformation Systems (GIS). The first category includes benefits related to improving operational and policy-making aspects of public administration through two mechanisms:

- Storing and integrating spatial data from various sources to enable sharing data and information by many users and applications within the region, the country and across the borders,
- Using this data (GI) and better facilities for its delivery to improve service to the public.

Once these mechanisms are in place, the major first category benefits, as exemplified by the expected INSPIRE benefits, will include:

- More efficient government policies that take better into account the spatial dimension,
- Better implementation of government policies and more efficient monitoring of policies,
- Increased interest and participation of the citizen in policy-making and implementation,
- Better services to citizens.

The second category, which is even more important, includes benefits related to providing much better support for analysis, planning and operation support in the administration, semi-government organisation and private sector. Some areas where this type of benefits can be realised include:

- National, regional and local planning, including sustainable development of economy, environment protection and emergency and disaster management at all levels,
- Infrastructure and housing development, incl. property market development, legal rights security, mortgage mechanisms and property taxation.

Particularly significant quantifiable benefits can be achieved by using cadastral data within the context of SDI and GIS based cadastral systems as described below.

Data Required to Achieve the Benefits

Typical GI data sets that are components of SDI and at the same time are needed to realise the benefits described above have been grouped into 16 categories of INSPIRE data sets in Table 1 below:

Table 1

INSPIRE Data Sets

1. Geographical location	2. Administrative units
3. Properties, buildings and addresses (cadastre)	4. Elevation
5. Geo-physical environment	6. Air and climate
7. Hydrography	8. Land surface, incl. orthophoto-images
9. Biodiversity	10. Transport
11. Natural resource	12. Area/land regulation
13. Utilities and facilities	14. Areas under anthropogenic stress
15. Natural and technological risks	16. Society and population

Cadastral data, shown in the table above as Category 3 of the INSPIRE data: " Properties, buildings and addresses (cadastre)", include description and attributes of such cadastral objects as land parcels, buildings and flats as well as owners and / or tenants and their rights / encumbrances, including mortgages. Often data on utilities and roads are also considered being cadastral data. When cadastral data are combined with geographical location and other categories of data, eg. taxation, zoning, environmental or emergency services, then the resulting data resources may be used for wide variety of tasks at various levels of public administration, private sector and individual citizens.

Cadastre as a Foundation of Modern GeoInformation Systems and SDI

Modern GeoInformation Systems used within the SDI context usually demonstrate an important feature not mentioned yet, ie. they are multi-purpose and multi-functional. Therefore, when developing and deploying GIS, one is faced with making a decision, which functions and databases to implement first to achieve the biggest short-term benefits.

When analysing the scope of cadastral data described above it becomes obvious that functions dealing with cadastre are the prime candidate for selection as the first functions to be implemented within a multi-purpose and multi-functional GIS. And dealing with cadastral data means at least providing access to the up-todate cadastral data and ability to combine them with other GI data available within SDI. It is worth remembering that cadastre not only provides basic information for many applications but cadastre also provides invaluable highly up-todate reference layer for many other GI systems and databases.

To demonstrate the importance of cadastre for modern GIS and SDI, let's consider just a few areas of application of cadastral data in combination with other data.

- **Property taxation** applications are irrevocably linked to cadastre. Here cadastre is the basis not only for defining the property value and determining the type and amount of tax but also, if necessary, identifying the taxpayer.
- **Spatial planning, and especially zoning in municipalities**, must be referenced to the cadastre to be of the optimal value to both the local authorities and the citizens.
- **Management and protection of environment** is another example of benefits of combining ecological data with cadastre. One can mentioned, for example overlaying cadastral parcel boundaries with the boundaries of contaminated sites or protected areas.
- **Emergency services and disaster management** cannot efficiently function without many cadastral data. Eg. when developing evacuation scenarios for potential flooding, the flood plans must be overlaid with the property boundaries and combined with the tenants data. Or, the knowledge of data on land use and building functions, stored in cadastre records, is often crucial when determining risks involved in a particular emergency situation.

These examples provide ample evidence to support a statement that success of modern GeoInformation Systems and SDI depends to a large extent on efficient development and functioning of modern cadastre. **There is no exaggeration in claiming that cadastre is a foundation of modern GIS and SDI.**