Informatics
and Information Technologies

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ANALYSIS OF THE PRACTICAL USE OF GEOINFORMATION SYSTEMS FOR TERRITORIAL MANAGEMENT AND DETERMINATION OF THEIR CRITICAL PROPERTIES

Introduction. *The practical experience of creation, implementation and operation of geoinformation system (GIS) for territory management allows to identify their critically important properties. GIS with critical properties do not fit the conventional definition because they are more advanced systems. Special attention to critical properties helps to reduce the risks involved in the development and implementation of such GIS, as well as to increase the effectiveness of their use for territory management.*

*****The purpose of the paper*** *is to analyze the use of GIS developed by the authors for the management of large territories and to determine their main critical properties. Critical GIS properties are being sought to manage territories that: 1) repeat for all such GIS, 2) differentiate them from conventional GIS, 3) must be taken into account when creating new GIS.*

*****Results****. The critical properties that are mandatory also for modern GIS for territory management are as follow : 1) the availability of education-scientific, production and management components, 2) the availability of a relatively independent atlas solution, 3) the obligation to use portals, 4) the need to supplement the territory modeling of their metamodeling.*

*****Conclusions****. Abductive inferences after analyzing the practical experience of creation, implemention and operation of GIS for territory management allow to confirm the presence of critical properties of GIS. Without any such property, we can speak about a corresponding critical shortcoming of the GIS project, and this project is likely to be a failure.*

Keywords: *geoinformation system, territory management, spatial data, abduction, critical property.*

INTRODUCTION

It is believed that the first geoinformation system (GIS) was created by "GIS Father" — Roger Tomlinson — in the 1960s in Canada for Canada Land Inventory [1]. That is, GISs have been created and used for various tasks for over 50^{ty} years. Over the years, the field of informatics has emerged that deals with spatial (spatially distributed, spatially coordinated) information. It is called geoinformatics and is defined as the science, technology and applied activities related to the collection, storage, processing, analysis and display of spatial data, as well as the design, creation and use of GIS [2].

One of the most common definitions of GIS is: "hardware-software man-machine complex providing collection, processing, display and dissemination of spatially coordinated data, integration of data, information and knowledge about the territory for their effective use in solving scientific and applied tasks, related with inventory, analysis, modeling, forecasting and management of the environment and territorial organization of society"[3]. O. Svitlychny, S. Plotnitsky [2] provide GIS definitions from several sources. One of them is: "GIS — is an information system (IS) designed to work with spatial or geographical data" [4]. IS, in turn, was defined as a set of subsystems that implement data collection and input processes; their preprocessing; data manipulation; data and information analysis; generating results.

The definition of GIS from [4] is used de facto in the Russian sector of Wikipedia, namely: "Geoinformation system (geographic information system, GIS) — is a system of collecting, storing, analyzing and graphically visualizing spatial (geographical) data and related information about necessary objects. The notion of GIS is also used in a narrower sense — as a tool (software product) that allows users to search, analyze and edit both a digital terrain map and additional information about objects" [5].

In the Ukrainian sector of Wikipedia, GIS is defined as: "Geoinformation system is a modern computer technology that allows to combine model representation of the territory (electronic display of maps, diagrams, space, aerial images of the earth's surface) with information of tabular type (various statistics, lists, economic indicators, etc.). GIS also refers to the spatial data management system and its associated attributes. More specifically, it is a computer system that enables the use, storage, editing, analysis and display of geographic data" [6].

There are four approaches to the definition of GIS, oriented, respectively, to: processes, applications, databases, tools [7]. The definition of GIS from [4] refers to the process-oriented approach. It was a major in the proposed by us Conception of the multigoal National GIS (NGIS) of Ukraine [8]. It should be noted that process-oriented definition of GIS is currently the most widespread, at least in Russia and Ukraine.

PROBLEM STATEMENT AND RESEARCH METHOD

The process-oriented definition of GIS and the understanding of GIS that it defines have its advantages and disadvantages. The benefits include simplicity, universality, relationship with IS (generalization/specialization) and more. Unfortunately, the shortcomings of this definition and understanding of GIS increase over time. This paper addresses the shortcomings that are fundamental in terms of practical implementation, and are therefore called critical GIS properties. First of all, our own experience of creating GIS in Ukraine is used for argumentation. In our opinion, this is more important than finding evidence in the literature. Moreover, almost all the cited drawbacks are poorly described in the literature because they are little known due to the lack of development of geoinformation theory. We emphasize that this lack of knowledge does not mean that the shortcomings are not fundamental.

Thus, the main method of research is abductive reasoning. H. Miller [9] states the following compact definitions of abduction, deduction, and induction: "Abductive reasoning starts with data describing something and ends with a hypothesis that explains the data. It is a weaker form of inference relative to deductive or inductive reasoning: deductive reasoning shows that X *must* be true, inductive reasoning shows that X *is* true, while abductive reasoning shows only that X *may* be true. Nevertheless, abductive reasoning is critically important in science, particularly in the initial discovery stage that precedes the use of deductive or inductive approaches to knowledge-construction". Three main forms of logical reasoning are considered in the monograph [10] from the standpoint of the most general idea of systems. Namely, any *system* has an *input* and an *output*, which are called *influence* on the system and its *reaction* (Fig. 1a).

Yu. Sventek [10] states that the highest degree of uncertainty is characteristic of abductive reasoning. Abduction occurs when the causal factor (influence) is to be determined by the reaction of the system and its structure (Fig. 1b). Abductive reasoning occurs in almost every step of our daily lives. For example, by measuring the temperature with a thermometer, we do not suspect that we are using the abduction. Indeed, knowing the system (raising the mercury column) we conclude that the temperature is rising. In this work, abduction is used for GIS.
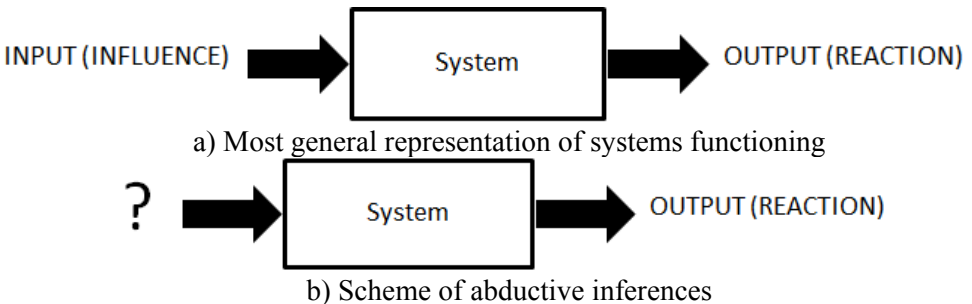

a) Most general representation of systems functioning

b) Scheme of abductive inferences

Fig. 1. Abduction (b) from the standpoint of the most general idea of the functioning of the system (a)

The purpose of the paper is to analyze the use of GIS developed by the authors and to identify the main critical properties that should be considered when creating new geoinformation systems.

CONCEPTION OF THE NATIONAL GEOINFORMATION SYSTEM

The concept of the multigoal National GIS (NGIS) of Ukraine [8] theoretically substantiated the need to solve three main problems when creating such a GIS:

1. Establish a national geoinformatics education-scientific center, modeled on the US NCGIA or similar centers in Europe. The center was to create a prototype of the NGIS tool kernel (hereinafter Education/Science NGIS1 – SGIS1), which needed to address the urgent educational and scientific needs of NGIS.

2. Establish a national center for digital public information (hereinafter Production NGIS1 — PNGIS1). Implement the three shown in Fig. 2 (sub)systems of the first phase of the NGIS (NGIS1) containing the adjective "Integrated" in the name. The unusual names of these (sub)systems are explained by the application of information standards in force in Ukraine at that time, which lacked the terms GIS and the Automated cartographic system (ACS).

3. Implement the ACS for the needs of the State statistics committee of Ukraine. This (sub)system corresponds to Fig. 2. Integrated geoinformation automated management system (hereinafter Management NGIS1 — MNGIS1).

The first phase of NGIS (NGIS1) is, on the one hand, the specialization of IS, and on the other hand, the specialization of multipurpose IS. IS consists (aggregates) of five (sub)systems. Writing a (sub)system means that a component or subsystem can be a component. That is, NGIS1 was determined according to a process-oriented approach [4]. It is important to note that NGIS1 should already be multi-purpose. It should include systems of goal generation, goal selection and goal realization. Due to this, NGIS could also be defined as a system of government, though not in the first place.

The NGIS of the first phase (NGIS1) was the IS specialization, consisting (aggregating) of five (sub)systems. The record a "(sub)system" means that the constituent may be a system or a subsystem. That is, NGIS1 was determined according to a process-oriented approach [4]. It is important to note that NGIS1 should already be multi-purpose. It should include systems for the generating, seeking and implementing of the goal. Due to this, NGIS could also be defined as a country management system, though not in the first place.

The first necessary property of NGIS was the presence of educational-scientific, production and management components. The components of this triad are shown in Fig. 2 by ellipse in green color. The absence of one of the three components of the triad is considered critical for large territorials GIS. The presence in the GIS of the indicated triad of systems is referred to as **Critical property 1 (CP1)**.

Finally, one of the elements of NGIS1 — Production NGIS1 (PNGIS1) — was aggregated through three production systems. It is important to note here that the terms SDTS, SAIF, DX90 and DIGEST meant the most advanced
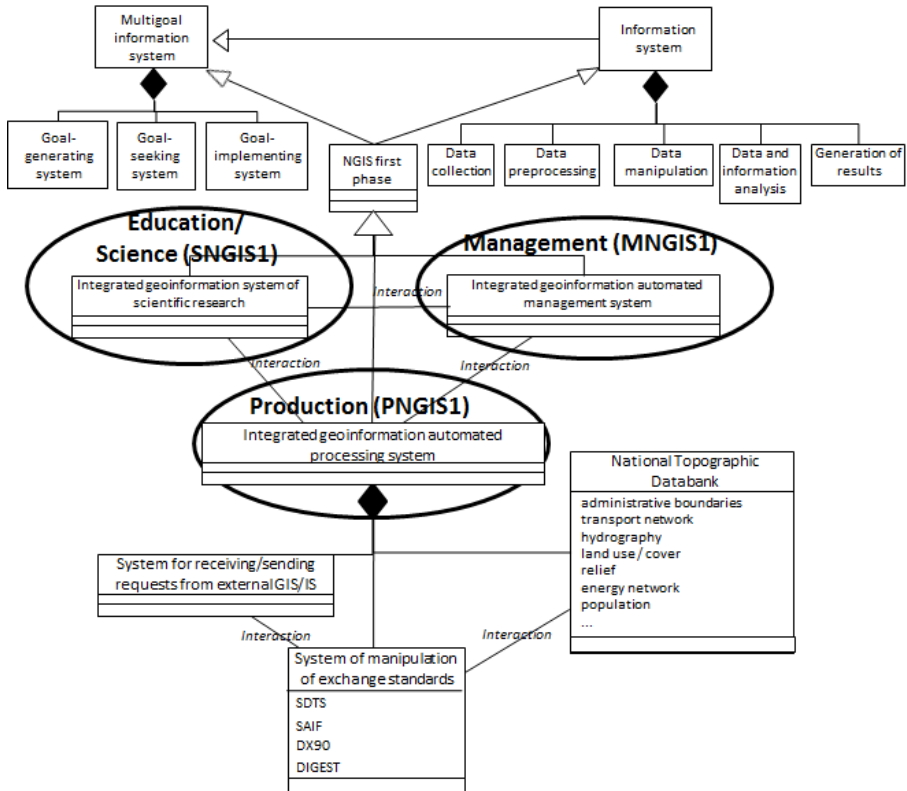
Fig. 2. The first phase of NGIS. The UML class and relation designation is applied to the systems

standards for the presentation and exchange of spatial data at that time. Instead of these standards, there is now an ISO 19100 series "Geographical information/Geomatics" and its partial adaptation for Ukraine [12].

RADIOECOLOGICAL GIS AS A ECOLOGICAL MANAGEMENT SYSTEM

Practical evidence of CP1 correctness was obtained in 1997-1999 during the development of the first national GIS in Ukraine. It was called the Radioecological GIS (RGIS) and belonged to the class of (geo-)information systems of ecological management (ISEM or GeoISEM, Fig. 3). Designed to support decision-making of the 1986 Chornobyl NPP (ChNPP) accident minimization activities for the territories of 12 of Ukraine's 25 oblasts.

The first phase of the system - GeoISEM Management component (shown on the right in Fig. 3) — was commissioned in 1997 at Department of Population Radiation Protection (DPRP) of the Ministry of Ukraine for protection of population from the consequences of the Chornobyl accident (MinChornobyl Ukraine). It was called "Information support system for DPRP activities" and was abbreviated as RadEco (RadioEcology). The goals of creating RadEco are planning, coordination and control of works on minimizing the consequences of the ChNPP accident using radiological control and monitoring of data, as well as cartographic information.
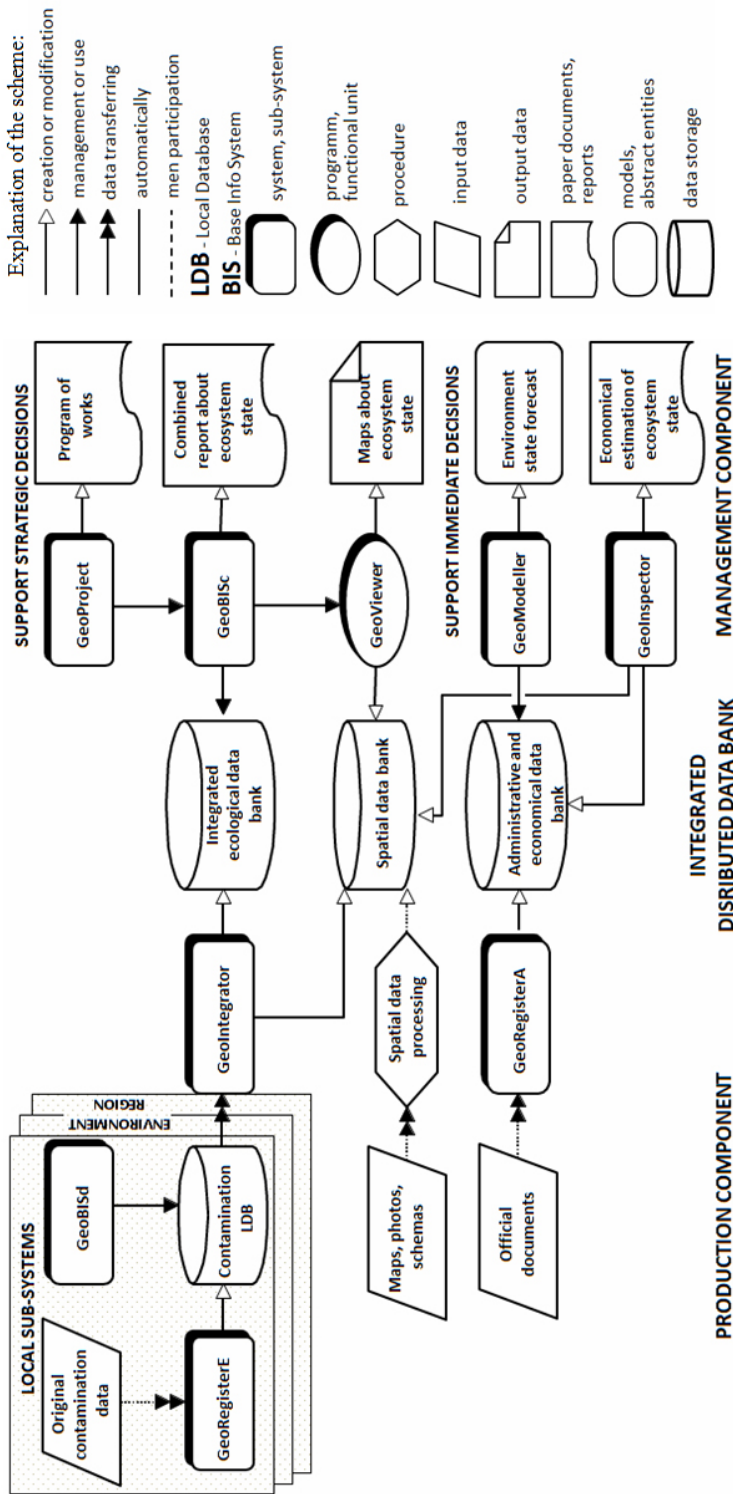
Chabaniuk V.S., Kolimasov I.M.

Fig. 3. Structure of GeoISEM/RGIS

In 1998–1999 the second phase of GeoISEM: Production component (shown on the left in Fig. 3) and Integrated distributed DBn (shown in the middle in Fig. 3) was developed and put into operation. The integrated distributed DBn has combined diverse information related to the DPRP activities to minimize the effects of the ChNPP disaster. Shown in Fig. 3 "Ecosystem status maps" have become the prototype and main source of the Atlases of radioactive contamination of Ukraine described below.

Note that in Fig. 3 are shown two components of the selected in Fig. 2 triads: production and management. We did not tailor Fig. 3 under the modern views and critical properties of GIS, which are described in this article. However, we must say that the Integrated Distributed DBn is an element of the production component, and the scientific and educational component is not shown in Fig. 3. In fact, it existed and was very essential for the creation and operation of the RGIS. After all, many scientific institutes of Ukraine took part in minimizing the consequences of the ChNPP accident. Even a simple listing of their results used in the RGIS will take up a lot of space.

Below we take a closer look at the RGIS management component and the Integrated distributed DBn — a part of the production component that could or may not be included in the management component. The production component in full (Fig. 3) at the time seemed fairly standard. It is only with time that we have realized that its main essence — determining the state of an object that simulates the investigated spatial entity in an information system — corresponds to a certain, well-defined process. In this process, irrespective of the context, there are duplicate checkpoints such as: request, notification, pre-accounting, permanent accounting (registry), status monitoring. In addition, we later realized that the objects at certain control points form systems whose relational properties between the objects of the same state and the different states have yet to be explored.

Due to article size issues, we also neglected the Support Immediate Solution modules (Fig. 3), which were developed in RGIS only as prototypes. They are included in the RGIS as the results of the Ukrainian-Canadian Chornobyl GIS project, which was implemented in two phases [13], [14]. From the viewpoint of modern views, the management of large territories cannot be done without taking into account the impact of emergencies. Emergencies such as wildfires, floods, technological, etc. take place in almost all "large" territories.

Key features of RadEco system. The RadEco system was intended for informational support of the basic business processes of DPRP, as well as to support strategic decision-making in planning and implementing long-term impacts on ecosystems. From the viewpoint of the goal approach to the analysis of management functions, a hierarchical decomposition of functions was performed, based on the main goal of management, and such decomposition is closed to the end result of the activity with a description of all sections in the chain: goal — means — result — criterion (Fig. 4).
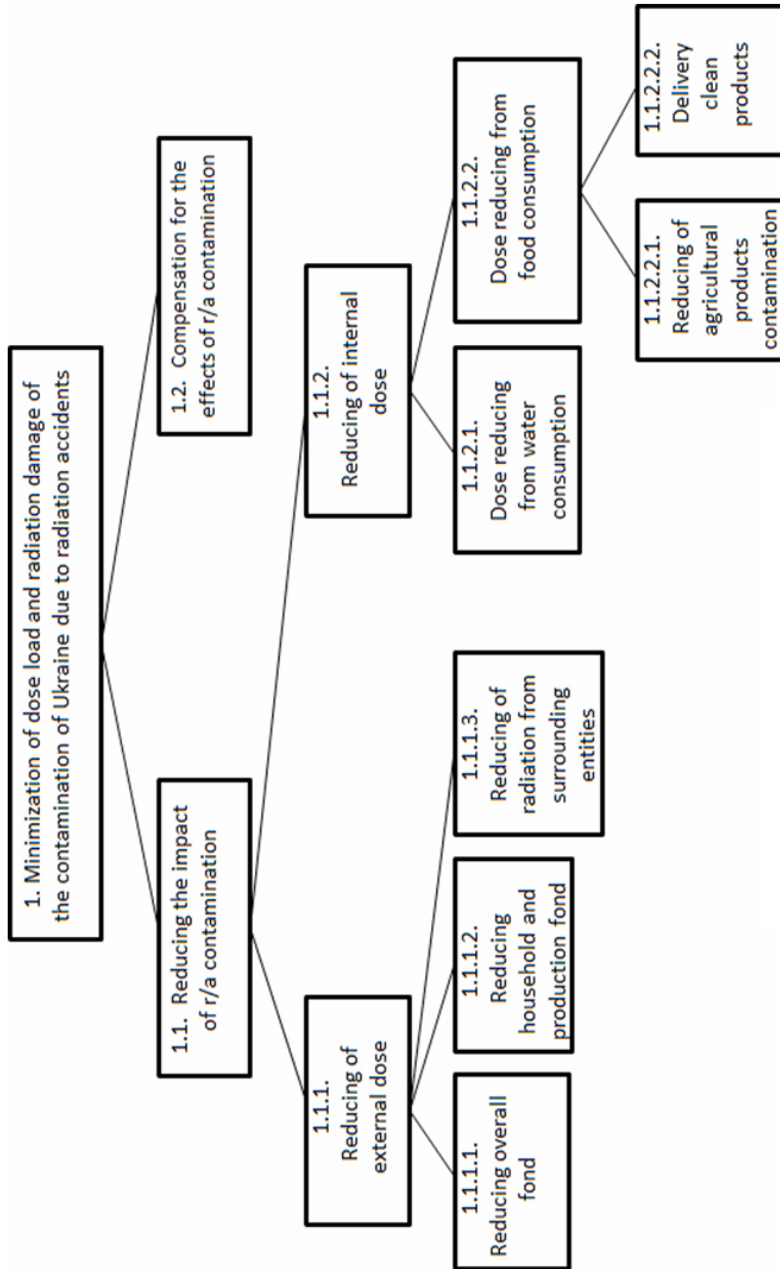
Fig. 4. Decomposition of DPRP activity goal

To achieve the goal, the following measures were implemented (for territories, premises, water bodies, products, people): inspection, maintenance of the radiation control system, issue of measuring instruments, maintenance of a database of observations, development of recommendations, development of laws and regulations, implementation of recommendations, evaluation efficiency of the conducted actions.

RadEco provided:

• improving the efficiency of organizational management procedures in the planning, coordination and control of work that is within the competence of the DPRP; improving the use of radiological control and monitoring data, increasing the completeness of the assessment of the ecosystems status of the contaminated area in order to improve the planning of countermeasures to minimize the negative impact of radioactive contamination of technogenic origin;

• use of digital mapping material (maps, map layers, thematic maps) as a means of qualitatively assessing the situation based on all system data having a spatial component.

RadEco implements a set of interconnected functional complexes of tasks (FCT) based on common internal components, unified approaches to obtaining, processing and presenting data, using a unified information base. RadEco is implemented in a multicomponent architecture and is capable of operating in a corporate and local version using Informix or Access DBMS. From the viewpoint of the tasks to be solved, RadEco distinguishes subsystems:

• GeoProjector — implements management functions; automates the formation and accounting of the implementation of the annual Work Program to minimize the consequences of the Chornobyl disaster by sections that fall within the competence of the Management, planning and control of the implementation of works, contracts within the Program.

• GeoBIS — implements production functions of access, processing and analysis of radiological database information; ensures the provision of generalized and detailed information on radioactive contamination at the level of the settlement, district, and oblast; provides the ability to create combined ecosystem status reports. GeoBISc — corporate version, GeoBISd — desktop version, BIS — Base Information System.

• GeoBank (Spatial DBn) — organizes available digital mapping materials in network-wide repositories; provides selection and modification of mapping data based on structured metainformation; provides the possibility of forming complex maps of the territory using specialized thematic layers.

• GeoView — designed for effective spatial data management: managing the spatial DBn; collecting all operations on mapping objects into a single interface, regardless of the mapping tools used (MapInfo, MapX, MapObjects, ExcelDataMap, ArcView).

• GeoIntegrator — implements receiving into databases of the system and transfer of external data in arbitrary formats of relational DB. Included in the RadEco management system when needed.

All subsystems provide data export to MS Word document formats, MS Excel spreadsheets and charts, external databases visual formation and execution of regular and spatial queries to the system database, presentation of query results in tabular, graphical and cartographic forms using thematic mapping tools.
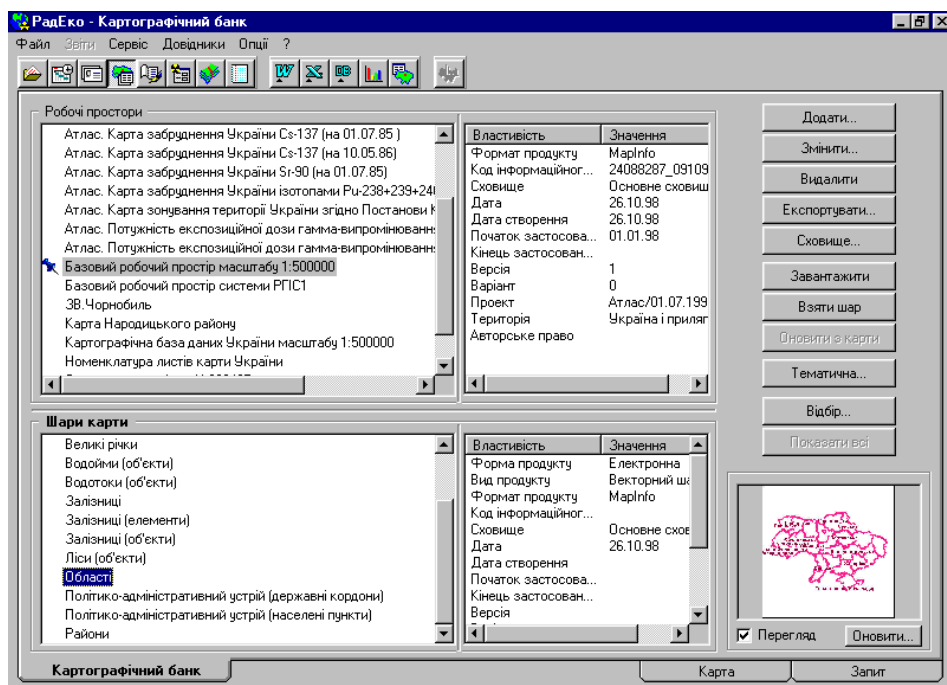
Fig. 5. Access interface to GeoBank (Cartographic DBn, GeoView)

Integrated ecological databank. The integrated ecological databank contains unit measurements and aggregated data on environmental and regional contamination and consists of the following databases: 1) Environmental load on humans; 2) Contamination of settlements; 3) Contamination of farmlands; 4) Contamination of forests.

In the subsystem of ecological data integration (GeoIntegrator) in DPRP the following functions on processing and reception in a DB of spatial data were executed in the automated mode:

•   obtaining data from a representative of the provider of data to the DPRP of MinChornobyl;

•   logging data in the logging log and saving a data diskette;

•   geocoding the data provided. The geocoding process of the data was performed in order to link the data provided with the identifiers of the observation objects (settlements, collective farms, fields, etc.) of radiological and topographic databases for further processing);

•   calculation of average, minimum and maximum values, calculation of quantitative indicators (data aggregation);

•   detection and "screening" of erroneous data;

•   input and import data into the Integrated ecological databank.

GeoBank (Spatial or Cartographic DBn) is associated with the Integrated Ecological Databank, which consists of databases: 1) contamination, 2) land use, 3) land tenure, 4) topographic. This databank is used for the accumulation, storage in a systematic form, the use of information products that came from external sources or created using their own software (cartographic systems, tools for the preparation of

maps and maps schemes the like). GeoBank's fields of application are activities related to the use in the production and management practice of information products in the form of maps, maps schemes, etc. to work with data that is spatially linked (in particular, data from the Integrated Ecological Databank) Fig. 5 shows the access interface to GeoBank (Cartographic DBn).

GeoBIS subsystem. The production component of RGIS was implemented by the GeoBIS subsystem. Its main function was to formulate and execute standard and arbitrary queries to radioecological databases and present results in tabular, graphical and cartographic forms. A combined ecosystem status report was one of the possible outcomes of GeoBIS. It is obtained as a sequence of requests to the Integrated ecological and the Spatial (Cartographic) databanks.

Solving the task of preparing a combined report, spatial queries were created (or saved queries were used), the desired settlements were selected from the hierarchical lists or from the map. Query results were exported to MS Word, MS Excel office products. Thematic maps (using cartographic system MapInfo) were built on the basis of individual requests. All results were collected into an MS Word document that contained a combined environmental report of the selected settlement (settlements). A similar problem could be solved for the preparation of combined reports by district and oblast. Fig. 6 shows an example of a request for data from the Integrated ecological DBn. Fig. 7 provides an example of a combined report: Fig. 7a — diagram of the changing the content of cesium-137 in milk in the settlement Ignatpil by years; Fig. 7b — thematic map. Observation of the Zhytomyr oblast districts (number of cesium samples in milk, 1997); Fig. 7c — Thematic map. The estimated dose is total for the settlements in the vicinity of the settlement Ignatpil in 1997. Graphic representations of the combined report are compemened by the table data as in Table 1.

GeoProjector subsystem. The GeoProjector subsystem was part of the RGIS management component designed to support strategic decisions. The DPRP Regulation provided for the performance of management functions, including the formation and control of the implementation of the Program of works to minimize the consequences of the Chornobyl disaster for a year. The Program of works was the main document for the implementation and control of works on the implementation of long-term impacts on ecosystems.Automation of management processes was performed through functional complex of tasks (FCT).

Such complex in RadEco system was a formalized set of actions (operations) of the system, the execution of which leaded to the certain result. FCT operations were performed on system data that were defined when configuring user access rights to data and operations.

Typically, a specific system user performed one or more logically linked FCT. The main FCT were: financing of works; support for the system of radiation control; planning the works on clarification of radiation status; accounting for works on radiation monitoring equipment; accounting for radiation monitoring support works; planning and accounting for agricultural and forestry radiology works.
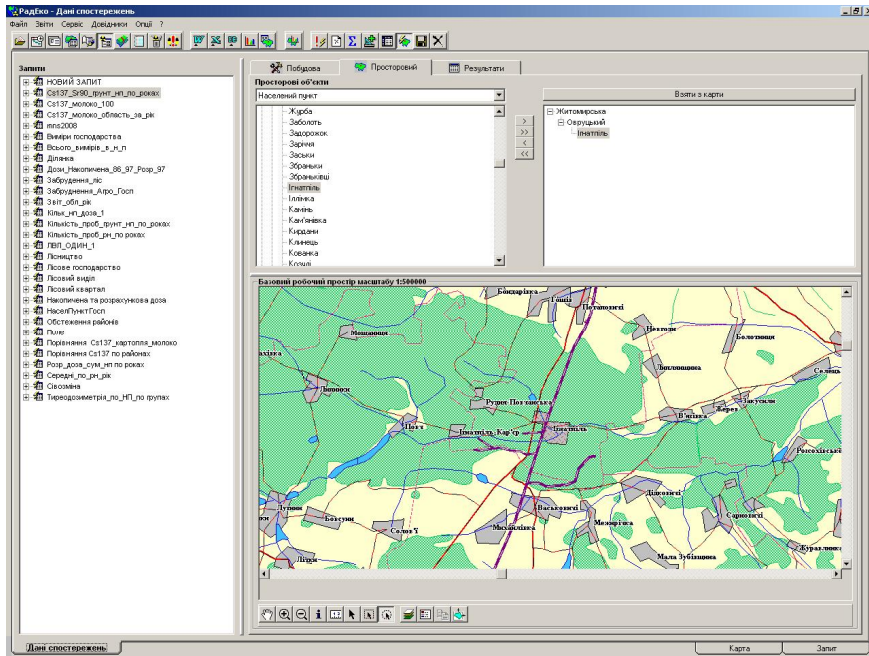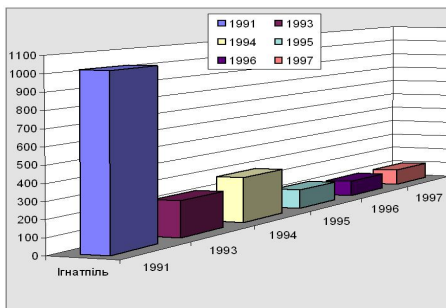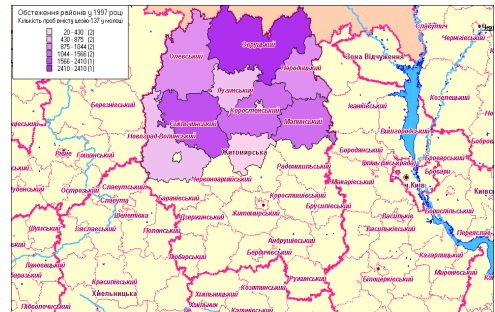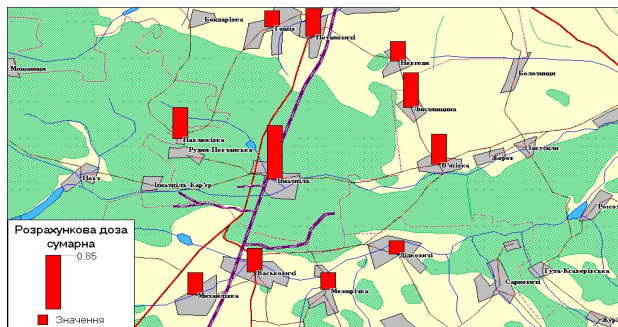
Fig. 6. Query execution to Integrated ecological DBn

a)

b)

c)

Fig. 7. Examples of the combined report for the districts of the Zhytomyr oblast and for the settlement Ignatpil (data from the Integrated ecological DBn).

Table 1. Number of cesium-137 samples in milk in 1997 in Zhytomyr oblast districts (data from the Integrated ecological DBn; translation from Ukrainian)

District	Measurement class	Number of samples	Year
Volodarsko-Volynsky	cesium-137 in milk	80	1997
Yemilchynsky	cesium-137 in milk	1566	1997
Korostensky	cesium-137 in milk	1359	1997
Luhynsky	cesium-137 in milk	850	1997
c. Korosten	cesium-137 in milk	20	1997
Malinsky	cesium-137 in milk	1044	1997
Narodytsky	cesium-137 in milk	875	1997
Novograd-Volynsky	cesium-137 in milk	430	1997
Ovrutsky	cesium-137 in milk	2410	1997
Olevsky	cesium-137 in milk	1010	1997

Each item of the Program of works provided the set of works, specific contracts, contractors and funding. It was possible to create a new Program, add a section or item, and edit the Program. The distribution of funding under the Program was carried out separately. This distribution could be done either manually or automatically. The system issued reports on the Program in the form of MS Word documents, ready for approval: a general report on the Program, decryption of expenditures by sections and items by recipients of funding and by oblast (decryption was performed on the basis of the work entered).

ATLASES OF RADIOACTIVE CONTAMINATION OF UKRAINE

Critical property 2 (CP2) is formulated as "Availability of the atlas solution (or Atlas system — AtS), relatively independent from other elements of the GIS of a large territory that could operate offline". In the period from 1996 to 2005, several atlases and atlas information systems were developed, which made it possible to formulate CP2. Below, due to volume problems, only one atlase solution is briefly described.

The Atlas of Radioactive Contamination of Ukraine (RadAtlas) was issued four times in 2002, 2008, 2011, 2014 in two versions — paper and electronic, in two languages — English and Ukrainian. The structures and contents of these editions are consistent and complementary.

The first version of RadAtlas was made under the conditions when some time after the Chornobyl disaster elapsed and there was a need for a publication that would give a general idea not only about the fields of formation of radioactive contamination, but also about the impact of ionizing radiation on human health and a wide range of medical, demographic, social and economic consequences of the Chornobyl disaster. Generalization of information not only about radioactive contamination of the territory by radionuclides, but also information about medical, social and economic aspects of the Chornobyl disaster was based on the latest author's developments and researches, data and materials accumulated over the years by leading institutions and organizations of Ukraine (including scientific institutes) in the field of radioecological monitoring.
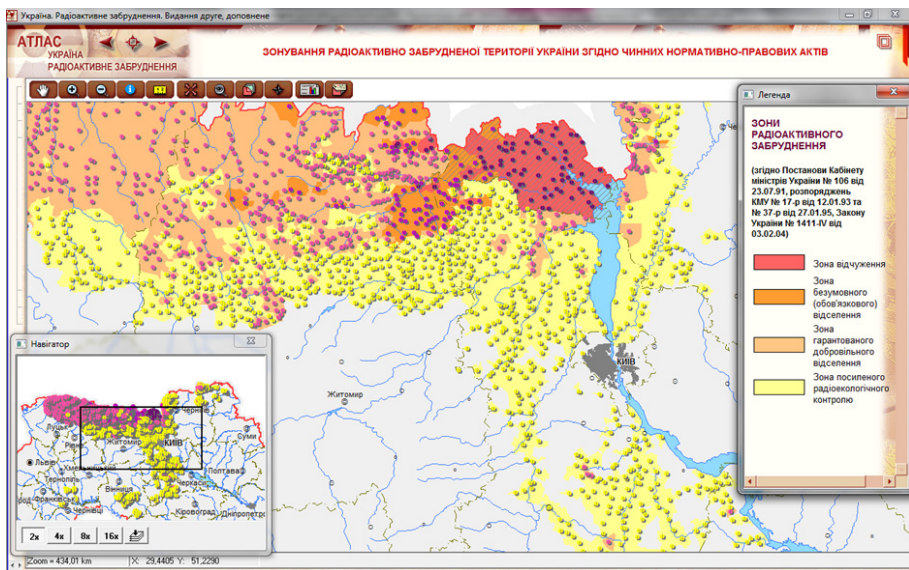
Fig. 8. Map of radioactive contamination zones from RadAtlas electronic version, 2nd edition (2008, ukr)

The paper version of the atlas was published in 2002, 2008, 2011 as an A3 album with a total volume of 52 pages. The atlas contains four sections, which include 40 maps and schemes, texts, graphs and diagrams. The maps are submitted to the territory of Ukraine in scales from 1:2.5 million to 1:12 million, for some territories the scale is increased to 1:100 thousand withthe inclusion of ActiveX components, containing interactive maps, texts, graphs and diagrams, tabular information (Fig. 8).

RadAtlas 2011 was issued only in a three-language (Ukrainian, Russian, English) paper version. RadAtlas 2014 is only available in English in electronic version. It can be viewed at the link [15].

GEOINFORMATION PROJECTS OF THE FRENCH-GERMAN CHORNOBYL INITIATIVE

In 1998–2003, three projects of the French-German Chornobyl Initiative (FGI) were implemented: Safety of sarcophagus (6 Sub-Projects) [16]; Radioecological consequences of the Chornobyl accident (9 Sub-Projects) [17]; Medical effects of the Chornobyl accident (10 Sub-Projects) [18].

More than 20 scientific and research institutes and organizations of Belarus, Russia, Ukraine, France and Germany participated in the creation of databases. As a significant number of Sub-Projects also consisted of Belarusian, Russian and Ukrainian units, the actual number of "thematic" Sub-Projects was 52. In addition to the thematic Sub-Projects, in each of the Projects 1–3 were also integrated Sub-Projects, and the Coordination project was completed. In addition to the large number of Sub-Projects, the situation was compounded by the fact that individual thematic databases had to create specialized institutions for each topic in Belarus, Russia and Ukraine with very different experience in developing information products.

All three Projects used geoinformation products: ArcView — in Project 1, MapInfo Professional — in Projects 2 and 3. Moreover, Project 1's database was developed on ArcView as a "highly" integrated system, and in Project 2 there was a special Sub-Project 0, the purpose of which was to provide the spatial and administrative-territorial bases for the radioecological Sub-Projects 1, 2, 3a, 3b, 3c, 3d, 4 and 5 of Project 2.

In order to coordinate the development of such a large number of information products (mainly databases), to ensure control and preservation of results, two main ideas of the Coordination project were put forward:

1. Apply the notion of a weak integrated information system to the organization of the results and materials of the Projects, using the notion of not a classical information system, but of an information system in a broader (wide) sense. At the same time, the authors of this idea were well aware that it is impossible to create a highly integrated (classical) information system, in the conditions of the already planned FGI.

2. To find or create a set of tools that would simplify and unify the development of information products of each Sub-Project, as well as ensure effective management and coordination of development at the level of each Project (ie, Sub-Projects of Projects 1, 2 or 3), and at the level of the FGI in general.

The information system in the broader sense (ISb) is called "The totality of all formal and informal data representation and processing activity within an organization, including the associated communication, both internally and with the outside world" [19]. The information system in the narrow sense (ISn or classical IS) is called "Computer-based subsystems, intended to provide recording and supporting services for organizational operation and management" [19].

It should be noted that the use of the notion and tools of the information system in a broad sense was forced measure. At the beginning of the FGI, such a system was not planned to be developed, but the problem of a large number of Sub-Projects and data forced management to start this development already during the implementation of the FGI.

Several ISb have been developed in the FGI Projects. Initially, simple desktop ISb REDAC1W, REDAC2W, ChIIS-FGI1 were created based on HTML for "weak" integration of project results and materials. Here, REDAC stands for RadioEcological Database After Chornobyl, a system for monitoring and accessing the results and materials of Project 2 of FGI, ChIIS-FGI stands for Chornobyl Internet/intranet Information System. The letter W in REDACnW, n = 1, 2, 3, had two meanings: Wide (or Broader), to identify the type of information system and Weak, to identify the approach of integration.

The analysis of the results of the FGI Projects substantiated two more critical properties of GIS. **Critical property 3 (CP3)**: Portal as a means of building GIS in some broader sense (GISb) with GIS in the narrow sense (GISn) and other elements, as well as to provide online teamwork with all elements-systems. **Critical property 4 (CP4)**: GIS of large territory must have a metasystem extension, which in turn must necessarily include meta-products and meta-processes for their creation. All elements of the system must be consistent with the particular Solutions Framework of the project in which the system was created.
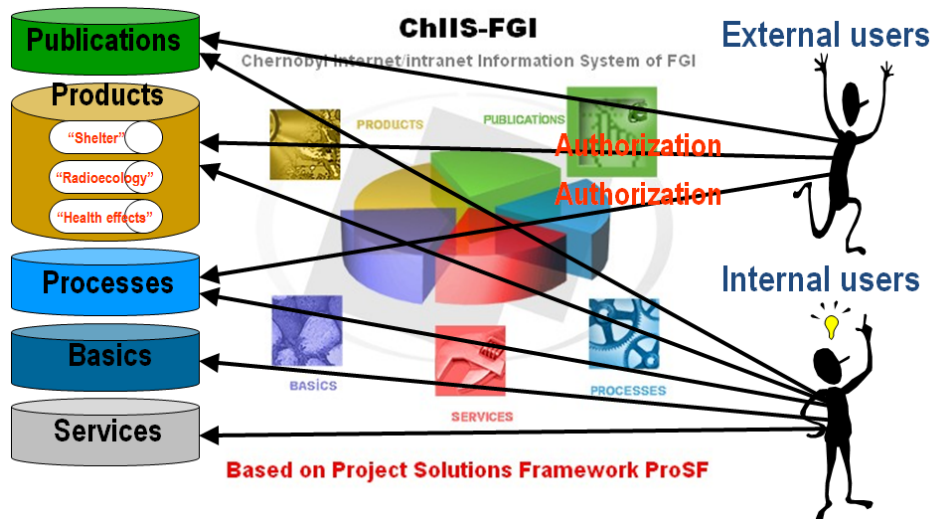
Fig. 9. Simplified structure of the (G)ISb ChIIS-FGI2

Critical property 3 (CP3). At the end of the FGI, it was decided to provide Internet access to the "weak" integrated (G)ISb REDAC2W and ChIIS-FGI1. To implement this idea, a dedicated ISGeo TripleNet Software Suite (ISGeoTriNet) portal software was created to develop the (G)ISb REDAC3W, HEDAC (HEalth Database After Chornobyl — control and access to the results and materials of FGI Project 3) and ChIIS -FGI2.

A key feature of our portal (G)ISb is the availability of a metadata database that describes portal content, helps you work with portal materials through the Web interface, and describes the relations between system elements. A simplified symbolic structure of the (G)ISb ChIIS-FGI2 is shown in Fig. 9.

The ChIIS-FGI2 portal part is shown in Fig. 9 in the middle, provides control and access to poorly integrated databases and file repositories (libraries) Publications, Products, Processes, Fundamentals, and Services (see Fig. 9 on the left). External users were required to log in to receive Reader or Author rights. Only internal users could obtain Coordinator group rights.

There was an "enhanced" approach to integration. For this purpose, portal structures such as Electronic dashboards, Web-modules and Portlets were used. For example, Web-modules were implemented such as Template — to create documents according to the selected template, and Pattern — to create groups of documents that are joined by certain logic, such as the management process. An example of Portlet is WIntegration (Weak Integration), which implemented two mechanisms of weak integration: establishing relations between documents and assigning a document to a specific category.

Critical property 4 (CP4). The result of implementation of the 2nd idea was the Project Solutions Framework (ProSF), which model is shown in Fig. 10. Here, the Products-Processes-Basics(Products, Processes) are called the main Solutions Framework (SoFr) triad.

In FGI Projects, this model had two implementations: 1) in the form of regular operating system directories containing sample files (version 1),
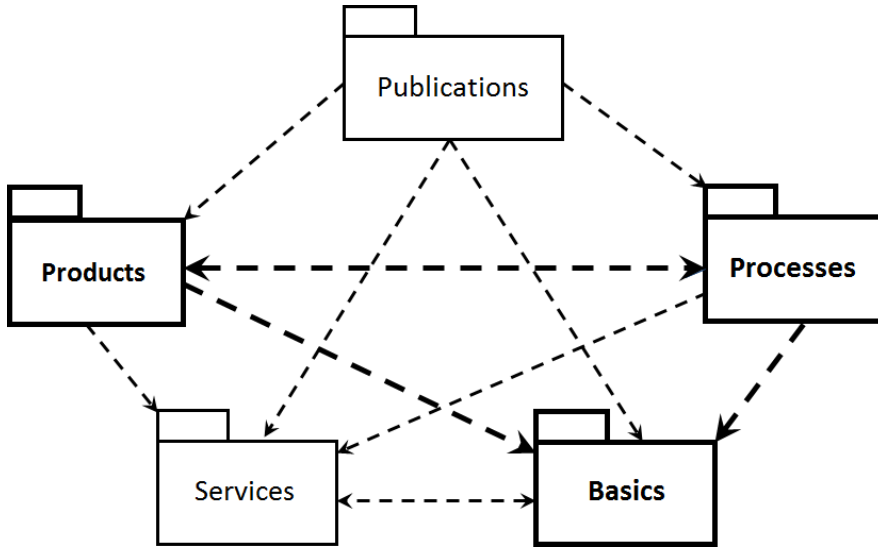
Fig. 10. Solutions Framework (ProSF) Model. The arrows show the usage relation

2) a version 1 file structure, supplemented with a metadata database and specialized portal software, ISGeoTriNet, which supported as creation of file structure and description of project results and materials, as well as authorized search and access of users through the portal (version 2).

The Publications package contains samples and templates: website, presentations, paper publications, demo versions of project results (products). Assigned to communicate with the project's external environment. Products package includs samples and templates: databases, maps, software, reports; their descriptions and metadata; operational documentation. Assigned for project product developers. The Processes package contains samples and templates of the project's business processes: requirements management, planning, survey, quality control, and configuration management. Assigned for project management. The Services package contains ISGeoTriNet specialized portal software, ProSF operational documentation, as well as samples and templates: training materials, metabases, product decoration elements, electronic and paper product repositories. Assigned for administrator, documentary and/or user training specialist. The Basics package contains global information resources for the project: a glossary, data dictionaries, classifiers, a base map, a geo-object database. Assigned (element by element) to all project participants. Supported by architect and project management.

The implementation of the described ProSF implementation made it possible to integrate the results and materials into an information system in a broader (wide) sense and, at the same time, into a weak integrated desktop and portal information system. Portal information systems are characterized by the presence of a metabase that describes portal content and helps to work with this content through the Web interface. In the portal version, the degree of data integration was "enhanced" compared to the desktop version.
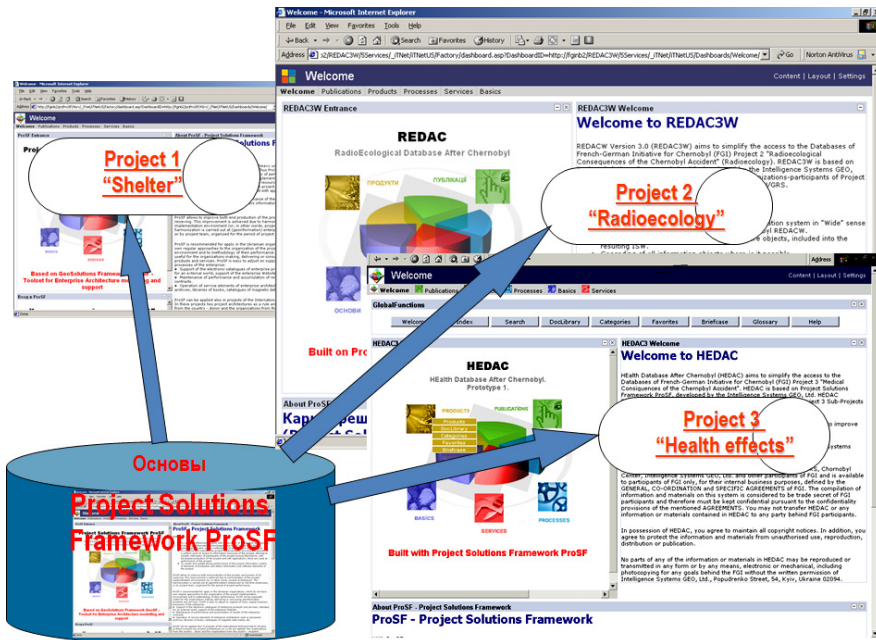
Fig. 11. Results of the ProSF Framework application to Projects 1–3 of FNI: REDAC3W, HEDAC and ChIIS-FGI2 (combining REDAC3W, HEDAC and Project 1 results and materials)

The Solutions Framework ProSF (Fig. 10, 11) was systematically used in the Coordination Project (also called Project 0) one year after the start of the FGI and the time before the initiative was over sufficient to monitor the results of each Sub-Project. The unification of the presentation of results, the use of the ProSF, have created the preconditions for organizing materials into a (geo)information system in an broader sense or weak integrated (geo)information system, with two versions: desktop and portal.

Here we must admit that in our practice there were projects of large territory GIS, for which the concept of scientific intensity was poorly applicable. This is, for example, the GIS of a national mobile operator. The development was carried out on a clear technical specification and the scientific intensity of this GIS was small, so, for example, in CP1 there was no educational-scientific component. However, for territorial projects of cultural and natural contexts, all critical properties are valid.

CONCLUSIONS

The defined four critical properties (CP) are valid for modern GIS and follow from our experience. They are:
- CP1. Availability of educational-scientific, production and management components in each GIS of a large territory.
- CP2. Availability of an atlas solution (or Atlas system — AtS), relatively independent of other elements of the large territory GIS, which could work offline.
- CP3. Portal as a means of building GIS in some broader sense (GISb) with GIS in the narrow sense (GISn) and other elements, as well as to provide online teamwork with all elements-systems.

- CP4. GIS of large territory must have a metasystem extension, which in turn must necessarily include meta-products and meta-processes for their creation. All elements of the system must be consistent with the particular Solutions Framework of the project in which the system was created.

In the absence of any such property, we can speak of a corresponding critical shortcoming of the GIS project, and this project is likely to be a failure.

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АНАЛІЗ ПРАКТИЧНОГО ВИКОРИСТАННЯ ГЕОІНФОРМАЦІЙНИХ СИСТЕМ ДЛЯ ТЕРИТОРІАЛЬНОГО КЕРУВАННЯ ТА ВИЗНАЧЕННЯ ЇХ КРИТИЧНИХ ВЛАСТИВОСТЕЙ

Вступ. Практичний досвід створення, впровадження та експлуатації геоінформаційних систем (ГІС) для керування великими територіями уможливлює виділити їх критично важливі властивості. ГІС за наявності критичних властивостей не відповідають загальноприйнятим визначенням, оскільки вони є розвинутішими системами. Приділення особливої уваги критичним властивостям дає змогу зменшити ризики під час розроблення та впровадження таких ГІС, а також підвищити ефективність їх застосування для керування територіями.

Метою роботи є аналіз використання розроблених авторами ГІС для керування великими територіями та визначення їх основних критичних властивостей. Відшукуються критичні властивості ГІС для керування територіями, які: 1) повторюються для всіх таких ГІС, 2) відрізняють їх від звичайних ГІС, 3) повинні обов'язково враховуватися під час створення нових ГІС.

Результати. Виділені такі критичні властивості, які є необхідними також і для сучасних ГІС для керування територіями: 1) наявність учбово-практичної, виробничої та управлінської компонент, 2) наявність відносно незалежного атласного рішення, 3) обов'язковість використання порталів, 4) необхідність доповнення моделювання територій їх метамоделюванням.

Висновки. Після аналізу практичного досвіду створення, впровадження та експлуатації ГІС для керування територіями абдуктивні умовиводи дають змогу стверджувати наявність критичних властивостей ГІС. За відсутності будь-якої такої властивості можемо говорити про відповідний критичний недолік проекту ГІС і цей проект буде найімовірніше провальним.

Ключові слова: геоінформаційна система, керування територіями, просторові дані, абдукція, критична властивість.

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АНАЛИЗ ПРАКТИЧЕСКОГО ИСПОЛЬЗОВАНИЯ ГЕОИНФОРМАЦИОННЫХ СИСТЕМ ДЛЯ ТЕРРИТОРИАЛЬНОГО УПРАВЛЕНИЯ И ОПРЕДЕЛЕНИЕ ИХ КРИТИЧНИХ ОСОБЕННОСТЕЙ

Введение. Практический опыт создания, внедрения и эксплуатации ГИС для управления большими территориями позволяет выделить их критически важные свойства. ГИС с критическими свойствам не соответствуют общепринятым определениям, поскольку они являются более развитыми системами. Особое внимание к критическим свойствам позволяет уменьшить риски при разработке и внедрении таких ГИС, а также повысить эффективность их применения для управления территориями.

Цель статьи — анализ использования разработанных авторами ГИС для управления большими территориями и определение их основных критических свойств. Отыскиваются критические свойства ГИС для управления территориями, которые: 1) повторяются для всех таких ГИС, 2) отличают их от обычных ГИС, 3) должны обязательно учитываться при создании новых ГИС.

Результаты. Выделены следующие критические свойства, необходимые и для современных ГИС для управления территориями: 1) наличие учебно-практической, производственной и управленческой компонент, 2) наличие относительно независимого атласного решения, 3) обязательность использования порталов, 4) необходимость дополнения моделирования территорий их метамоделированием.

Выводы. После анализа практического опыта создания, внедрения и эксплуатации ГИС для управления территориями абдуктивные умозаключения позволяют утверждать о наличии определенных критических свойств ГИС. При отсутствии любого такого свойства можем говорить о соответствующем критическом *недостатке проекта ГИС и этот проект будет скорее всего провальным.*

Ключевые слова*. геоинформационная система, управление территориями, пространственные данные, абдукция, критическое свойство.*