SAMOILENKO V.M.
DATSENKO L.M.
DIBROVA I.O.

GIS DESIGNING

TEXTBOOK

ПІДРУЧНИК

ПРОЕКТУВАННЯ ГІС

В.М.САМОЙЛЕНКО
Л.М. ДАЦЕНКО
І.О. ДІБРОВА

Kyiv – Київ
SE 'Print Service' – ДП "Прінт Сервіс"
2015 (редакція 2023)

УДК 911.9:004(075.8)
ББК 26.8я73
С 17

Самойленко В.М.

С 17 Проектування ГІС: Підручник (англ. і укр.) / В.М. Самойленко, Л.М.Даценко, І.О. Діброва. – К.: ДП "Прінт Сервіс", 2015 (редакція 2023). – 228 с.

ISBN 978-617-7069-19-4

У англійсько-українському **п**ідручнику розглядаються методологічні основи й технології проектування географічних інформаційних систем (ГІС).

Для студентів і викладачів університетів і вищих навчальних закладів, а також науковців і фахівців з географічних інформаційних технологій.

Автори: *В.М.Самойленко* – професор кафедри фізичної географії та геоекології Київського національного університету імені Тараса Шевченка, доктор географічних наук, професор
Л.М.Даценко – завідувач кафедри геодезії та картографії Київського національного університету імені Тараса Шевченка, доктор географічних наук, професор
І.О.Діброва – асистент кафедри фізичної географії та геоекології Київського національного університету імені Тараса Шевченка, кандидат географічних наук

Рецензенти: *М.Д.Гродзинський*, член-кореспондент Національної академії наук України, доктор географічних наук, професор *(Київський національний університет імені Тараса Шевченка)*
В.І.Осадчий, член-кореспондент Національної академії наук України доктор географічних наук *(Український гідрометеорологічний інститут)*
Я.Б.Олійник, член-кореспондент Національної академії педагогічних наук України, доктор економічних наук, професор *(Київський національний університет імені Тараса Шевченка)*

УДК 911.9:004(075.8)
ББК 26.8я73

Рекомендовано до видавання вченою радою географічного факультету Київського Національного університету імені Тараса Шевченка (протокол № 6 від 10 червня 2014 року)

ISBN 978-617-7069-19-4

S 17

Samoilenko V.M.

S 17 GIS designing: Textbook (in English and Ukrainian) / V.M. Samoilenko, L.M. Datsenko, I.O. Dibrova. – Kyiv: SE 'Print Service', 2015 (edition of 2023). – 228 p.

ISBN 978-617-7069-19-4

English-Ukrainian textbook deals with methodological bases and technologies of geographic information systems (GIS) designing.

Textbook is intended for students and lecturers of universities and institutions of higher education, and also for scientists and experts in geographic information technologies.

Authors: *V.M.Samoilenko* – Professor of the Department for Physical Geography and Geoecology of Taras Shevchenko Kyiv National University, Doctor of Science in Geography, Professor
L.M.Datsenko – Chief of the Department for Geodesy and Cartography of Taras Shevchenko Kyiv National University, Doctor of Science in Geography, Professor
I.O.Dibrova – Assistant of the Department for Physical Geography and Geoecology of Taras Shevchenko Kyiv National University, Candidate of Science in Geography

Reviewers: *M.D.Grodzynskyi*, Corresponding Member of Ukrainian National Academy of Science, Doctor of Science in Geography, Professor (*Taras Shevchenko Kyiv National University*)
V.I.Osadchyi, Corresponding Member of Ukrainian National Academy of Science, Doctor of Science in Geography, (*Ukrainian Hydrometeorological Institute*)
Y.B.Oliynyk, Corresponding Member of Ukrainian National Academy of Pedagogic Science, Doctor of Science in Economics, Professor (*Taras Shevchenko Kyiv National University*)

Recommended for publication by academic council of geographic faculty of Taras Shevchenko Kyiv National University (protocol No 6 dated June 10, 2014)

ISBN 978-617-7069-19-4

TABLE OF CONTENTS – ЗМІСТ

GIS DESIGNING

INTRODUCTION

A textbook initiates a set of study editions, which support a delivering of certain academic disciplines in English at Geographic Faculty of Taras Shevchenko Kyiv National University.

The textbook is directly connected with the academic discipline '***GIS designing***' that is the part of educational-qualification program for master training. **The goal of the academic discipline** is to form students' requisite knowledge, skills and expertise on an application of methodological bases and technologies for designing of geographic information systems (GIS designing) and to consolidate such knowledge etc. by particular examples, especially by use of management game elements.

On the one hand, the textbook evolves and improves educational-methodological achievements of its authors in the scope of geographic information systems and technologies ([27-54, 10-16]). On the other hand, the textbook uses long-standing experience and applied treatments of authors concerning the textbook subject ([27-29, 32-36, 38-41, 11, 13, 15]), considering, in particular, the participation of one of the authors as an expert on behalf of Ukraine in international commissions and projects on development of GIS for the trans-boundary Danube and Dnipro River Basins.

The textbook is intended, first of all, for already initially trained in the GIS scope students, which additionally are able to use knowledge on profile common-geographic academic disciplines, and also knowledge concerning information networks, geographic modeling, environmental management and management of projects and programs in the scope of geography and cartography. Properly the textbook is presented in two units: the first unit in English and the second in Ukrainian with identical content of both units. Such combination, firstly, will improve an understanding of professional geoinformation terminology by the textbook users. Secondly, mentioned approach will further a potential partnership of

the textbook users in international cooperation, concerning, in the first place, GIS and global and national spatial data infrastructures.

However, the textbook is intended for miscellaneous audience and can be used not only by students and lecturers of universities and institutions of higher education, but also by scientists and experts in geographic information technologies.

The authors are thankful for correct remarks to textbook scientific reviewers, namely to: Corresponding Member of Ukrainian National Academy of Science, Doctor of Science in Geography, Professor Grodzynskyi M.D., Corresponding Member of Ukrainian National Academy of Science, Doctor of Science in Geography, Osadchyi V.I. and Corresponding Member of Ukrainian National Academy of Pedagogic Science, Doctor of Science in Economics, Professor Oliynyk Y.B.

Taking into consideration that such textbook is published for the first, the authors will be obliged for censorious remarks and suggestions concerning structure and content of this edition, which can be mailed to address: Prof. Samoilenko V.M. Geographic Faculty, Taras Shevchenko Kyiv National University, Volodymyrska Str., 64, Kyiv-601, MSP-01601. *E-mail: viksam1955@gmai.com*

1. GENERAL NOTIONS AND BASIC (INITIAL) GIS DESIGNING

A GIS designing, as an imperative premise of further GIS operating at the highest level of this concept interpretation is greatly complicated, like any other present-day technologies of modern designing and project management. Such technologies generally organized at present a separate scope of mankind analytic-objective activity. Therefore, taking also into consideration that GIS now is one of the most integrated hardware-software devices, it's reasonable to examine *the principal approaches to designing of geographic information systems*.

Notes.

1. **GIS (geographic information system, geoinformation system)** – an information system, which provides an administration (acquisition, retention, processing, access, visualization, dissemination), examination and simulation of spatial (geographic) data.

2. **Design** (synonym *project*) in the broad sense – a complex of purposeful, component- and time-allocated tasks and activities (measures, efforts) to accomplish these tasks, which embodies a general intention, instruments and consistency of this intention implementation and foreseeable results and can be presented in the form of a special document (documentation). Such phases are differentiated as: a design preparation (design planning and development), a design implementation and also a post-designing phase.

3. In this textbook the term '*GIS designing*' is identified with the above mentioned first phase – *GIS design preparation (GIS design planning and development)*.

So, ***the GIS designing as a whole*** (*synonym here* – ***the GIS design preparation***) will be understood as the *process of foundation and formation of concepts and the development of proper engineering and technologic documentation concerning key GIS components, which is aimed at the strategic-documentary support of final development of GIS as a hardware-software complex and an information base of determinate spatial data domain*.

According to such position, a ***general algorithmic scheme of GIS designing*** (Fig.1) includes:

1) **The entities of GIS designing**, including:

a) Design employer;

b) Designer properly;

c) Other entities recruited to the general designing process by the employer or/and the designer;

2) **The objects of GIS designing**, which in such case are:

a) Future (potential) GIS users;

b) Spatial data and data bases (GIS data domain);

c) GIS software (SW);

d) GIS hardware (HW);

e) Operating conditions and regulations for functioning (use) of GIS;

f) Designed-estimated documentation (properly GIS design);

g) GIS developer ('realizer' of GIS design);

3) **The processes and** different level **sub-processes of GIS designing** (with intermediate and final resulting products of process implementation), which, in total, support the identification and/or development of particular designing entities and objects. Such processes include the first, mainly 'entity-entity' process and the set of other 'entity-object' processes, namely:

a) Basic (initial) GIS designing;

b) Strategic GIS designing;

c) GIS software designing;

d) GIS hardware designing;

e) Operation GIS designing;

f) Final GIS designing.

Note. The processes of GIS software and hardware designing due to their essential intersystem relation, and as it is methodically reasonable, have to be consolidated into a *hyper-process of system GIS designing*.

The content of basic (initial) GIS designing as a process is formed by such first-level *sub-processes*, as (Fig.2):

1) Identification of principal GIS designing entities;

2) Definition of other GIS designing entities;

3) Development of a plan (strategic framework), a schedule and a budget of GIS design preparation.

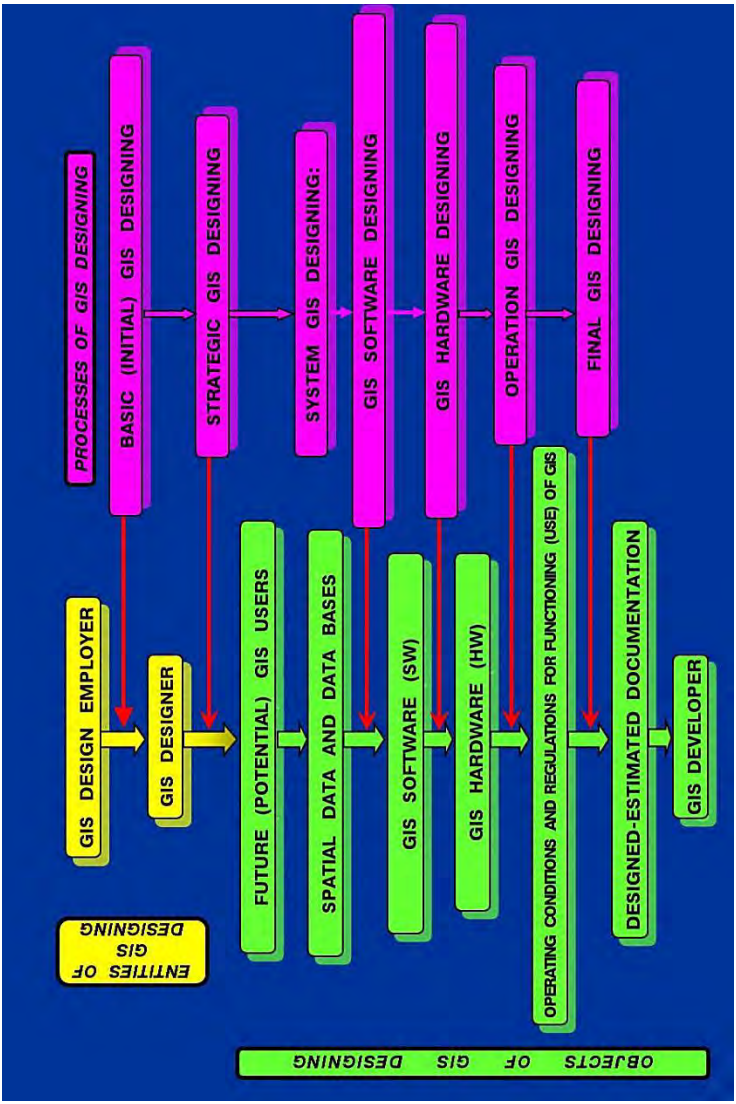

Fig.1 – General algorithmic scheme of GIS designing

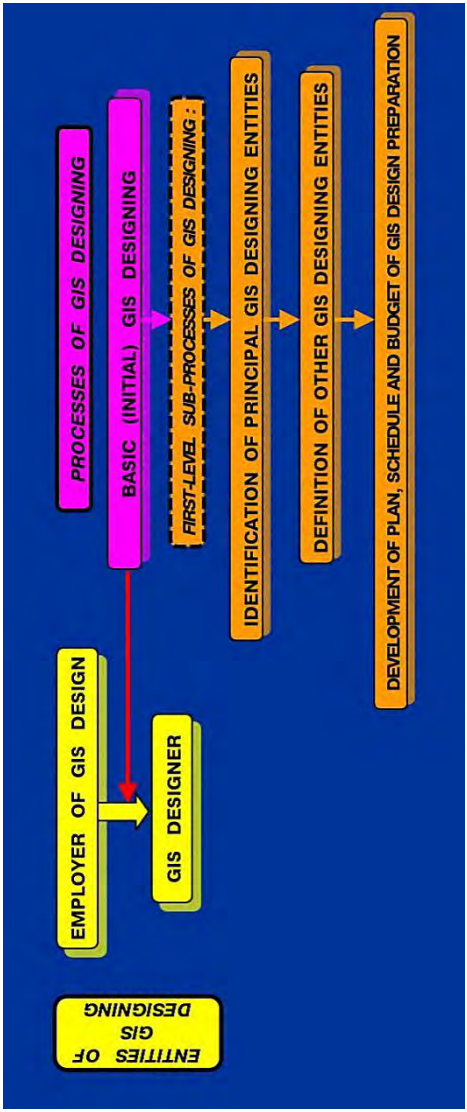

Fig.2 – Detailed fragment of GIS designing general algorithmic scheme (the process of basic (initial) GIS designing, see Fig.1)

The employer and the designer are the ***principal GIS designing entities***.

The GIS design employer is *one or several natural and/or corporate bodies, which are interested in the implementation of GIS designing process, put to this process own and/or obtained or entrusted funds (invest the designing) and are holders (sometimes co-holders) of GIS design* (and, very often, of the design implementation results too).

Somewhere **the GIS design investor** is separately differentiated as the designing entity, who (which) directly puts own funds to the designing process with a view to a profit-making.

In addition to that, the situations are possible, when:

1) The investor and the employer of design is the same body (bodies);

2) The investor and the employer are different bodies and legal, organizing and other relations among them and other designing entities are regulated by the special agreements etc.

Also occasionally, firstly, a term **'GIS design sponsor'** is in the operation and this term under different particular cases can be identified both with the design employer and with the design employer-investor or investor, including 'nonprofit' or 'extra' entities, etc.

Note. The term **'sponsor'** under given context can be understood, except strictly 'sponsor' in the just mentioned interpretation, also as 'a guarantor', 'a bail granter', 'an organizer', 'an initiator', 'that who (which) finances', 'that who (which) subsidies'.

Secondly, taking into consideration international system of environmental management, a term **'GIS design beneficiary'** also is applicable and means natural and/or corporate body (bodies), who (which) gain(s) a profit or benefit (not necessarily financial) with certain design.

Thirdly, a resumptive term **'GIS design stakeholders'** also is used and means all, incorporated at partner foundations, natural and/or corporate bodies, who (which) in this or other way maintain the process of GIS designing and take an interest in design outcomes.

The GIS designer is a *specialized contracting design organization (company), including consulting and/or engineering body, which ensures the whole process of development of designed-estimated documentation concerning future GIS*. Not infrequently as the designer is used a set of organizations (companies) and in that case among them a **general designer**

is differentiated with responsibility for coordination and implementation of the whole GIS designing process.

Notes.

1. **Consulting** is an activity type, which ensures not only properly consulting, but also scientific-technical, financial-analytic, engineering-economic, technologic, prognostic and organizing-legal preparation and maintenance of design implementation.

2. **Engineering** is an activity type, which embodies engineering-consulting services and works in scientific-research, design-constructive and calculating-analytic scope, combined with process of engineering-economic design formulation and implementation of design outcomes. Engineering can cover stages of activity planning, engineering designing, testing and control on putting into operation design objects or technologies etc.

3. Not infrequently for the present it is done an establishment of organizations (companies), which integrate consulting and engineering activity (*consult-engineering companies, bureaus* etc.).

Both relationships among principal designing entities and general organizing-financial background of the total designing process largely depend on selected *alternate for a scheme of GIS design management as a whole*. Such alternates are differentiated, in particular, on:

1) The scheme, according to which the designer is under mainly contract relations only with the design employer (as his agent or structural subdivision etc.) with the implementation of certain functions concerning coordination and management of designing process without a liability for management decisions and with attributing of all designing risks to the employer;

2) The scheme, according to which the designer, as not frequently a contracting company, independent of the employer, besides contract with the employer makes contracts with all other designing entities, practically completely manages designing process, saving certain control and other determined employer phase functions, and undertakes a liability and designing risks;

3) The other schemes, including combinations of first two alternates or so-called turnkey designing scheme, according to which relationships

among the employer and the designer are practically limited by two principal actions: 'an order – an obtainment of GIS design' etc.

Notes.

1. **Design management** is a system of process principles, methods, procedures, means and forms and also properly a process (i.e. 'actions on') of certain design management aimed at increase of such management efficiency.

2. Everyone can acquaint itself with design management peculiarities by reference to corresponding sources, for example to the textbooks and manuals on design management ([57, 62, 64]) and the papers on environmental management ([26, 56]), principal definitions of which were partly used in this chapter, etc., and also by attending the course of lectures on the academic discipline 'Management of projects and programs in the scope of natural geography', which is delivered in English by one of this textbook author – prof. Samoilenko V.M. This chapter was not aimed at detailed examination of mentioned above peculiarities, taking into consideration that key attention was concentrated on disclosure of basic *disciplinary-meaningful features* of GIS designing.

The definition of other GIS designing entities, which are recruited to designing process by the employer and/or the designer, is implemented, first of all, taking into consideration that a *support of GIS design preparation* totally is differentiated into:

1) Marketing support;
2) Conceptual-analytic support;
3) Organizing support;
4) Information support;
5) Material-technical and technologic support;
6) Normative-legal, including licensing, support;
7) Human recourses' support;
8) Financial and other support, in particular certain combinations for the components of GIS design preparation support.

Notes.

1. **Marketing** is an activity type, aimed at an adaptation of designing process and/or a development of certain product (wares, technologies, works, services etc.) to market conditions by research of this product users' needs, assessment and/or shaping of demand on a product with corresponding optimization of its development and content under general improvement of a product developer's

market strategy, which must ensure a product supply, having a consumer value and increasing a profit or other gain of such developer.

2. Sometimes designs, especially international or national environmental (geo-ecological) designs, including those which concerns properly GIS designing and development, have an indirect valuable-profitable nature, when a profit is, for example, socially-environmental – due to a rehabilitation of environmental conditions for certain region and to this rehabilitation consequences etc. In such case an increasing of developer profit has to be suitably understood in presented interpretation of the marketing.

Hence, considering on the peculiarities and adequate available 'design-supporting' resources of the employer and the designer (see previous text), as **other GIS designing entities** in particular can be used:

1) **Consultant**, which as a resumptive term is identical to *one or several natural and/or corporate bodies, which are recruited to GIS design preparation on contract bases on a purpose to render consulting services to the employer and/or the designer in a scope of designing process*. The last determines the Consultant composition which can include the *experts (organizations) in*:

a) *GIS marketing*. They are very important for a support of marketing research implementation, first of all under GIS needs assessment, definition of GIS potential users and a content of their queries to GIS etc. (see further text);

b) *Supply of GIS software and hardware*. They are serviceable, in particular, for a selection of those software/hardware suppliers, which will ensure not only adequate level of supplying ware, but also a maintenance of ware implementation, renovation and also, in case of need, training of a staff for GIS operating etc.;

c) *Supply of GIS spatial data*. Such experts have to assist, in the first place, in determination of sources for obtainment of spatial data concerning GIS data domain, taking into consideration both the quality and modification possibility of these data (for example a transformation into formats selected for GIS etc.), and optimal cost characteristics of the mentioned supply;

d) *Development of GIS application programs (applications)*. These consulting entities are important under the designing for efficient

orientation of the GIS employer and designer towards an involvement of experienced programming experts, who are able to use modern programming languages and up-to-date tools for a visualization of information, including *web*-designing tools on condition that future GIS will be allocated in the global information network;

e) *GIS system and conceptual analysis*. These GIS designing entities are responsible for a selection of GIS system analysts, who are able to substantiate and control the observance of all conceptual-analytic principles for the designing and then implementation of GIS;

f) *Design management* etc. In addition to that it is principal to determine in the whole a staff of *GIS design management team*, which are headed by a design leader (design manager or top manager) and which together with such manager is contract for the employer team of natural bodies or corporate body, which (who) has organizing responsibility for planning, implementation control and coordination of all activities concerning GIS design preparation and future implementation of such design;

2) **Licensor**, which in this case as a resumptive term is identical to *one or several natural and/or corporate bodies, which are holders and/or managers of possessory rights (registered by patents, know-how etc.) concerning the products, including the technologies, which are used under GIS design preparation*. In other words, the Licensor, under terms of a license agreement with a *Licensee*, which is here one or both principal GIS designing entities, empowers such Licensee to apply patent (patented) products, know-how etc., required under GIS preparation.

Notes.

1. **License** – in this case a permission to use patent products, know-how etc., the special features of which are regulated by particular document – a license agreement – between a licensor and a licensee.

2. **Patent** – in this case an official act (document), which certifies the authorship of scientific, intellectual, engineering or technologic invention and the exclusive right of patent holder to use such invention.

3. **Know-how** – a documented corpus of scientific-technical, technologic, financial-economic, commercial, legal and other confidential knowledge, which are imperative for efficient designing and/or development of certain product

(wares, technologies, works, services etc.) and has author's individual or corporative protection at the least at a level of business secrecy. The know-how, as an object of intellectual property, is transferred in use under the terms of license agreement or according to proper agreement on cooperation etc.;

3) **Lawyer**, which also generally personifies *one or several natural and/or corporate bodies, which altogether are responsible for normative-legal support of all components forming GIS design preparation process*, including, in case of need, for a registration of certain GIS designing results as patent products etc.;

4) **Bank**, which once again as a resumptive term is identical to *one or several banking institutions, which have to ensure the direct financial support to all components forming GIS design preparation process* by a servicing of routine business transactions, concerning, first of all, the design employer and the GIS designer, by certain financial mediation as to such transactions, including crediting, etc.

Note. It should be taken into consideration, that certain bank or other financial institution (investment facility etc.) can be also properly the GIS design employer (the investor, the sponsor, the beneficiary) and this can somewhat change responsibilities or in general liquidate the presence of the Bank as other GIS designing entity;

5) **Other possible entities**, for example typical representatives of future (potential) GIS users (see next text) or bodies, which (who) ensure certain autonomous expert inspection on the designing process etc.

Altogether the *final resulting products of basic (initial) GIS designing process implementation* will be:

1) Defined *the GIS design employer and the GIS designer*, which represent the selected alternate for the scheme of GIS design management by formation of proper contractual documentation.

Note. Sometimes the design employer really has to be defined (nominated) particularly, for example in case if *properly the state* is the investor of national GIS designing by the funds of state budget and the responsibilities of direct design employer are delegated to certain body of state executive authority or to institution or organization;

2) Required *other GIS designing entities* recruited to this process under contract and other stipulated bases by the employer and/or the designer;

3) Plan (strategic framework), schedule and budget of GIS design preparation, including key points of their execution etc. (see more detailed, for example, [71]).

Let's illustrate some mentioned above statements on the example. Thus, at the beginning of present millennium the International Commission for the Protection of the Danube River (hereafter briefly '**the Danube Commission**') for implementation of the European Union Water Framework Directive initiated the activities concerning the designing and development of **the Danube River Basin GIS** (hereafter briefly '**the GIS 'Danube**'') (see more detailed our monograph [45] and Fig.3). Further operating of the common, combined and harmonized GIS 'Danube' is aimed at, first of all, activity coordination among the countries of the Danube Basin and consolidation of existing and future information recourses, which present the basin watermanagement and environmental conditions.

The GIS 'Danube' design employer(s) are the countries of the Danube Basin in the person of the Danube Commission, *the GIS designer* (under the application of peculiar combination of the first and second alternates for the scheme of GIS design management, see above) is the expert group on information management and GIS of this international commission, which executes methodical and coordinating-management functions under the GIS designing and development, and the specialized Austrian consult-engineering bureau.

The set of *design sponsors* are represented by the European Commission of the European Union, the United Nations Development Program (the UNDP) and the Global Environment Facility (the GEF) etc.

Notes.

1. **The International Commission for the Protection of the Danube River (the ICPDR)** is the international organization, established under the Danube River Protection Convention, which is underwritten at 1994 in Sofia, joined into the force since 1998 and at present is ratified by 14 Danube countries, among them by Ukraine in 2003, and the European Union. This commission in general looks after problems of the Danube Basin modern trans-boundary management under a priority of its environment preservation and the ICPDR Permanent Secretariat operates since 1999 in Vienna.

2. **The European Union Water Framework Directive (the EU WFD)** is the Directive 2000/60/EU of the European Parliament and the European Union Council of October 23, 2000, which establishes the framework for activity of the European Community in the scope of water policy (see [6]).

3. **The United Nations Development Program (the UNDP)** is the international institution (subdivision of the United Nations Organization), which was established in 1965, has numerous offices in several countries and looks after a provision of aid directed to the sustainable mankind development, first of all by maintenance of various international, transnational and national programs and designs, including the environmental scope.

4. **The Global Environment Facility (the GEF)** is the facility which was established in 1991 by the World Bank and the UNDP etc. with purpose to ensure the financial expenses, which is aimed at the worldwide environment preservation and step outside national interests and/or capabilities, in the first place by financial support of global or transnational-regional environmental programs and designs.

Control questions and tasks to chapter 1:

1. *What does the GIS designing mean?*

2. *Explain the general algorithmic scheme of GIS designing.*

3. *Who (what) can be the entities of GIS designing?*

4. *Who (what) are the objects of GIS designing?*

5. *Explain the difference between the objects and the processes of GIS designing.*

6. *How do you understand the term "beneficiary of GIS design"?*

7. *How many alternates for the scheme of GIS design management do you know?*

8. *What is the principal function of the Licensor during GIS designing?*

9. *What is the principal function of the Lawyer during GIS designing?*

10. *What is the principal function of the Bank during GIS designing?*

11. *How do you understand the strategic framework of GIS design preparation?*

12. *Illustrate by the examples the implementation of the components of basic GIS designing process.*

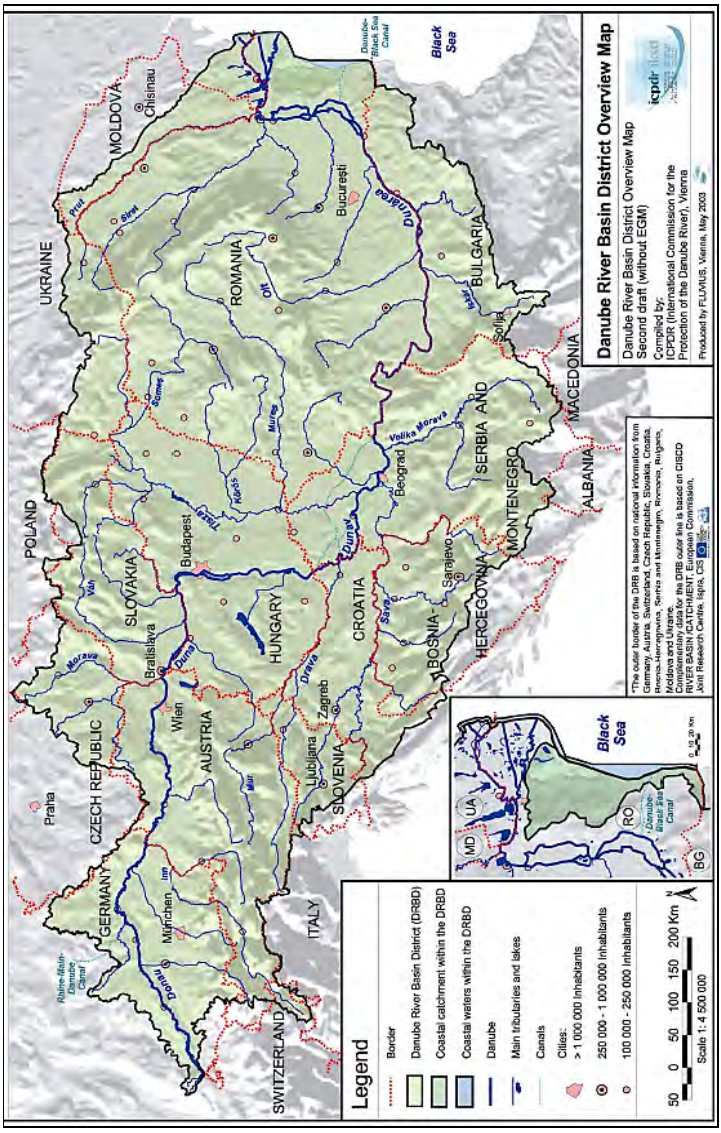

Fig.3 – International Danube River Basin ([82])

Sources recommended to chapter 1

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011.* – 228 p.
5. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
6. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8.* – P.77-85.
7. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.*– P.200-208.
8. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6*. – P.20-31.
9. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – P.11-22, P.71-142.
10. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
11. *Samoilenko V.M., Dibrova I.O. et al.* Didactics of Geography: Monograph (electronic version). – *Kyiv: Nika-Center, 2013.* – CD, ISBN 978-966-521-619-3. – 570 p.

12. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
13. *Datsenko L.M.* Fundamentals of geoinformation systems and technologies in school courses of study abroad // *Periodical of Cartography. – 2010. – Vol.1.* – P.197-205.
14. *UNEP* project manual: formulation, approval, monitoring and evaluation. – *UNEP, 2005.* – 126 p.
15. *Tian R.B. et al.* Project management: Textbook (in Ukrainian). – *Kyiv: Center of educational publishing, 2004.* – 224 p.
16. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
17. *http://www.icpdr.org.*
18. *http://www.unep.org*.
19. *http://www.undp.org*.
20. *http://en.mimi.hu/gis.*
21. *http://www.esri.com.*

2. STRATEGIC GIS DESIGNING

Next ***strategic GIS designing process***, on the one hand, supports interrelated identification of those designing objects, as **future (potential) GIS users** and GIS **spatial data** with their bases, and on the other hand, includes such first-level sub-processes, as (Fig.4):

1) GIS needs assessment;
2) Conceptual GIS designing;
3) GIS data base (DB) designing.

2.1 GIS NEEDS ASSESSMENT

The GIS needs assessment as designing sub-process are aimed at obtaining of certain *intermediate resulting products* of process implementation, which are ensured by such second-level sub-processes, as:

1) Definition of general future GIS typology;
2) Setting of a staff for future (potential) GIS users;
3) Formulation of possible users' queries to GIS;
4) Creation of preliminary list for required initial spatial data, which present GIS data domain and are needful for a generation of adequate data bases;
5) Delineation of a list for functional requests to GIS (including preliminary scripts of GIS operating), which represent users' queries and GIS data domain;
6) Definition of preliminary list for application software, which have to be produced and/or adapted for program support of functional requests to GIS.

The components of **general future GIS typology** are defined in consideration of GIS development *principal goal* and *classified features*, cited in [27], considering, in particular, on attribution of designing GIS to:

a) Open or locked systems, first of all by paying attention to GIS access possibilities for users considering, in the first place, the global information network;

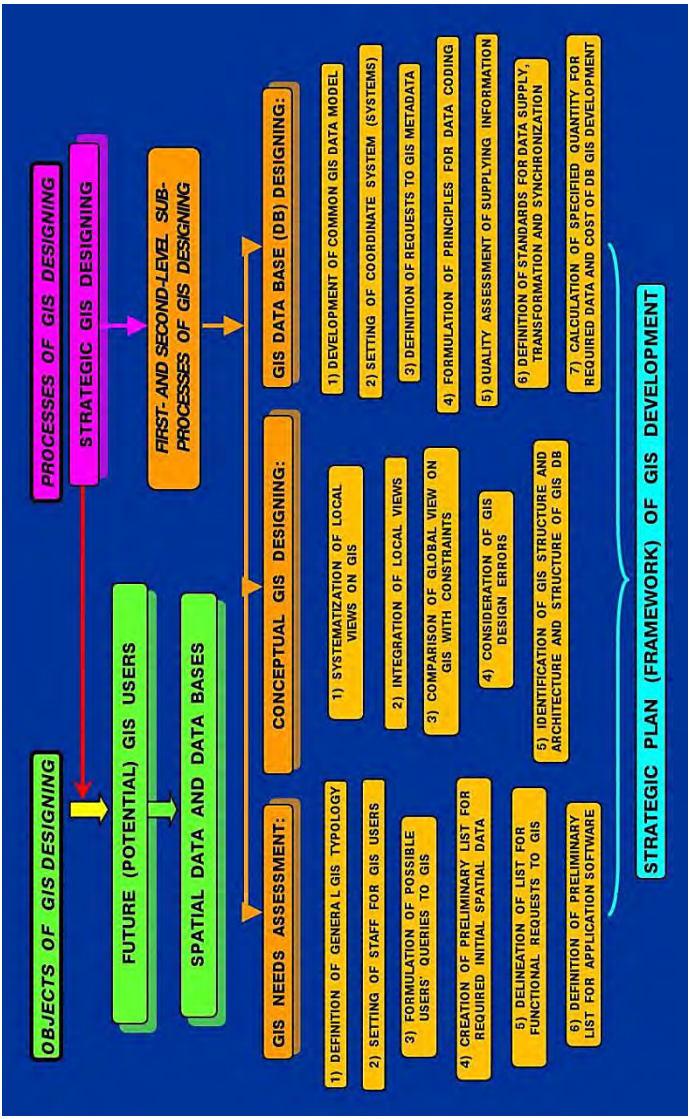

Fig.4 – Detailed fragment of GIS designing general algorithmic scheme (the process of strategic GIS designing, see Fig.1)

b) Global, regional or local systems in consideration of geoinformation mapping spatial levels;

c) International, national, corporate and so on systems, paying attention, first of all, to the GIS employer, relations with international and/or national spatial data infrastructure etc.

The setting of a staff for future (potential) GIS users requires individual special investigation and can be implemented:

a) *Imperatively* in consideration of development goal and certain abovementioned typological peculiarities of designing GIS, in the first place in consideration of GIS territorial scope and GIS holder;

b) As a result of proper *professionally-sociological and marketing investigations*, taking into consideration that the designing and development of modern GIS is rather high-costed business and the principle 'a development of system for its development' here is unacceptable, because prospective GIS has to be orientated at particular users, including those who can become users in the future.

So, firstly, mentioned at previous example the GIS 'Danube' was designed as international, regional and open system. It as a whole was conceived as efficient open information tool for communication of spatial data, which represent needs of the whole-basin management as to the Danube. The GIS 'Danube' had to become international property and all basin countries' contribution, which will support achievement of the Danube Convention (1994) goals with planning and management improvement and with adaptation to variable needs of these countries. As the potential GIS 'Danube' users were determined:

1) Internal users of the International Commission for the Protection of the Danube River (the expert groups, the Permanent Secretariat);

2) Countries-members of the Danube Commission, including their plenipotentiaries at the Permanent Secretariat of this Commission;

3) External users, who (which) maintain the development aim and goals of the Danube Commission, including the public;

4) Authorities and other countries of the European Union.

Secondly, a typical composition of future (potential) users may also be:

1) Legislative, administrative and executive state authorities of other levels and ranks;

2) Authorities of education and science and their organizations;

3) Industrial and other entrepreneurial circles;

4) National non-government organizations and local communities, supporting ideas of environment protection and sustainable development, and also mass media;

5) Government and public organizations from transboundary countries;

6) International organizations, which support a development of global and regional environmental programs and designs.

The formulation of possible users' queries to GIS is a result, on the one hand, of GIS typification, on other hand – of staff definition for these users. Therefore, holding the principle that the user is more interested in the GIS products then how these products will be developed, the mentioned formulation, as a rule, is realized:

a) by *logically-analytic constructions* considering future GIS end use, also taking into account imperative 'general-system' queries, which meet requirements of technologic standards for GIS and software tools, which will be used for GIS development;

b) similar to GIS users' definition, *at base of special professionally-sociological and marketing investigations*, which not infrequently embody a survey by questionnaire for typical representatives of future GIS users, first of all concerning procedures and *spatial information (syn. geoinformation) products* expected by GIS users etc.

For example, as a result of proper investigation and analysis it was defined that the sets of users' queries to GIS, with proper their refining, have to support:

1) Preparation of reports on the European Union Water Framework Directive implementation;

2) Coordination of ways for the Danube River Basin management, in the first place by means of the Danube Commission structure;

3) Arrival of strategic solutions concerning the protection of environment in the basin;

4) Investigations and support of educational process;

5) Informing of public at large as to environmental situation in the basin.

The creation of preliminary list for required initial spatial data, which are needful for a generation of adequate GIS data bases (DB), is realized paying attention to the following.

Firstly, it has to be defined the scope investigated by means of GIS – **GIS data domain**, which *circumscribes information sphere of GIS designing and object types for mentioned domain*, initial spatial data on

which (with their position and attributive components) are needful for GIS DB development, considering, first of all, needs of GIS users.

For example, the data domain of the GIS 'Danube' was set by special guidance (see [45, 63]) and as the object types of another basin GIS data domain can be used positioned in the basin:

1) Water bodies (rivers, reservoirs, ponds, lakes, cooling ponds, sewage tanks);
2) Catchments (including rivers of 1-4 degrees);
3) Territorial-time distribution of water resources;
4) Landscapes of catchments;
5) Objects of water use (water intakes, spillways etc.);
6) Objects for monitoring of water (stations and look-out posts of agencies performing monitoring);
7) Units of administrative-territorial division;
8) Sectoral and intra-sectoral water use territorial distribution;
9) Objects with nature-protected status;
10) Objects, which are sources of increased environmental risk;
11) Territorial binding of activities aimed at water and nature protection.

Secondly, under the designing definition of required GIS spatial data it takes into consideration such **general criteria of efficiency for future GIS information basis** (see [23, 54, 37]) as:

a) *Meta-system and procedural uniformity of information obtainment*, including adherence of proper international standards;

b) *Criteria uniformity of information quality*;

c) *Information compatibility* as a result of two first criteria adherence and which is identified by an extent of GIS capability to store and organize the uniform data bases from other sources of data supply;

d) *Aggregate comprehension of information basis*, which is adequate to an extent of information coverage of all processes determining object state at GIS data domain;

e) *Promptness of information basis*, which are defined by potential availabilities to use information-communication means of timely and complete obtainment, transformation, filtering and assessment of initial spatial data (for example remote sensing data etc.) and their preparation to thematic generalization according to GIS development aim;

f) *Information adequacy* with additional taking into consideration prospective possibility to control such adequacy and to determine a reliability and representativeness of information sources.

Thirdly, under compiling of a list for required initial GIS spatial data, **sources and modes for obtainment and/or supply of** such **data** (see [27]) **and their status** (formats, scale, actuality, necessity of transformation or adaptation etc.) are allowed considering territorial and functional coverage, data content and cost and also a possibility of mentioned obtainment and/or supply:

a) On irregular basis, i.e. one time during GIS development;

b) On regular basis, i.e. during future GIS operating, which not infrequently is regulated by special documentation concerning future information communication and supply to GIS.

1. Principal sources of initial spatial data for used as the example the international GIS 'Danube' were (see [38, 45]):

1) So-called *EuroGlobalMaps*, which are the property of the international European organization *EuroGeoraphics* and were used as supporting ones for the thematic maps;

2) Digital thematic data of the Danube Commission countries-members in the shape specified by the GIS 'Danube' designer;

3) Other digital data concerning the set of proper European designs etc.

2. The sources of GIS spatial data obtainment can include also resources of the global information network (see [7, 61]), in particular such mapping services for three-dimensional visualization of the Earth surface as:

1) The *NASA* Program (the Program of the *National Aeronautics and Space Administration* – the USA government organization for space research) '*World Wind*' with its allocation at [94], which requires an involvement of experts in geoinformation technologies under the Program products application;

2) The Project '*Google Earth*' (the *web*-site [78]), which human-engineered interface is intended for non-trained user and lets him to develop even own digital GIS layers with specified classification and matched attributes and option for data communication (see the example at Fig.6);

3) The ongoing common Project '*Digital Earth*' (the *web*-site [76]) developing the substantial relational global spatial data base, which is simple for visualization and serviceable both for experts in geography and wide range of other users.

4. The sources of spatial data under GIS designing also can be presented by a geodata affiliated to software tools for GIS development (see [27]), which

occasionally by certain way can be combined with data in the global network (for example the package '*Data*' from the software GIS-package assembly by *ESRI Inc*., see [79, 27]).

The formulated users' queries to GIS under designing and this system data domain allow to start in the first approximation **the delineation of a list for general functional requests to GIS, including preliminary scripts of GIS operating**.

Such **scripts** in this case in general are interpreted as *subject and fragmentary distribution of GIS spatial data and modes for their obtainment, processing, evaluation and visualization by users' queries according to operation resources of multilevel and multipurpose adequate GIS software tools*.

Properly the formulation of general functional requests to GIS under designing first of all pays attention to:

a) Presence of *general-system requests* caused by requests to GIS as a system of hardware-software devices;

b) Existence of *special requests* connected with operating scripts and geoinformation procedures (operations) defined directly by principal aim and goals of GIS development;

c) Presence or absence of *certain crucial GIS structural blocks (modules)* (see [27]), in particular a block of models (simulation block), including definition of this block matter and functions, and also, that is very important, a block of decision assessment and arrival, including delineation of this block form – notional or explicit;

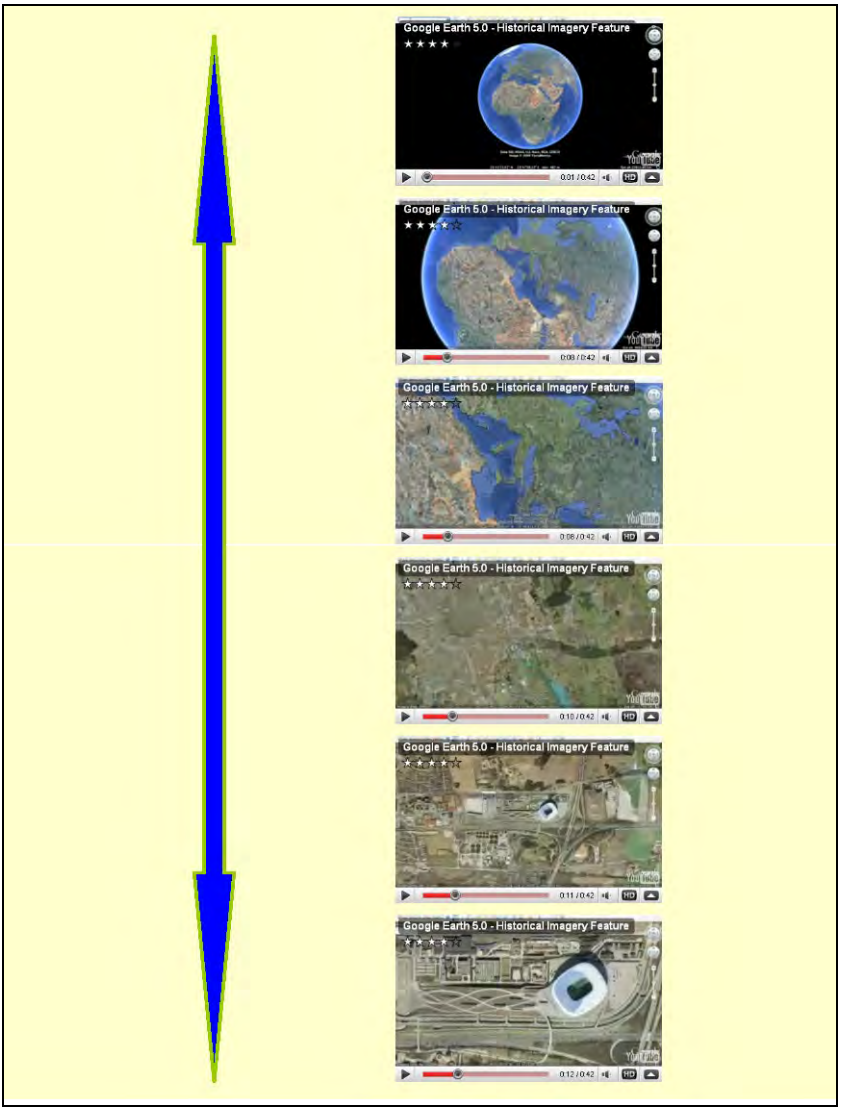

Fig.6 – The example of browsing at 'Google Earth' (by [78])

d) *Logical order of procedures* having to be implemented by future GIS and supply of each grade (step) at these procedures by requisite spatial data in appropriate for this form;

e) Formulation of conceptions on graphical GIS user interface, considering the concrete groups of such users and their peculiarities;

f) Allocation of GIS under designing in the global, regional or local information network or network combination (additionally concerning network type – open, corporate and so on) with considering of GIS locality in international and/or national spatial data infrastructure and, in case of need, an expectation of *web*-designing tools application etc.

The definition of preliminary list for application software which have to be produced and/or adapted for program support of functional requests to GIS is held paying attention to:

a) *Properly mentioned requests* reflecting users' needs for certain spatial information (geoinformation) products and their handling;

b) *Software tools*, which potentially can provide a basis of future GIS functioning, including GIS DBMS etc., considering particular typological features of such tools (see [27]), their possible integration and an extent of necessity for adaptation, modification and final preparation of certain nonstandard procedures and tasks for GIS under designing etc.;

c) *Other software types*, including 'add-on' DBMS, which should be used for implementation of GIS operating scripts;

d) *Profiled-by-technology tools*, requisite for GIS under its allocation in certain type of information network etc.

Note. **Data Base Management System (DBMS)** – a complex of computer programs and programming language means serving to develop, support and use data bases.

The sub-process of strategic GIS designing process – the GIS needs assessment, which principal components were indicated above, is largely orientated to an identification of concrete potential users as GIS designing object and their needs, and relatively slightly – to an identification of spatial data exactly in the form of their bases as designing object (see Fig.4). Such sub-process moreover represents generally, as a rule, even highly useful, but local proper views on future GIS.

Control questions and tasks to sub-chapter 2.1:

1. *What is the GIS needs assessment?*

2. *Comment the definition of the general GIS typology.*

3. *Explain the necessity of a staff setting for future (potential) GIS users.*

4. *Illustrate by the examples possible users' queries to GIS.*

5. *What is preliminary list for initial spatial data?*

6. *What is the difference between GIS data domain and region of GIS designing?*

7. *How many criteria of efficiency for GIS information basis do you know?*

8. *Why have we to define sources and modes for obtainment and supply of GIS data?*

9. *What is the difference between functional requests to GIS and scripts of GIS operating?*

10. *Why do we use preliminary list for application software which has to be produced and/or adapted?*

11. *Illustrate by the examples the implementation of the components of GIS needs assessment sub-process.*

Sources recommended to sub-chapter 2.1

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011*. – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011*. – 228 p.
5. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*

6. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph (in Russian). – *Kyiv: Nika-Center, 2004.* – 152 p.
7. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
8. *Samoilenko V.M., Dibrova I.O. et al.* Didactics of Geography: Monograph (electronic version). – *Kyiv: Nika-Center, 2013.* – CD, ISBN 978-966-521-619-3. – 570 p.
9. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
10. *UNEP* project manual: formulation, approval, monitoring and evaluation. – *UNEP, 2005.* – 126 p.
11. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
12. *http://www.icpdr.org.*
13. *http://www.esri.com.*

2.2 CONCEPTUAL GIS DESIGNING

Next, already more 'simulation-resumptive' first-level sub-process – ***the conceptual GIS designing*** – includes the set of second-level sub-processes with proper intermediate results of their implementation, namely such *sub-processes* as:

1) Systematization of local views on GIS;

2) Integration of such local views;

3) Comparison of global view on GIS with constraints of its development;

4) Consideration of GIS designing errors;

5) Identification of GIS structure, GIS architecture and conceptual structure of GIS data bases.

The systematization of local views on GIS is based on generalization of GIS needs assessment results and is purposed:

a) To follow and analyze *relations* among each future (potential) GIS user and procedures (operations) and spatial information products expected by the user under his future GIS operating;

b) To develop for a *formalization* of just mentioned *relations*:

– either **Initial Decision System Matrix** (see [17]) in two alternates according to content of first vertical column and first horizontal row in such matrix: 'user – GIS procedures' and 'user – GIS products';

– or **Initial Decision System Tree** as a graphic model (a graph, see our monograph [37]), which branches links concrete users with proper set of required by them GIS procedures or GIS spatial information products.

Note. **Formalization** is: 1) a use of certain graphic and semantic-signal symbols for a reproduction and explication of some regularities; 2) a presentation of content notions or terms and relations among them using graphic and semantic-signal symbols, in particular equations.

The integration of local views on GIS:

a) Is realized for obtainment of **global view on GIS**, also by content clustering of GIS required operations and products and determination among them the most important and urgent for the most of users;

b) Is implemented by construction:

– either **Generalized Decision System Matrix** (see [17]);

– or **Generalized Decision System Tree** (see [37]).

Notes.

1. The integration of local views on GIS can be implemented particularly efficiently by means of *a cluster analysis* (see [37]).

2. **Cluster analysis** is the set of simulation methods aimed at classification and identification of homogeneous variables at their sub-sets (clusters).

The priorities in procedures and spatial information GIS products, defined under the systematization and integration of local user views on GIS, are compared concerning their correspondence to principal aim of GIS development. In addition to that, prospective conflicts among such local views, and sometimes among certain components of global view on GIS, can be overcome by conducting of:

a) Additional appraisal, modification and even redetermination of local views;

b) Iterations of local views integration into their clusters.

Note. **Iteration** is a retrying application of certain operation, including simulation etc., with modification of its parameters and/or conditions aimed at step-by-step the greatest possible approaching to desired result.

The comparison of global view on GIS (generalized users' GIS needs) **with constraints of its development** is realized considering a necessity of:

1) *Typification of GIS development constraints*, which can be differentiated on:

a) *Cost constraints*, first of all preset by the GIS design employer in reference to total cost of GIS development;

b) *Time constraints* caused by a limitation of future GIS development completely or a duration of data supply or model solution obtainment etc. required for the GIS development, and also a limitation of time, necessary for advanced training of employer's staff for information system operating and so on;

c) *Organizing-technologic constraints* defined, for example, by available for the employer type of hardware and, occasionally, software and also mentioned level of staff proficiency on condition that the employer

will refuse from substantial modification of this hardware/software or extension of such level;

d) *Constraints of other kind* occasioned by certain corporate interests, interests connected with a membership in pools or associations and other interests of the GIS design employer;

2) Preliminary *assessment of cost constraints*, which can be caused by a limitation of GIS development expenses (with their distribution on seed money and operation expenses) to:

a) Acquisition of required spatial data, including one-time acquisition during GIS development and/or as a payment for long-term regular supply of information to GIS (see above);

b) Acquisition of hardware and software and their support during GIS development and operating;

c) Training and remuneration of a staff that will operate future GIS;

d) Equipping of business premises and other infrastructural units needed for 'physical' operating of GIS as a hardware-software complex etc.;

3) *Determination of potential benefits* (gain, profit) from GIS development, which can be caused by:

a) Higher efficiency of new methods for geoinformation analysis and simulation of spatial data ('with future GIS') in comparison with methods applied before ('without such GIS');

b) Generation of more progressive and qualitative spatial information products and non-commercial geoinformation services;

c) Development and application of advanced technologies and products, which can be supplied on commercial principles to other organizations and so on, including service selling and a transfer of knowledge and experience concerning GIS designing, development and operating;

d) Higher quality for a support of decisions tacking by means of GIS (this issue not infrequently can be evaluated only after certain, rather continuance of developed GIS operating);

e) Other non-commercial advantages, which concern organization of direct GIS operating and can be revealed through an improvement of its operational structure and functioning, information-network

communication and also, in general, internal and external business activity etc.;

4) *Comparability analysis of views on GIS and non-cost constraints* with updating and/or retrieval of different designing decisions on time, organizing-technologic and other GIS development problems;

5) *Comparability analysis of views on GIS and cost constraints* in a context of traditional cost-benefit analysis (see [57] etc.) with updating and/or tacking of alternative designing decisions aimed at an adjustment of conflict situations, which disallow to balance generalized GIS users' needs and its development constraints. Such balance can be obtained due to:

a) Attribution of certain hierarchic priorities for a correlation of components in Generalized Decision System Matrix or Tree (vide supra) and for a cost of such components both GIS cost in general;

b) Retrieval of alternative designing decisions based on just mentioned hierarchy and aimed either at lower by cost approaches or to a refusal from certain GIS users' needs or a lowering of these needs' level, or at an increase of GIS development cost (the last issue is solved exclusively by an agreement with the GIS design employer).

Notes.

1. **Hierarchy** in the broad sense is an arrangement of certain system components by determined order: from component, higher by meaning or generalization extent, to lower by these features component or vice versa.

2. Not infrequently, first and foremost for environmental designs with indirect valuable-profitable nature (vide supra) and certain other designs, cost-benefit analysis results are not critical to a tacking of decisions concerning GIS development financing, including if the design employer pays attention, in the first place, to indirect or far future prospect material (financial) or non-material (non-financial) gain from future GIS operations and products etc.

The consideration of GIS designing errors is important auxiliary and concomitant second-level sub-process in the first-level sub-process of conceptual GIS designing, as on the whole also in the total process of GIS design preparation. A concept of such consideration is based on theses that it is possible to use *two types of GIS designing models* ([17, 28]), application of the first from which properly causes an appearing of the

mentioned errors, but application of the other, on the contrary, prevents their appearing. To that the question is:

a) So-called *linear GIS designing model*, under which future GIS users practically absolutely are isolated from the general GIS designing process, beginning with the conceptual designing sub-process. This may causes, even in spite of advance GIS needs assessment availability, system design preparation, which anyway will not meet requirements and, in the first place, technologic capabilities of concrete GIS users – either through a 'redundancy' of system functions or because of such functions' insufficiency;

b) So-called *spiral GIS designing model*, under which non-stop system research (an improving of views on GIS) as if advances GIS designing. Such is possible on a condition that future GIS users or their typical representatives are a subject of consultation for the GIS designer also during the processes and sub-processes of GIS designing, next to the GIS needs assessment, in particular those processes, which support an identification of software and hardware and, especially, operating conditions and regulations for GIS functioning. Due to the mentioned approaches, future concrete GIS users, though partially but effectively, can direct the system designing process that allows to avoid essential errors of such designing and ensures coming availability of efficient modification for developed GIS per users' needs, which can functionally expand etc.

The identification of GIS structure and architecture and conceptual structure of GIS data bases as the last second-level sub-process under the conceptual GIS designing is implemented in consideration that in addition:

1) *Conception on GIS structure* is molded:

a) According to peculiarities of future implementation of GIS principal structural-functional subsystems (see [27]), namely the subsystems for supply and capture of spatial data, their generation and selection, and also analysis, including model analysis, of these data and an output of such results' analysis;

b) According to block (modular) GIS scheme (see [27]) with principal concern to conceptions on graphical GIS user interface (taking into account an extent of its 'regularity' or 'originality'), functions of block

concerning mathematical-cartographic models and principles of decision support by GIS means;

2) *General GIS architecture* is defined, stretching its meaning to general organization of relations (links) among components of GIS hardware-software complex, considering its DB and users and also GIS functioning in selected information networks, a type of mentioned architecture (distributed, centralized and so on) etc.;

3) *Conceptual structure of GIS data bases (DB)* is identified:

a) Using, as a rule, of logical-hierarchical chain 'thematic block (section) – sub-block (subsection) – element (sub-element) of sub-block (value of data domain)' and/or in essence a similar structure 'thematic map – main GIS layers composing it – GIS layers supporting main GIS layers etc.' as a principle of BD composition;

b) Holding the opinion that blocks (sections) are adequate to generalized first-level users' queries and sub-blocks (subsections) – to sublevels of such queries etc.;

c) Suitably detailing schemes of graphical GIS user interface composition.

For example, firstly, the general architecture of the international GIS 'Danube', served to use in the global and corporate regional information network, under the conceptual designing had the form cited at Fig.7 (working language of the Internet version is English). And the typical fragment of the international GIS, similar by the network serving, is presented at Fig.8.

Notes (to Fig.7-8).

1. **File server** – a file-server (see [27]).

2. ***DBMS* server** – a server with a Data Base Management System (see [27]).

3. ***FTP* server** – a server with software for a files' transfer by the Internet on base of the transfer protocol called *FTP* (abbr. from *File Transfer Protocol*).

4. **Corporate network** – a corporate information network.

5. **Firewall** – hardware-software devices for a trans-network protection of information and information systems.

6. ***HTTP*** (abbr. from *Hypertext Transfer Protocol*) – a protocol for transfer of *HTML*-documentation by the Internet.

7. ***HTML*** (abbr. from *Hypertext Markup Language*) – a programming markup language serving to organizing and markup of a documentation with hypertext,

images etc. used to supply by such *HTML*-documentation a content operating of the Internet.

8. **Hypertext** – special text of an electronic document, which is organized and structured by a certain programming language (languages) and markup means for this text and which has an ability to contain hypertext links.

9. **Hypertext link (hyperlink)** – a link in a hypertext electronic document, which is distinguished by a color, in italics or by an underlining and reference to which (by a cursor etc.) ensures nonlinear jump to correspondent to such link other text, graphic and so on component in this document (an internal hyperlink) or to other document or its component allocated in a computerized system, especially in an information network (an external hyperlink). A reference to hyperlinks activates ready-made hypertext system with its hyperlinks among information units which belong to mentioned system.

10. ***HTTP* server** (synonym ***web*-server**) – a server with software allowing an access to services and *web*-pages for Internet users, including the access based on *HTTP*.

11. ***CGI*-applications** – application programs supporting *CGI* as interface (abbr. from *Computer Graphics Interface*) and/or *CGI* (abbr. from *Common Gateway Interface*) as network standard used to develop server applications for *HTTP*.

12. ***SQL*-server** – a server with application programs (*SQL*-applications) which are required for use of *SQL* – Standard Query Language for relational DB (see [27]).

13. ***Web*-browser** – software for generation and navigational visualization of certain Internet information (see [27]).

14. ***ArcIMS*** – software of mapping *web*-server (GIS-*web*-server) (see [27]).

15. ***ArcSDE*** – programming geoinformation technology, which supports information-network access to decentralized DB by means of modern relational DBMS (see [27]).

Secondly, the general conceptual structure of the international GIS 'Danube' DB, according to the command paper concerning implementing the GIS elements of the Water Framework Directive (EU WFD) (see [63]), was oriented to certain set of GIS thematic maps and layers such as (see also [6]):

1) Map 'River Basin District Overview' with the layers 'River Basin District', 'River Basin and Sub-basins' and 'Main Rivers';

2) Map 'Competent Authorities (of the Basin Management)' with information layer concerning the areas covered by such authorities;

3) Map 'Surface Water Body Categories' with the layer containing specially encoded rivers, lakes, coastal waters etc.;

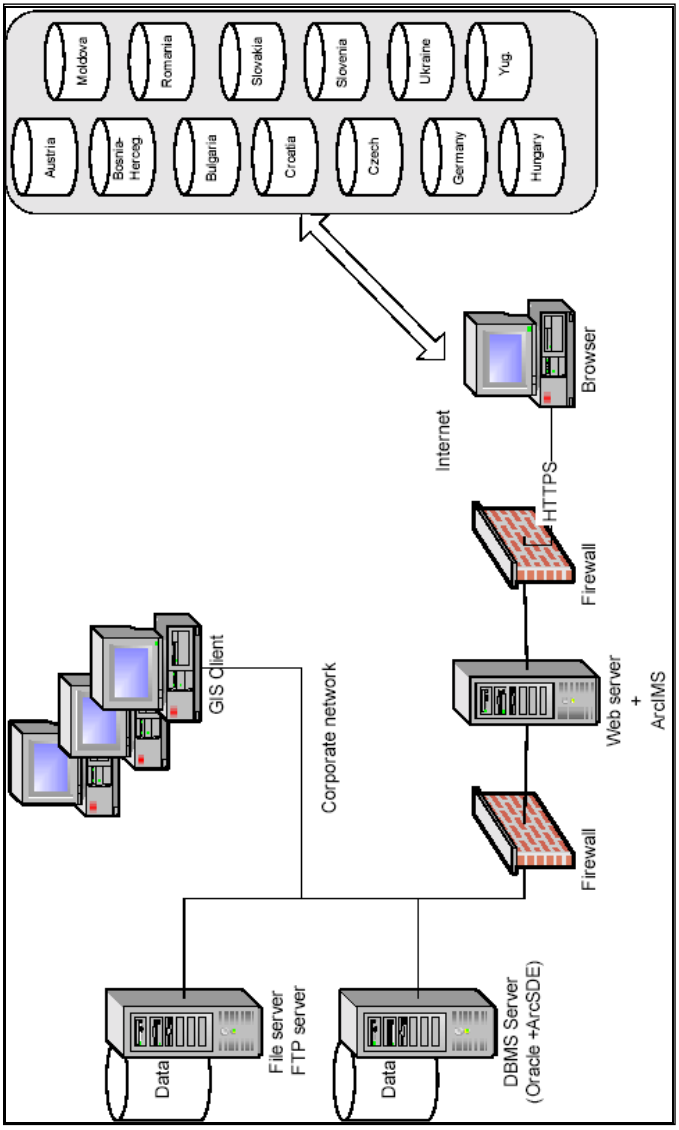

Fig.7 – General architecture of international GIS 'Danube' (see notes)

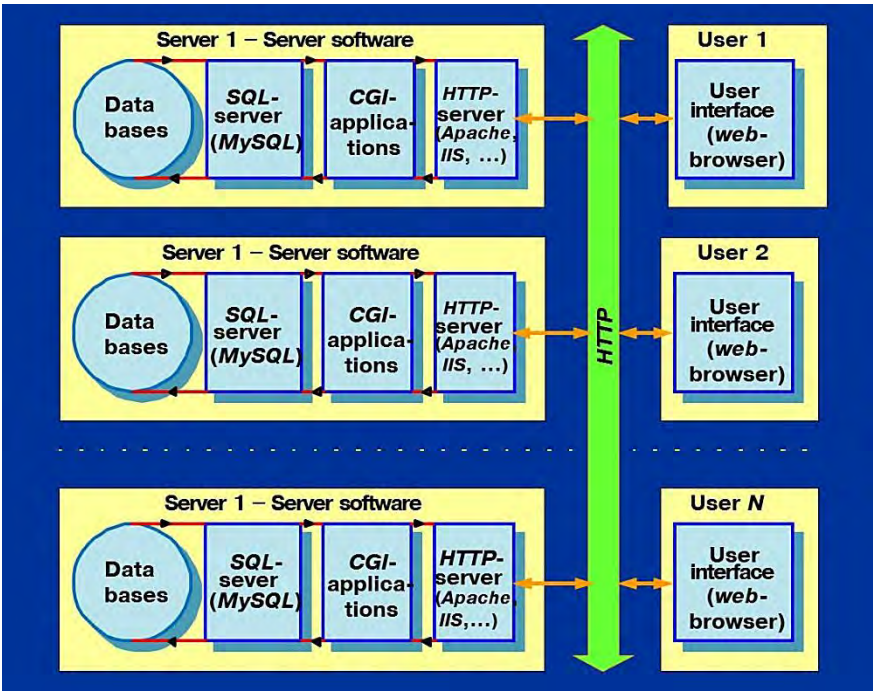

Fig.8 – Typical fragment of GIS architecture (see notes)

4) Map 'Surface Water Body Types' with layer of the same name and the layer 'Ecoregions' (geographic regions differentiated in the Water Framework Directive);

5) Map 'Groundwater bodies' with layer of the same name;

6) Map 'Monitoring Network of Surface Water Bodies' with the layers representing location and attributes of monitoring sites according to monitoring types;

7) Map 'Ecological Status and Ecological Potential of Surface Water Bodies' with the layers concerning, accordingly, a status (state) and a potential of mentioned bodies and also with individual layer as to the bodies with bad status;

8) Map 'Chemical Status of Surface Water Bodies' with layer of the same name;

9) Map 'Groundwater Status' with such layers, concerning these waters, as 'Quantitative Status', 'Chemical status' and 'Pollutant trend';

10) Map 'Groundwater Monitoring Network' with the layers according to the types of such monitoring;

11) Map 'Protected Areas' with the layers according to the types of such areas;

12) Map 'Status of Protected Areas' with layer of the same name;

13) Map 'Background' with different layers which contain information on administrative-territorial organization, relief, settlements, transport etc.

Thirdly, the general conceptual structure of electronic data bases (EDB) for the future GIS 'Dnipro' (hereafter briefly '**EDB GIS 'Dnipro**'') in our monograph [23] and papers [40, 32, 24] in the first approximation was defined by the first-level users' queries and adequate to them thematic blocks (sections) (Table 1).

Table 1 – General structure, functional categories and service of implementation and spatial features of EDB GIS 'Dnipro' users' queries

Name of first-level queries and EDB blocks (sections)	Functional categories of execution	Spatial features	Implementation service
1. 'Surface water recourses (quantitative aspect) and water use'	Fixed digital thematic maps (map fragments or layers) with attributes; graphs, diagrams, tables, text documentation, combination of types	Point, line and polygon features	Fixed spatial-time queries, spatial (basin-wide, per administrative units) integration and/or dynamic time series
2. 'Surface water quality'	The same	Point, line and polygon features	Fixed spatial-time queries, spatial (basin-wide, per administrative units) integration and/or dynamic time series, comparison with given environmental standards
3. ''Hot spots' of pollution in the basin'	The same except graphs	Point features	Fixed spatial-time queries, comparison with given environmental standards
4. 'Biotic and landscape diversity'	The same and figures	Point and polygon features	Fixed spatial-time and content queries
5. 'Legislation and regulatory framework'	Text documentation (with static maps, tables etc. if needed and available)		Thematic document browsing and retrieval using key words, dates etc.

Control questions and tasks to sub-chapter 2.2:

1. *What is the conceptual GIS designing?*

2. *Explain the systematization of local views on GIS.*

3. *What is the difference between Initial Decision System Matrix and Initial Decision System Tree?*

4. *How can we integrate local views on GIS?*

5. *What is the difference between Initial Decision System Matrix and Generalized Decision System Matrix?*

6. *What is the difference between Initial Decision System Tree and Generalized Decision System Tree?*

7. *Illustrate by the examples the comparison of global view on GIS with constraints of GIS development.*

8. *What types of GIS designing errors do you know?*

9. *Explain the difference between GIS structure and GIS architecture.*

10. *How can we form conceptual structure of GIS data bases?*

11. *Illustrate by the examples the implementation of the components of conceptual GIS designing sub-process.*

Sources recommended to sub-chapter 2.2

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
5. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8.* – P.77-85.
6. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) //

Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.– P.200-208.

7. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6*. – P.20-31.
8. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
9. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
10. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
11. *http://www.icpdr.org.*
12. *http://dnipro.ecobase.org.ua*
13. *http://www.esri.com.*

2.3 GIS DATA BASE (DB) DESIGNING

Properly **the *GIS data base (DB) designing sub-process*** finalizes the strategic GIS designing and is directly oriented to spatial data as the object of GIS designing with including, considering adequate products to be developed, the second-level sub-processes of (see Fig.4):

1) Development of common (generalized) GIS data model;
2) Setting of coordinate system (systems) for GIS;
3) Definition of requests to GIS metadata;
4) Formulation of principles for spatial data coding;
5) Quality assessment of information, which will be supplied to GIS DB;
6) Definition of standards for data supply (communication) and data transformation and synchronization;
7) Calculation of specified quantity for required data from determined sources and a cost of GIS DB development.

The development of common (generalized) GIS data model is conducted reasoning from that such model on base of conceptual structure (see above) presents *logical structure of GIS data bases*, i.e. specifies:

a) Models of *logical links* among components of DB GIS conceptual structure (the example at Fig.11);
b) Principle *type* (or *scheme*) of GIS DB (see [27]);
c) Particular *multilayer GIS data models* (see [27]) considering their geometric and topologic relationships;
d) *Templates for attributive part* of GIS DB spatial data;
e) *Formats* (description) and *standards* of GIS DB spatial and non-spatial data (files), which are presented in the form of GIS layers, texts, tables, graphics etc. including possibility of such data communication (transfer) (the example at Table 2);
f) Approaches to organizing of position and attributive information's *connection* (link) (see [27]) etc.

Table 2 – Example of general requirements to formats and description of EDB GIS 'Dnipro' data, among them to network communication of these data

Files	Acceptable formats and annotations
1) with tables	a) *TXT, CSV, SDF* – text files with divider – the best format. Semicolon **';'** is advised to use as dividing sign; b) *DBF* – (*dBase of any version*) – acceptable format; c) *XLS* – (*Microsoft Excel*) – acceptable format
2) with general description of data and some text documentation	a) *TXT* – text files – the best format; b) *HTML* – acceptable format; c) *DOC* – (*Microsoft Word*) – acceptable format
3) with description of table fields	The same
4) attached files	a) *TXT, HTML, DOC* – (*Microsoft World*) – text documentation; b) *PNG, GIF* – graphic files – charts, graphs and diagrams; c) *JPG* – image files – photographs; d) *PDF* – documents and images of high resolution for print; e) *ZIP* – archiving files; f) *TAB (Mapinfo Table), MIF (Mapinfo Interchange Format)* – digital layers in *Longitude/Latitude* system (mandatory requirement)
Coding for files with text information	a) *coding table cp-1251- Windows Cyrillic* – the best; b) *coding table cp-866 - DOS Cyrillic* – acceptable; c) *coding table koi-8r - UNIX Cyrillic* – acceptable

The setting of coordinate system (systems) (geographic, projected, reference etc.) with its (their) components, in particular a projection (projections) and so on, for future GIS:

a) Is on principle defined by developed DB GIS *logical structure* and main system *end use* (the example at Fig.12);

b) Is essentially dependent on a *region* of GIS designing, GIS *data domain*, future *users* and available *spatial data*;

c) Foresees an additional considering of *operating scale* for principal GIS digital maps and layers, which is a result under a determination of minuteness (generalization) degree and a spatial resolution for GIS information etc.

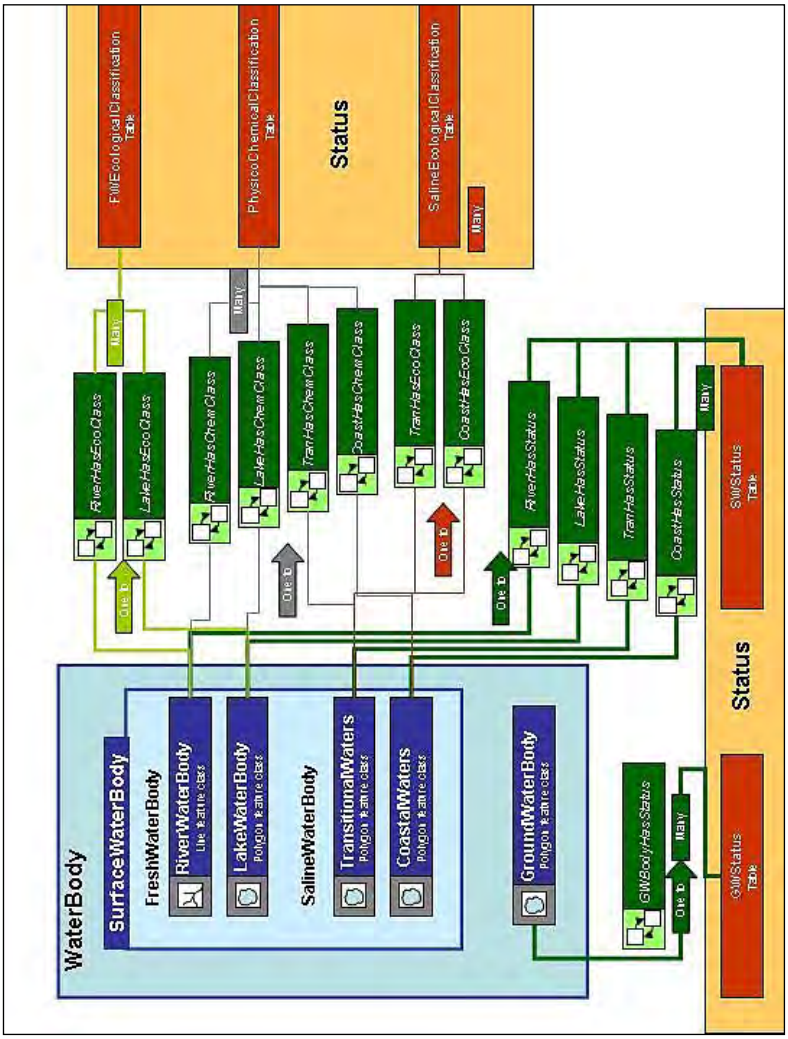

Fig.11 – Model of logical links among map layers of water bodies and their status in the GIS 'Danube' (see above and [45, 63])

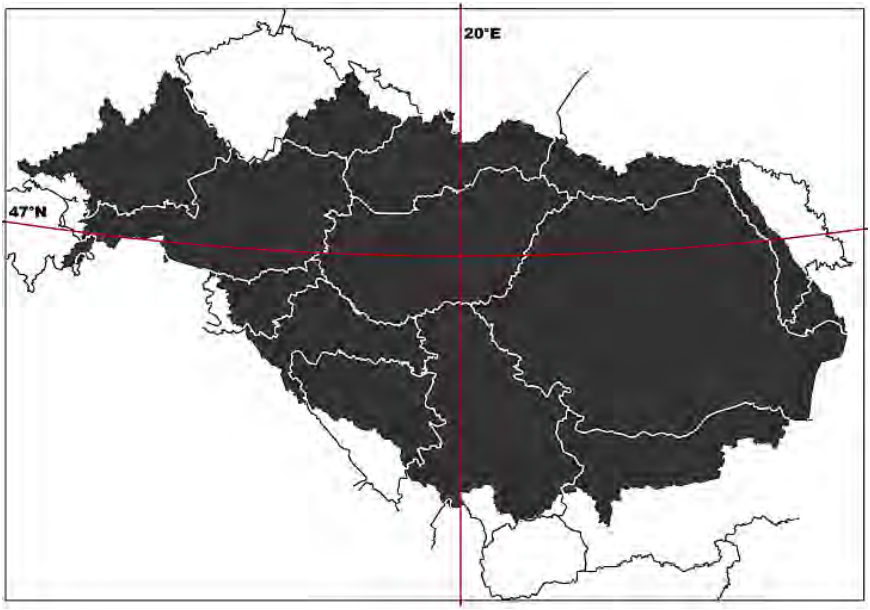

Fig.12 – Presenting of international Danube Basin territory under accepted in the GIS 'Danube' Lambert azimuthal equal-area projection (see [27, 45. 65])

The definition of requests to GIS metadata is implemented focusing first of all on requirements of the international standard *ISO 19115* (see [27]) especially concerning:

a) Mandatory and stipulated *metadata topics*, content of these topics and their elements' composition;

b) *Minimal metadata set* required for support of metadata application;

c) *Accessory metadata elements*, which admit, in case of need, to implement more detailed description of spatial data;

d) *Procedures of metadata spread-out* for specialized requirements of GIS development.

The formulation of principles for spatial data coding is implemented in consideration of:

a) Using of *hierarchic coding for spatial features* of GIS data domain, in the first place tacking into account GIS DB conceptual structure (the example at Fig.13);

b) Necessity to assign *unique identification codes* to each component of GIS data domain considering, in the presence, an urgency of such uniqueness at different GIS information levels (for example, international, national etc.);

c) Coding referring to a facilitation of data communication and a simplification of generation for centralized queries to GIS DB under GIS decentralized structure and so on.

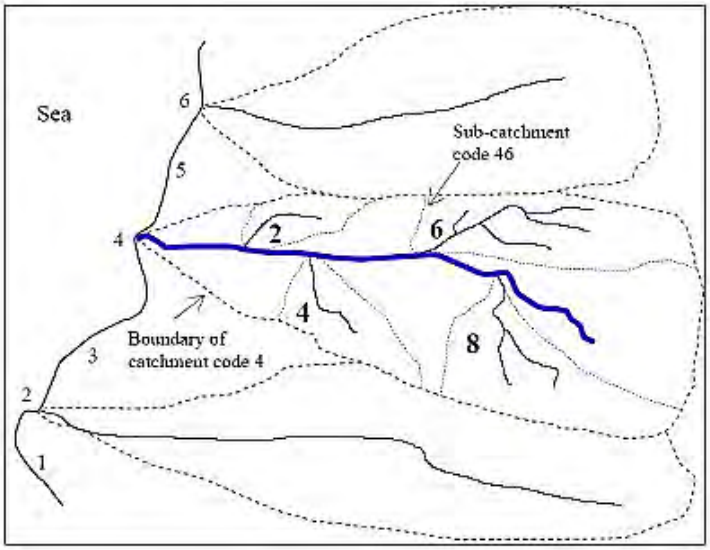

Fig.13 – Coding of main rivers' catchments and their sub-catchments applied under the GIS 'Danube' designing ([45, 63])

Upon **the quality assessment of information which will be supplied to GIS DB**:

1) *Lineage of initial information*, selected for GIS DB development, is determined, first of all according to a metadata of such information suppliers;

2) *Quality components* of mentioned initial information are tested, namely such information:

a) Completeness, paying attention to representativeness and defects in such completeness;

b) Logical consistency, embodying conceptual consistency, data domain consistency and also consistency of data topologic characteristics and formats;

c) Absolute and relative position accuracy;

d) Thematic accuracy, representing a reasonableness of classifying structures as regards information.

Under **the definition of standards for data supply (communication) and data transformation and synchronization** it's paid attention to (more in detail data communication aspect is showed up later concerning operating conditions and regulations for GIS functioning):

a) Stipulated *standards* (see [27]) and *protocols* (see Fig.7-8) of GIS data supply and communication, in the first place under use of certain information networks;

b) Required modes and time constraints for a *transformation, updating, including position harmonization, and unification* of heterogeneous initial information which will be stored from different sources *under GIS DB generation*;

c) Necessary modes for a *transformation and updating, including position harmonization,* of data, which will be received *under GIS DB operating and modification* (for example remote sensing data etc.) considering real information flows of initial data, including monitoring systems etc.;

d) Appropriate *synchronization of GIS different information levels* (in the presence) and a possibility for permanent expanding and updating of GIS DB information range and quality under DB modification etc.

The calculation of required data quantity and a cost of DB GIS development as the second-level sub-process of these bases designing is aimed at:

a) Computation of *specified quantity and range* of data required for DB from certain particular sources of their obtainment;

b) Appropriate resulting assessment of *DB generation cost*.

The whole strategic GIS designing process are ended with working out of strictly **strategic plan (framework) of GIS development** as final product, which:

1) *Combines and integrates intermediate and final resulting products* of all examined above sub-processes-components (GIS needs assessment, its conceptual designing and GIS DB designing);

2) Includes preliminary *time schedule* of GIS development.

Note. Content of strategic plan (framework) of the international GIS 'Danube' development can be learned in detail by referring to our works [27, 45, 23].

Control questions and tasks to sub-chapter 2.3:

1. *What is GIS data base designing?*

2. *Explain the elaboration of common GIS data model.*

3. *Why GIS data model is named 'common'?*

4. *Why have we to set coordinate system for GIS?*

5. *Illustrate by the examples some requests to GIS metadata.*

6. *What principles for spatial data coding do you know?*

7. *Why must we do quality assessment of information which will be supplied to GIS DB?*

8. *What is the difference between standards for data supply (communication) and standards for data transformation and synchronization?*

9. *Why have we to calculate specified quantity of required GIS data from determined sources?*

10. *Explain the calculation of cost for DB GIS development.*

11. *What is the strategic plan (framework) of GIS development?*

12. *Illustrate by the examples the implementation of the components of GIS data base (DB) designing sub-process.*

Sources recommended to sub-chapter 2.3

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.

2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
5. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8.* – P.77-85.
6. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.*– P.200-208.
7. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6*. – P.20-31.
8. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
9. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
10. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
11. *Boosygin B.S. et al.* English-Russian-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
12. *http://www.icpdr.org.*
13. *http://www.esri.com.*

3 SYSTEM GIS DESIGNING

The following ***hyper-process of system GIS designing*** is synergy integration of two processes – the designing of GIS software and GIS hardware.

3.1 GIS SOFTWARE DESIGNING

The first from just mentioned, ***the GIS software (SW) designing process*** includes, also considering development of proper products, such first-level sub-processes, as (Fig.14):

1) Development of application (program) requirements model;

2) Definition of software configuration and SW modules' specifications;

3) Formation of SW architecture;

4) Survey and selection of existing ready for service software tools for GIS;

5) Definition of final list and approaches to development of application programs which have to be adapted, modified or developed for GIS;

6) Elaboration of framework for future GIS software testing.

The development of application (program) requirements model (see [17, 28]) has to:

a) Be relied on *model synthesizing* of preliminary results, in particular concerning the integration of local views on GIS (see above);

b) Be formed on *mutual operating* with common (generalized) GIS data model (vide supra), taking into consideration well-known equation (see [17]): 'programs = algorithms + data';

c) Be based, as a rule, on *lightly formalized simulation methods* (mostly on graph method, see our textbook [37]).

The definition of software configuration and SW modules' specifications is realized considering a need for:

a) Framing of final *input data list*, definition of *types for GIS spatial information (geoinformation) products* and modeling of relationship between mentioned types and geodata (spatial data) (see the examples);

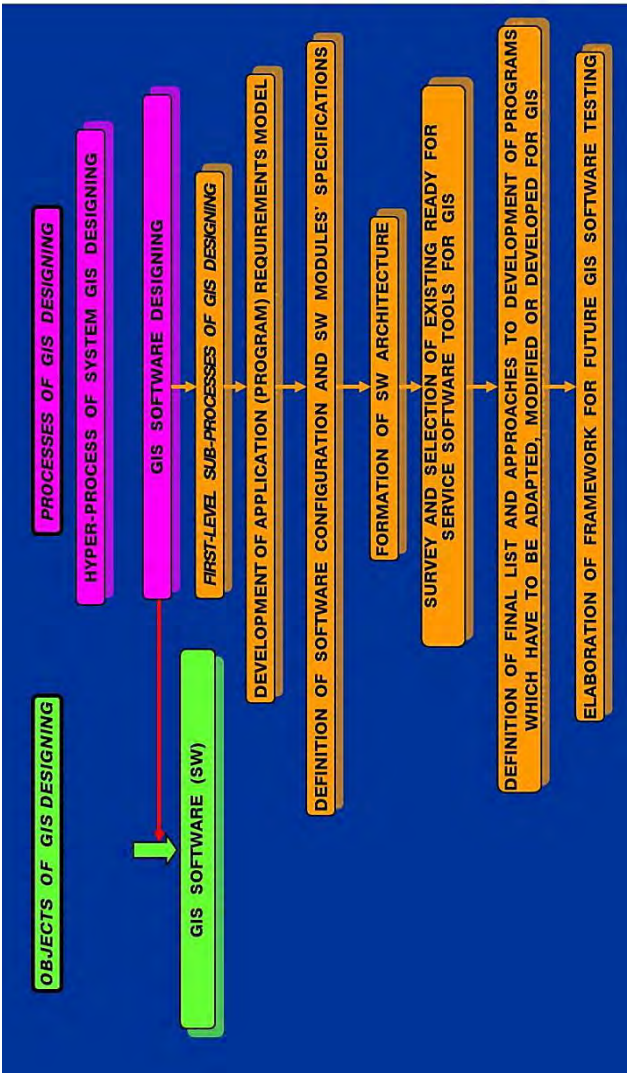

Fig.14 – Detailed fragment of GIS designing general algorithmic scheme (the process of GIS software (SW) designing as the component of system GIS designing hyper-process, see Fig.1)

b) Identification of *SW configuration*, namely all modules of this software and GIS operating system;

c) Setting of exact functions (without a computation of their implementation algorithms), files' formats, modes for data removal, updating and visualization, dimensions and so on, in other words *specifications of each SW module*.

For example, as to the international GIS 'Danube', it was proposed:

1) Geodata catalog, the fragment of which is cited at Table 3, in which:
   a) geodata_id – geodata set identifier;
   b) geodata_set – short name of such set;
   c) geodata_description – description of such set;
   d) max_scale – maximal display scale;
   e) opt_scale – optimal display scale;
   f) min_scale – minimal display scale;
   g) geodata_type – geodata format;
   h) geodata_def – spatial feature type;

2) List of the GIS 'Danube' geoinformation products' types (GIP types), cited at Table 4;

3) Model of relationship between geoinformation product types and geodata, illustrated at Fig.15.

Secondly, as to EDB GIS 'Dnipro', queries' visualization designs were determined, concerned to certain modes of these queries implementation and to different types of spatial features (the examples are at Fig.16-19, see also Table 1 and Fig.9).

The formation of software architecture as the first-level sub-process of this software designing embodies:

a) Development of algorithms preset by modules' specifications that is *algorithms for a realization of SW modules' functions*;

b) Consequent to foregoing formation of *strictly SW architecture* taking into consideration a formulating of tasks for adaptation or development of each SW module.

The survey and selection of existing ready for service software tools, required for GIS operating, involve:

1) Analysis of *preferences and faults* for existing system and application tools, an experience of their use, 'becoming old-fashioned' and modification of tools, their rate of actuality and progressiveness etc. (see [27]);

Table 3 – Fragment of the GIS 'Danube' geodata catalog ([45, 27])

geodata_id	geodata_set	geodata_description	max_scale	opt_scale	min_scale	geodata_type	geodata_def
1	State	State polygons	500000	1000000	5000000	shape	polygon
2	AdminBound	Administrative Boundaries	500000	1000000	5000000	shape	line
3	AdminEntit	Administrative Entities	500000	1000000	5000000	shape	polygon
4	Cities_p	Cities	500000	1000000	5000000	shape	point
5	Cities_a	Extensive cities (have to be presented as areas)	500000	1000000	5000000	shape	polygon
6	Settlement	Settlement Area	100000	500000	1000000	shape	polygon
7	RBD	River basin district Danube	500000	1000000	5000000	shape	polygon
8	Rivbasin	Riverbasins and Subbasins	500000	1000000	5000000	shape	polygon
9	Catchment	River catchments	100000	500000	1000000	shape	polygon
10	Compauth	Location of competent authorities for WFD in the DRBD	500000	1000000	5000000	shape	point
11	CWbody	Coastal Waters	500000	1000000	5000000	shape	polygon
12	GWbody	Groundwater Body	500000	1000000	5000000	shape	polygon

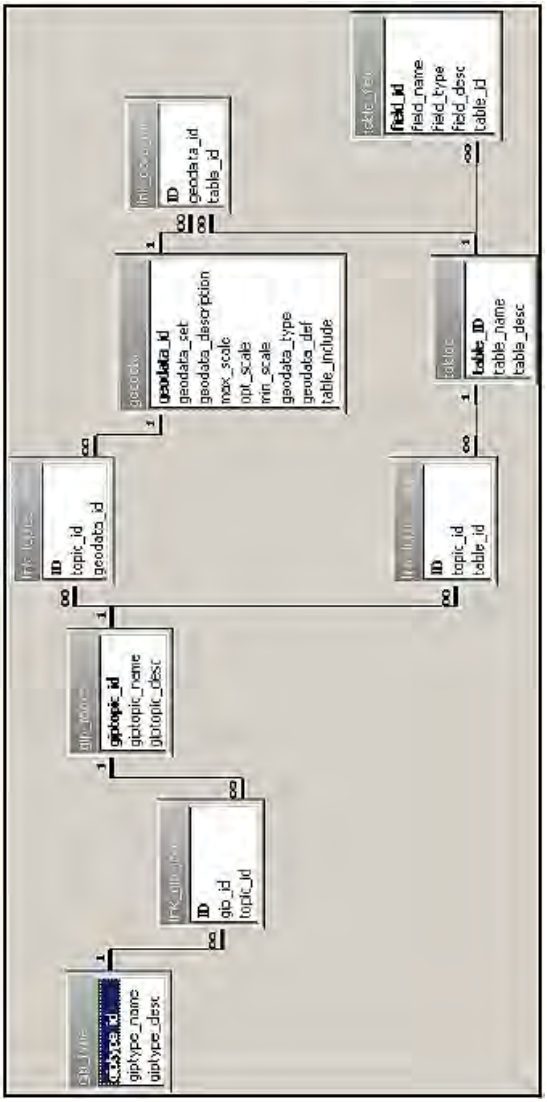

Fig.15 – Model of relationship between geoinformation product types and geodata in the GIS 'Danube' ([45, 27])

Table 4 – Geoinformation products' (GIP) types of the GIS 'Danube' ([45, 27])

GIP descriptor	GIP name	GIP description
1	map	already finished maps in *PDF*-format
2	*web*-map	map created via *web*-GIS for onscreen display with export/print option
3	table	information table (with available links to geographic features)
4	query	query string
5	diagram	diagram
6	statistics	statistic tables for data

2) *Assessment of supply sources* of ready for service tools, paying attention to *two types of such sources* in the global software industry, namely sources orientated to:

a) Commercial off-the-shelf GIS software;

b) Open source software – free licensed tools, in this case for GIS, embodying initial description of such tools and have no constraints of its application, further modification and distribution with only necessity for retention of information on initial authorship and made alterations.

Notes.

1. At times certain developers of software GIS-package offer *free software tools which expand functional potential* of such packages (so-called *free add-on software*) (see [7]).

2. It is distinguished also *shareware* (synonym *trial software, trial version of software*), which can be obtained free by a user for evaluation application for a period, stipulated by a developer (holder), whereupon further software use is possible only at paid basis;

3) Computation of *time and costs* for an installation of certain ready for service GIS tools and training of a staff, which will apply these tools;

4) Realization of *benchmark testing* as comparative probing concerning potential of ready for service SW for GIS development by different alternates and proposals regarding SW supply;

5) Comparison of *total costs* for a procurement and/or obtainment of mentioned tools or their individual modules by different alternates (sources) of supply (obtainment);

6) Selection of GIS tools' *suppliers* and means of such tools' transfer, installation and so on.

Note. Under a selection of GIS software tools it's allowed also appropriate tools, which the GIS employer has at its disposal, including possibility of such tools' adaptation and/or modification as to new requirements on GIS development etc. (see the GIS needs assessment).

The definition of final list and approaches to development of application programs, which have to be adapted, modified or developed for GIS, is implemented considering:

1) *Refinement of results* concerning preliminary definition of a list for application software (see the GIS needs assessment);

2) Necessity for use of high level *algorithmic languages*, procedures for *structural and object-oriented programming* etc.;

3) *Differentiation of software* for mentioned GIS programs' development into *four categories*, namely:

a) *Software in the form of programming languages*, which now are a component of many GIS-packages (see [27]) and which permit to modify or develop new application programs for specified nonstandard procedures and tasks of future GIS operating. In addition properly this software serves as if 'an operating system' for support of such 'nonstandard' programs;

b) *Universal purpose software*, which as a rule don't need qualified programmers and use application program libraries (see [7]) aimed at a generation and adaptation of required set of such programs, including their new combinations etc., for specified operating system;

c) *Direct programming software*, which is well-known environment for development of new application programs by different programming languages (for example, *Microsoft Visual C++*, *Microsoft Visual Basic*, *Borland/Inprise Delphi*, *Borland/Inprise C++ Builder*, see [19, 27]);

d) *Different combinations* of software mentioned at a) – c).

The elaboration of framework for future GIS software testing is based on a conclusion that such framework, formed in advance still during the designing process, has to envisage:

1) Creation of a *list for the most operations and procedures*, which will be tested in future according to GIS SW programming modules;

2) Presence of *three testing stages* for future GIS SW, namely stages of:

a) Offline testing, under which programming environment of each programming module is imitated by means of testing administration program, containing simulated programs instead of valid programs forming this module;

b) Integrated testing, under which testing of programming modules' clusters is implemented;

c) System (or valuation) testing, under which GIS software is tested in general.

Control questions and tasks to sub-chapter 3.1:

1. *What is the hyper-process of system GIS designing?*

2. *What are the peculiarities of GIS software designing?*

3. *Explain the development of application (program) requirements model for GIS.*

4. *What is the difference between software configuration and software modules' specifications?*

5. *Illustrate by the examples the definition of GIS software configuration.*

6. *Illustrate by the examples the formation of GIS software architecture.*

7. *What is ready for service software tools for GIS?*

8. *Why application programs can be adapted, modified or developed for GIS?*

9. *What approaches to a development of application programs do you know?*

10. *What is the GIS software testing?*

11. *Why have we to elaborate the framework for future GIS software testing?*

12. *Illustrate by the examples the implementation of the components of GIS software designing process.*

Sources recommended to sub-chapter 3.1

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011.* – 228 p.
4. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
5. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
6. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
7. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
8. *http://www.icpdr.org.*
9. *http://www.esri.com.*

3.2 GIS HARDWARE DESIGNING

The second component of system designing hyper-process is ***the process of GIS hardware designing***. Such process is aimed, of course, at an identification of GIS hardware (HW) as the designing object and it consists of the sub-processes, which are somewhat similar by functional content to the sub-processes of GIS software designing, but however are different by products created at the same time. Such first-level *sub-processes of GIS hardware designing* are represented by (Fig.20):

1) Particularization of general GIS hardware requirements;

2) Definition of GIS hardware configuration and hardware requirements for HW functional units;

3) Formation of GIS hardware architecture;

4) Survey and selection of necessary ready for service hardware for GIS;

5) Consideration of problems for installation and montage of GIS hardware.

The particularization of general GIS hardware requirements is implemented taking into consideration first of all:

a) *Already specified GIS functions* as a whole and *GIS type* (a combination of types) (see [27]);

b) Preliminary identified *general GIS architecture*.

The definition of GIS hardware configuration and hardware requirements for HW functional units is implemented considering necessity of:

1) Identification of a *composition for all HW functional units*, namely:

a) Key units (computers);

b) Peripheral units, including units for network connection;

c) Additional units (for example *GPS*-devices etc., see [27]);

2) *Typification* of mentioned functional units (for example with a distribution of computers on personal computers, workstations, servers and their sub-types etc.);

3) Formulation of proper *hardware requirements* for every type and sub-type of HW functional components, in particular concerning system

memory and video buffer, processors, hard disks, a configuration and performance of network means etc.

Under **the formation of GIS HW architecture**, *modes for organization of relationships (links)* are appreciated, concerning *relationships (links)*:

a) Inside of *individual HW functional units* and/or their complexes (modules) (at times such units or modules are combine in so-called tiers of general GIS configuration, see, for example, [45]);

b) For GIS hardware in general.

The survey and selection of necessary ready for service hardware for GIS include:

a) Analysis of *preferences and faults* for existing hardware, necessary for GIS;

b) Assessment of *HW supply sources*, including a supply of ready for service or specially integrated by supplier such hardware, and also resources and an extent of own HW use by the GIS employer;

c) Computation of *time and costs* for HW installation and, in case of need, training of a staff, which will operate hardware;

d) Comparison of *total costs* for a procurement and/or obtainment of HW or its individual modules by different supply alternates (sources) (taking into consideration also alternate of partial own employer HW use);

e) *Selection of GIS hardware suppliers* and means of HW transfer etc.

Under **the consideration of problems for installation and montage of GIS hardware**, attention is paid to:

a) *Technologic aspects* of such installation and montage, including a testing of installed hardware in the whole or its components;

b) *Organizing aspects* of HW montage, among them aspects concerning GIS network operating and so on.

Two **final resulting products of the system GIS designing hyper-process**, which, as also it was mentioned, combines the processes of software and hardware designing, are:

1) Final GIS configuration and architecture as a whole;

2) Modes for GIS system protection against unauthorized access to GIS.

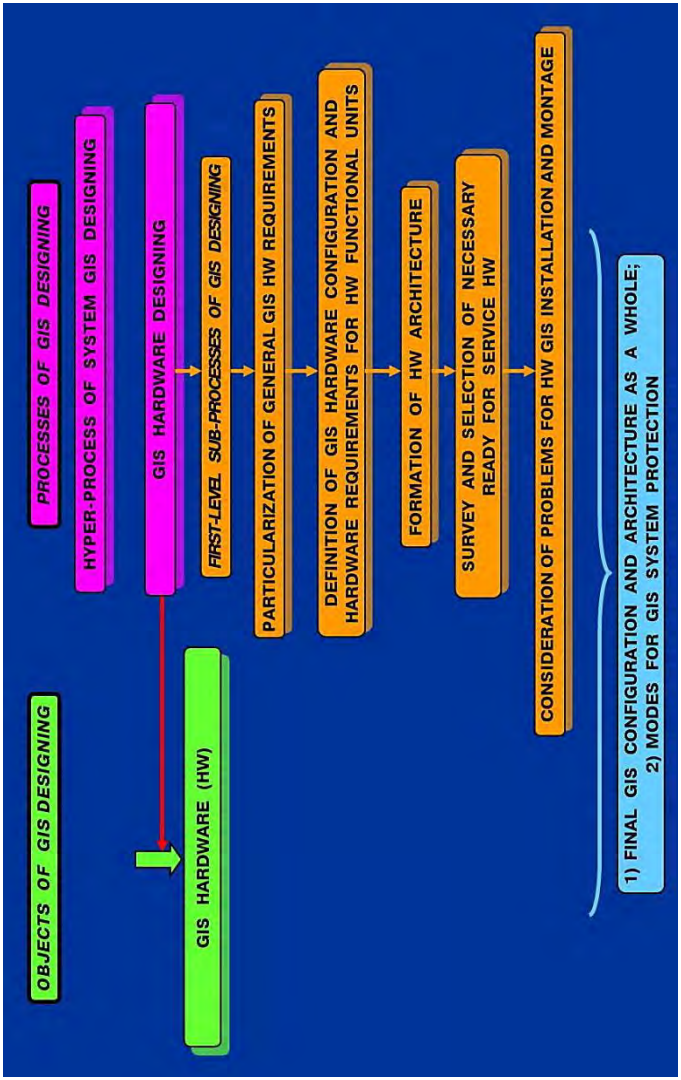

Fig.20 – Detailed fragment of GIS designing general algorithmic scheme (the process of GIS hardware (HW) designing as the component of system GIS designing hyper-process, see Fig.1)

Control questions and tasks to sub-chapter 3.2:

1. *What is the process of GIS hardware designing?*

2. *What are the common features for GIS software and hardware designing?*

3. *What is the difference between GIS software and hardware designing?*

4. *Explain the content of some general GIS hardware requirements.*

5. *What GIS hardware functional units do you know?*

6. *What is GIS hardware configuration?*

7. *Explain the difference between GIS hardware configuration and architecture.*

8. *What is ready for service hardware for GIS?*

9. *How can we select necessary ready for service hardware for GIS?*

10. *What are the ways for consideration of problems for installation and montage of GIS hardware?*

11. *Explain the content of final GIS configuration and architecture definition.*

12. *What modes for GIS system protection do you know?*

Sources recommended to sub-chapter 3.2

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22).* – P.8-32.
5. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
6. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
7. *http://www.icpdr.org.*
8. *http://www.esri.com.*

4 OPERATION AND FINAL GIS DESIGNING

4.1 OPERATION GIS DESIGNING

The following, under Fig.1 scheme, ***process of operation GIS designing*** is formed by the sub-processes ensuring an identification and/or development of such designing objects, as **operating conditions** (frameworks) and **regulations** (rules) **for functioning (use) of** future **GIS**. Such sub-processes, with adequate to their implementation resulting documentation, concern:

1) Formulation of *final GIS operating scripts*;

2) Definition of *operating conditions and schedules* for components of GIS hardware-software complex;

3) Preparation of line with *manuals, directions, recommendations* etc. relating GIS development and putting into operation, technologic application of its certain components and so on;

4) Determination of principles and modes for *organizing and coordinating activity* under a development and use of GIS and its information basis, and also for *command administration and support of GIS operating* in general;

5) Identification of *system for access to GIS* and its data bases with access levels' determination etc.;

6) Elaboration of *information supply and exchange regulations* under GIS development and use (see the example of regulations in our monograph [23]);

7) Determination of modes and time constraints for a training of various *staff* for GIS operating;

8) Consideration of *potential modification* concerning GIS scripts, operating conditions and regulations under future GIS development;

9) Consideration of other potential aspects of operation GIS designing.

Hereinafter it is cited the figure, which illustrates, firstly, the formulation of final GIS operation scripts as the sub-process and, secondly, certain products of other foregoing sub-processes under the operation GIS designing.

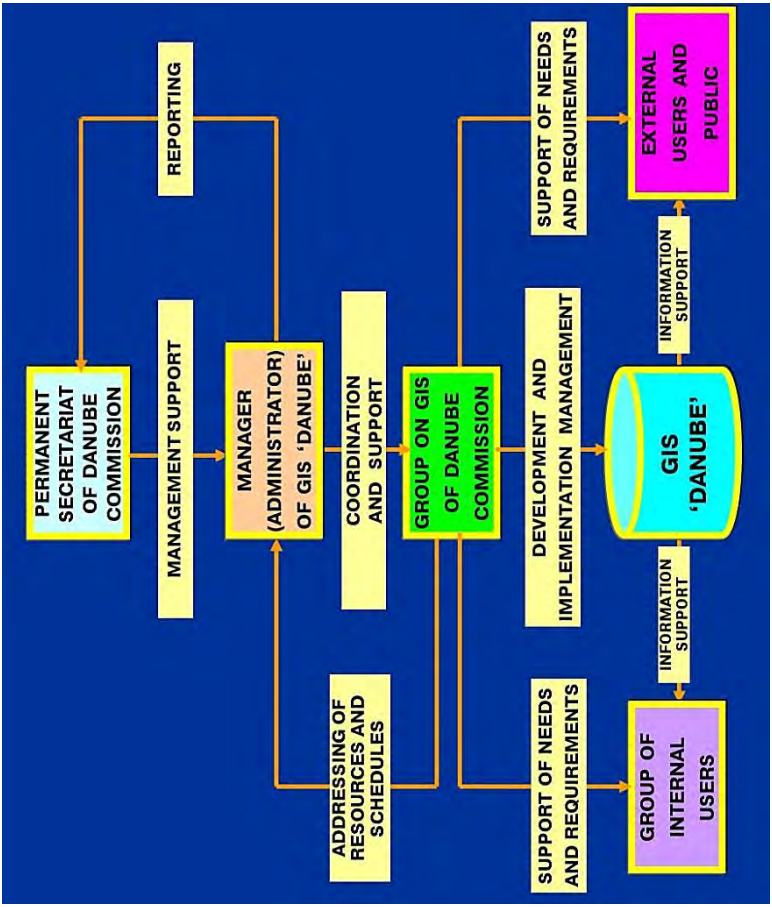

Fig.26 – Scheme of coordinating activity under development and use of the GIS 'Danube' (see the first example at chapter 1)

4.2 FINAL GIS DESIGNING

The final GIS designing process is aimed at a producing of required **designed-estimated documentation** and an identification of **GIS developer**, both as the designing objects. This process embodies such sub-processes, as (see in detail [57, 62, 64]):

1) *Paper work of properly GIS design* in the form of designed-estimated documentation for GIS development and operating. Such documentation includes in particular:

a) All engineering and technologic documentation concerning key future GIS components and their elements;

b) Final plan (strategic framework), schedule and budget of GIS development;

c) Targets of so-called post-designing phase, i.e. a phase after GIS development (aimed at a monitoring of certain design implementation results etc.);

2) Conducting of GIS design *audit and appraisal*, and also, in case of need, design coordination at certain authorities;

3) Definition of **GIS developer** (design 'realizer'). Such developer is interpreted as *one or several mostly corporate bodies, which assume a responsibility for GIS design implementation at terms, specified by a contract with GIS design holder or authorized by him body*. In the presence of several GIS developers, among them a **general developer** is differentiated with responsibility for coordination and support of the whole GIS design implementation process;

4) *Delivery of GIS design* to its employer.

Notes.

1. **GIS design audit** – a documentary process of validity revision concerning primarily GIS design financial aspects which is implemented by natural or corporate body called an auditor.

2. **Contract** – an agreement under which one party (a contractor) covenants on own responsibility to do certain work according to a task of another party (of an employer) at specified cost, which a contractor receives from an employer for delivered result of such work.

3. Definition of the GIS developer by the GIS designer is not imperative; at times such developer can be selected directly by the GIS design holder and without participation of the GIS designer.

The example for overall planning of the GIS 'Danube' design implementation is illustrated at Table 6.

Table 6 – Time sequence of the GIS 'Danube' design implementation

Levels	2004	2005-2006	2007-2009	2010-2012
Danube Commission	System centralized decisions and GIS infrastructure preparation	System checkout, standard implementation	Preparation to Danube Basin management planning, final integration of all centralized GIS units	Decentralized data processing and information networks' interaction in real-time operating conditions, long-term planning and implementation of management at basin level
National	Preparation of GIS national infrastructure	Checkout of information networks' interaction, the first data capture into system	Complete integration of national units into centralized GIS	Generation of resources for efficient interaction of all information networks

Control questions and tasks to chapter 4:

1. *What is the process of operation GIS designing?*

2. *What is the difference between the operation and the final GIS designing?*

3. *What are the common features for the operation and the final GIS designing?*

4. *Explain the steps of the operation and the final GIS designing.*

5. *What are the operating conditions (frameworks) for functioning (use) of future GIS?*

6. *What are the regulations (standards) for functioning (use) of future GIS?*

7. *Explain the content of some operating conditions for GIS functioning.*

8. *Explain the content of some standards for GIS functioning.*

9. *Illustrate by the examples the implementation of the components of operation GIS designing process.*

10. *What are the peculiarities of final GIS designing?*

11. *What is the paper work of properly GIS design?*

12. *What is the difference between GIS design audit and GIS design appraisal?*

13. *Who can be the GIS developer?*

14. *Explain the steps for GIS design delivery.*

Sources recommended to chapter 4

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011.* – 228 p.
4. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.* – P.20-31.
5. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
6. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
7. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
8. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
9. *http://www.icpdr.org.*
10. *http://www.esri.com.*

SOURCES RECOMMENDED TO THE TEXTBOOK

Basic sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – *Kyiv: Nika-Center, 2010.* – 448 p.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011.* – 228 p.
5. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
6. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8.* – P.77-85.
7. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.*– P.200-208.
8. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.* – P.20-31.
9. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
10. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22).* – P.8-32.

11. *Samoilenko V.M., Dibrova I.O. et al*. Didactics of Geography: Monograph (electronic version) (in Ukrainian). – *Kyiv: Nika-Center, 2013*. – CD, ISBN 978-966-521-619-3. – 570 p.

Additional sources:

12. *Samoilenko V.M.* Development of lakes & reservoirs dynamics and stability information/simulation systems for environmental monitoring and management on Ukraine example // *Schriftenreihe zur Wasserwirtschaft. Technische Universität Graz. – 1996. – Vol.19/2*. – P. C141-C146.
13. *Samoilenko V.M.* Structure and functional principles for watermanagement-environmental monitoring creation as a conceptual interface of river basins GIS // *Schriftenreihe zur Wasserwirtschaft. Technische Universität Graz.* – 1996. – Vol.19/2. – P. C135-C140.
14. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
15. *Datsenko L.M.* Fundamentals of geoinformation systems and technologies in school courses of study abroad // *Periodical of Cartography. – 2010. – Vol.1.* – P.197-205.
16. *UNEP* project manual: formulation, approval, monitoring and evaluation. – *UNEP, 2005*. – 126 p.
17. *Tian R.B. et al.* Project management: Textbook (in Ukrainian). – *Kyiv: Center of educational publishing, 2004.* – 224 p.
18. *Peters, D.* Building a GIS: System Architecture Design Strategies for Managers, Second Edition. Esri Press, 2012. 374 p.
19. *Somers, R.* Quick Guide to GIS Implementation and Management. Chicago: URISA, 2001. 33 p.
20. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007*. – 433 p.

Web sources:

21. *http://www.icpdr.org.*
22. *http://dnipro.ecobase.org.ua*

23. *http://www.unep.org*.
24. *http://www.undp.org*.
25. *http://en.mimi.hu/gis.*
26. *http://www.esri.com.*

GLOSSARY

Architecture (*архітектура*) – general organization of relations (links) among components of a certain system.

Bank (*банк*) – one or several banking institutions, which have to ensure the direct financial support to all components forming *GIS design preparation* process by a servicing of routine business transactions, concerning, first of all, a *GIS design employer* and a *GIS designer*, by certain financial mediation as to such transactions, including crediting, etc.

Basic (initial) GIS designing (*установче (ініціальне) проектування ГІС*) – the process of *GIS designing*, which embodies such first-level sub-processes, as: identification of principal *GIS designing entities*; definition of *other GIS designing entities*; development of a plan (strategic framework), schedule and budget of *GIS design* preparation.

Cluster analysis (*кластерний аналіз*) – the set of simulation methods aimed at classification and identification of homogeneous variables at their sub-sets (clusters).

Conceptual GIS designing (*концептуальне проектування ГІС*) – the first-level sub-process of *strategic GIS designing* process, which embodies such second-level sub-processes, as: systematization of local views on *GIS*; integration of such local views; comparison of global view on *GIS* with constraints of its development; consideration of *GIS designing* errors; identification of *GIS* structure, *GIS architecture* and conceptual structure of *GIS data bases*.

Configuration (*конфігурація*) – a component complex of certain system as a whole.

Consultant (*консультант*) – one or several natural and/or corporate bodies, which are recruited to *GIS design preparation* on contract bases on a purpose to render consulting services to an employer and/or designer in a scope of designing process.

Consulting (*консалтинг*) – an activity type, which ensures not only properly consulting, but also scientific-technical, financial-analytic, engineering-economic, technologic, prognostic and organizing-legal preparation and maintenance of *design* implementation.

Data Base Management System (DBMS) (*система управління базами даних, СУБД*) – a complex of computer programs and programming language means serving to develop, support and use *data bases*.

Data bases (DB) (*бази даних, БД*) – a complex of data organized by specified standards, which set general principles of data description, retention and management using computerized devices.

DB (*БД*) – see *data bases*.

DBMS (*СУБД*) – see *Data Base Management System*.

Decision System Matrix (*матриця рішень щодо системи*) – a matrix in two alternates according to content of first vertical column and first horizontal row in such matrix: 'user – *GIS* procedures' and 'user – *GIS* products'.

Decision System Tree (*"дерево рішень" щодо системи*) – a graphic model (a graph), which branches links concrete users with proper set of required by them *GIS* procedures or *GIS* spatial information products.

Design (syn. **project) (*проект*)** – a complex of purposeful, component- and time-allocated tasks and activities (measures, efforts) to accomplish these tasks, which contains a general intention, instruments and consistency of this intention implementation and foreseeable results and can be presented in the form of a special document (documentation).

Design management (*менеджмент проектів*) – a system of process principles, methods, procedures, means and forms and also properly a process (i.e. 'actions on') of certain *design* management aimed at increase of such management efficiency.

Engineering (*інжиніринг*) – an activity type, which embodies engineering-consulting services and works in scientific-research, design-constructive and calculating-analytic scope, combined with process of engineering-economic design formulation and implementation of *design* outcomes. Engineering can cover stages of activity planning, engineering designing, testing and control on putting into operation *design* objects or technologies etc.

Final GIS designing (*завершальне проектування ГІС*) – the process of *GIS designing*, which embodies such first-level sub-processes, as: paper work of properly *GIS design* in the form of designed-estimated

documentation for *GIS* development and operating; conducting of *GIS design audit* and appraisal, and also, in case of need, design coordination at certain authorities; definition of *GIS developer* (design 'realizer'); delivery of *GIS design* to its employer.

Formalization (*формалізація*) – 1) a use of certain graphic and semantic-signal symbols for a reproduction and explication of some regularities; 2) a presentation of content notions or terms and relations among them using graphic and semantic-signal symbols, in particular equations.

Geodata (*геодані*) – see *spatial data*.

Geographic data (*географічні дані*) – see *spatial data*.

Geographic information system (*географічна інформаційна система*) – see *GIS*.

Geoinformation system (*геоінформаційна система*) – see *GIS*.

GIS (geographic information system, geoinformation system) (*ГІС, географічна інформаційна система, геоінформаційна система*) – an information system, which provides an administration (acquisition, retention, processing, access, visualization, dissemination), examination and simulation of *spatial (geographic) data*.

GIS architecture (*архітектура ГІС*) – general organization of relations (links) among components of *GIS* hardware-software complex, considering its *data bases* and users and also *GIS* functioning in selected information networks, a type of mentioned architecture (distributed, centralized and so on) etc.

GIS data base (GIS DB) designing (*проектування баз даних ГІС*) – the first-level sub-process of *strategic GIS designing* process, which embodies such second-level sub-processes, as: development of common (generalized) *GIS* data model; setting of coordinate system (systems) for *GIS*; definition of requests to *GIS metadata*; formulation of principles for *spatial data* coding; quality assessment of information which will be supplied to *GIS DB*; definition of standards for data supply (communication) and data transformation and synchronization; calculation of specified quantity for required data from determined sources and a cost of *GIS DB* development.

GIS data domain (*предметна область ГІС*) – a domain, which circumscribes information sphere of *GIS designing* and object types for mentioned domain, initial *spatial data* on which are needful for *GIS data bases* development, considering, first of all, needs of *GIS* users.

GIS design audit (аудит проекту ГІС) – a documentary process of validity revision concerning primarily *GIS design* financial aspects which is implemented by natural or corporate body called an auditor.

GIS design beneficiary (*бенефіціарій проекту ГІС*) – natural and/or corporate body (bodies), who (which) gain(s) a profit or benefit (not necessarily financial) with certain *GIS design*.

GIS design employer (*замовник проекту ГІС*) – one or several natural and/or corporate bodies, which are interested in an implementation of *GIS designing* process, put to this process own and/or obtained or entrusted funds and are holders (sometimes co-holders) of *GIS design*.

GIS design investor (*інвестор проекту ГІС*) – an *entity of GIS designing*, who (which) directly puts own funds to designing process with a view to a profit-making.

GIS design preparation (*підготовка проекту ГІС*) – see *GIS designing*.

GIS design sponsor (*спонсор проекту ГІС*) – an *entity of GIS designing*, who (which) under different particular cases can be identified both with a *GIS design employer* and with a design employer-investor or *investor*, including 'nonprofit' or 'extra' entities, etc. (a term 'sponsor' in general can be understood as 'a guarantor', 'a bail granter', 'an organizer', 'an initiator', 'that who (which) finances', 'that who (which) subsidies')

GIS design stakeholders (*заінтересовані сторони проекту ГІС*) – all, incorporated at partner foundations, natural and/or corporate bodies, who (which) in this or other way maintain a process of *GIS designing* and take an interest in *design* outcomes.

GIS designer (*проектант ГІС*) – a specialized contracting design organization (company), including consulting and/or engineering body, which ensures the whole process of development of designed-estimated documentation concerning future *GIS*.

GIS designing (syn. **GIS design preparation) (*проектування ГІС*,** син. ***підготовка проекту ГІС*)** – a process of foundation and formation

of concepts and a development of proper engineering and technologic documentation concerning key *GIS* components, which is aimed at strategic-documentary support of final development of *GIS* as a hardware-software complex and an information base of determinate spatial data domain (see also *entities*, *objects* and *processes of GIS designing*).

GIS designing entities (*суб'єкти проектування ГІС*) – *GIS design employer*, *GIS designer* and *other GIS designing entities*.

GIS developer (*розробник ГІС*) – one or several mostly corporate bodies, which assume a responsibility for *GIS design* implementation at terms, specified by a contract with *GIS design* holder or authorized by him body.

GIS hardware (HW) designing (*проектування апаратного забезпечення ГІС*) – the process of *GIS designing*, which embodies such first-level sub-processes, as: particularization of general *GIS hardware* requirements; definition of *GIS hardware configuration* and *hardware* requirements for *HW* functional units; formation of *GIS hardware architecture*; survey and selection of necessary ready for service *hardware* for *GIS*; consideration of problems for installation and montage of *GIS hardware*.

GIS needs assessment (*оцінка потреб у ГІС*) – the first-level sub-process of *strategic GIS designing* process, which embodies such second-level sub-processes, as: definition of general future *GIS* typology; setting of a staff for future (potential) *GIS* users; formulation of possible users' queries to *GIS*; creation of preliminary list for required initial *spatial data*, which present *GIS data domain* and are needful for a generation of adequate *data bases*; delineation of a list for functional requests to *GIS* (including preliminary *GIS operating scripts*), which represent users' queries and *GIS data domain*; definition of preliminary list for application software, which have to be produced and/or adapted for program support of functional requests to *GIS*.

GIS operating scripts (*сценарії функціонування ГІС*) – subject and fragmentary distribution of *GIS spatial data* and modes for their obtainment, processing, evaluation and visualization by users' queries according to operating resources of multilevel and multipurpose adequate *GIS software* tools.

GIS software (SW) designing (*проектування програмного забезпечення ГІС*) – the process of *GIS designing*, which embodies such first-level sub-processes, as: development of application (program) requirements model; definition of *software configuration* and *SW* modules' specifications; formation of *SW architecture*; survey and selection of existing ready for service *software* tools for *GIS*; definition of final list and approaches to development of application programs which have to be adapted, modified or developed for *GIS*; elaboration of framework for future *GIS software* testing.

Hardware (HW) (*апаратне забезпечення, АЗ*) – technical equipment of certain computerized system, which includes properly computer and mechanical, magnetic, electric, electronic and optic peripheral devices or similar instruments, operating under control of such system or offline, and also any devices required for operating of computerized system.

Hierarchy (*ієрархія*) – an arrangement of certain system components by determined order: from component, higher by meaning or generalization extent, to lower by these features component or vice versa.

HW (*АЗ*) – see *hardware*.

Hyper-process of system GIS designing (*гіперпроцес системного проектування ГІС*) – consolidated processes of *GIS software designing* and *GIS hardware designing*.

Initial GIS designing (*ініціальне проектування ГІС*) – see *basic GIS designing*.

Iteration (*ітерація*) – a retrying application of certain operation, including simulation etc., with modification of its parameters and/or conditions aimed at step-by-step the greatest possible approaching to desired result.

Know-how (*ноу-хау*) – a documented corpus of scientific-technical, technologic, financial-economic, commercial, legal and other confidential knowledge, which are imperative for efficient designing and/or development of certain product (wares, technologies, works, services etc.) and has author's individual or corporative protection at the least at a level of business secrecy. Know-how, as an object of intellectual property, is

transferred in use under the terms of *license* agreement or according to proper agreement on cooperation etc.

Lawyer (*правник*) – one or several natural and/or corporate bodies, which altogether are responsible for normative-legal support of all components forming *GIS design preparation* process.

License (*ліцензія*) – a permission to use patent products, *know-how* etc., the special features of which are regulated by particular document – a license agreement – between a *licensor* and a licensee, which want to get this permission.

Licensor (*ліцензіар*) – one or several natural and/or corporate bodies, which are holders and/or managers of possessory rights (registered by patents, know-how etc.) concerning products, including technologies, which are used under *GIS design preparation*.

Marketing (*маркетинг*) – an activity type, aimed at an adaptation of designing process and/or a development of certain product (wares, technologies, works, services etc.) to market conditions by research of this product users' needs, assessment and/or shaping of demand on a product with corresponding optimization of its development and content under general improvement of a product developer's market strategy, which must ensure a product supply, having a consumer value and increasing a profit or other gain of such developer.

Metadata (*метадані*) – information that describes the content, quality, condition, origin and other characteristics of certain data.

Objects of GIS designing (*об'єкти проектування ГІС*) – such objects as: future (potential) *GIS* users; *spatial data* and *data bases*; *GIS software*; *GIS hardware*; operating conditions and regulations of *GIS* functioning (use); designed-estimated documentation (properly *GIS design*); *GIS developer*.

Operation GIS designing (*експлуатаційне проектування ГІС*) – the process of *GIS designing*, which embodies such first-level sub-processes, as: formulation of final *GIS operating scripts*; definition of operating conditions and schedules for components of *GIS* hardware-software complex; preparation of manuals, directions, recommendations etc. relating *GIS* development and putting into operation, technologic application of its certain components and so on; determination of principles

and modes for organizing and coordinating activity under a development and use of *GIS* and its information basis, and also for command administration and support of *GIS* operating in general; identification of system for access to *GIS* and its *data bases* with access levels' determination etc.; elaboration of information supply and exchange regulations under *GIS* development and use; determination of modes and time constraints for a training of a staff for *GIS* operating; consideration of potential modification concerning *GIS* scripts, operating conditions and regulations under future *GIS* development; consideration of other potential aspects of operation *GIS designing*.

Other GIS designing entities (*інші суб'єкти проектування ГІС*) – a *Consultant*, a *Licensor*, a *Lawyer*, a *Bank* and other possible entities.

Patent (*патент*) – an official act (document), which certifies the authorship of scientific, intellectual, engineering or technologic invention and the exclusive right of patent holder to use such invention.

Processes of GIS designing (*процеси проектування ГІС*) – such processes, as: *basic (initial) GIS designing*; *strategic GIS designing*; *GIS software designing*; *GIS hardware designing*; *operation GIS designing*; *final GIS designing* (see also *hyper-process of system GIS designing*).

Project (*проект*) – see *design*.

Software (SW) (*програмне забезпечення, ПЗ*) – a complex of computer-based programs for certain computerized system and documentation required for these programs' operating.

Spatial data (syn. **geographic data, geodata) (*просторові дані, географічні дані, геодані*)** – data concerning *spatial features*, which are a combination of such data two components – position(al) data and attributive (nonpositional) data, both of which, including conjointly, has a time dimension also.

Spatial features (*просторові об'єкти*) – spatial components of real world, which are presented in computerized (digital) form in order to display geographic objects, processes and phenomenon and are divided into four principal initial types: point features (points), line features (lines), polygon (area) features (polygons) and volumetric features (surfaces).

Strategic GIS designing (*стратегічне проектування ГІС*) – the process of *GIS designing*, which embodies such first-level sub-processes,

as: *GIS needs assessment*; *conceptual GIS designing*; *GIS data base (GIS DB) designing*.

Support of GIS design preparation (*забезпечення підготовки проекту ГІС*) – marketing, conceptual-analytic, organizing, information, material-technical, technologic, normative-legal, including licensing, human recourses', financial and other *GIS designing* support, and also certain combinations for mentioned components of such support.

SW (*ПЗ*) – see *software*.

System GIS designing (*системне проектування ГІС*) – see *hyper-process of system GIS designing*.

Note. The terms, highlighted in italics in principal term definitions, have individual own definition.

ANNEX A – WORK PROGRAM OF THE ACADEMIC DISCIPLINE 'GIS DESIGNING' (THE EXAMPLE)

INTRODUCTION

The academic discipline **"*GIS designing*"** is the part of educational-qualification programs for master training.

The discipline is taught at the ***1st*** *semester* of the ***1st*** *year* of magistracy in the amount of *108* hours (***3.6 ECTS credit***), in particular: ***lectures*** *– 24 hours*, ***practical trainings*** *– 24 hours*, ***self-ruling studies*** *– 60 hours*. The form of final testing is an *examination*.

The goal of the academic discipline is to form students' requisite knowledge, skills and expertise on an application of methodological bases and technologies for designing of geographic information systems (GIS designing) and to consolidate such knowledge etc. by particular examples, especially by use of management game elements.

The tasks of the discipline are students' contraction of requisite knowledge, skills and expertise on an application of methodological bases concerning GIS designing and use of geoinformation designing technologies.

The discipline consists of ***two*** *content modules*. *The first module* is dedicated to a studying of the technologies of basic (initial) and strategic GIS designing, *the second* – the technologies of system, operation and final GIS designing.

As a result of academic discipline study, students are obliged:

1) To know:

a) General principles and approaches to GIS designing;
b) Technology of basic (initial) GIS designing;
c) Technology of strategic GIS designing;
d) Technology of GIS software designing;
e) Technology of GIS hardware designing;
f) Technology of operation GIS designing;
g) Technology of final GIS designing;

2) To be able to:

a) Set GIS designing region and principal entities of such designing;

b) Define general GIS typology, a staff of potential GIS users, possible their queries to GIS and sources of spatial data supply;

c) Establish general GIS architecture and conceptual structure of GIS data bases (DB);

d) Determine principles of spatial data coding and standards for GIS data communication;

e) Specify types of spatial information (geoinformation) products and sources of software supply;

f) Define GIS hardware requests and sources of hardware supply;

g) Specify access levels to GIS data bases and targets of GIS post-designing phase;

h) Implement general application of geoinformation technologies in the scope of geography and cartography taking into consideration international environmental cooperation.

The place of the discipline within the system of professional training in the scope of geography and cartography: the academic discipline "GIS designing" is aimed to provide masters with basic notions on designing of geographic information systems and to form the ability to coming self-ruling action in this scope.

The connection with other disciplines. The academic discipline synthesizes already gained knowledge concerning profile common-geographic academic disciplines and disciplines on geographic information systems and technologies and information networks, geographic modeling, environmental management, management of projects and programs in the scope of natural geography and education, international environmental conventions and treaties, regional and international ecologic networks.

Testing of knowledge and distribution of points get by students

A testing of knowledge is implemented according to a module-rating system, which foresees bimodal evaluation of gained knowledge and skills. In particular, ***theoretical training evaluation (50%)*** takes into consideration: a presentation (10%), a depth of methodology in represented study (10%), a feasibility and coordination of proposals (10%), a rate of

originality (10%) and a determination of conceptual problems on a theme and situation (10%).

Practical training evaluation (50%) considers: qualitative integrity of experiment (15%), an ability to evaluate a problem (15%), an identification of ways and methods for a solution of existing or probable problem (10%), a search of approaches to solution of specific problem (10%).

The discipline consists of two content modules. The first content module embodies themes 1-2 (with sub-themes 2.1-2.3), the second – themes 3-5. An execution of both modular tests is obligatory for an examination.

Evaluation by the forms of testing:

	First content module		***Second content module***	
	Min. – ***15*** *points*	*Max. –* ***30*** *points*	*Min. –* ***15*** *points*	*Max. –* ***30*** *points*
Verbal answer	***„2”*** x 2 = **4**	***„3”*** x 3 = **9**	***„2”*** x 2 = **4**	***„3”*** x 3 = **9**
Additional answer	***„1,5”*** x 2 = **3**	***„2”*** x 6 = **6**	***„1,5”*** x 2 = **3**	***„2”*** x 6 = **6**
Modular test No 1	***„8”*** x 1 = **8**	***„15”*** x 1 = **15**		
Final modular test			***„8”*** x 1 = **8**	***„15”*** x 1 = **15**
„3” **–** minimal/maximal point which can be get by student. 1 **–** minimal/maximal test quantity of answers or tasks				

The results of students' academic study are evaluated by 100-point scale. Students who got point quantity, which is lesser than *critical-calculating minimum* (***30*** *points*), have to pass final modular test for the second time in order to allow them to take an examination. Maximal examination grade is ***40*** *points*.

In case of student absence due to reasonable excuses, working a debt out and passing final modular tests for the second time are realized according to "Regulations on procedure of students' knowledge testing under a module-rating system of academic process organization" dated October 1, 2010.

The result of simple calculation (in points):

	First content module	Second content module	Examination	Final grade
Minimum	*15*	*15*	*30*	*60*
Maximum	**30**	**30**	**40**	**100**

Points – grades correspondence scale

Points by 100-point scale	*Grades by national scale*	
90-100	**5**	**Excellent**
75-89	**4**	**Good**
60-74	**3**	**Satisfactory**
1-59	**2**	**Unsatisfactory**

PROGRAM OF THE ACADEMIC DISCIPLINE

Content module 1. BASIC (INITIAL) AND STRATEGIC GIS DESIGNING

Theme 1. GENERAL NOTIONS AND BASIC (INITIAL) GIS DESIGNING (20 hours)

General notions on GIS designing and general algorithmic scheme of such designing. Entities, objects, processes and sub-processes of GIS designing.

Notion on process of basic (initial) GIS designing. Employer, investor, sponsor and beneficiary of GIS design. GIS designer. Notion on alternates for scheme of GIS design management as a whole. Other entities of GIS designing (Consultant, Licensor, Lawyer, Bank). Plan (strategic framework), schedule and budget of GIS design preparation. Examples of the implementation of the components of basic GIS designing process.

Theme 2. STRATEGIC GIS DESIGNING (40 hours)

Sub-theme 2.1. GIS NEEDS ASSESSMENT (12 hours)

Notion on process of strategic GIS designing. Needs assessment for GIS as sub-process. Definition of general future GIS typology. Setting of staff

for future (potential) GIS users. Formulation of possible users' queries to GIS. Creation of preliminary list for initial spatial data. GIS data domain. General criteria of efficiency for GIS information basis. Sources and modes for obtainment and/or supply of GIS data. Delineation of list for functional requests to GIS and preliminary scripts of GIS operation. Definition of preliminary list for application software, which have to be produced and/or adapted. Examples of the implementation of the components of GIS needs assessment sub-process.

Sub-theme 2.2. CONCEPTUAL GIS DESIGNING (12 hours)

Conceptual GIS designing as sub-process. Systematization of local views on GIS. Initial Decision System Matrix and Initial Decision System Tree. Integration of local views on GIS. Generalized Decision System Matrix and Generalized Decision System Tree. Comparison of global view on GIS with constraints of GIS development. Consideration of GIS designing errors. Identification of GIS structure, GIS architecture and conceptual structure of GIS data bases. Examples of the implementation of the components of conceptual GIS designing sub-process.

Sub-theme 2.3. GIS DATA BASE (DB) DESIGNING (16 hours)

GIS data base (DB) designing as sub-process. Development of common GIS data model. Setting of coordinate system (systems) for GIS. Definition of requests to GIS metadata. Formulation of principles for spatial data coding. Quality assessment of information, which will be supplied to GIS DB. Definition of standards for data supply (communication) and data transformation and synchronization. Calculation of specified quantity for required data from determined sources and cost of GIS DB development. Examples of the implementation of the components of GIS data base designing sub-process. Strategic plan (framework) of GIS development.

Content module 2. SYSTEM, OPERATION AND FINAL GIS DESIGNING

Theme 3. GIS SOFTWARE DESIGNING (16 hours)

Notion on hyper-process of system GIS designing and process of GIS software (SW) designing. Development of application (program) requirements model. Definition of software configuration and SW modules' specifications. Formation of SW architecture. Survey and selection of existing ready for service software tools for GIS. Definition of final list and approaches to development of application programs which have to be adapted, modified or developed for GIS. Elaboration of framework for future GIS software testing. Examples of the implementation of the components of GIS software designing process.

Theme 4. GIS HARDWARE DESIGNING (16 hours)

Process of GIS hardware (HW) designing. Particularization of general GIS hardware requirements. Definition of GIS hardware configuration and hardware requirements for HW functional units. Formation of GIS hardware architecture. Survey and selection of necessary ready for service hardware for GIS. Consideration of problems for installation and montage of GIS hardware. Definition of final GIS configuration and architecture as a whole and modes for GIS system protection.

Theme 5. OPERATION AND FINAL GIS DESIGNING (16 hours)

Notion on process of operation GIS designing. Operating conditions (frameworks) and regulations (standards) for functioning (use) of future GIS. Examples of the implementation of the components of operation GIS designing process. Notion on process of final GIS designing. Paper work of properly GIS design. GIS design audit and appraisal, definition of GIS developer and design delivery.

STRUCTURE OF THE ACADEMIC DISCIPLINE

SUBJECT PLAN OF LECTURES AND PRACTICAL TRAININGS

No of theme, sub-theme	Theme / sub-theme name	Number of hours		
		lectu-res	practical trainings	self-ruling studies
***Content module 1*. Basic (initial) and strategic GIS designing**				
1	**Theme 1.** General notions and basic (initial) GIS designing	4	4	12
2	**Theme 2.** Strategic GIS designing, including:	*8*	*8*	*24*
3	**Sub-theme 2.1.** GIS needs assessment	2	2	8
4	**Sub-theme 2.2.** Conceptual GIS designing	2	2	8
5	**Sub-theme 2.3.** GIS data base (DB) designing	4	4	8
Modular test No 1				
***Content module 2*. System, operation and final GIS designing**				
6	**Theme 3.** GIS software designing	4	4	8
7	**Theme 4.** GIS hardware designing	4	4	8
8	**Theme 5.** Operation and final GIS designing	4	4	8
Final modular test				
	TOTAL	**24**	**24**	**60**

Total amount – *108 hours*, including:
Lectures – *24 hours*,
Practical trainings – *24 hours*,
Self-ruling studies – *60 hours*.

CONTENT MODULE 1

BASIC (INITIAL) AND STRATEGIC GIS DESIGNING

Theme 1. GENERAL NOTIONS AND BASIC (INITIAL) GIS DESIGNING (20 hours)

Lecture 1. General notions and basic (initial) GIS designing *– 4 hours*.

General notions on GIS designing and general algorithmic scheme of such designing. Entities, objects, processes and sub-processes of GIS designing.

Notion on process of basic (initial) GIS designing. Employer, investor, sponsor and beneficiary of GIS design. GIS designer. Notion on alternates for scheme of GIS design management as a whole. Other entities of GIS designing (Consultant, Licensor, Lawyer, Bank). Plan (strategic framework), schedule and budget of GIS design preparation. Examples of the implementation of the components of basic GIS designing process.

Practical training 1. Basic (initial) GIS designing *– 4 hours*.

Task to define:

1) The purpose and region of GIS designing and the name of GIS design;
2) The principal entities of GIS designing;
3) The alternate for scheme of GIS design management;
4) The other entities of designing;
5) The approximate duration and the cost of GIS design preparation.

Task for self-ruling study (*12 hours*):

A budget of GIS design preparation ([1, 2, 9-14]).

Control questions and tasks:

1. *What does the GIS designing mean?*
2. *Explain the general algorithmic scheme of GIS designing.*
3. *Who (what) can be the entities of GIS designing?*

4. *Who (what) are the objects of GIS designing?*

5. *Explain the difference between the objects and the processes of GIS designing.*

6. *How do you understand the term "beneficiary of GIS design"?*

7. *How many alternates for the scheme of GIS design management do you know?*

8. *What is the principal function of the Licensor during GIS designing?*

9. *What is the principal function of the Lawyer during GIS designing?*

10. *What is the principal function of the Bank during GIS designing?*

11. *How do you understand the strategic framework of GIS design preparation?*

12. *Illustrate by the examples the implementation of the components of basic GIS designing process.*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011.* – 228 p.
5. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
6. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8.* – P.77-85.
7. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) //

Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.– P.200-208.

8. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6*. – P.20-31.
9. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – P.11-22, P.71-142.
10. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
11. *Samoilenko V.M., Dibrova I.O. et al.* Didactics of Geography: Monograph (electronic version). – *Kyiv: Nika-Center, 2013.* – CD, ISBN 978-966-521-619-3. – 570 p.
12. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
13. *Datsenko L.M.* Fundamentals of geoinformation systems and technologies in school courses of study abroad // *Periodical of Cartography. – 2010. – Vol.1.* – P.197-205.
14. *UNEP* project manual: formulation, approval, monitoring and evaluation. – *UNEP, 2005.* – 126 p.
15. *Tian R.B. et al.* Project management: Textbook (in Ukrainian). – *Kyiv: Center of educational publishing, 2004.* – 224 p.
16. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
17. *http://www.icpdr.org.*
18. *http://dnipro.ecobase.org.ua*
19. *http://www.unep.org*.
20. *http://www.undp.org*.
21. *http://en.mimi.hu/gis.*
22. *http://www.esri.com.*

Theme 2. STRATEGIC GIS DESIGNING (40 hours)

Sub-theme 2.1. GIS NEEDS ASSESSMENT (12 hours)

Lecture 2. GIS needs assessment *– 2 hours.*

Notion on process of strategic GIS designing. Needs assessment for GIS as sub-process. Definition of general future GIS typology. Setting of staff for future (potential) GIS users. Formulation of possible users' queries to GIS. Creation of preliminary list for initial spatial data. GIS data domain. General criteria of efficiency for GIS information basis. Sources and modes for obtainment and/or supply of GIS data. Delineation of list for functional requests to GIS and preliminary scripts of GIS operation. Definition of preliminary list for application software which have to be produced and/or adapted. Examples of the implementation of the components of GIS needs assessment sub-process.

Practical training 2. GIS needs assessment *– 2 hours*.

Task to define:

1) The general GIS typology;
2) The staff for future (potential) GIS users;
3) The possible users' queries to GIS;
4) The GIS data domain;
5) The sources and modes for obtainment and supply of necessary initial spatial data;
6) The composition of GIS units (modules).

Task for self-ruling study (*8 hours*):

General criteria of efficiency for GIS information basis ([1-4, 7, 8]).

Control questions and tasks:

1. *What is the GIS needs assessment?*
2. *Comment the definition of the general GIS typology.*
3. *Explain the necessity of a staff setting for future (potential) GIS users.*
4. *Illustrate by the examples possible users' queries to GIS.*
5. *What is preliminary list for initial spatial data?*
6. *What is the difference between GIS data domain and region of GIS designing?*

7. *How many criteria of efficiency for GIS information basis do you know?*

8. *Why have we to define sources and modes for obtainment and supply of GIS data?*

9. *What is the difference between functional requests to GIS and scripts of GIS operating?*

10. *Why do we use preliminary list for application software which has to be produced and/or adapted?*

11. *Illustrate by the examples the implementation of the components of GIS needs assessment sub-process.*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011.* – 228 p.
5. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
6. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
7. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
8. *Samoilenko V.M., Dibrova I.O. et al.* Didactics of Geography: Monograph (electronic version). – *Kyiv: Nika-Center, 2013.* – CD, ISBN 978-966-521-619-3. – 570 p.

9. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
10. *UNEP* project manual: formulation, approval, monitoring and evaluation. – *UNEP, 2005.* – 126 p.
11. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
12. *http://www.icpdr.org.*
13. *http://www.esri.com.*

Sub-theme 2.2. CONCEPTUAL GIS DESIGNING (12 hours)

Lecture 3. Conceptual GIS designing *– 2 hours.*

Conceptual GIS designing as sub-process. Systematization of local views on GIS. Initial Decision System Matrix and Initial Decision System Tree. Integration of local views on GIS. Generalized Decision System Matrix and Generalized Decision System Tree. Comparison of global view on GIS with constraints of GIS development. Consideration of GIS designing errors. Identification of GIS structure, GIS architecture and conceptual structure of GIS data bases. Examples of the implementation of the components of conceptual GIS designing sub-process.

Practical training 3. Conceptual GIS designing *– 2 hours.*

Task to define:

1) The constraints of GIS development;
2) The general GIS architecture;
3) The conceptual structure of GIS data bases.

Task for self-ruling study (*8 hours*):

GIS designing errors ([1-4]).

Control questions and tasks:

1. *What is the conceptual GIS designing?*

2. *Explain the systematization of local views on GIS.*

3. *What is the difference between Initial Decision System Matrix and Initial Decision System Tree?*

4. *How can we integrate local views on GIS?*

5. *What is the difference between Initial Decision System Matrix and Generalized Decision System Matrix?*

6. *What is the difference between Initial Decision System Tree and Generalized Decision System Tree?*

7. *Illustrate by the examples the comparison of global view on GIS with constraints of GIS development.*

8. *What types of GIS designing errors do you know?*

9. *Explain the difference between GIS structure and GIS architecture.*

10. *How can we form conceptual structure of GIS data bases?*

11. *Illustrate by the examples the implementation of the components of conceptual GIS designing sub-process.*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011*. – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013*. – 184 p.
4. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
5. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8.* – P.77-85.
6. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.*– P.200-208.
7. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6*. – P.20-31.

8. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
9. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
10. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
11. *http://www.icpdr.org.*
12. *http://dnipro.ecobase.org.ua*
13. *http://www.esri.com.*

Sub-theme 2.3. GIS DATA BASE (DB) DESIGNING (16 hours)

Lecture 4. GIS data base (DB) designing *– 4 hours.*

GIS data base (DB) designing as sub-process. Development of common GIS data model. Setting of coordinate system (systems) for GIS. Definition of requests to GIS metadata. Formulation of principles for spatial data coding. Quality assessment of information, which will be supplied to GIS DB. Definition of standards for data supply (communication) and data transformation and synchronization. Calculation of specified quantity for required data from determined sources and cost of GIS DB development. Examples of the implementation of the components of GIS data base designing sub-process. Strategic plan (framework) of GIS development.

Practical training 4. GIS data base (DB) designing *– 4 hours.*

Task to define:

1) The particular multi-layered GIS data model;
2) The coordinate system (systems) for future GIS;
3) The principles for spatial data coding;
4) The standards and the protocols of GIS data supply (communication) and GIS data transformation and synchronization, first of all under the use of certain information networks.

Task for self-ruling study (*8 hours*):

Quality assessment of information, which will be supplied to GIS DB ([1-9]).

Control questions and tasks:

1. *What is GIS data base designing?*

2. *Explain the elaboration of common GIS data model.*

3. *Why GIS data model is named 'common'?*

4. *Why have we to set coordinate system for GIS?*

5. *Illustrate by the examples some requests to GIS metadata.*

6. *What principles for spatial data coding do you know?*

7. *Why must we do quality assessment of information which will be supplied to GIS DB?*

8. *What is the difference between standards for data supply (communication) and standards for data transformation and synchronization?*

9. *Why have we to calculate specified quantity of required GIS data from determined sources?*

10. *Explain the calculation of cost for DB GIS development.*

11. *What is the strategic plan (framework) of GIS development?*

12. *Illustrate by the examples the implementation of the components of GIS data base (DB) designing sub-process.*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011*. – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013*. – 184 p.
4. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*

5. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8. –* P.77-85.
6. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.–* P.200-208.
7. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6. –* P.20-31.
8. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004. –* 152 p.
9. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22). –* P.8-32.
10. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
11. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. *– Kyiv: Carbon, 2007. –* 433 p.
12. *http://www.icpdr.org.*
13. *http://dnipro.ecobase.org.ua*
14. *http://www.esri.com.*

CONTENT MODULE 2

SYSTEM, OPERATION AND FINAL GIS DESIGNING

Theme 3. GIS SOFTWARE DESIGNING (16 hours)

Lecture 5. GIS software designing *– 4 hours.*

Notion on hyper-process of system GIS designing and process of GIS software (SW) designing. Development of application (program) requirements model. Definition of software configuration and SW

modules' specifications. Formation of SW architecture. Survey and selection of existing ready for service software tools for GIS. Definition of final list and approaches to development of application programs which have to be adapted, modified or developed for GIS. Elaboration of framework for future GIS software testing. Examples of the implementation of the components of GIS software designing process.

Practical training 5. GIS software designing *– 4 hours*.

Task to define:

1) The types of spatial information (geoinformation) products;

2) The designs concerning the visualization of typical queries to GIS DB;

3) The supply sources of ready for service software tools, necessary for GIS operating.

Task for self-ruling study (*8 hours*):

Application (program) requirements model ([1-3, 6, 8-10]).

Control questions and tasks:

1. *What is the hyper-process of system GIS designing?*

2. *What are the peculiarities of GIS software designing?*

3. *Explain the development of application (program) requirements model for GIS.*

4. *What is the difference between software configuration and software modules' specifications?*

5. *Illustrate by the examples the definition of GIS software configuration.*

6. *Illustrate by the examples the formation of GIS software architecture.*

7. *What is ready for service software tools for GIS?*

8. *Why application programs can be adapted, modified or developed for GIS?*

9. *What approaches to a development of application programs do you know?*

10. *What is the GIS software testing?*

11. *Why have we to elaborate the framework for future GIS software testing?*

12. *Illustrate by the examples the implementation of the components of GIS software designing process.*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011*. – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011*. – 228 p.
4. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
5. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
6. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
7. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
8. *http://www.icpdr.org.*
9. *http://dnipro.ecobase.org.ua*
10. *http://www.esri.com.*

Theme 4. GIS HARDWARE DESIGNING (16 hours)

Lecture 6. GIS hardware designing *– 4 hours.*

Process of GIS hardware (HW) designing. Particularization of general GIS hardware requirements. Definition of GIS hardware configuration and hardware requirements for HW functional units. Formation of GIS

hardware architecture. Survey and selection of necessary ready for service hardware for GIS. Consideration of problems for installation and montage of GIS hardware. Definition of final GIS configuration and architecture as a whole and modes for GIS system protection.

Practical training 6. GIS hardware designing *– 4 hours*.

Task to define:

1) The composition of GIS hardware functional units;
2) The hardware requirements for the GIS hardware functional units;
3) The GIS hardware supply sources.

Task for self-ruling study (*8 hours*):

Problems of GIS hardware installation and montage ([1-3, 7, 8]).

Control questions and tasks:

1. *What is the process of GIS hardware designing?*

2. *What are the common features for GIS software and hardware designing?*

3. *What is the difference between GIS software and hardware designing?*

4. *Explain the content of some general GIS hardware requirements.*

5. *What GIS hardware functional units do you know?*

6. *What is GIS hardware configuration?*

7. *Explain the difference between GIS hardware configuration and architecture.*

8. *What is ready for service hardware for GIS?*

9. *How can we select necessary ready for service hardware for GIS?*

10. *What are the ways for consideration of problems for installation and montage of GIS hardware?*

11. *Explain the content of final GIS configuration and architecture definition.*

12. *What modes for GIS system protection do you know?*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011.* – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
5. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
6. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
7. *http://www.icpdr.org.*
8. *http://www.esri.com.*

Theme 5. OPERATION AND FINAL GIS DESIGNING (16 hours)

Lecture 7. Operation and final GIS designing – *4 hours*.

Notion on process of operation GIS designing. Operating conditions (frameworks) and regulations (standards) for functioning (use) of future GIS. Examples of the implementation of the components of operation GIS designing process. Notion on process of final GIS designing. Paper work of properly GIS design. GIS design audit and appraisal, definition of GIS developer and design delivery.

Practical training 7. Operation and final GIS designing – *4 hours*.

Task to define:

1) The scheme of organization and coordination activity under GIS development and use;

2) The levels of access to GIS and GIS data bases;

3) The targets of GIS post-designing phase;
4) The GIS developer.

Task for self-ruling study (*8 hours*):
GIS regulations ([1-6, 9]).

Control questions and tasks:

1. *What is the process of operation GIS designing?*

2. *What is the difference between the operation and the final GIS designing?*

3. *What are the common features for the operation and the final GIS designing?*

4. *Explain the steps of the operation and the final GIS designing.*

5. *What are the operating conditions (frameworks) for functioning (use) of future GIS?*

6. *What are the regulations (standards) for functioning (use) of future GIS?*

7. *Explain the content of some operating conditions for GIS functioning.*

8. *Explain the content of some standards for GIS functioning.*

9. *Illustrate by the examples the implementation of the components of operation GIS designing process.*

10. *What are the peculiarities of final GIS designing?*

11. *What is the paper work of properly GIS design?*

12. *What is the difference between GIS design audit and GIS design appraisal?*

13. *Who can be the GIS developer?*

14. *Explain the steps for GIS design delivery.*

Recommended sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011*. – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – Kyiv: Nika-Center, 2010. – P.268-332.

3. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011*. – 228 p.
4. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6*. – P.20-31.
5. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
6. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
7. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
8. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.
9. *http://www.icpdr.org.*
10. *http://www.esri.com.*

Recommended sources

Basic sources:

1. *Samoilenko V.M.* Geographic information systems and technologies: Electronic Manual (in Ukrainian), DVD. – *Kyiv: Nika-Center, 2011*. – ISBN 978-966-521-585-1.
2. *Samoilenko V.M.* Geographic information systems and technologies: Manual (in Ukrainian). – *Kyiv: Nika-Center, 2010.* – 448 p.
3. *Datsenko L.M., Ostroukch V.I.* Fundamentals of geoinformation systems and technologies: Manual (in Ukrainian). – *Kyiv: SRPE 'Cartography', 2013.* – 184 p.
4. *Datsenko L.M.* Educational cartography under conditions of public informatization: theory and practice [Monograph]. – *Kyiv: SRPE 'Cartography', 2011*. – 228 p.

5. *DeMers, Michael N. Geographic information systems. Fundamentals. Wiley; 4th edition, 2008. 464 p.*
6. *Samoilenko V.M.* Substantiation of subject units for electronic data base of Dnipro Basin state as GIS component (in Ukrainian) // *Cartography and High School. – 2003. – Vol.8. –* P.77-85.
7. *Samoilenko V.M.* Experience on development on data bases and information systems of hydro-environmental data (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.–* P.200-208.
8. *Samoilenko V.M.* Strategy for trans-boundary Danube Basin GIS development (in Ukrainian) // *Hydrology, Hydrochemistry and Hydroecology. – 2004. – Vol.6.* – P.20-31.
9. *Samoilenko V.M. et al.* Information management of international Dnipro basin environmental rehabilitation: Monograph. – *Kyiv: Nika-Center, 2004.* – 152 p.
10. *Samoilenko V.M.* Geographic information systems: designing with examples from international hydro-environmental cooperation // *Hydrology, Hydrochemistry and Hydroecology. – 2011. – Vol.1 (22)*. – P.8-32.
11. *Samoilenko V.M., Dibrova I.O. et al*. Didactics of Geography: Monograph (electronic version) (in Ukrainian). – *Kyiv: Nika-Center, 2013.* – CD, ISBN 978-966-521-619-3. – 570 p.

Additional sources:

12. *Samoilenko V.M.* Structure and functional principles for watermanagement-environmental monitoring creation as a conceptual interface of river basins GIS // *Schriftenreihe zur Wasserwirtschaft. Technische Universität Graz.* – 1996. – Vol.19/2. – P. C135-C140.
13. *Draft* Guidance on Implementing the GIS Elements of the WFD / *http://www.icpdr.org.*
14. *Datsenko L.M.* Fundamentals of geoinformation systems and technologies in school courses of study abroad // *Periodical of Cartography. – 2010. – Vol.1.* – P.197-205.

15. *UNEP* project manual: formulation, approval, monitoring and evaluation. – *UNEP, 2005*. – 126 p.
16. *Tian R.B. et al.* Project management: Textbook (in Ukrainian). – *Kyiv: Center of educational publishing, 2004.* – 224 p.
17. *Boosygin B.S. et al.* English-Ukrainian glossary on geo-informatics. – *Kyiv: Carbon, 2007.* – 433 p.

Web sources:

18. *http://www.icpdr.org.*
19. *http://www.unep.org*.
20. *http://www.undp.org*.
21. *http://en.mimi.hu/gis.*
22. *http://www.esri.com.*

Questions for examination

1. General algorithmic scheme of GIS designing.
2. Entities, objects, processes and sub-processes of GIS designing.
3. Process of basic (initial) GIS designing.
4. Employer, investor, sponsor and beneficiary of GIS design.
5. GIS designer.
6. Alternates for scheme of GIS design management as a whole.
7. Other entities of GIS designing (Consultant, Licensor, Lawyer, Bank).
8. Plan (strategic framework), schedule and budget of GIS design preparation.
9. Examples of the implementation of the components of basic GIS designing process.
10. Process of strategic GIS designing.
11. Needs assessment for GIS as sub-process.
12. Definition of general future GIS typology.
13. Setting of staff for future (potential) GIS users.
14. Formulation of possible users' queries to GIS.
15. Creation of preliminary list for initial spatial data.
16. GIS data domain.
17. General criteria of efficiency for GIS information basis.

18. Sources and modes for obtainment and/or supply of GIS data.
19. Delineation of list for functional requests to GIS and preliminary scripts of GIS operation.
20. Definition of preliminary list for application software which have to be produced and/or adapted for GIS.
21. Examples of the implementation of the components of GIS needs assessment sub-process.
22. Conceptual GIS designing as sub-process.
23. Systematization of local views on GIS.
24. Initial Decision System Matrix and Initial Decision System Tree.
25. Integration of local views on GIS.
26. Comparison of global view on GIS with constraints of GIS development.
27. Consideration of GIS designing errors.
28. Identification of GIS structure, GIS architecture and conceptual structure of GIS data bases.
29. Examples of the implementation of the components of conceptual GIS designing sub-process.
30. GIS data base (DB) designing as sub-process.
31. Development of common GIS data model.
32. Setting of coordinate system (systems) for GIS.
33. Definition of requests to GIS metadata.
34. Formulation of principles for spatial data coding.
35. Quality assessment of information, which will be supplied to GIS DB.
36. Definition of standards for data supply (communication) and data transformation and synchronization under GIS designing.
37. Calculation of specified quantity for required data from determined sources and cost of GIS DB development.
38. Examples of the implementation of the components of GIS data base designing sub-process.
39. Strategic plan (framework) of GIS development.
40. Hyper-process of system GIS designing and process of GIS software (SW) designing.
41. Development of application (program) requirements model.

42. Definition of GIS software configuration and GIS SW modules' specifications.
43. Formation of GIS SW architecture.
44. Survey and selection of ready for service software tools for GIS.
45. Definition of final list and approaches to development of application programs which have to be adapted, modified or developed for GIS.
46. Elaboration of framework for future GIS software testing.
47. Examples of the implementation of the components of GIS software designing process.
48. Process of GIS hardware (HW) designing.
49. Particularization of general GIS hardware requirements.
50. Definition of GIS hardware configuration and hardware requirements for HW functional units.
51. Formation of GIS hardware architecture.
52. Survey and selection of necessary ready for service hardware for GIS.
53. Consideration of problems for installation and montage of GIS hardware.
54. Definition of final GIS configuration and architecture as a whole and modes for GIS system protection.
55. Process of operation GIS designing.
56. Operating conditions (frameworks) and regulations (standards) for functioning (use) of future GIS.
57. Examples of the implementation of the components of operation GIS designing process.
58. Process of final GIS designing.
59. Paper work of properly GIS design.
60. GIS design audit and appraisal, definition of GIS developer and design delivery.