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ATLAS SOLUTIONS FRAMEWORK AS A METHOD OF THE RENEWED MODEL-COGNITIVE CONCEPTION OF CARTOGRAPHY

There are described the method and, partly, atlas technology, currently used in the Institute of Geography of NASU to create Electronic atlases and Atlas information systems. Such dyads of methods and technologies/means in atlas context are generally called Atlas Solution Frameworks (AtlasSF). A clarification is used to denote “AtlasSF method” or “AtlasSF technology/means”. Since the beginning of the century our “initial” AtlasSF technology changed every five years with the unchangeable AtlasSF method. The third change of technology, starting in 2016, was revolutionary. Most principal was implicit changing of K. Salishchev’s Map knowledge conception of cartography. The new conception is still poorly understood, although the renewed AtlasSF method and technology are already based on it. The new conception/paradigm of cartography is called the renewed Model-cognitive paradigm (MCP). The original MCP is known in post-Soviet countries thanks to A. Berlyant. It has much in common with the paradigms of cartography, which are known in Western countries as Analytical (model part of MCP) and Communicative/Cognitive (cognitive part of MCP). Model-based engineering (MBE) and Relational cartography (RelCa) are used to provide “modern life” to MCP. Special models known as patterns are essential in the use of MBE and RelCa. Among the patterns a special place is occupied by frameworks. To interpret the theoretical constructions are used: 1) "Atlas of the Population of Ukraine and its Natural and Cultural Heritage" [1], created in 2020 with the help of 2) renewed initial AtlasSF technology. ***Keywords:*** *model-cognitive conception/paradigm: original and renewed; atlas solutions framework, solutions and conceptual frameworks, relational cartography*

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АТЛАСНИЙ КАРКАС РІШЕНЬ ЯК МЕТОД ВІДРОДЖЕНОЇ МОДЕЛЬНО-ПІЗНАВАЛЬНОЇ КОНЦЕПЦІЇ КАРТОГРАФІЇ

Описано метод і, частково, атласне технологі., які зараз використовують в Інституті географії НАНУ для створення Електронних атласів і Атласних інформаційних систем. Такі діади методів і технологій/засобів у атласному контексті називаються загалом Атласними Каркасами Рішень AtlasSF. Уточнення використовують для позначення «методу AtlasSF» або «технології/засобу AtlasSF». З початку століття наша «початкова» технологія AtlasSF змінювалася кожні п’ять років без зміни метода AtlasSF. Третя зміна технології, починаючи з 2016 р., стала революційною. Найважливішою стала неявна зміна Картознавчої концепції картографії К. Саліщева. Нова концепція ще мало усвідомлена, хоча перебудовані метод і технологія AtlasSF вже базуються на ній. Нова концепція/парадигма картографії називається відродженою Модельно-пізнавальною парадигмою (МПП). Оригінальна МПП відома в пострадянських країнах завдяки А. Берлянту. Вона має багато спільного з парадигмами картографії, відомими в західних країнах як Аналітична (модельна частина МПП) і Комунікативна/Пізнавальна (пізнавальна частина МПП). Для надання «сучасного життя» МПП використовують Базовану на моделях інженерію (БМІ) і Реляційну картографію (РелКа). У використанні БМІ і РелКа істотними є спеціальні моделі, відомі як патерни. Серед патернів особливе місце займають каркаси. Для інтерпретації теоретичних конструкцій використано «Атлас Населення України та його Природна і Культурна спадщина» [1], створений за допомогою перебудованої початкової технології AtlasSF.

Ключові слова: *модельно-пізнавальна концепція/парадигма: оригінальна і відроджена; каркас атласних рішень; концептуальний каркас і каркас рішень; реляційна картографія*

Problems and purpose of the research

Model-cognitive conception of cartography is an evolution of K. Salishchev's Map knowledge conception/paradigm [2]. This is stated in the monograph [3; Fig. 3], where this fact is shown in the context of the evolution of the theory of cartography over 50 years of the late 20th century. We supplemented this figure (white part) with a modern renewal (gray part), which is exactly what this article is about ***(Fig. 1)***. Instead of the term "conception" in European and American countries (hereinafter - Western), the term "paradigm" is used.

Dot 22 in Fig. 1 denotes the monograph [4], and dot 16 - the monograph [5], from which it follows that the "model" part of the MCP is based on them. Although the views of these authors on the model and on the subject of modeling differ. A. Berlyant considered the map as a model of its "protoplast", remaining within the frame of K. Salishchev's Map knowledge paradigm. A. Aslanikashvili first defined the spatial system of actuality that needs to be modeled, and then built its image - a map as a model of this system.

It is more difficult to briefly explain the "cognitive" part of the MCP, as it is based of K. Salishchev's Map knowledge paradigm, which is described in detail in many publications. Since we do not have the opportunity to consider them directly, we will look at this issue from the side of Western cartographies. For example, in the work [6] it is said that in the Communicative/Cognitive paradigms the research subject is the Map as Image in the sense of "picture". But this is also truth for K. Salishchev's Map knowledge paradigm. If the main issue is the subject of cartography, then it should be assumed that K. Salishchev's Map knowledge paradigm corresponds to the Cognitive and/or Communicative paradigms of Western cartographies. Therefore, Fig. 1 needs to be corrected by pointing out that Map knowledge has also become a Communicative conception/paradigm.

A. Aslanikashvili's metacartography, in addition to the mentioned inclusion in the MCP, in its "language" part was also included in A. Liuty's Language paradigm, the basics of which are published in 28 [7]. The question is the legitimacy of A. Berlyant's inclusion of the Language paradigm in his "Geoinformation" paradigm of cartography. After all, the "Geoinformation" paradigm most likely meant technological cartographic languages that would be used to manipulate maps within a certain technology. And they have a much narrower meaning than the A. Liuty's language of map.

Finally, we do not agree with the introduction of new term "Geoinformation" by A. Berlyant to denote the future integrated paradigm of Model-cognitive, Language and Communicative paradigms of cartography (Fig. 1). After all, the term "Geoinformation" and its meaning according to A. Berlyant actually mean only the use of geo-information technology for mapping, and therefore this paradigm can not be scientific.

From the above we can formulate problem 1: the uncertainty of the modern paradigm of cartography, which should be the most characteristic follower of

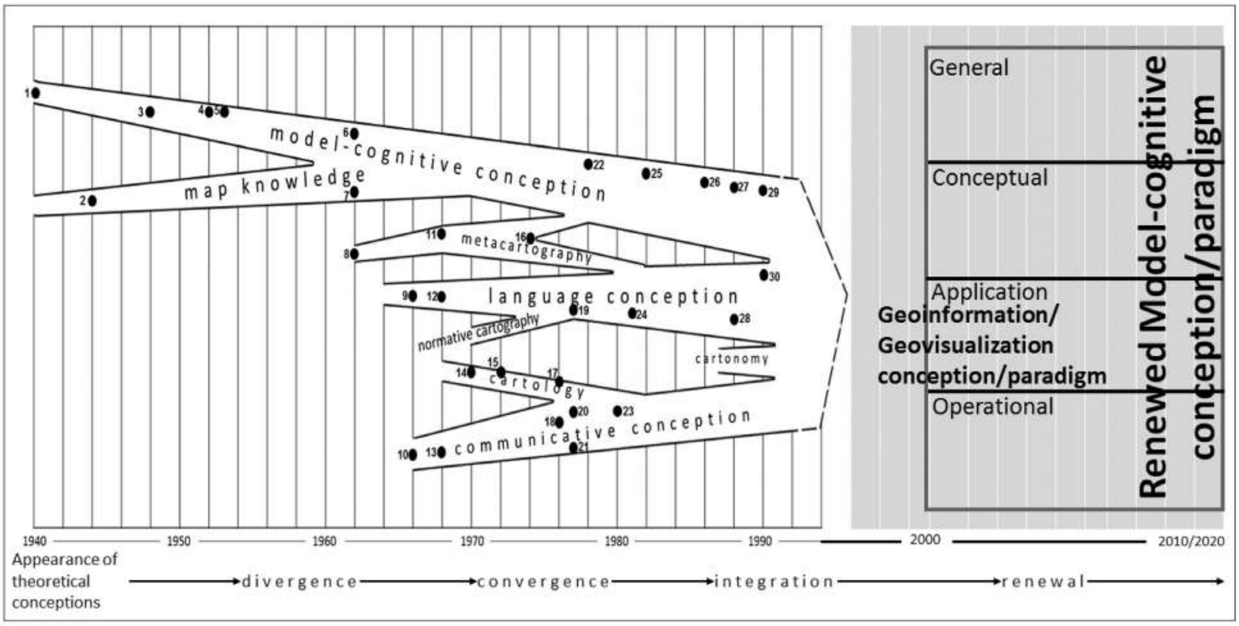

Fig. 1. Superposition of [3; Fig. 3] and the research of this article

Model-cognitive, Language and Communicative paradigms of cartography (Fig. 1). Moreover, the questions are 1.1) the correctness of the term "Geoinformation conception/paradigm", 1.2) the meaning of the "correct" term and finally, 1.3) at least the main features of this new paradigm of cartography.

Apparently, it is not necessary to prove that modern cartography is required, compared to the last century, in a much larger number of "electronic" applications, and among them the most important are the various "systemic" applications. We mean both "classic" Electronic atlases (EA), Atlas-, Map- and Geo- information systems, and "non-classic" Map-/Geo-information systems like OpenStreetMap (OSM) / Google Maps, which are generally called Spatial information systems (SpIS). Therefore, we need cartography that would help to research the "domains" of these systems and that would help to "scientifically" create such systems. It should be noted that we are convinced of the need for cartography as a separate science, although at the moment the idea of cartography as an applied science still prevails. We do not have the opportunity to discuss this issue in detail. We recommend to the interested reader to begin with a [7] and thoughts of its author about K. Salishchev's Map knowledge.

In modern cartography, as in science, it is necessary to define three components [8]: 1) a *domain* of inquiry - in our case it is spatial phenomena and the entities of reality, 2) a body of *knowledge* regarding the domain, which include knowledge of spatial models, used to model individual subdomains of a domain of inquiry, 3) *a methodology* for the acquisition of new knowledge within the domain. Given the possible system applications in the field of research, it is best to specify "real" spatial systems, models of which can be implemented as modern SpIS. Knowledge of such SpIS is part of the second component of cartography as a science.

In this article attention is paid to one of the methods of a methodology for obtaining new knowledge, which is called the Atlas Solutions Frameworks (AtlasSF) method. The AtlasSF method is one of the spatial SoFr methods. The term X SoFr (Solutions Framework), X = Geo, Atlas, …, "borrowed" from the term Microsoft Solutions Framework (MSF). MSF is a methodology that developed from 1993 to 2005 as "a set of principles, models, disciplines, concepts and guidelines for the provision of information technology services from Microsoft. MSF was not limited to application development; it (she) has also been applicable to other IT projects, such as deployments, network or infrastructure projects. MSF did not force the developer to use a specific methodology (for example, Waterfall models or Agile development software)" [9]. The term "SoFr" was used at the turn of the century to denote typical solutions of typical problems that have constantly arisen and are arising in the geo-information activities of both individual projects and enterprises. Therefore, it is more correct to speak of Spatial Solutions Frameworks or Frameworks of Spatial Solutions, although the term "Spatial" is often omitted. The first published example of such a SoFr is the GeoSolutions Framework [10].

Ruzavin [11; p. 7] considers the method in the broadest sense as a "systematic procedure consisting of a sequence of certain operations, the use of which either leads to the achievement of the goal, or approaches it". "Means" (tools or even technology) is an "epistemologically lower" conception than "method". Otherwise, the "means" is used to implement the "method" and there may be several such implementations. Despite this rather logical understanding of this term, we have not found the right definition in common use. Only in the Pharmaceutical Encyclopedia (!) we found a satisfactory definition [12]: "the means as a term can define several diverse concepts (manner, way, medium, device, tool, some special action, etc.) and can be used in various areas of human activity: communication, education, movement, production, treatment, in the list of objects and products labour, information, etc. For example, health promotion M., industrial production M., technical production M., main production M., media M., etc. In economics and finance, the term M. can mean funds, capital, loans, or their partial purpose, e.g. circulating M. …".

In the middle of the second decade of the current century it became impossible to neglect the evolution of Web cartography. Modern Atlas systems (AtS) could no longer be separate, independent of SpIS, such as OSM or Google Maps. This problem could not be solved without a revolutionary change in AtlasSF1.0 technology. A new AtlasSF1.0+ technology was developed and used to create APN&CH EA. Changes in technology have become revolutionary, which has also affected changes to the AtlasSF1.0 method. A domain of inquiry expanded, which, in turn, led to the generalization of the Map knowledge paradigm of cartography. That is, the basics of the AtlasSF1.0 method have changed. Thus, problem 2 of the article is defined here as the essence of revolutionary and actual changes in the AtlasSF method and technology/means depending on changes in IT and the paradigm of cartography.

The purpose of the research is: 1) to fix the existence of a new paradigm of cartography, which would be a follower of Model-cognitive, Language and Communication concepts/paradigms actual in the late 20th century; 2) illumination of the essence of changes in the AtlasSF method and technology/means depending on changes in IT and the paradigm of cartography.

Research methods

The AtlasSF method is used to create EA, which are a variety of SpIS. EA/SpIS are models of the modeled reality. The modeled part of reality in this case is useful to describe using the Spatial system (SpS). SpS is defined using [8] as an ordered pair (A, R), where A is a set of things, among which are spatial, and R is a set of relations between things of the set A, which form a unity or an organic whole. For example, the Electronic version of the National Atlas of Ukraine (ElNAU, [13]) is the model of Ukraine. Using ElNAU, the user explores the real "Ukraine" SpS. However, ElNAU was created using AtlasSF1.0. Such a simple chain of inferences allows us to understand why the AtlasSF1.0 method can be called a method of real SpS research.

To answer the question of how the renewed MCP is related to this and what it is, let us first recall that according to [14; p. 247] "A pattern is, if briefly, both a thing that happens in the world and a rule that explains how to create this thing and when to create it. It is both a process and a thing; both a description of the thing that exists and a description of the process that gives rise to that thing". This definition is another explanation for why AtlasSF is called a method, as it is an architectural pattern called a framework. At the same time, AtlasSF SoFr is a submodel of a more general pattern, which is called the Conceptual Framework (CoFr) of some SpIS, including EA. In the first chapter of the monograph [15] the structure of this framework is obtained for the example of ElNAU. The truth of both EA CoFr and AtlasSF SoFr was first proved by abduction, and later by induction and even deduction.

In particular, applied information science, now called Model-Based Engineering (MBE), has evolved over the past 20 years: "An approach to engineering that uses models as an integral part of the technical baseline, that includes requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle" [16]. Please note that all the most advanced product/system life cycle models necessarily include the research, development and support phases. MBE states that in each of these phases there should be appropriate models of the system under research.

Viennese diagrams are used in [17; Fig. 2.1] to show that MDA $\subset$ MDD $\subset$ MDE $\subset$ MBE, where MDA is Model-Driven Architecture and MDD is Model-Driven Development. However, more important for us is the "epistemological" relations between the models of two "neighboring" sets, for example, between MDA and MDD. J.-M. Favre [18] uses a very clear analogy of the MBE hierarchy with the four-cascade Egyptian pyramids to describe the essence of the "meta-step" pattern, which "works" between the models of neighboring "cascades".

But EA CoFr corresponds to the Favre's four-cascade pyramid, assuming that the lower cascade consists of specific implementations of EA. Since the map is part of the EA, the CoFr and the Favre's pyramid are valid for each atlas map. Thus on the lower cascade there are concrete implementations of a map, and on the higher cascades of a pyramid there are models of a map. Therefore, both constructions can be used to find a new paradigm of cartography. More specifically, we need a paradigm that would describe each implementation of both the electronic map and the electronic atlas in the form of components of the lower cascade of the Favre's pyramid or, what is the same, in the form of components of the CoFr EA Operational stratum.

The essence of the Atlas Solutions Frameworks method

The essence of any SoFr method is that for creation of a specific information object, it is needed a corresponding model, which accumulates basic system knowledge about the object itself. There are two important limitations to information objects and models: models must be patterns of object, and the transition from a model to an object must be an epistemological transition (reduction) only one cascade (stratum) down. The object can be a product, process, system or just another object/model, and the transition is described by the relations model-product/process, model-system, metamodel-model, model-implementation, method-means, etc. The described relation is called a dyad and is denoted by ↕. Another important property of the SoFr method is the dualism of product and process: a product cannot be created without a process, and a process makes no sense without a product being created. The described dyad and dualism must form a triad.

In the monograph [15] SoFr is considered in Chapter 3 as one of the main methods of Relational cartography. There, a pentagram of five packages of elements called Products, Processes, Basics, Services, and Publications is used to depict the scheme of the SoFr method. There are dependency/use relations between package elements that are specified as needed. The corresponding elements of the Products, Processes, and Basics packages and the relations between them form the main SoFr triad. This triad is described in the previous paragraph.

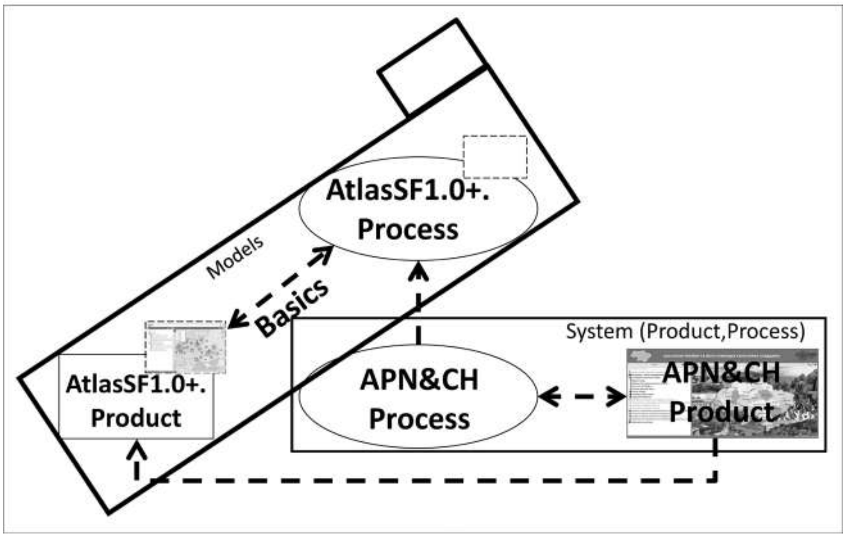

Fig. 2. The main triad of AtlasSF1.0+ SoFr on the example of APN&CH

The SoFr restriction of geo-information activities to create EA/AtIS is called the Framework of Atlas Solutions or, at the same time, the Atlas Solutions Framework (AtlasSF). The implementation of the AtlasSF method for a fixed set of IT is called here not just a means, but AtlasSF technology. An example of the main AtlasSF triad of activities to create APN&CH is shown in ***Fig. 2***. In all three editions of "our" AtlasSF1.0 technology K. Salishchev's Map knowledge was used, as it is allowed to create AtS which corresponded to two basic characteristics. First, the AtS maps were only "organically interconnected" and "complementary."

In the electronic implementation of AtS, the relations between the maps were reduced to maintaining the display state of each subsequent map depending on the current state: scale, extent, legend, map description. The more complex meaning of the relations of "interconnectivity" and "complementarity" did not have an electronic implementation. It remained in the intangible knowledge of the authors of maps, who were professional cartographers with knowledge of K. Salishchev's Map knowledge.

Second, the individual AtS maps created on AtlasSF1.0 were image maps. We get the best evidence from the experience of the ElNAU project. Let's start with the fact that the first paper version of NAU was released, and ElNAU was its image. In the ElNAU project 4 of 6 thematic blocks of maps were formed by maps in .swf format. This Adobe format is designed for high-quality contents visualization. Maps of the other two thematic blocks were in vector formats that reflected not physical but abstract magnitudes (for example, the population density in the region). The best type of such maps is a choropleth, for which the most important method is the formation of classes for display. Of the ten most popular choropleth classification methods of abstract quantities, the authors of such ElNAU maps used not formal (analytical) methods, but the so-called "author's" method. But the essence of the author's method is the "adjustment" of data to the image required by the author, if it is the main one for the author according to K. Salishchev's Map knowledge.

When creating APN&CH EA as AtIS [1] the modern variant of AtlasSF1.0+ SoFr was used. Let's explain this phrase with the help of Fig. 2.

On it: 1) the relations of dependence/use between the elements of the packages is shown by dotted arrows, 2) a specific product is shown by a rectangle (APN&CH Product), 3) a typical product is shown by a rectangle with a dotted rectangle at the top right (with the initial value of the pattern), 4) a specific process is shown by a simple oval, 5) a typical process is shown by an oval with a dotted rectangle at the top right (which means a parameter). A typical process is called a "specific methodology" in the definition of MSF or, alternatively, a "life cycle model".

The process of creating APN&CH Product was a concretization of a typical process of "staged delivery", when the final system (depending on the created product and the creation process) is supplied by stages with gradually increasing logical parts or versions. At the beginning of the project, the initial value of the AtlasSF1.0+.Product pattern was used to

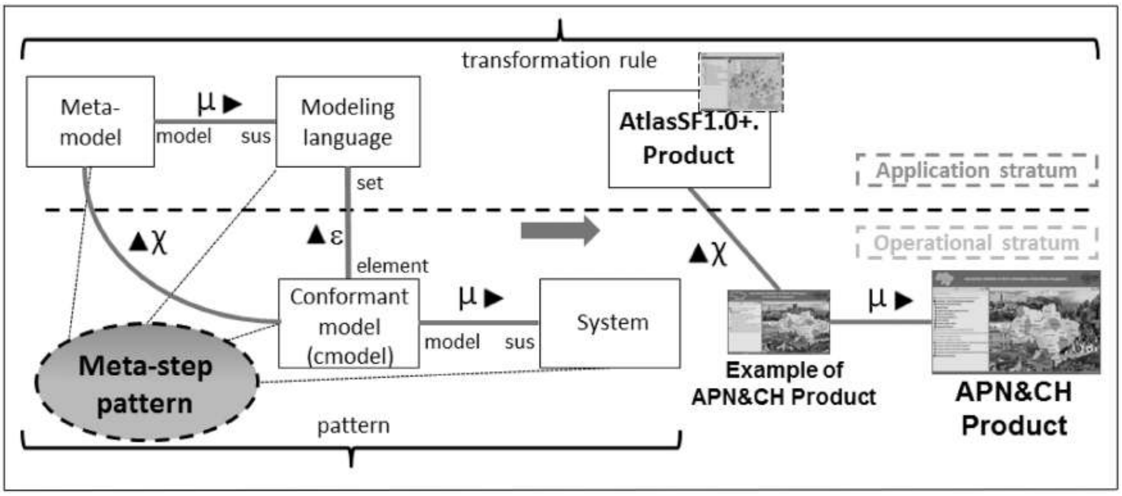

Fig. 3. The "meta-step" pattern and the transformation [18; Fig. 4, Fig. 6] on the example of "our" AtlasSF

obtain an Example of APN&CH Product, limited to several maps. It was then used to create a complete APN&CH Product using a specific APN&CH Staged Delivery Process. APN&CH AtIS is called an application APN&CH Product, created using AtlasSF1.0+.Product. This AtIS allows changes and they can be transformed into (operational) APN&CH EA Product. AtIS is epistemologically "higher" APN&CH EA Product.

Facts from MBE allow specifying values of APN&CH Product and AtlasSF1.0+ models and the relation *uses* between them (Fig. 2). In fact, this is the relations between the MDA and MDD strata models. The "revolutionary" of AtlasSF1.0+ technology is the implementation of one of the modern MDA. This architecture is called fractal MVC (Model-View-Controller), which allowing use MBE in full. The mentioned use relation clarifies ***Fig. 3****,* where [18]:

1. The model is a simplification of the system under study (sus), built taking into account the intended purpose. The model should be able to answer questions instead of the actual system. A metamodel is a model of a modeling language. Conformal model (cmodel) is a model that corresponds to a metamodel.

2. μ – RepresentationOf, model/sus. The model is a representation of sus. This relation is a key to modeling. Sometimes there are differentiations of specification models that represent the future system and descriptive models that describe the existing system. These associations can be represented as a specialization of μ. ε - ElementOf, element/set. This relation applies to the conception of set in set theory. For example, Ukraine is an element of the set of all countries; a JavaScript program is an element of the JavaScript language (languages are sets that should not be confused with models of these sets). χ - ConformsTo, metamodel/cmodel. This relation defines the notion of metamodel concerning to the cmodel. The cmodel must correspond to its metamodel. In fact, χ is derived from μ and ε.

AtlasSF and the renewed Model-cognitive paradigm

J.-M. Favre [18] argued that in the meta-step pattern (see left-hand side of Fig. 3) the conformsTo relation can be determined not only between the Metamodel and the Conformal model, but also between the Modeling language and the System, and even between the Metamodel and the System. It means that the conformsTo relation is not unambiguous. In the theory of Relational cartography [15] it is stated that these components belong to different but neighbouring "Application" and "Operational" epistemological strata.

In the monograph [15] it is proved that any AtS from the EA and AtIS sets consists of components of three levels or, otherwise, contexts: Datalogical level (Technological context, denoted D – Datalogics), Infological level (Language context, I – Infologics), Organizational level (Usage World context, U – Uselogics). Levels/contexts reflect three viewpoints on the AtS: D – developpers-cybernetists/programmers, I – developers-geographers/cartographers, U – users, who are usually ordinary end users, but they can be, in particular, these developers. Each level consists of its own set of components that are interdependent, and AtS is their union (∪): D∪I∪U.

In classic cartographies, such as Transformational cartography [19], AtS maps are created by transformations (→): PActuality → D→I→U → map(D∪I∪U), where PActuality is studied part of the Physical or Abstract-physical worlds (see below). In computer science, AtS/maps are created by inverse transformations (←): AtS/map(D∪I∪U)←D←I←U← Actuality, where AActuality is the studied part of the Abstract-physical or Abstract worlds (see below). That is, depending on the viewpoint for a particular AtS, the following records are valid: D⊂I(∪D)⊂U(∪I∪D) (geographers/cartographers) and U⊂I(∪U)⊂D(∪I∪U) (cybernetists/programmers). In successfully implemented AtS, the respective components of all three levels must be balanced with each other. The same is stated by the theory of Relational cartography [15], so AtS=D∪I∪U. Balancing levels does not mean that one of the levels should not be the main one. In this case, the main level is "accented".

In the work [20] on the example of an electronic map building it is shown how Transformational (Analytical) cartography correlates with the transformational relations of RelCa. It shows that the RelCa conception of levels/contexts can be applied to maps. For Analytical cartography, the Datalogics level is accented. This means that the transformations are carried out from left to right (→), but Datalogics (D) affects Infologics (I) and through it - the Uselogics (U). If we use the dependence/use relation (←), then for Analytical cartography PActuality←D←I←U. Therefore, for Analytical, Communicative/Cognitive and Critical paradigms from [6] the *Table 1* is valid, where for each of these paradigms the D, I or U levels are accented.

Critical cartography maps are easy to explain with the help of RelCa verification relations. The level U is accented here and for each map the (pseudo) verification relations D←I←U←AActuality are true. These relations are called (pseudo)verifications here, because levels I and D serve to justify the Map as Intent, and the intent may be incorrect. If we involve the dependence/use relation, then this idea will become clearer: D→I→U→AActuality. That is, if there is U map intent, then its Infologics (I) must use this intent, regardless of its "truth". In turn, Datalogics (D) must use such Infologics (I). In other words, you need to find data that would satisfy the Infologics (I) and through it - the Uselogics (U).

Due to the correspondence of A. Berlyant's Model-cognitive and Communicative paradigms to the paradigms shown in Table 1, they can be considered as explained from the viewpoint of RelCa. For the Communicative/Cognitive paradigm with an accented level of RelCa, there will be Informatics (I), and the Map as Image corresponds to the transformation relations D←I→U and the dependence/use relations D→I←U. However, the question remains: "Where is Language paradigm here?" (see Fig. 1). K. Salishchev's Map knowledge paradigm belongs to the Communicative/Cognitive paradigm, so this question is also related to Map knowledge paradigm. Their subject study is the Map as Image. To obtain a cartographic image, you need a cartographic language that will be used in each map for reading, visualization, communication, etc. In the Communicative/Cognitive paradigm, cartographic language is clearly not distinguished or studied. It exists only in the knowledge of adherents of this paradigm, knowing, how to use it.

However, (technological) cartographic languages exist. Thus, in the work [20] for visualization of the map is used mapping Leaflet JavaScript library [21]. With this library it is possible to build a set of maps, among which can be maps as images. If we say that each map on Leaflet is a sentence of its cartographic language, then the Leaflet library can be called a

Table 1.

Dominant in the last century paradigms of cartography from [6] and their correspondence to the "accented" levels/contexts of RelCa

[15]	[6]		
RelCa Levels/Contexts	Paradigm	Research focus	
		Making a map	Using the map
(D) Datologics/ Technological context	Map as Model (analytical tradition)	Data structure design, algorithm, development	Analytical modeling, hypothesis testing; model
(I) Infologics/Language context	Map as Image (communicative/cognitive tradition)	Design of visual symbols, use of colors, graphic hierarchy, drawing/basis	Reading, visualization, communication; metaphor
(U) Uselogics/ Organizational context	Map as Intent/Social construction (critical tradition)	Built-in distortions/ displacements, power relations, ethical considerations	Power and control, management, propaganda tool; myth

cartographic language.

The monograph [15] shows that SoFr methods are components of the Conceptual Frameworks (CoFr) method. The implementation of CoFr for many EA such as ElNAU was called EA in a “broader” sense and was denoted by EAb. ElNAU itself was an atlas from set of EA in the narrow sense (EAn). The structure of modern EAb is shown in ***Fig. 4***. For a wide range of inquiry domains, it is a SpIS of the “Atlas geographic information systems” (AGIS) set, which corresponds to the “Atlas geographic information models” (AGIM) set. Due to the limited scope of the article, we will focus only on the most necessary comments.

1. There are few grey scale colours which are used in the Fig. 4: 1) Silver (#C0C0C0) = RGB(192,192,192) (corresponds Green in RGB colours, O stratum); 2) Dusty Grey (#969696) = RGB(150,150,150) (corresponds Orange, A stratum); 3) Tundora (#4d4d4d) = RGB(77,77,77) (corresponds Blue, C stratum); 4) Mine Shaft (#292929) = RGB(41,41,41) (corresponds Red).

2. Each AGIS (2-dim AGIS/EAb) is an echeloned integrated SpIS (ISpIS), which consists of components of four echelons (from the user’s viewpoint) or strata (from the system’s viewpoint): O (Operational), A (Application), C (Conceptual stratum or Infrastructure echelon), G (General). The relation between the respective components of neighbouring strata/echelons is epistemological, where each hierarchically higher stratum contains more knowledge about the system S as one of the SpIS and as a component of the ISpIS.

3. The AGIS χ AGIM relation means that it is valid both for the complete AGIS system and for its strata and “on-stratum” components. For example, XYS χ XYM, where $X=D(O)\cup I(O)\cup U(O)$, Y=O, S - System, M - Model.

4. The Dusty Grey horizontal oval indicates the application AtlasSF1.0+ SoFr, and the Silver horizontal oval - the operational AtlasSF1.0+ SoFr. These SoFr (models $D(A)\cup I(A)\cup U(A)AM$, $D(O)\cup I(O)\cup U(O)OM$ and their relation to the systems $D(A)\cup I(A)\cup U(A)AS$, $D(O)\cup I(O)\cup U(O)OS$) are partly described above. The Mine Shaft colour shows the relations “external” concerning to the Operational and Application strata of system S. They clarify the previous description of AtlasSF1.0+ Atlas SoFr.

5. Transformation PActuality $\rightarrow$ DOS$\rightarrow$ IOS $\rightarrow$ UOS $\rightarrow$ EAn is described in [20] on the example of a map that corresponds to the Transformational (Analytical) paradigm. The Mine Shaft horizontal oval indicates map or AtS models that are fabricated according to Analytical (accent on level D and stratum O) or Communicative/Cognitive paradigms (accent on level I and stratum O).

6. The Mine Shaft vertical oval (accent on level I and stratum G) shows a map model or IGM, which

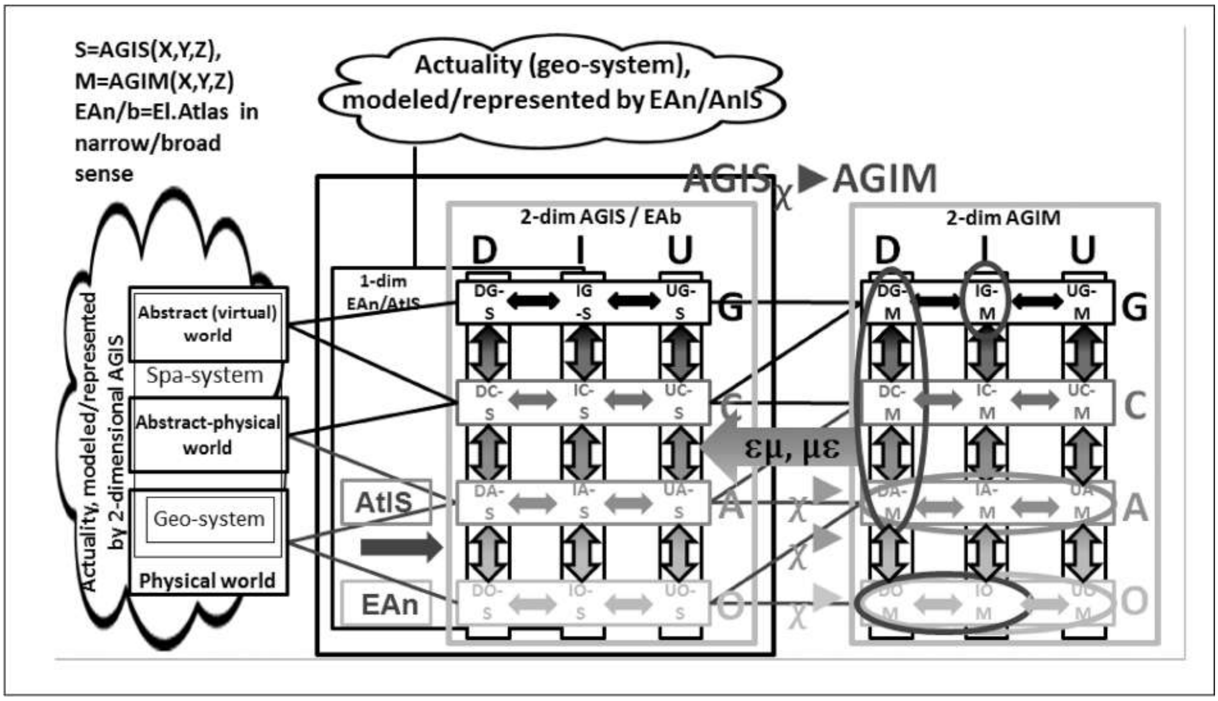

Fig. 4. AGIS structure and its AGIM models

are made in accordance with the Language paradigm of A. Liuty. This part of Fig. 4 explains that A. Liuty's Language paradigm is epistemologically "higher" than the Communicative/Cognitive paradigm. It also follows that the Communicative/Cognitive paradigm does not have its "own" Actuality for modeling, as [7] wrote. Therefore, this paradigm is not scientific, but only applied.

7. The Mine Shaft vertical oval (accent on level D) shows a very important construction, which can even be called the theory of Analytical relational cartography "Map Framework" [22]. In this monograph, general map models or DGM are abstract mathematical models, conceptual map models or DCM are discrete models of graph theory, application map models or DAM are implementation models of relational DBMS, between which there are RelCa inverse epistemological (reduction) relations. On implementation models, the algebra is constructed, based on the operators of intersection, relabel and refine, which apply to so-called "partitions".

8. MBE has a fair "mantra": models are "everything". In particular, languages are also models (see example in Fig. 3). Therefore, the renewed Model-cognitive paradigm of cartography is a combination of components of all shown in Fig. 4 Mine Shaft ovals plus as yet undefined ICM and IAM.

Conclusions

The novelty of the research. For the first time in the scientific literature, the idea of the existence of modern theoretical constructions of cartography that can initiate the creation of its new paradigm is expressed and substantiated. One such construction is the Map Framework, researched in the monograph [22]. It is shown that this Framework is accented by the Datalogical level of the Conceptual Framework of pattern-based Relational cartography [15], so it can be called Analytical relational cartography. If we supplement the Relational cartography with Analytical (subject) cartography, it will be possible to build both a renewed Model-Cognitive paradigm of cartography and System (or Systemic as minimum) cartography in general.

The renewed (reengineered) AtlasSF method/ pattern refers to the Application strata of theoretical-practical constructs of atlas cartography. In the renewed Model-cognitive paradigm, it allows to create Spatial information systems of the Operational stratum (Electronic atlases) and the Application stratum (Atlas information systems).

Scientific and practical significance of the research. The research indicates the direction in which modern cartography can exit from the 2010 crisis [15]. The practical significance of the research was proved by the creation of APN&CH [1]. Further usages of AtlasSF1.0+ will be more effective, and the final results of usage - modern EA and AtIS - will be better substantiated theoretically.

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ГЕОІНФОРМАЦІЙНИЙ АНАЛІЗ АНТРОПОГЕННИХ ЗМІН ЛАНДШАФТІВ ЛІСОСТЕПОВОЇ ЗОНИ УКРАЇНИ

Мета публікації – представити результати дослідження антропогенних змін ландшафтів лісостепової зони України, реалізованого шляхом оцінювання показників антропогенного перетворення, різноманіття і фрагментації (роздроблення) ландшафтів. Базові методи – геопросторовий ГІС-аналіз, геоінформаційне картографування. Результати оцінювання антропогенних змін ландшафтів Лісостепу України свідчать, що станом і на 1992, і на 2018 роки переважна більшість ландшафтів території є сильно та надмірно перетвореними внаслідок антропогенної діяльності. Такі закономірності зберігаються, незважаючи на те, що протягом аналізованого періоду спостерігається незначне зменшення антропогенного навантаження на ландшафти. Встановлено закономірні співвідношення між показниками антропічного ландшафтного різноманіття та фрагментованістю (роздробленістю) ландшафтів. Новизна дослідження полягає у запропонованих методичних прийомах оцінювання просторово-часових змін ландшафтів та у визначенні таких змін у ландшафтах на рівні фізико-географічних районів за період 1992-2018 рр. та розкритті трендів у структурі використання земель, насамперед сільськогосподарських угідь, лісів, забудованих територій як провідних типів землекористування у Лісостепу України.

Ключові слова*: *ландшафт; фізико-географічний район; антропогенне перетворення ландшафтів; антропічне ландшафтне різноманіття; фрагментованість ландшафтів; земний покрив; дані дистанційного зондування Землі; ГІС.