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CROSSCUTTING CARTOGRAPHIES: LANGUAGE PARADIGM IN PAST, NOW, AND IN FUTURE

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Crosscutting cartographies: Language paradigm in past, now, and in future

Abstract: "Crosscutting cartographies" notates conceptions and/or paradigms of cartography "perpendicular" in some sense to classic "subject" cartographies, such as the Communication paradigm. The examples in the "Western" scientific literature are Bunge's Metacartography and Tobler's Analytical cartography. We are naming also as crosscutting cartography the Language conception. A. Lyuty and J. Pravda, among others, were engaged in the research of the latter at the end of the last century in Eastern Europe. In our century, the Language conception did not evolve. There are only certain practical achievements that do not correspond yet to the level of theoretical achievements of the predecessors. Notions of conception and paradigm of cartography in this article do not differ. The purpose of the article is to restore due attention in the cartographic community to the Language paradigm, and with it to crosscutting cartographies. This purpose is important because the latter was and remains extremely important for the evolution of cartography as a science. The authors believe that in the near future the Language paradigm will evolve and, in many ways, thanks to this, the theory of system cartography will be created. The theory can become a "Cartesian multiplication" of some subject cartography and corresponding crosscutting cartography. Candidates for such subject cartography are updated Analytical cartography or Model cartography. Contenders for an appropriate crosscutting cartography are an updated Language paradigm or perhaps an updated Relational cartography. The work researched the evolution of the cartographic language and language of maps as the most important components of the Language paradigm. Aslanikashvili's cartographic method is used to research language structures that prevailed in the past. In particular, Ramírez's cartographic language is analyzed and its similarity to one of the two sublanguages of Lyuty's language of maps is shown. To study the state of the modern evolution of the Language paradigm, the so-called system cartographic method is used. It is a system generalization of the "classic" cartographic method of Aslanikashvili. First, it helps to explain a modern modification of Lyuty's "map making-using" system model. Then this method is used to find similarities between the classic Cartographic languages shown on the famous Kolachny's scheme and the constructions of Relational cartography. The system generalization of Aslanikashvili's cartographic method is also used to analyse the future evolution of the subject of this article. We see the future of Language of maps and Language paradigm in combination with Relational cartography and/or in integration with Model Based Engineering. In both cases, the result should be System cartography, in which the updated Language of maps and Language paradigm should be important parts. The results of the evolution of the Language paradigm described in the article assure that the latter should be and will be revived. In addition to its own need, it has every chance to become the second component of the Cartesian multiplication of one of the subject cartographies and the corresponding crosscutting cartography for the creation of System cartography. That is, such multiplication can become an analogue of System cartography, which can be the theory of cartography, still missing now.

Keywords: crosscutting cartographies, language conception/paradigm, overview the evolution: past, present and future

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Introduction and purpose and methods of research

From the viewpoint of cartographic systems, crosscutting are the cartographies perpendicular in the sense of (Klir, 1985), to subject cartographies. This statement follows from the Klir's classification of systems in terms of subjects and problems being studied, as well as the perpendicular classification of systems in terms of their structural (relational) properties. It is shown in the figure (Klir, 1985; Fig. 1.1). When using Klir's constructions, we usually mean cartographic systems instead of general systems, and instead of subjects/maps being studied. Such subject cartographies are communication, cognitive, and even geovisualization paradigms, shown on Fig. 1.

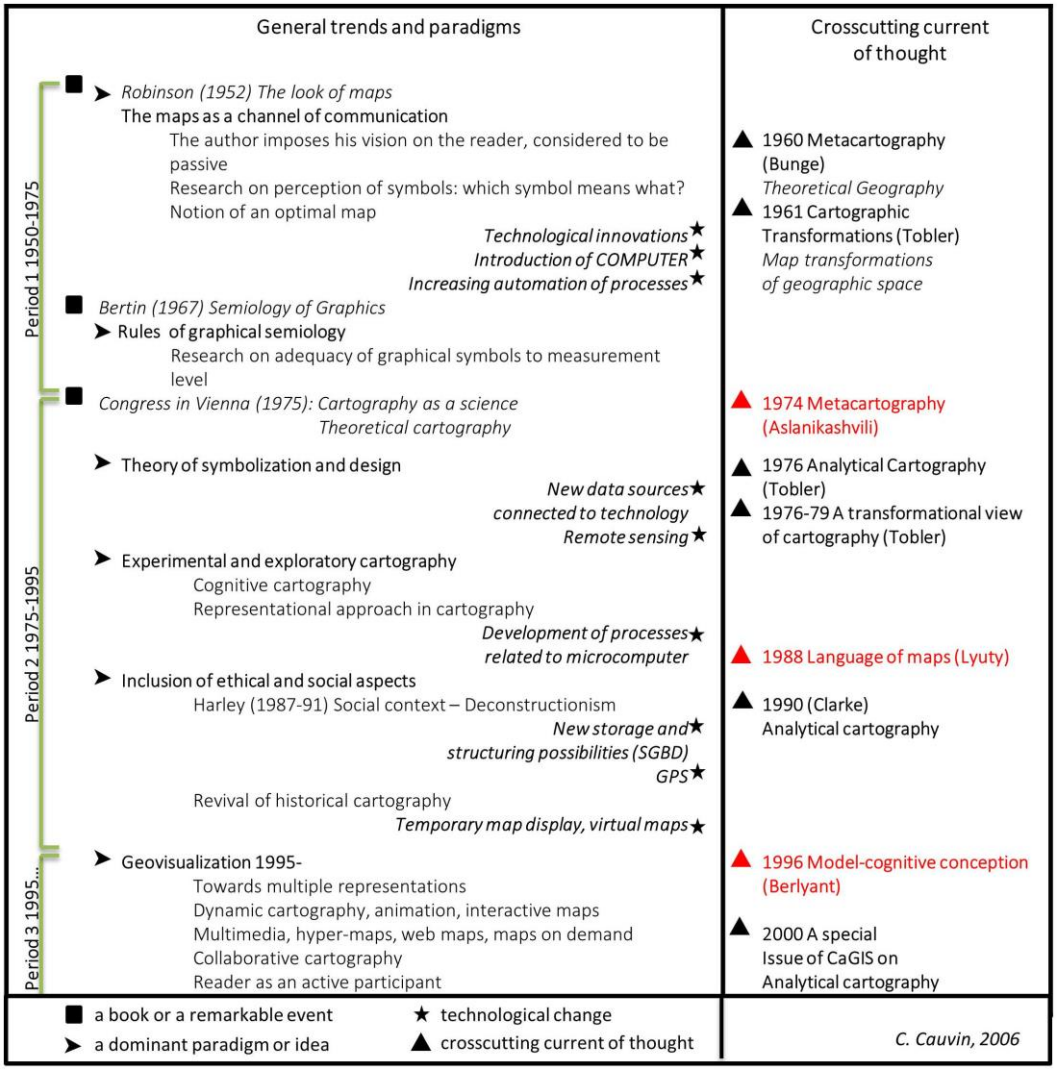

Fig. 1 Corrected cartographic trends and paradigms since 1950 following (Cauvin, et al., 2010, Fig. 1.2). Our additions is highlighted (*Remark to Fig. 1. Except of books, dates are only approximate and indicate periods, not exact years. The emergence of new ideas and paradigms does not necessarily imply the disappearance of the previous ones, which were more or less actively preserved*)

In cartography the term “crosscutting” comes from the name of the second column of the figure (Cauvin, et al., 2010, Fig. 1.2). We added in red the results from Eastern Europe and received Fig. 1. We emphasize that the Language paradigm of cartography in Fig. 1.2 was not mentioned. This fact testifies to the main **problem** of the work – the lack of due attention in the Western scientific cartographic community to the Language paradigm, although the latter was and remains extremely important for the evolution of cartography as a science. In particular, in Eastern Europe at the end of the last century, the Language paradigm was called one of the three main conceptions/paradigms of cartography (Berlyant, 1996).

In our century, the evolution of the Language paradigm was mainly carried out only in practice – through the creation and use of “map” programming languages. Specific examples include MapBasic from the MapInfo Professional software technology and the Leaflet JavaScript library. Although there are already attempts to treat these phenomena as cartographic Domain Specific Languages (DSL).

The problem is much more serious than the absence of a Language paradigm in one or another classification of cartography conceptions and/or paradigms. Which there have been many from the mid-50s of the last century to our time. The authors are sure the theory of cartography is now in the process of transition from object (subject) to system cartography. In other words, theoretical cartography moves from the study of objects (subjects) modelled by maps to the study of reality systems modelled by cartographic systems. If the specified transition will not be successful, the future of cartography as a science seems very doubtful. The Language paradigm in this transition should occupy a very significant place.

Taking into account the above, the **clarified purpose** of the work is to restore due attention in the cartographic community to the Language paradigm, and with it to crosscutting cartographies. Particular, the purposes are:

1. Tracing the evolution of the Cartographic language and the Language of maps.
2. Awareness that in our time the Language of maps as an important element of the Language paradigm should be a hierarchical linguistic or semiotic system crosscutting to the hierarchy of relevant subject cartographies.
3. Showing that the modern “crown” of the evolution of the Language paradigm is the Language of maps as a component of Model Based Engineering.

The research uses two **methods**:

1. The “classic” cartographic method described in monograph (Aslanikashvili, 1974).
2. System cartographic method, obtained by generalizing Aslanikashvili’s cartographic method. The generalization is described in the article (Chabaniuk and Rudenko, 2020). In short, the generalized method is applied at each of the three hierarchical strata, called α-, β-, and γ-strata, respectively. α-, β-, γ- systems, or α-, β-, γ- models are consistent with the indicated strata. Between the strata there are epistemological relations in the direction of vertical increase.

The best example of crosscutting cartography is Metacartography, which is an epistemologycally “higher” concept than any particular “subject” cartography. It best explains the concept of “crosscuttness” in cartography. Thus, (Bunge, 1962) in his Metacartography considered cartography on three interconnected hierarchical strata (bottom-up): premaps (reality), maps (cartography) and metamaps (mathematics). Transitions between objects of adjacent levels/strata were called “traverses”. If Metacartography objects are described by models, it is easy to find correspondence between the levels/strata of Bunge’s Metacartography with the Object, Model and Metamodel strata (van Gigch, 1991) or with the Operational, Application and Conceptual strata of Relational cartography (Chabaniuk, 2018a). (Aslanikashvili, 1974) considered the Language of maps as an important component of his Metacartography.

1. Crosscutting cartographies in the context of the Language paradigm

The first column in Fig. 1 is called “General trends and paradigms”. These trends and paradigms are subject, as they examine subjects – maps. (Cauvin et al., 2010) do not take into account the already mentioned opinion of (Berlyant, 1996) about belonging the Language paradigm to the main paradigms of cartography. Therefore, we consider their opinion to be partial, restricted.

We translated the term “crosscutting” into Ukrainian not only with the meaning “crosscutting”, but also with the meaning “intersecting”. The second translation gives an additional meaning to the understanding of the term “crosscutting”. These translations are our first attempt to explain the meaning of the term. Both translations are valid, especially if we accept our understanding of the Language of maps and the Language paradigm. Although, our understanding is still not widespread in the cartographic community. The second attempt to explain the meaning of the term through the understanding of the components of column 2 cannot be considered successful either. This is because (Cauvin et al., 2010) call crosscutting such theoretical constructions of cartography as Bunge's Metacartography, and Tobler's Transformational and Analytical cartography. None of these constructions is “popular” in the Ukrainian cartographic community, so their understanding, at least in Ukraine, is limited.

A third attempt to explain the term “crosscutting” is made according the (Conceptual Framework K-12, 2011). This explanation refers to concepts more general than those considered in this work, so we decided that it would overburden this article. Although interested readers can familiarize themselves with this third explanation of the “crosscutting” concept.

We use further two meanings of the term “crosscutting”: from the monograph (Cauvin et al., 2010), and one that satisfies our constructs from Relational cartography (Chabaniuk, 2018a). To syntactically distinguish the term “crosscutting”, we can use the term “intersecting” and write “Intersecting the flow of thoughts”. This translation we used in the monograph (Chabaniuk, 2018a; Chapter 2). We are sure that it is among crosscutting cartographies we need to look for the necessary second component of the future theory of cartography. If we have in mind only the “cartographic” part of the future system cartography, then the most promising of them is the updated Language paradigm of Lyuty.

At the end of the section, we are presenting Fig. 2 correspondence of the hierarchy of Bunge's Metacartography and van Gigch’s Metamodeling concepts. In its creation we used the system approach from (van Gigch, 1991). We applied the approach to the Language of maps as a hierarchy of three inquiring systems. Fig. 2 states that the inquiring system of Language of maps should be considered at three strata, called (van Gigch, 1991): Intervention, Object, Meta (see left). The middle on Fig. 2 shows the corresponding Metamaps, Maps, and Premaps in the terminology of Metacartography (Bunge, 1962). On the right, the definition of strata from (van Gigch, 1991) is shown, with examples of such strata values as metamodeling, modelling, and reality.

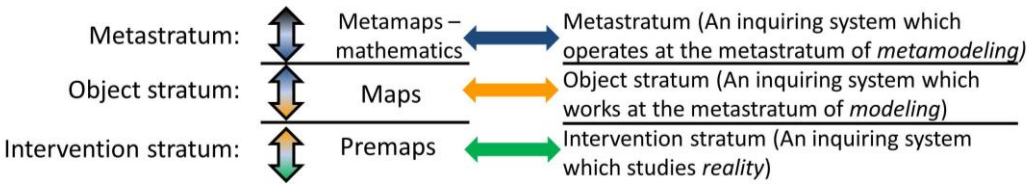

Fig. 2 Correspondence of the hierarchy of Bunge's Metacartography and van Gigch’s

2. Language paradigm in the past

This section uses the “classic” cartographic method described in the monograph (Aslanikashvili, 1974). The scheme of the method is repeated in (Chabaniuk and Rudenko, 2020; Fig. 5). There compared to the original (Aslanikashvili, 1974; p. 120), we replaced the Cartographic method of cognition with the cartographic method of cognition of the so-called geo-systems or α-systems. Such replacement is not a limitation of the method, since: 1) geo-systems or α-systems

include systems of “subject” maps, and with them the “subject” maps themselves; 2) the mantra “everything is a system” is valid here, from which it follows that the “subject” map is also a system.

According to (Chabaniuk and Rudenko, 2020; Fig. 5) the Cartographic method of cognition is a hierarchy (of sub-methods): Cartographic comparison, Cartographic analysis and synthesis, Cartographic abstraction and generalization, Cartographic modelling of geo-systems α-systems) and, finally, Cartographic method of cognition of geo-systems α-systems). All of them are based on Cartographic methodology (the unity of executive and technical methods). The pointed sub-methods are used in this section, although their use is not detailed. The main thing is the final result of the usage of the Cartographic method – the model of map obtained by the usage of the Cartographic method of cognition.

The “past” here means the last quarter of the 20th century. We consider (Ramirez, 1993), (Lyuty, 1988) and (Pravda, 1990) to be the most characteristic works on the Language paradigm of that time. Although in the presentation of the collection “Cartographic thinking and map semiotics” at the 17th International Cartographic Conference, Barcelona, Spain, 3–9 September 1995, three well-known cartographers at that time – Hansgeorg Schlichtmann, Alexander Wolodtschenko and Jan Pravda – defined the Map language (at that time) “as a system of map signs and rules of their use. The knowledge of this system enables anyone who wishes to do so (i.e. not only cartographers) to express spatial information in map form and/or to read and understand the map contents which are denoted by signs of map language” (see p. 1840 of conference proceedings). They believed that “there are currently three conceptualizations of map language: Lyuty’s, Pravda’s and Schlichtmann’s.”

The article (Ramirez, 1993) was published prior to the 1995 ICA conference in Barcelona, but was not highlighted by the cited there authors. Perhaps they decided that the conceptualization of R. Ramirez’s Cartographic language is no different from the conceptualization of A. Lyuty’s Language of maps. Instead, H. Shlichtman’s conceptualization of map language is included in the three conceptualizations. About the latter on p. 1840 proceedings of the conference is said: “Map symbolism (also called map language) is the type of semiotic systems on which map making and map use are based. It has been quite well studied over the past quarter century. The present author's conception of map symbolism – there are other conceptions – has first been published a decade ago (Schlichtmann, 1985) and has since then been broadened and refined”.

We highlight the work (Ramirez, 1993) for several reasons:

– The monograph (Lyuty, 1988) was not translated into English, so it is scarcely available to the English-speaking reader. And “conceptually” it is “similar” to the works of R. Ramirez.
– R. Ramirez (Ramirez, 1993) built a hierarchy of Cartographic language as one of the possible implementations of epistemological relations “from the bottom to up”, starting from the cartographic alphabet. (Ramirez, 1993) claims that his 5 cartographic hierarchical levels correspond to concept of structural Chomsky language (Chomsky, 2002).
– (Lyuty, 1988) also adhered to the hierarchy of linguistic systems, but outlined in the monograph (Stepanov, 1971). Perhaps that is why we can talk about the similarity of the conceptualizations of R. Ramirez’s Cartographic language and A. Lyuty’s Language of maps.
– It helps to understand better the monograph (Lyuty, 1988), which we consider not only the best representation of the Language of maps at that time, but also an introduction to the Language paradigm and an explanation of its importance for the theory of cartography in the past.

In the work (Chabaniuk, 2018b), the Cartographic language of Ramirez is considered using modern software geo-information tool - MapInfo Professional. Thanks to this, we suppose it "alive", implementable today on modern software technologies. Unfortunately, we do not have information about modern implementations of the Lyuty’s Language of maps. In general, as follows from the next chapter, the Language paradigm of cartography has not acquired today the evolution it deserves from the viewpoint of cartography theory.

Next, we will need the relations between Language of map/Cartographic language and models of actuality, which are shown in Fig. 3. When creating it, we used the required part of reality

(actuality, satellite image from World Imagery, ArcGIS Online, accessed 2024-jan-13, Model1), a part of topographic map (Model2) by Geomatic Solutions, LLC and the Cartographic language (modelling language) applied to the part of topographic map from (Ramirez, 1993). They correlate with an architectural plan (model) and its language (modelling language) from (Hinkelmann, 2016). The example uses terrain models that include the territory of the International Exhibition Center (IEC) near the Livoberezhna metro station in the Kyiv, as well as the territory on which there is a building that houses a store of the well-known in Ukraine retail chain "Novus".

On Fig. 3a, the satellite image of IEC in Kyiv, accepted from ESRI World Imagery with the help of ArcGIS Pro/Online at 2024-jan-13. It is used to represent actuality, which is modelled also by the part of topographic map by Geomatic Solutions, LLC (Fig. 3b). Note that both representations are models (Model1 and Model2) of the specified territory, however, in this work we do not dwell on the differences between these models. Let us point out only some differences between the data of the two models. For example, the part of topographic map by Geomatic Solutions (Fig. 3b) in fact does not have the one shown in Fig. 3a of the green zone, on the bottom. On Fig. 3b are shown only buildings and city blocks (areas) in order to better highlight the example of Skeletal Cartographic Information (SCI) from (Ramirez, 1993), which here is the 1st linguistic level. There should be no colour at the SCI linguistic level. It is an element of the map legend and belongs to the 2nd linguistic level – SCI + INI (Internal information). It is a part of essential cartographic information, the removal of which makes the spatial representation disappearing.

Model1 (actuality, satellite image, World Imagery, ArcGIS Online)	**Model2 (part of topographic map by Geomatic Solutions, LLC)**	**Cartographic language of Ramirez**
		SCI + INI + LOI + ECI + CCI – Level 5 (not shown in (b)) SCI + INI + LOI + ECI – Level 4 (not shown in (b)) SCI + INI + LOI) – Level 3 (not shown in (b)) SCI + INI – Level 2 (shown in (b)) SCI – Skeletal Cartographic Information (Level 1, shown in (b))
a)	**b)**	**c)**

Fig. 3 a) Model 1 – Actuality, b) Model2 – only objects of the SCI and SCI + INI levels are shown, c) Modelling language (Cartographic language of R. Ramirez) – Cartographic (linguistic) levels

Cartographic (linguistic) levels 3–5 from Fig. 3c are not shown in Fig. 3b. According to (Ramirez, 1993), their meaning is as follows:

– Level 3: SCI + INI + LOI - (Local information) is a part of essential cartographic information, the removal of which affects the perception of the local representation of the territory.

– Level 4: SCI + INI + LOI + ECI - (External cartographic information) is a part of essential cartographic information, the removal of which affects the global perception of the territory but does not affect the local representation.

– Level 5: SCI + INI + LOI + ECI + CCI - (Complementary cartographic information) is a part of the complete cartographic information, which can be removed from the map without disturbing essential cartographic information.

It should be noted that, in our opinion, R. Ramirez and A. Lyuty research two different languages. Without further explanation, we call the language of R. Ramirez by the Cartographic language, and the language of A. Lyuty by the Language of maps. At the same time, R. Ramirez's Cartographic language is a subset of A. Lyuty's Language of maps, at least because R. Ramirez studied only topographic maps, and A. Lyuty - arbitrary maps. The issue of differences between languages requires separate consideration, although our work contains enough information to understand the most basic of them.

One of the differences can be found on Fig. 4. On it, Ramirez's Cartographic language is similar to the Lyuty's SubLanguage of maps I - one of the two SubLanguages of his Language of map.

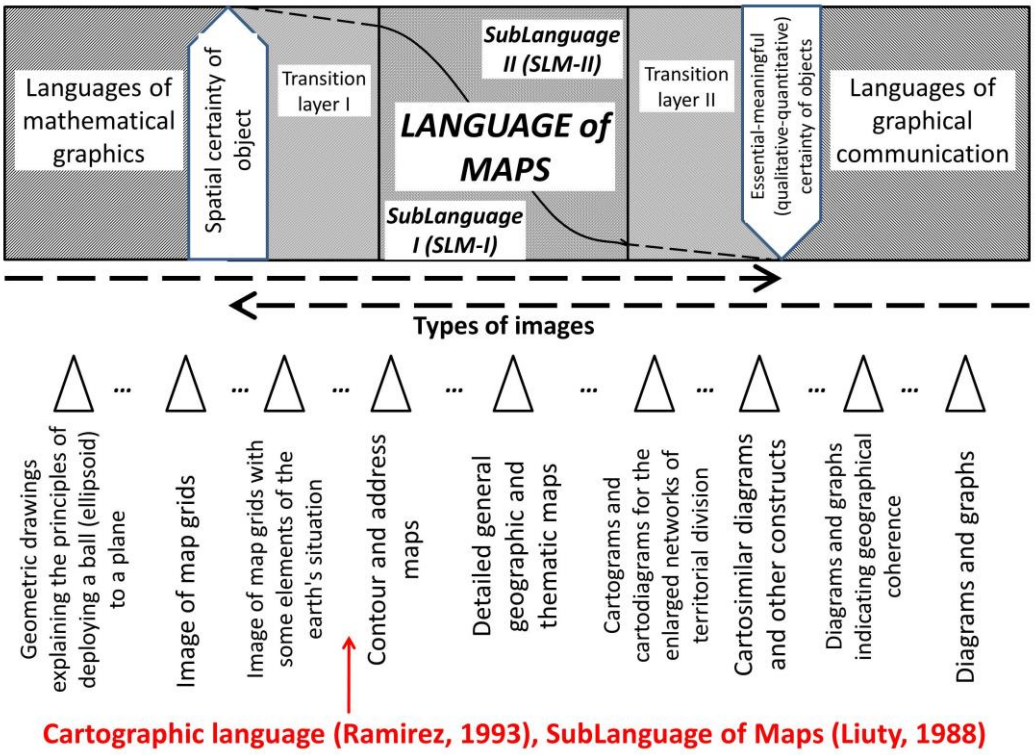

Fig. 4 The dual structure of the Language of maps and its "position" among other language systems (Lyuty, 1988; Fig. 9)

Fig. 5 shows the 5 levels of Lyuty's SubLanguage of maps I which correlate with the levels of Ramirez's Cartographic language. For explanation it is needed to understand "Grammar" (GraphoElements) and "Set of Places" levels below 1, 2, 3 levels of Lyuty. It's just that the content of these levels is somewhat different of Ramirez levels.

Unfortunately, we do not have enough space to examine in detail the grammars of Ramírez and Lyuty and compare them in order to prove similarities. Nor can we examine in detail the hierarchical constructions of language used by Ramírez and Lyuty. Let's just say that here we are talking about Chomsky's language structuring (Chomsky, 2002) used by Ramirez and Stepanov (Stepanov, 1971) used by Lyuty. Proving the similarity of the approaches is beyond the scope of this article.

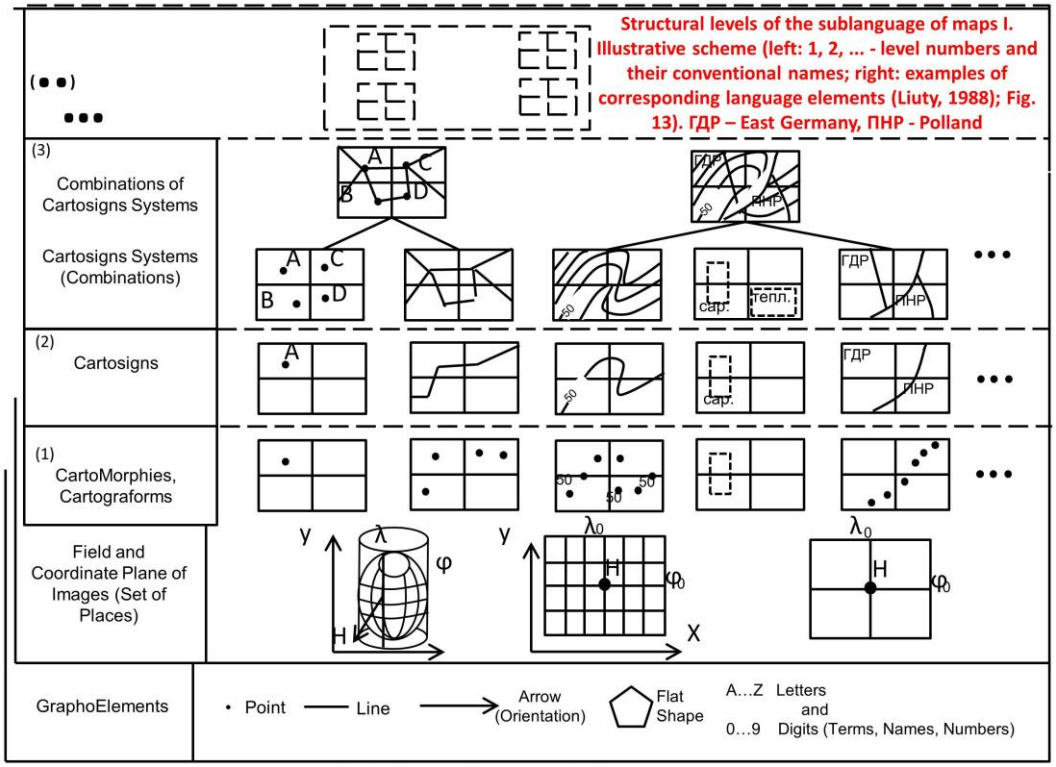

Fig. 5 Structural levels of the SubLanguage of maps I. Illustrative scheme (left: 1, 2, ... - level numbers and their conventional names; right: examples of corresponding language elements) (Lyuty, 1988; Fig. 13). ГДР – East Germany, ПНР – Poland

3. Language paradigm today

In this and the following sections, it is used a generalization of the "classic" cartographic method, described in the monograph (Aslanikashvili, 1974). The scheme of the generalized method is shown in (Chabaniuk and Rudenko, 2020; Fig. 6). Compared to the scheme of the "classic" cartographic method (Chabaniuk and Rudenko, 2020; Fig. 5), it is supplemented with two strata. The supplemented strata correspond to the β- and γ- strata of the inquiring systems. In short, the new strata are intended to represent strata epistemologically higher the α-stratum on which the "classic" cartographic method "works" used in the previous section.

The first quote from the previous section captures the essence of the "maps making-using" model. It became widely known thanks to the work (Kolachny, 1969). The main scheme of the latter was called "Communication of cartographic information", which was carried out from the cartographer (author) to the user (reader) of maps, which reflected the essence of the Communication paradigm of cartography. Several of its variants are given in the monograph (Lyuty, 1988) with reference to sources. Note that A. Kolachny showed two cartographic languages of: the cartographer (author) and the user (reader) of maps. This fact is "forgotten" in the schemes of many authors created on its basis.

The revolutionary nature of the results of A. Lyuty's monograph consists in separating the language of maps from the activity of making and using maps and proving the objectivity of the language of maps. Last should be a separate research subject. The modern vision of the "maps making-using" system model by A. Lyuty is presented in the work (Chabaniuk and Dyshlyk, 2016),

published in Ukrainian. Therefore, in this English-language work, we will repeat the argumentation used there to explain the modern vision presented in Fig. 6. The original model of A. Lyuty is also shown in Fig. 6. It can be presented if there to select and to arrange all records with references (Lyuty, 1988; Fig. 5).

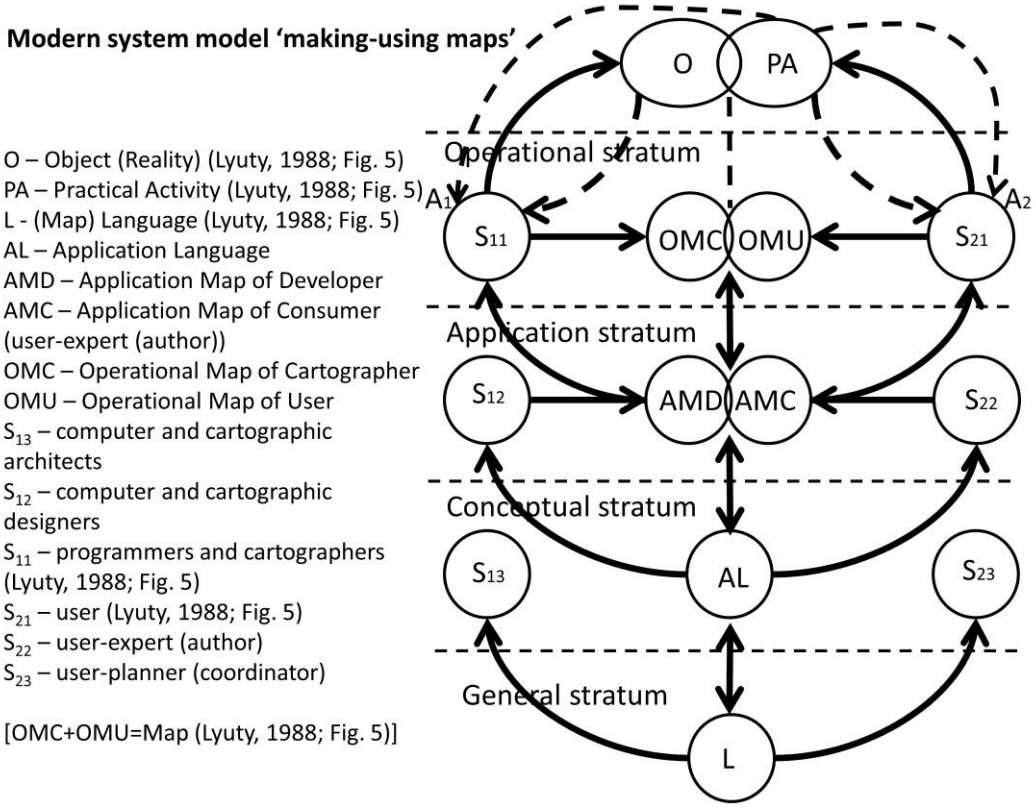

Fig. 6 Modern vision of the A. Lyuty's "maps making-using" system model

The creation of any Information System (IS), including Spatial Information Systems (SpIS), is carried out by performing three phases of design: conceptual, logical, physical. At each phase, a model, corresponding this phase, is developed. Models as the results of execution of design phases include model of maps corresponding to phases if SpIS is developing. The listed phases in Relational cartography are consistent with the strata: Conceptual, Application and Operational. In most models of IS life cycles, the conceptual model is a model of the subject area, and logical models can be called realizable or application models.

Conceptual model is very often called as conceptual scheme constructed using knowledge of domain and some conceptual modelling language. Nowadays, the most well-known such language is the Unified Modeling Language (UML). In simplified form it can be considered that modeling language of domain (UML for SpIS, Language of maps (L) for maps) is selected in General stratum and a conceptual model, which is an artefact of Conceptual stratum, is constructed with its help. Then the conceptual model implementation language, named application language (AL), is selected in Conceptual stratum.

An example of such an application language AL can be Visual Basic for SpIS (MapBasic for maps) or relational data model for databases DB. The result of the AL usage is a logical (application) model of the system or logical scheme of DB, received as the result of relational data model usage. Finally, the physical (operational) model can be a program that is performed, or physical DB scheme, implemented by means of a specific DBMS. Physical model or scheme refers to Operational stratum and/or physical design phase and then, to operational phase.

The following analogies are quite obvious. A. Lyuty's Language of maps is an artefact of General stratum. If it could have an implementation in any application language of Conceptual stratum, we could use it for construction of Application stratum specific maps. In order that the map could be used by end user, Operational models are required.

The relations between the maps of Application and Operational strata allow understanding with following analogy. A vector map can be considered as an application stratum map, for example, in the MapInfo Professional format or ESRI shape format. The map in shape format can be changed using many software tools, working with this format, such as ArcGIS or QGIS. Rasterized map image on a computer screen or printed on a paper will be Operational stratum map.

Let's make several principal remarks to Fig. 6:

1. In order not to overload the figure, we have not shown all relations. So, there are relations: 1) between groups of developers, 2) between groups of maps users, 3) between all groups of subjects (subjects-developers, subjects-users) and outside world (O and PA), 4) there are activators on practical activity (PA) for all groups of users, 5) others.
2. Unfortunately, developer rarely "feels comfortable" in each of three groups S11-S13. Most often, "per stratum" specialization leads to the fact that developers from different groups do not understand each other.
3. Relations between elements of various strata are shown as bilateral (for example, relations between L and AL). It is true, if to remember the relations of classification/instantiation.
4. We insist on the distinguishing between viewpoints of map developer and map user. That is why we have introduced weakly overlapping circles for displaying these viewpoints (see, for example, AMD and AMC). During "paper" epoch, the differences between these viewpoints were not so big. During "digital" epoch we talk even about various levels of maps existence: Datalogical (developer's), Infological and Organizational (user's).

Fig. 6 raises many additional questions about the elements/objects/components and relations between them of modern Language of maps. At the same time, it unambiguously states that we are dealing with the combination and/or integration of several components - languages of maps - and maps obtained with their use. The hierarchy of the components of the Language of maps is obvious, as well as the fact that integration is not "weak", as it was in the last century, but "strong". In short, Fig. 6 is a very simplified representation of the modern system model of "maps making-using".

4. Language paradigm in the future

Any current modern concept/paradigm of cartography should be if not integrated, then at least combined with modern information technologies. A simplified explanation of the difference in meanings of these terms is as follows: "As nouns the difference between 'combination' and 'integration' is that 'combination' is the act of combining, the state of being combined or the result of combining while 'integration' is the act or process of making whole or entire" (https://wikidiff.com/combination/integration, accessed 2023-nov-10).

We see the future of the Language of maps and Language paradigm in combination with Relational cartography (RelCa) and/or in integration with Model Based Engineering (MBE). In both cases, the result should be a System cartography, in which the updated Language of maps and Language paradigm should be some parts.

With the help of Fig. 7, we will explain what we mean by combining with Relational cartography. It is obtained from the scheme (Kolachny, 1969) by first "flipping" to 1800 with the replacement of the term "Reality" with "Actuality". This is because in Relational cartography, we show Abstract Reality on our diagrams from above, and Physical Reality from below. We replaced

Reality with Actuality, because all our research must be accompanied not only by theory, but also by (actual) practice. Then we took advantage of the fact of the theory of Relational cartography, according to which the map used by end users at the Operational stratum (OMM – Operational Map Model) is made (making) by cartographers at the Application layer, and then transformed into the OMM. At the same time, the cartographic language of “making” is used for AMM, and the cartographic language of "reading" is used for OMM.

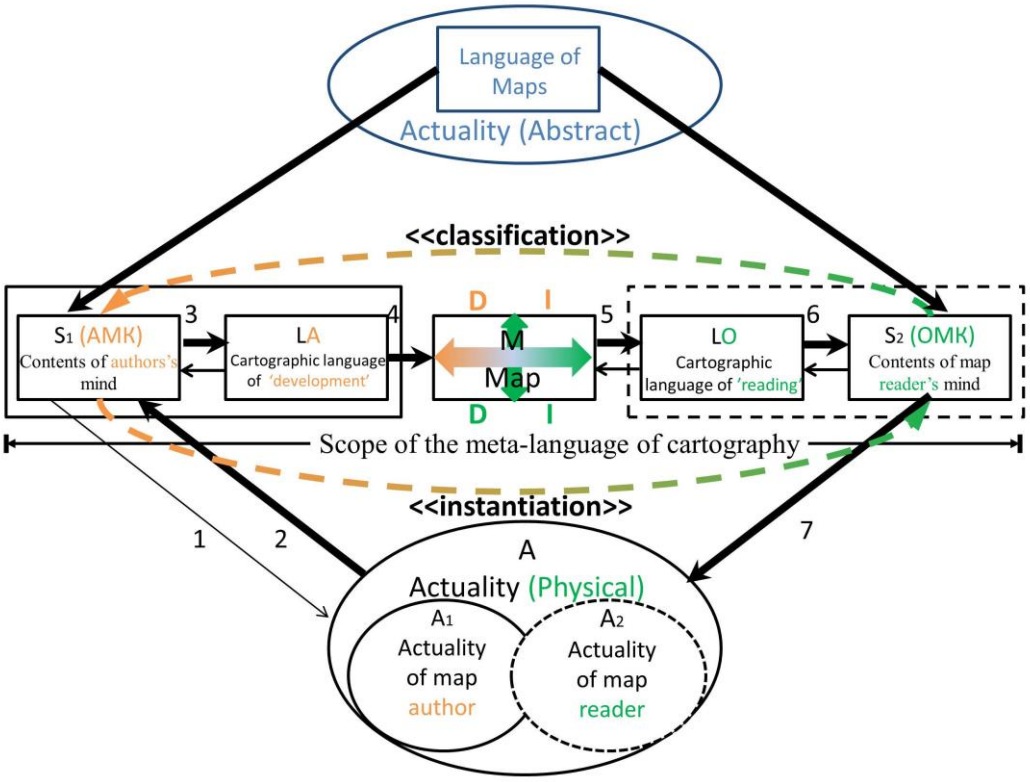

Fig. 7 Communication of cartographic information (Kolachny, 1969) from the RelCa viewpoint

At the same time, the map M (Map) itself should include both Datalogic (D) and Infologic (I) components, and both Application (orange color) and Operational (green color) strata.

The work (Chabaniuk and Rudenko, 2020) shows that the relational spaces and spatial systems of RelCa have a lot in common with the specific spaces of A. Aslanikashvili’s Metacartography. In particular, “if we consider only analog models of reality (for example, paper maps), then the coincidence will be complete. If we consider modern electronic models of reality, then the specific space of Metacartography is included in the relational spaces of RelCa”. To give another explanation of the term “metacartography”, let's use several well-known cartographic works. For this, we will use Fig. 8, which is obtained from the following schemes/figures:

– “Communication of cartographic information Ic” from the article (Kolachny, 1969).

– “Model of the ‘maps making – using’ system (author's version)” from the monograph (Lyuty, 1988; Fig. 5).

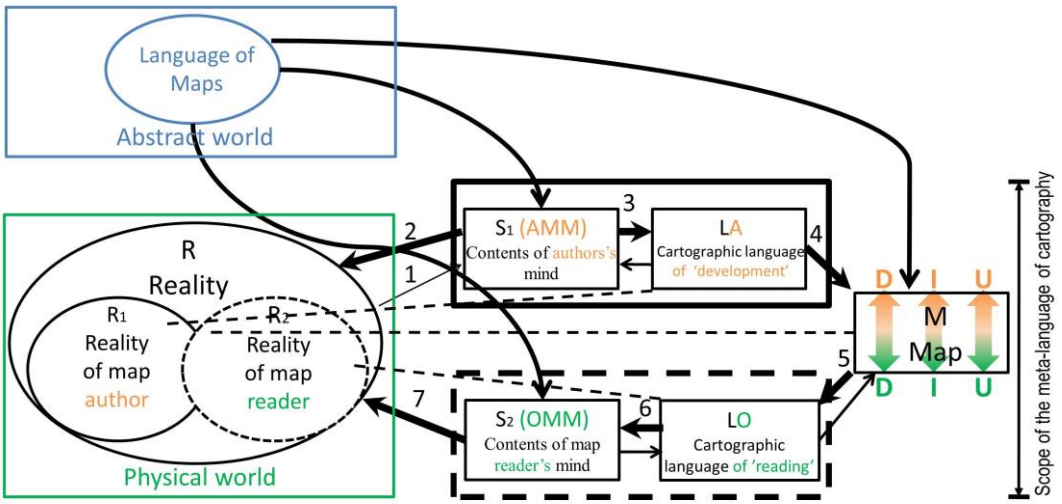

Fig. 8 Combination of Kolachny and Lyuty schemes/figures using RelCa

We expect that the interested reader will familiarize himself with the original schemes/figures and their descriptions from the cited sources, so we will comment only the main:

1. In the scheme (Kolachny, 1969): 1) there is no rectangle "Abstract world" and oval "Language of Maps" in it, 2) there are no other elements shown in black, 3) the figure itself is rotated 90 degrees counterclockwise so that the oval "R Reality" was on the left, in the "Physical world" rectangle, 4) S1 (subject 1 – author of the map) and S2 (subject 2 – reader of the map) in RelCa, we usually show on the right, respectively, in the Application and Operational echelons some (virtual) organizational system, 5) we left the elements of "L Cartographic language" in the same place as A. Kolachny, although he showed some relation to reality with dashed lines. At first glance, it seems that these languages should be attributed to our Abstract world and to the Language of maps by A. Lyuty, but this is not quite the case.
2. The oval "Language of Maps" and arrows from it are borrowed from the figure (Lyuty, 1988, Fig. 5). The oval is included in the "Abstract world" rectangle because Language of maps is an abstract system and thus an element of the Abstract world from Fig. 9. They are shown in blue color to: 1) note the absence of this element in the scheme (Kolachny, 1969), 2) in blue color in RelCa we mark the elements of the Conceptual stratum to which the Language of maps may correspond. Note separately that part of the picture/scheme (Lyuty, 1988, Fig. 5) is a simplification of the scheme (Kolachny, 1969). In particular, A. Lyuty removed the rectangles depicting the "Cartographic languages" L (the author and the reader) of the map M. Next, we explain how Language of maps and Cartographic language differ. A. Lyuty silences this question by comparing his figure with the figures of L. Ratayskyi, K. Salishchev, and A. Berlyant, which are repeated in the figure (Lyuty, 1988, Fig. 1). The latter are similar to the scheme (Kolachny, 1969), but they lack Cartographic languages L.
3. Fig. 7 shows the application of RelCa Conceptual Framework (CoFr) to the scheme of A. Kolachny: 1) the author of the map and its reader belong to the Application (orange color) and Operational (green color) echelons of users, respectively; 2) these users are dealing with elements of two different strata in RelCa terminology. For example, the cartographic languages for these echelons are different, so the letters A and O are added to L, 3) the representation of the map by users of the two echelons is different. Therefore, in parentheses after the presentations of the author S1 and the reader S2, the dependence on AMM (Application Map Model) and OMM (Operational Map Model), respectively, is added. OMM coincides with M (S(sus), if the studied system is the map itself); 4) each map in RelCa consists of Datalogics D, Infologics I and Usagelogics (Organologics) U; 5) in fact, there should be at least two

M maps: the author's map (AMM) and the reader's map (OMM). Therefore, two sets D, I, U were used - for each Application and Organizational strata. Arrows with variable color (from orange to green) between implicit elements show the classification/instantiation relation.

4. We emphasize that the classification relation is epistemological. It means that the AMM contains the knowledge of the map author, which is significantly greater than the knowledge of the OMM map of the map reader. It is quite obvious that in the scheme of A. Kolachny, the rectangle of the author (together with the AMM map) can be called the stratum of making (or mapping or designing or modelling) the map, and the rectangle of the reader (together with the OMM map) – the stratum of using the map or the real world of the map.

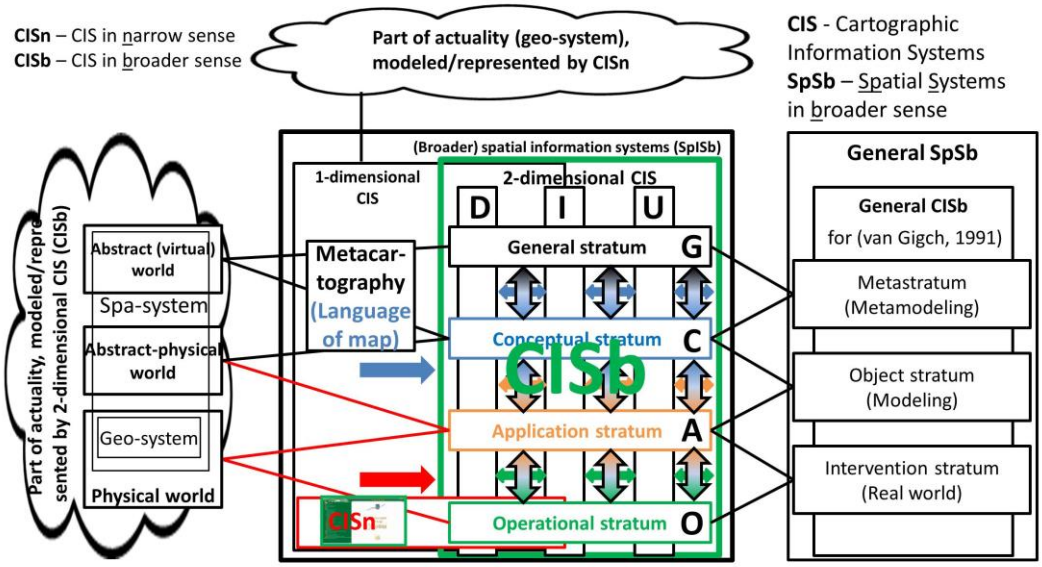

Fig. 9 The general scheme of the study on the example of arbitrary CIS (Chabaniuk, Rudenko, 2020; Fig. 2)

A more general version of Fig. 9 obtained in the work (Chabaniuk and Rudenko, 2020; Fig. 2) for Spatial Information Systems (SpIS), including CIS. It describes the meaning of letter designations, which are also used in Fig. 9. The letters D, I, U on the top are indicating so called RelCa levels: D – Datalogics (Datalogical), I – Infologics (Infological), U – Usagelogics (Organizational). The letters G, C, A, O on the right indicate RelCa strata: G – General, C – Conceptual, A – Application, O – Operational. We will use the presented construction to explain the concept of integration of Language of maps and/or Language paradigm with Model Based Engineering (MBE).

Language of maps in Fig. 9 significantly manifests itself at least twice: 1) in the linguistic (language) modeling of actuality systems, 2) in the modeling of CIS, starting with the Language paradigm of cartography, which is “accentuated” by Infological level I. The difference between linguistic and ontological modeling is considered in (Chabaniuk, Kolimasov, 2021). Following (Kühne, 2006), there is presented Fig. 10, clarified in Fig. 11.

The “accentuation” notion for the RelCa levels is used in (Chabaniuk, 2021). It is said there, that for the Communicative/Cognitive paradigm, the accented level of RelCa will be Infologics (I), and the Map as an Image corresponds to the transformational relation D←I→U and the same dependence/use relation. This record means that it is necessary to start with the Image of the map I, imaginary by cartographer, and then get its confirmation in Datalogics D or in Usagelogics U or both in sequence – D→I or I←U and vice versa. However, the question remains: “Where is the Language paradigm?”.The concept of "accentuation" of the RelKa level was used in the work (Chabaniuk, 2021).

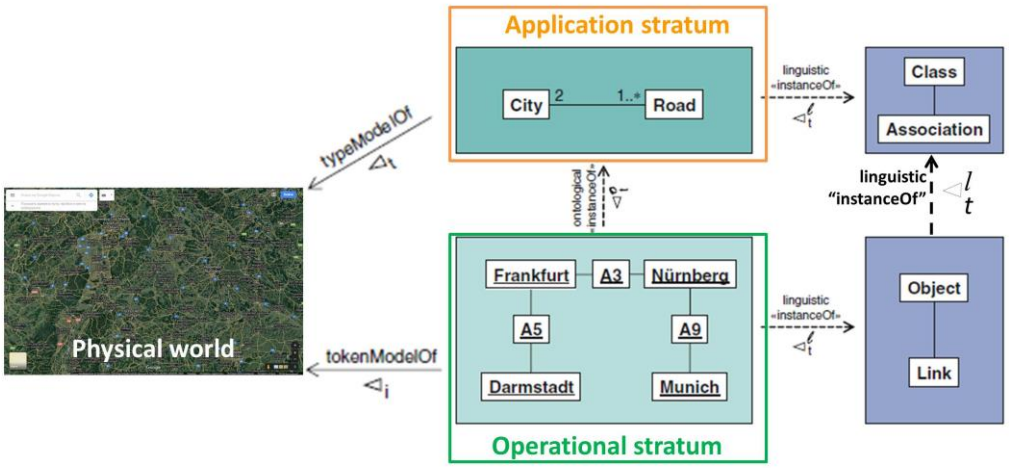

Fig. 10 The relation between the actual spatial system of the Physical world and its ontological and linguistic models of the Application and Operational strata, respectively. (Kühne, 2006; Fig. 2, Fig. 6) are used

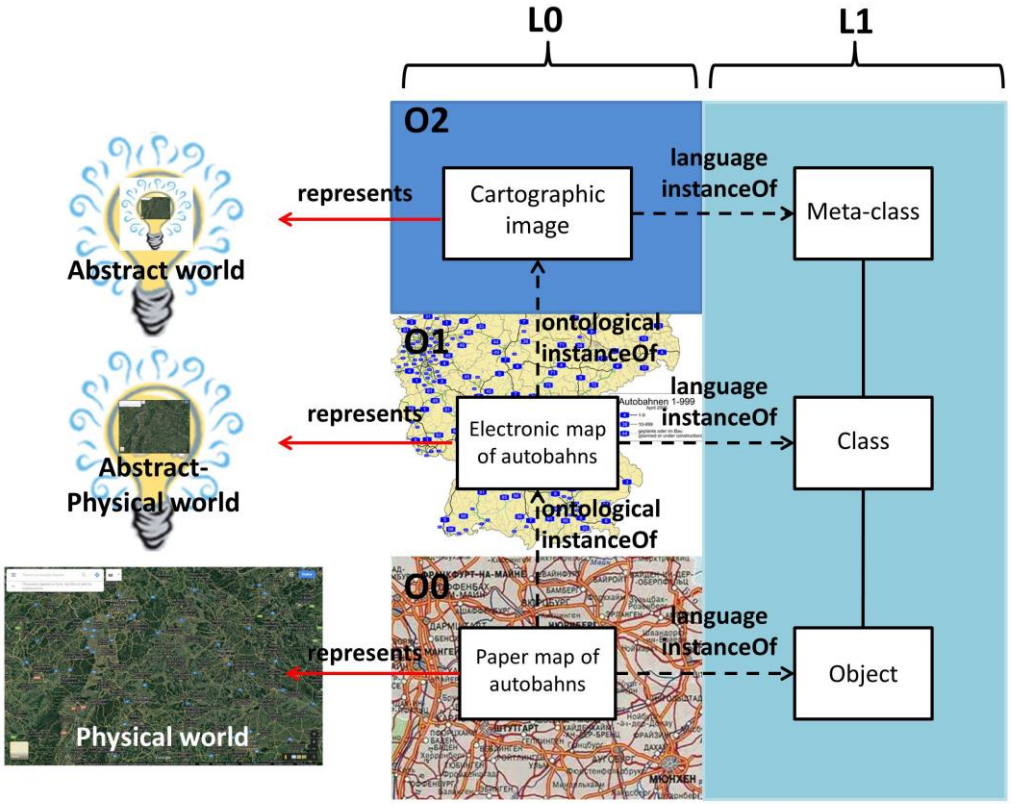

Fig. 11 Clarification of the left and middle parts of Fig. 10

K. Salishchev's Map knowledge belongs to the Communicative/Cognitive paradigm. Their subject of research is Map as Image. To obtain a cartographic image requires some kind of cartographic language that will be used in each specific map for reading, visualization, communication, etc. In the Communicative/Cognitive paradigm, cartographic language is clearly not singled out or explored. It exists only in the knowledge of supporters of this paradigm, who know how to use it.

In the article (Chabaniuk, 2021), we did not answer the above-formulated question regarding the Language paradigm / Language of maps. To do this, it is needed this article and an understanding of the two thoughs substantiated here: 1) Language of maps is an epistemologically higher concept than a specific map created with it, 2) after selecting information technology today it is needed to use the Map Application Language (MAL); the result of its usage must be operated by the Map Operational Language (MOL). Now we can offer the following schemes: DA→IA←UA, IA↓IO, DO→IO←UO. ↓ here denotes "instantiation", which can also be used for DA↓DO, UA↓UO.

In recent years, many results have been obtained in Model Based Engineering (MBE). Works on the use of MBE in geoinformatics have begun to appear (Alvarado, et al., 2022). Interestingly, there are already published works that can be attributed to Cartographic Domain Specific Languages (DSL) (Alvarado, et al., 2020), (Poorthuis, et al., 2020). In the work (Chabaniuk, 2018b), we performed the decomposition of the "language-knowledge" system (Fig. 12), using the works (Karagiannis and Kuhn, 2002), (Frank, 2011).

Fig. 12 substantiates the modern vision of the "maps making-using" system model of A. Lyuty (Fig. 6). It provides a lot of useful knowledge about the modern Language of maps.

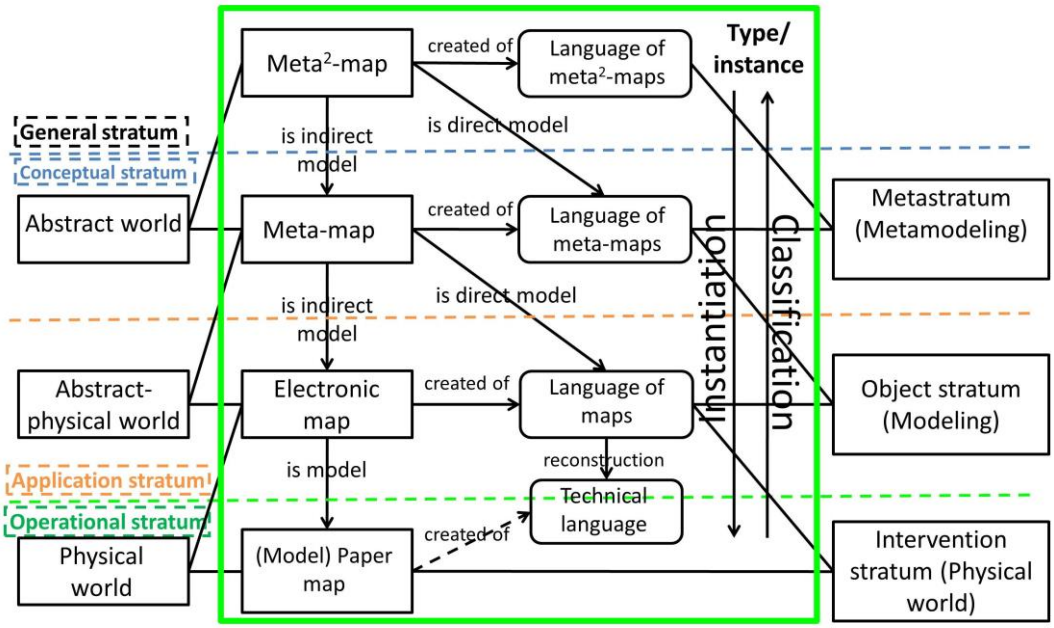

Fig. 12 Deconstruction of the "language-knowledge" system

5. Discussion

We understand that the material of the article will raise many questions from readers. We hope that the reason for this is not our mistakes, but the complexity of the question and our not quite successful presentation of the material. Especially since the limitation of the size of the article was "hanging" over us. Let's try to discuss some problems that may arise when reading the article.

1. The *first problem* is understanding the differences between the concepts of cartographic language and the language of maps. These are not the same thing, although "classic" cartographers rarely think about it. Let's say right away that these two concepts belong to two different epistemological strata. This means that we have two fundamentally DIFFERENT concepts, between which, however, there are specific hierarchical relations. "Classic" cartographers usually do not think about it. For them, the concept of stratum, higher than the concept on which they operate with a specific cartographic language, simply exists. Although this higher stratum does not simply exist. Cartographers are called "classic" precisely because they have a regular cartographic education, through which they receive knowledge of this higher epistemological stratum.

The most significant result of A. Lyuty compared to the result of R. Ramirez and others is the separation of the Language of maps into a separate research. For Lyuty, it sounded like a proof of the objectivity of the Language of maps, which other researchers did not talk about. This is clearly evidenced by Fig. 8 and its description. By the way, we ourselves used the term "language of map" for quite a long time until we came to the conclusion that it is necessary to use the term "language of maps", which means not one, but many (all?) maps.

2. The *second problem* is the recognition of the ambiguity of modern cartographic languages. We proved that cartographic subject languages exist for each of the strata: Operational, Application, Conceptual and General (Fig. 6). It is probably difficult to accept that, for example, the Application language of maps differs from both the Conceptual language of maps (located at a higher level) and the Operational language of maps (located at a lower level). However, this is exactly the case - Cartographic language is not the only one. There are several of them for the subject of each stratum. Moreover, the subject cartographic languages of each stratum are related with languages of neighboring strata.

3. The *third problem* is the understanding of the concepts of systematicity, system cartography and the participation in them of the Language paradigm and crosscutting cartographies. These are complex concepts, so for their explanation we are forced to involve the article of (van Gigch, 1993), which significantly uses what was said later in the monograph of (van Gigch, 2003) and in the already cited monograph of (van Gigch, 1991). We pay attention to the titles of articles and monographs. We can testify that these are not just names. They thoroughly explain the epistemology of concepts that are often used in our constructions.

In general, we explicitly or implicitly use van Gigch's system approach, which is to consider the higher-order system compared to the one under investigation in this particular context. Simply, A. Lyuty in his language of maps studied the metasystem of maps compared to some specific cartographic languages.

Let's not hide that the article is an overview. Although for an English-speaking reader, it is probably not just an overview, but an independent result, if we trust the Cyrillic-language scientific sources we used. Readers familiar with the works (Lyuty, 1988) and (Pravda, 1990, 1993a, 1993b), with our monograph (Chabaniuk, 2018a), etc., will have a better justification of the results. Obviously, because of the size problem, we didn't say everything we wanted to. Therefore, many remains perhaps not clear enough for an English-speaking reader who cannot check our reasoning in non-English-language sources.

Model-cognitive conception is shown as crosscutting cartography on Fig. 1. Its name is received from monograph (Berlyant, 1996), written in Russian. In English we recommend the article (Chabaniuk, 2021). There is proposed Model paradigm of cartography as renewal and evolution of Model-cognitive conception, Analytical and Transformational cartographies.

Conclusions

The work examines the evolution of the Language of maps and the Language paradigm of cartography as crosscutting and at the same time intersecting constructions of theoretical cartography are considered. Three periods of evolution are distinguished: past, now (present), and future. In the past period of evolution - the last quarter of the past century, attention was paid to work (Ramirez, 1993) and monograph (Lyuty, 1988). The main source for clarification is the monograph (Lyuty, 1988), which sets out the full Language of maps at that time.

In the modern period of evolution, the system model of "maps making-using" of A. Lyuty's has been updated. It is shown that in modern times the Language of maps is a hierarchical linguistic or semiotic system of several levels/strata, with which the general, conceptual, application and operational languages of maps are consistent. For this result, Aslanikashvili's system cartographic method was used, which was also used to justify the future of the Language of maps.

In the near future, the Language of maps can/should become one of the two constituents of system cartography as a theory of cartography. The first constituent of cartography theory can/should be one of Subject cartographies. The Language of maps as crosscutting cartography can become one of the constituents of System cartography through combination with Relational cartography (RelCa) or through integration into Model Based Engineering (MBE).

MBE is developing last few years or even decades, so the term has fixed. There are many sources the reader can easily find. This is a serious topic that needs a separate article. Therefore, we will not give even brief information about it.

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R e s u m é

Prierezové kartografie: jazyková paradigma v minulosti, súčasnosti a budúcnosti

„Prierezové kartografie" označujú koncepcie a/alebo paradigmy kartografie v istom zmysle „kolmé" na klasické „predmetové" kartografie, ktorou je napríklad komunikačná paradigma. Príkladmi v „západnej" vedeckej literatúre sú Bungeho metakartografia a Toblerova analytická kartografia. Prierezovou kartografiou označujeme aj jazykovú koncepciu A. Ľutého a J. Pravdu, výskumom ktorej sa venovali aj ďalší autori koncom minulého storočia vo východnej Európe. V našom 21. storočí sa jazyková koncepcia nevyvíjala. Existuje len určité praktické využitie koncepcie, ktoré však neodpovedá úrovni jeho teoretického prínosu. Pojmy koncepcie a paradigmy kartografie sa v tomto článku neodlišujú.

Účelom článku je kartografickej komunite prinavrátiť náležitú pozornosť jazykovej paradigme a s ňou aj prierezovým kartografiám. Tento účel je dôležitý, pretože ide o poslednú a stále mimoriadne dôležitú paradigmu pre vývoj kartografie ako vedy. Autori veria, že v blízkej budúcnosti sa táto paradigma rozvinie a vyústi do vzniku novej teórie systémovej kartografie. Tá sa môže stať „karteziánskym znásobením" predmetu kartografickej vedy a odpovedajúcej prierezovej kartografii. Kandidátmi na takúto kartografiu je aktualizovaná jazyková paradigma, resp. kartografické modelovanie.

Príspevok skúmal vývoj kartografického jazyka a jazyka máp ako najdôležitejších komponentov jazykovej paradigmy. Aslanikašviliho kartografická metóda sa použila na výskum jazykových štruktúr, ktoré prevládali v minulosti. Analyzovaný bol najmä Ramírezov kartografický jazyk a jeho podobnosť s jedným z dvoch podjazykov Ľutého jazyka máp.

Na štúdium stavu moderného vývoja jazykovej paradigmy sa využila tzv. systémová kartografická metóda. Ide o systémové zovšeobecnenie „klasickej" kartografickej metódy Aslanikašviliho, ktorá môže vysvetliť modernú modifikáciu Ľutého modelu systému „využívania mapy". Táto metóda sa použila aj na nájdenie podobností medzi klasickými kartografickými jazykmi zobrazené v známej Koláčneho informačnej schéme a v jeho konštrukciách relačnej kartografie.

Systémové zovšeobecnenie Aslanikašviliho kartografickej metódy sa použilo aj v analýze budúceho vývoja predmetu tohto článku. Budúcnosť jazyka máp a jazykovej paradigmy vidíme v kombinácii s relačnou kartografiou a/alebo v integrácii s inžinierstvom založenom na kartografickom modeli. V oboch prípadoch by mala byť výsledkom systémová kartografia, ktorej dôležitou súčasťou by mal byť „upgrade“ mapového jazyka a jazykovej paradigmy. Výsledky evolúcie jazykovej paradigmy opísané v článku naznačujú, že táto paradigma by mala byť, a my veríme, že bude oživená.

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