

Cartographic support of scientific and production activities: terminology, modeling and communication aspects

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Abstract: The paper presents the first steps towards the revision of the accumulated experience of cartographic support of scientific and production activities. The results of the bibliographic analysis of publications have shown that the term "support" is more often used as a synonym for maps themselves, thematic mapping and cartographic works for scientific and production activities. However, today, in addition to maps, users need spatial data and tools to work with them, so that geoinformation and information support related to GIScience, data science, AI, etc. are increasingly in demand. For this reason, cartographic science is faced with the task of maintaining the demand for cartographic support as a practical bridge between users and cartographers. A summarizing term is proposed that allows to consider cartographic support as a system process and activity. A conceptual model of the cartographic support system is developed. The model includes internal components – the result itself, paradigms (methods and concepts), data sources, technical means, and staff. Accordingly, the communication aspect of cartographic support is represented at the level of interactions between system components and at the level of human relations (dialog "industry expert – cartographer"). It is established that the state of each component generates the functions of support, influences its realization and demand for it in a certain historical period. The paper points out the need for further study of the Cartographic Support of scientific and production activities as a systemic process aimed at providing consumers with digital cartographic products and methodological tools for their use.

Keywords: Cartographic support, cartographic communication, scientific and production activity, terminology, user-oriented approach

1. Introduction

The implementation of global and regional sustainable development programmes, national economic sectors and individual areas of scientific and production activity can't be done without maps. Historically, one of the main tasks of a cartographer, as a highly qualified engineering specialist, has been to provide the user with tools that allow him to recognise the spatial, but also the content aspect of the object of study. Depending on the scientific and production activity, the object of study may be the geological structure of the Earth (geological exploration), ecosystems (environmental management), social processes (sociology), political processes (political science), etc. In any case, the provision of maps is always a priori and taken for granted. In reality, the identification and satisfaction of society's practical needs for a wide range of cartographic products is a complex process that requires specific feedback channels. Cartographic support is understood in this study as one of these channels.

Cartographic support is an important aspect of the production and use of cartographic products. It stands at the border between the real world needs and the theoretical world of cartography; in fact, it is a "bridge" that has been built over the centuries and still serves the realization of human tasks (from navigation to decision-making). However, its status and, above all, its demand in

the current conditions of rapid development of GIScience, Data Science, Geomatics and AI, require close attention. Today's practice needs spatial data (Apollo et al., 2023) and tools for working with them (including cartographic visualization). As a result, developments in the field of geoinformation and information support (in rare cases geomatics support) are coming to the fore. Since the state of cartographic support can be considered as a direct indicator of the demand for cartographic science in society, the maintenance of the functionality and the state of such a "bridge" is one of the key tasks of cartography in modern conditions of diversification of "transport flows" of the scientific and production activity needs.

The aim of the study is to identify current points of view on the question "What is cartographic support?" and to modernize approaches to understanding one (including its modeling and communication aspects).

2. Terminological aspect of Cartographic Support

2.1 About the word "Support"

Before starting the discussion, it seems necessary to state the basic understandings of the word "support" that are closest to the current context.

In English-speaking environment (according to “Oxford Learner’s Dictionaries”), the noun “support” means “*approval that you give to somebody/something because you want them to be successful*”. The verb “support” means “*to help or encourage somebody/something by saying or showing that you agree with them/it*” and “*to give or be ready to give help to somebody if they need it*”. In the Russian-speaking environment (according to “Big explanatory dictionary of the Russian language”), the noun “support” in its verbal form means “*to supply something in the required amounts*”, as well as “*that which ensures the safety, realization of something*”.

2.2 Input data

To assess the terminological aspect, contemporary publications containing the term “cartographic support” were analyzed. The results of bibliometric analyses of scientific publications in Web of Science, Scopus, ORCID, ResearchGate, Academia, other international and Russian scientific reference systems showed that the term is rarely used in the global community (e.g., Armstrong and Densham, 2008; Voženilek and Zajíčková, 2010; Jobst et al, 2021) and is largely associated with the use of maps. Semantic constructions such as “Cartography in ...”, “map-based decision-support system” are more common (e.g., Wong et al, 2007; Pipišková et al, 2022).

The situation is different in the post-Soviet countries. In particular, the term “cartographic support” and its different variations have been used in titles, keywords and abstracts in more than 400 publications of different levels (from abstracts to theses and monographs) in Russia during the last 30 years. Moreover, the number of such publications has been increasing every year for the last ten years, and they belong to different fields of activity (Figure 1). This shows the importance of this direction as an application of cartographic achievements in solving problems of various spheres of scientific and production activity.

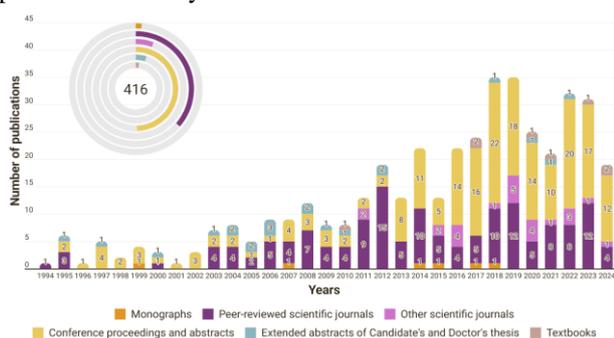


Figure 1. Number of publications on cartographic support of scientific and production activities in the Russian Federation

Due to the more representative sample (which may be due to the author’s wide access to publications in the Russian Federation), it seems appropriate to further characterize the main interpretations of the term “cartographic support” based on the experience of Russian researchers in order to achieve the goal of the current study.

2.3 Support as a Result

In the traditional Russian understanding, cartographic support means to produce and/or use the result of cartography for practical purposes. In this respect, in the vast majority of the reviewed publications, cartographic support is most often equated with the result of thematic mapping, i.e. with a thematic map. This approach has been and still is very widespread in Russia since the formation of the model-cognitive concept foundations was laid down by K.A. Salishev and his colleagues.

In publications from the early 2010s that deal with the issue of cartographic support for various spheres of activity (from cadastre and tourism to subsoil and environmental management), electronic maps, GIS projects, multimedia products, web mapping services, geoportals, mobile applications, etc. are understood as a result in addition to the traditional map. The same applies to foreign publications: e.g. the work (Beard et al, 2011), which does not focus on the numerous census maps themselves, but on the development of an automated cartographic system for their production.

The appearance of the above mentioned digital cartographic products among the results of cartographic support is a logical consequence of the improvement not only of the technical aspect of cartographic works, but also of the development of the paradigms of cartography itself. In particular, the variety of modern results of cartographic support has been influenced by the achievements of the concept of geovisualization, the foundations of which were laid by D. DiBiase, D.R.F. Taylor, A. MacEachren and later developed by M-J. Kraak, F. Ormeling, et al.

But is it only the form of the result that characterizes cartographic support?

2.4 Support as a Cartographic works

The transition of traditional cartography to a digital environment with the corresponding use of new technologies for creating, storing and providing access to digital cartographic products has been reflected in the normative field of Russian cartography since 1999. The State Standard GOST 28441-99 “Digital Cartography. Terms and Definitions” defines the term “(digital) cartographic support” as “*a set of activities aimed at creation, storage and delivery of digital cartographic products to users*”. This term implies that support is understood not only as a result, but also as the process of creating this result, i.e. the cartographic works.

Today, the technical side of cartographic work has completely shifted to the use of GIS and web technologies. This is proved by the analysis of modern cartographic work with spatial data on the example of geological exploration (Loginov, 2024). However, this situation is also typical for other areas of scientific and production activity, but a systematic approach to this transition is needed.

At the same time, the need to use database management systems, GIS, web technology, visualization tools and to provide access to spatial data is not only the soil for the

integration of cartography and modern ways of working with spatial data, but also, in many ways, the reason for blurring the boundaries of the understanding of cartographic support and, consequently, of the cartography as a science. The bibliographic analysis has shown that authors of publications often combine terms such as “geoinformation-cartographic” and “web-cartographic” support in an attempt to emphasize the use of new technologies in the production and use of maps and cartographic products. The popularity of such terms creates habits among users, so that cartographic products are more often understood as the result of independent directions, such as “geoinformation support”, “information support”. In this way, electronic maps, geoportals, web services, etc. are being associated with Geoinformatics, Data Science, but not with the cartography, which gives the average user an “ancient” feeling. Thus, modern cartographic technologies have intensified the problem that cartographic support is associated only with the result and with cartographic works that lead to this result.

2.5 Support as a System & Activity

The common interpretations of the term “cartographic support” do not allow, in our opinion, to describe the role that the cartographic support plays for the cartography. If we extend the understanding of cartographic support to the systemic activity aimed at implementing the tasks of scientific and production activities using the experience of cartography, the consensus between the accumulated experience and the current realities can be reached. In other words, it should be understood that cartographic support does not take place in the context of thematic mapping, but *in the context of scientific and production activities*. The purpose is not only to produce a map, but to use cartographic products to understand the meaning and spatial aspects of the object under study for decision-making.

The understanding of support as an activity (also in accordance with the basic terms of the English and Russian dictionaries) is the starting point for the application of the systematic approach and the formation of theoretical and methodological foundations of cartographic support. However, the transition to the activity aspect is a complex process that requires a rethinking of views on cartography and, in particular, on the map. The first steps in this direction have been taken in studies where the term “cartographic support” appears as part of the functions of the map. For example, Lyuty A.A. in his fundamental work on the map language (Lyuty, 2002) [p. 286], referring to the later works of K.A. Salishchev (1982, 1983), notes that within the cartographic concept “maps in their application are endowed with three main functions – communicative (storage and transfer of information), operational (direct solution of practical tasks), cognitive (for the acquisition of new knowledge in spatial research). Later, two more functions were specified – *constructive (cartographic support of various projects)* and *predictive (anticipation of unknown or not yet occurred phenomena)*”. The work

of U. Freitag (Freitag, 1993) can be interpreted in a similar vein. In addition to the cognitive, communicative and social functions of maps, he highlights the “*decision support function*”, which “encompasses all processes and operations which – based on evaluation of spatial phenomenon – result in spatial decisions and spatial actions”.

These examples can be seen as the first attempts to embed cartographic support in the system of map functions, i.e. to understand cartographic support as an important aspect of cartographic science. However, cartographic support should not be considered only as a function of the map, because as an activity it has its own functions in an era of diverse forms of cartographic products. For example, work on crisis management cartography points out that cartographic support is a specific activity that fulfils specific roles (visualization and communication) through cartographic visualization (Stanek et al, 2007), web maps and applications (Zupan et al, 2022). Cartographic support of protected area activities is also defined as a “practically oriented functional direction of cartography” (Alekseenko, 2019), which has two main aspects: a “systematic approach to the mapped phenomena and a systematic organization of the mapping process”. Cartographic support is considered in the same way by the new 2023 state standard GOST R 70955-2023 “Digital Cartography. Terms and definitions”, which defines (digital) cartographic support as “*a set of activities aimed at facilitating the solution of a wide range of tasks of users with (digital) cartographic products*”.

2.6 Proposed understanding of the term “Cartographic Support”

The above examples show that there are different interpretations of the term “cartographic support”. It seems important to create a generalized understanding of the term, which will make it possible to combine the accumulated experience of the implementation of support and to take into account the current conditions in which it is carried out. This is necessary not only to overcome the language barrier, but also to prevent the uncontrolled diffusion of cartography and technological trends related to spatial data.

As a starting point, it is proposed to understand cartographic support as *a systemic, socially oriented process that accompanies rational interaction with aspects of reality and decision-making within the framework of scientific and production activities through the creation and use of cartographic products with the help of various technical means*.

The definition captures the following key features of cartographic support:

- Systemic nature of the process – it is assumed that there are internal components whose interactions drive the whole system and allow it to respond to the impact of external factors in different historical epochs.

- A socially oriented process – the formulation of support tasks and their implementation are the result of communication between cartographers and industry specialists (user-oriented approach).
- Technical aspect of support – the structure, functionalities and the way of using technical means correspond to the specifics of the target activity and its changes over time.

3. Conceptual model of the Cartographic Support

The conceptual model of the system of cartographic support of scientific and industrial activities is shown in Figure 2. The system consists of the following components:

- Results (*R*) – system of output cartographic products and services.
- Paradigms (*P*) – theoretical and methodological foundations of cartography (“collection of principles, theories, methods, norms and standards” (Fairbairn et al, 2021)) and branches of science related to scientific and production activities.
- Data sources (*D*) – a set of information resources (cartographic materials, spatial data, Earth remote sensing, LIDAR, UAV data, statistical data, textual materials, etc.) used in the performance of scientific and production activities tasks.
- Technics (*T*) – software for processing, analysis, interpretation of data sources, modeling of research objects of scientific and production activity (including GIS & specialized software).
- Staff (*S*) – human resources that perform task formulation, its fulfillment and practical application of the results obtained in scientific and production activities (divided into Industry expert (*IE*) and Cartographer (*C*)).

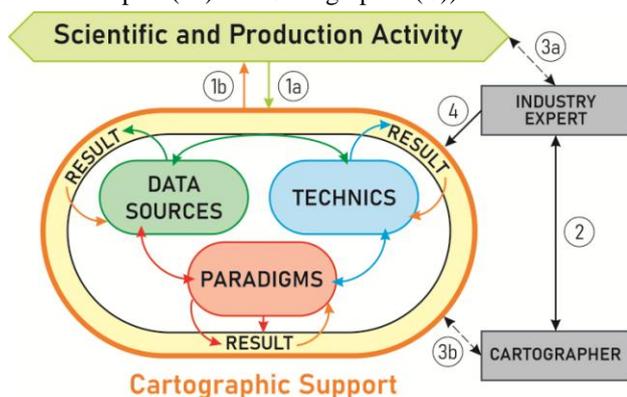


Figure 2. Schematic model of the Cartographic support system of scientific and production activities (digits describes in text)

The proposed model allows to describe, consider and predict the interaction between the internal components of the system and the main process actors – “Scientific and Production Activity” (*S&PA*) and “Cartographic Support” itself (*CS*).

The cartographic support process is carried out according to the following principle. The *S&PA* forms a request for *CS* (1a in Figure 2) to be provided with geospatial-based tools that allow to assess the spatial aspect of the research object in addition to specialized tools for studying the content aspect of the research object. For example, topographic maps were needed for the first mining operations, and the first methodological documents for mining maps developed. Responding to the request (1b in Figure 2), the *CS*, accumulating the interrelationships between the components within the system, prepares the result (*R*), the form of which is best suited to solve the task of *S&PA*. Simultaneously, interrelation provides for influence of cartographic support on the state of *S&PA*. For example, one of the first tasks of digitalization of the geological research process was the digital geological mapping (Whitmeyer et al, 2010).

The transfer of 1a and 1b interactions to the human relations (2 in Figure 2) is achieved by identifying main process actors with two states of the “Staff (*S*)” component – “Industry expert” (*S&PA = IE*, as 3a in Figure 2) and “Cartographer” (*C = CS*, as 3b in Figure 2). Modern technologies make it easier for the industry specialist to provide cartographic support himself (4 in Figure 2), i.e. to produce own map or cartographic product via specialized software or GIS. However, in such cases not only the quality of the final product may suffer, but also the role of cartographer in scientific and production activities can reduce. Therefore, the optimal functioning of the cartographic support system is achieved according to the following interaction formula:

$$(S&PA = IE) - (C = CS) \quad (1)$$

The activation of the process and the overall functioning of the system are achieved through the interaction of internal components. It is based on a complex interaction of the type “*D - P - T - R*”, which represents the process of cartographic work. Separate interactions (“*D - R*”; “*T - R*”; “*P - R*”) influence the properties of the final result of support; contribute to the improvement of other components (“*D - T*”; “*R - P*”), are responsible for the cyclicity of production processes (“*R - D*”), etc. Based on this understanding, combinations of interactions give to *CS* a set of functions (not map functions), including cognitive, modeling, communicative, social, organizational, managerial, etc., as well as other functions.

Separately, it is worth noting the specific links that can be formed within the components of the cartographic support system itself. For example, the “*P - P*” connection illustrates the formation of theoretical concepts through the disputes of different points of view on the subject and methods of a branch of science (e.g. model-cognitive and communication concepts in cartography, mobilism and fixism in geology, etc.).

“*T - T*” connection illustrates the processes of modernization of the functional capabilities of technical means), but also the competition between software developers. “*R - R*” connection – mutual transformation of forms of cartographic support results (e.g. creation of

electronic maps on the basis of scanned paper cartographic materials). “*D – D*” connection – conversion of information from one format to another (e.g. creation of digital surface models from vector data), data interoperability, OGC-services, etc.

4. Discussion

4.1 Communication aspect of cartographic Support

The proposed conceptual model emphasizes the communicative aspect of cartographic support as a socially oriented process that also includes user interaction with specific digital cartographic products and services. Consequently, the proposed scheme of the model is inspired by the legacy of the Commission on Cartographic Communication and the works of the main ideologues (A. Koláčný, L. Ratajski, A. Robinson, B. Petchenik, J. Morrison, U. Freitag, C. Board et al).

At the same time, the evolution of cartographic outputs also fits well with the paradigm of cartographic visualization. Thus, the “*IE – C*” interaction in the proposed model actually corresponds to the extremes of the “public – private” axis of A. MacEarchen & M-J. Kraak's (Cartography)³ cube of map use. The “human-map interaction” axis regulates the choice of output form from a static electronic map to web services and story maps. The axis “presenting the known – revealing the unknown” implies the opposite questions of using published cartographic products as sources and creating new cartographic products that reveal previously unknown aspects of the research object. In any case, the aims of cartographic products use (as results of cartographic support) also correlate with the C³ cube diagonal and can be represented at the level of exploration, analysis, synthesis or presentation.

The communicative aspect of the cartographic support system also implies interactions at the level of the technical process (e.g. “*D – T*”; “*T – R*”). Some of these interactions are responsible for the digital cartographic products transformations, i.e. they can be considered as a modern interpretation of the achievements of the Analytical cartography paradigm associated with W. Tobler, and in particular the concept of Real/Virtual Maps by H. Moellering. An attempt to illustrate the transformation of maps using the example of preparing a web service for cartographic support of geological exploration was discussed in detail in the author's previous work (Loginov, 2023).

Modern cartographic communication combines attempts to understand “how feedback from social media can be used more effectively to inform better map design and communication” (Kent, 2018). Therefore, current cartographic support should not do without the principles of UX/UI design (“User Experience” ICA commission works), issues of map design and visualization of spatial data (“Map Design”, “Visualization”, other ICA commissions), consideration of psycho-physiological aspects of the different cartographic products content perception (“Cognitive Issues in

Geographic Information Visualization” ICA commission works). Depending on the specifics of the scientific and production activities, other issues now on the agenda of the international cartographic community also become important. For example, for cartographic support of public processes (e.g. elections), the issues of cartographic ethics (“Ethics in Cartography” ICA Commission) and trustworthiness of maps (Gartner, 2022) are relevant.

4.2 The principle of historicism in the study and implementation of Cartographic support

The description of the main interactions has shown that the proposed model has an invisible “time” dimension. “Time” is expressed in the logical development, in the change of state of each system component at certain stages of the historical development of science, technology and art. It is clearly illustrated by the development of technical means used for cartographic work, but also by the expansion of cartographic products (including those presented at ICC map exhibitions). These changes, in turn, determine the implementation and demand for cartographic support in solving the tasks of scientific and production activities (it also undergoes parallel temporal changes, including the emergence of new requirements for cartographic products and spatial data). The precise adaptation of the internal components allows the cartographic support system to exist since time immemorial and to remain in demand when technological modes change – thus giving modern cartography flexibility in relation to current trends in the field of spatial data analysis and visualization.

Hence, the proposed model shows that the study of cartographic support of different epochs should use the historicism principle, according to which any historical phenomenon and event should be studied in accordance with the historical situation in their interrelation, interdependence and development. Thus, the thesis of the current study is confirmed that *it is a logical mistake to continue to look at modern cartographic support through the eyes of cartographers of the second half of the XX century* (including understanding the term “cartographic support” solely as a map). For example, the advent of GIS and web-based technologies has influenced the cartographic support system through its components. Thus, on the technical side, there are new means of producing and communicating with maps, what we know as web cartography. As noted with Tsou (Tsou, 2011), this direction has led to the growth of a user-centered map design (i.e. a new methodological approach) and a change in the vector of relationships within the “Staff” component. As a result, new digital map products (GIS projects, web maps, multimedia products) and new data formats (including those distributed under OGC standards) are shaping the face of modern cartographic support. However, over time (i.e. as each component changes), the core of the system remains the same. It is these changes within cartographic support that allow cartography to respond to new challenges.

So, it is necessary to take into account the evolution of all components of cartographic support, which led to the goal of the modern cartographic support process – to supply the cognitive aspect of scientific and production activities with the necessary geospatial tools, which are sufficient to reveal the internal processes of the research object and its adaptation to the production needs and practical needs of society.

It seems to be important for us to start the formation of research agenda of *cartographic support as a practice-oriented direction of theoretical cartography* now, when the principles of geovisualisation are being actively developed in the professional community (Krassanakis et al., 2023), while the scientists reflects on the current directions of cartography (Habib and Okayli, 2023), the role of maps (Fairbairn et al, 2021), and there's a debate on the status of Data Science, GIScience and other synthetic fields (Reitsma, 2012; Scheider et al, 2020; López-Vázquez et al, 2023) going on at the same time. Increased interest in revising the legacy of scientific theoretical schools of world cartography within post-representational cartography (Azócar Fernández and Buchroithner, 2013) and critical cartography (del Carmen Ernstberger et al, 2024) is also contributing to a refreshed perspective on the understanding and importance of cartographic support for cartography.

5. Conclusions

This paper is an attempt to systematize the experience of understanding the *nature of cartographic support* and its role in the development of cartography. The variety of interpretations of the term, mainly found in Russian-speaking cartography, confirms its complexity, but also its relevance as a means of communication between cartographic science and the outside world, and between cartographers and industry experts on a human level. The proposed conceptual model is the result of understanding the existing experience of implementing cartographic support in various areas of scientific and production activities (including personal experience in geological exploration). It is *an attempt to consider cartographic support as a systemic activity, a human-centered process*, which includes various components and their interactions, the development of which allows cartography to remain in demand in science, technology and art.

Like any first attempt (whether schemes of cartographic communication and the cartographic cube of map use), the proposed conceptual model is not without conventions and it needs to be discussed and refined. It seems important to start a comprehensive study of cartographic support for a number of spheres of scientific and production activities, including in the context of interregional differences of economy and management, decision-making, achieving the goals of sustainable development of the world, *to develop a unified theoretical and methodological basis of cartographic support as a practical mirror of cartography in the modern world*.

Why is it important? This is because cartographic support is not just one of the ways of providing scientific and industrial activities with spatial data and the means of using them. It is closely related to geoinformation, information and other types of data support, each of which is equipped with its own powerful tools and methods of related sciences (GIScience, information science, etc.). The evaluation of possible ways of adapting cartographic support to such huge neighbors under mutually beneficial conditions is the next aspect to which the author's research is devoted.

These questions are not the result of practical or theoretical curiosity. In the era of new technologies, it is essential to define the nature of cartographic support in order to keep cartography on the right track and not to lose its own “compass” for navigating the practical needs of scientific and production activities and to ensure the usefulness of cartographic methods for their tasks. *The stronger our views on the place of cartographic support within cartography, the stronger the position of our scientists and cartographers as specialists needed by various branches of science and technology to solve their tasks requiring the use of spatial data*.

There is no doubt that cartographic support as a practical process has also a theoretical potential. A striking example is the book “Mapping for a Sustainable World” (Kraak et al, 2020), which is nothing less than a methodological realization of cartographic support for sustainable development goals. The fact that the international community needs such a book shows that scientific and production activities need not only results, but also theoretical and methodological aspects of cartographic support. The principles of their identification and description are the subject of the author's current research, which I invite you to join.

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