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Digital economy and geoinformation technologies

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***Abstract* — The article characterizes the essentials and peculiarities of digital economy and lists its basic technologies. A hybrid space, formed by means of integrating a virtual space component into a real one, serves as its basis. The article underlines that in hybrid space, an object can acquire the properties of a subject; things can communicate with each other, the possibility to model everything that can be represented in formalized form appears. The article states the special role of geo-information technologies as the generators of special part of digital economy. For the first time the paper shows the changing of the role function of the geospatial branch in the process of changing the analogue economy to the digital one: from locating real objects of environment to forming spatial knowledge and management solutions as virtual prescriptive (normal) models to influence real objects. The article introduces a new notion of geo-cognitive technology as a special class of cognitive information technologies, related to perception and usage of geospace. The paper formulates three strategic goals of geospatial activity transformation for requirements and conditions of digital economy: the creation of the geo-informational digital platform, the development of cognitive formation and usage of technologies of unified geo-informational space (UGIS), the development of a number of "through" geo-informational technologies, providing service geospatial functions for different applications. The example of the transition of the concept to geo-cognitive technologies is the open high technology system for managing the region territory – "Smart region".**

Keywords* — *geoinformational space, normative model, descriptive model, hybrid space, geocognitive tecnologies, "smart region".

I. Introduction

The term "digital economy" is more and more conquering the vocabulary of the world community of scientists, politicians, businesspersons and journalists. One of the main reports of The World Bank (WB) in "World Development" for 2016 became the report of the digital economy condition in the world (it was issued by the heading "Digital Dividends"[1]). The notion of "digital economy" in this report is rather indistinct and this report does not give any distinct definitions of other basic notions. That is why the economists prefer to draw the essential of digital economy from comparison with essentials of so-called usual "analogue" economy – economic social activity, and also the set of relations, being formed in the system of production, distribution, exchange and consumption. And as long as the usage of computers, internet, mobile communication refers to the sphere of consumption and becomes actually the production power, this part of economic relations can be seen as digital economy. From this point of view, all human actions in computer virtual reality can be related to the system of production, distribution, exchange or consumption.

In spite of a rather wide number of viewpoints on the notion of digital economy, it seems possible to take into account different viewpoints and approaches and to formulate the general notion of it, of the basic concept, basic principles, statements and notions of it [2]). This basis allows us to put the question about the development of particular activities, gives reasons for concepts of new technologies, states new criteria and parameters.

The analysis of domestic and foreign literature of this sphere shows that digital economy in the narrow sense is the economy based on such digital technologies as internet trading, distant education, delivery of all kinds of information services, computer games, electronic mass media publications and so on. In a broader sense, the sphere of electronic economy implies such notions as "Big data" technologies, "Digital Earth", Internet of things, Industry 4.0 , "Smart City", "Smart Plant", additive technologies of prototyping and other virtual world realizations [3-6]).

Let us underline that previously, the virtual world component, being in human intellectual sphere, was only indirect productive power. In postindustrial times, the virtual component is integrated into reality, and it becomes possible to form hybrid space, combining real and virtual worlds, and representing the basis of digital economy [7]. The advantage of this world is the possibility to perform the most diverse manipulations with the virtual images of real objects and to realize verified and checked solutions in the real world. In this space, an object acquires the properties of a subject, things communicate with each other, and the possibility to model everything that can be represented in a formal view appears.

The information mentioned above concerns the sphere of geospatial activity, based on geoinformational technologies. They are actually becoming the generator of a spatial cluster of digital economy [8], as modern development of civilization together with new needs is characterized by increasing dynamic processes (including the changing of the territory), an increasing number of hazardous production facilities and technogenic load on the environment. Under these conditions, the potential of numerous geodetic and cartographic approaches is considerably exhausted. New computer geoinformational space models are required as they provide more details, accuracy and suitability to realia. It is important to renew geoinformation technologies that provide creation and implementation of a unified state geospatial basis, as well as geoinformation services for the widest range of applications [9]).

The special significance of mentioned transformations is conditioned by the circumstances given below.

II. Results and discussion

Geospatial IT together with digital economy have special significance for Russia, as its territorial, natural resource and industrial potential makes the basis of national wealth. That is why the implementation of purposeful and system-related spatial policy, taking into account the requirements of economic effectiveness is the state task of high priority. The rational use of spatial and territorial advantages becomes the most important principle of the economic strategy for RF subjects and the state at large.

The most important feature of Russia in comparison with other countries and regions is huge territory, characterized by a significant natural, resource and production potential, which significantly exceeds the percentage of similar components of the national wealth of other countries.

Another important circumstance is the comparatively very small population density within Russian territory. Therefore, one of the main results of the geoinformation industry transformation in accordance with the requirements of the digital economy is the high efficiency of development of the territory and resources.

For a more complete picture of the upcoming changes in geoinformation technologies in the digital economy, let us consider them in comparison with the geospatial technologies of the analog economy.

In the analog economy, the main role function of the geospatial industry was to determine the spatial position of the real objects of the surrounding world, involved in the economic activities of the society. This process was carried out by the subject - a person who owns a set of relevant geoinformation technologies.

As a result, information arrays were created, characterizing the location of objects and their parts in the form of catalogs of coordinates and maps of various details and accuracy, i.e. in fact, their virtual discrete models (Fig.1).

S_i – subject by number i, defining spatial data about objects (can be either a man or a robot);

O_r – subject by number r, the location and other parameters of which are defined by subject S_i;

T_{gd} – set of geoinformation technologies, used by subject S_i for obtaining spatial data about object O_r;

T_g – set of all possible geoinformation technologies;

D_{ir} – spatial data array, obtained by subject S_i as a result of implementation of geoinformation technologies T_g to object O_r.

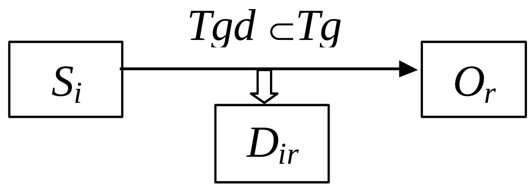

Fig.1. Obtaining spatial data about the object in the analogue economy

With the development of technical and technological capabilities, development of satellite systems for determining coordinates, methods of remote sensing from spacecraft, aircraft, unmanned aerial aircraft systems, ground-based laser systems, computers to process the data obtained, the productivity of labor was radically increased, but the role function remained unchanged. In fact, geospatial technologies in the analog economy provided a response in the form of information to the question "Where?".

The establishment of the digital economy with new information and communication capabilities, the concept of the "Hybrid World" caused, first of all, a change in the basic role function of geospatial activities.

Now this function is directed (Fig. 2) to the formation of spatial knowledge and management solutions in the form of virtual prescriptive (normative) models for influencing real objects and responding to the question "How?".

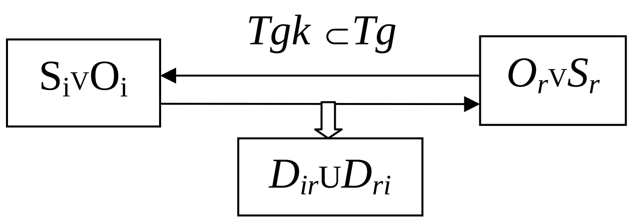

Fig.2. Use of spatial data about subjects and objects in digital economy

$S_i \vee O_i$ - subjects and objects by number i can be in condition of subject S_i or object O_i,

T_{gk} - set of prospectively developing geocognitive technologies,

D_{ri}- set of spatial data, obtained by subject S_r as a result of implementation of geoinformation technologies T_g to object O_i,

$D_{ir}UD_{ri}$ – united set of spatial data, obtained as a result of communicative interactions between subject and object $S_i \vee O_i$ and subject and object $S_r \vee O_r$.

Geoinformation technologies T_{gk}, included in T_g, ensure the achievement of the objectives of subjects, associated with the use of the surrounding space and based on spatial knowledge and intellectual methods, methods and algorithms. In this regard, they acquire the properties of cognitive technologies, the essence of which is the use of data "on the processes of cognition, learning, communication, and information processing by a person" [10], and which are built on the formalization of human cognitive abilities [11].

Thus, this subset of geoinformation technologies T_{gk} can be represented as the intersection of sets of geoinformation T_g and cognitive T_k technologies, i.e. $T_{gk} = T_g \cap T_k$.

In this regard, in the authors' opinion, it is advisable to introduce a new concept of "geocognitive technologies", reflecting the features of the use of spatial data in the digital economy and that are included in a special class of cognitive-information technologies, related to the perception and use of geospace.

It should be emphasized that geoinformation and geocognitive technologies acquire a special role in the discourse of the intellectualization of the economy, using the concepts and terms "smart" (smart data, smart models, intelligent habitat, such as the organization of movement of disabled people, orders and delivery of goods and exercise services through the Internet, etc.), smart industries (smart factories, intelligent transport, smart industries, etc.), smart territories (smart region, smart city, smart quarter, smart crossroads, etc.) [12,13,14].

As an example, let us consider the place and the role of the geo-information industry in the concept of "Smart City" (Fig. 3).

It can be seen from the figure that at the first stage, with the help of a set of geoinformation technologies Tgd, a transition is made from the real to virtual world, the result of which is the construction of a single geoinformation space of the city as a digital model of the object-subject space of the city. Then, on the basis of this model and still within the virtual world, effective spatial solutions are already developed using the geocognitive technologies of Tgk, which are transferred to the space of the city's life for further implementation in a real object-subject space.

The implementation of a new approach to geo-information support of the digital economy provides the implementation of several strategic goals.

As the first strategic goal in the formation of the digital economy, it is necessary to set the creation of a geo-information digital platform that provides the solution of the entire spectrum of spatial problems in the interests of the economy, government, society and individual citizens.

The second strategic goal is the development and implementation on the basis of the created platform of geocognitive technologies for the formation and use of a united geoinformation space (UGIS) as a system of computer mapping of real and virtual spatial objects that would include geoinformation resources, information and communication tools and geoinformation infrastructure.

As a structure, UGIS represents a set of geoinformational dynamic and/or static 4D-models of territories; spatial data arrays encompassing ground; underground and aboveground space, connected with each other by a single coordinate net and single infrastructure of spatial data that allow one to display and process spatial objects simultaneously from different data arrays of any scales, including the arrays of different user-related data.

Formally, the essence of UGIS can be presented in the following way.

Each subject-object $S_i \vee O_i$ can correspond to a unified set of spatial data by formula:

$$S_i \vee O_i \Leftrightarrow \bigcup_{r \in R_i} \left(D_{ir} \cup D_{ri}\right),$$

where R_i - set of subject-object numbers $S_r \vee O_r$, connected by interaction with subject-object $S_i \vee O_i$.

In this case, geoinformation space SD that encompasses all subjects - objects $S_i \vee O_i$, interacting in the economy with quantity N, will represent the set of spatial data obtained by formula:

$$SD = \bigcup_{i=1}^{N} \bigcup_{r \in R_i} \left(D_{ir} \cup D_{ri}\right).$$

Therefore, the geoinformation space is formed and maintained in the digital environment and is intended for setting up spatial and spatial tasks and developing their solutions. A number of effects are achieved in this case:

- provision of up-to-date [15] reliable, accurate and complete information of all types of economic activity in the territory;
- provision of modeling and forecasting of the consequences of the adopted spatial and economic decisions, risk calculation, early warning of crisis situations, etc.;
- qualitative growing level of information support for the management of territories and fast processes;
- integration into a single information format of a wide range of information arrays and models [16], reflecting real and virtual territorial space for effective interaction of all participants in economic activity.

The third strategic goal is the development, based on the digital platform created, of a series of "end-to-end" geoinformation technologies that support the implementation of service geospatial functions within a wide range of applications.

One of the examples of realization of the considered concept of transition to geocognitive technologies can be the development of a pilot project in the Siberian State University of Geosystems and Technologies (SGUGiT) of an open high-tech system for the management of the territory of the region. The project is aimed at creating a fundamentally new standard technological system of information and analytical support for the functioning of the social and economic complex of the subject of the Russian Federation ("Smart Region") based on the principles of intellectualization of solution, preparation, rational nature of management and innovative geospatial solutions. The system is based on the formation of a single geoinformation space, access to it in real time on a single space-time coordinate basis and spatial data infrastructure. The geoinformation space in combination with intellectual geoinformation technologies of spatial solutions development allows one to transfer to a new level of all types of industrial, managerial activity and a sphere of vital activity of the population.

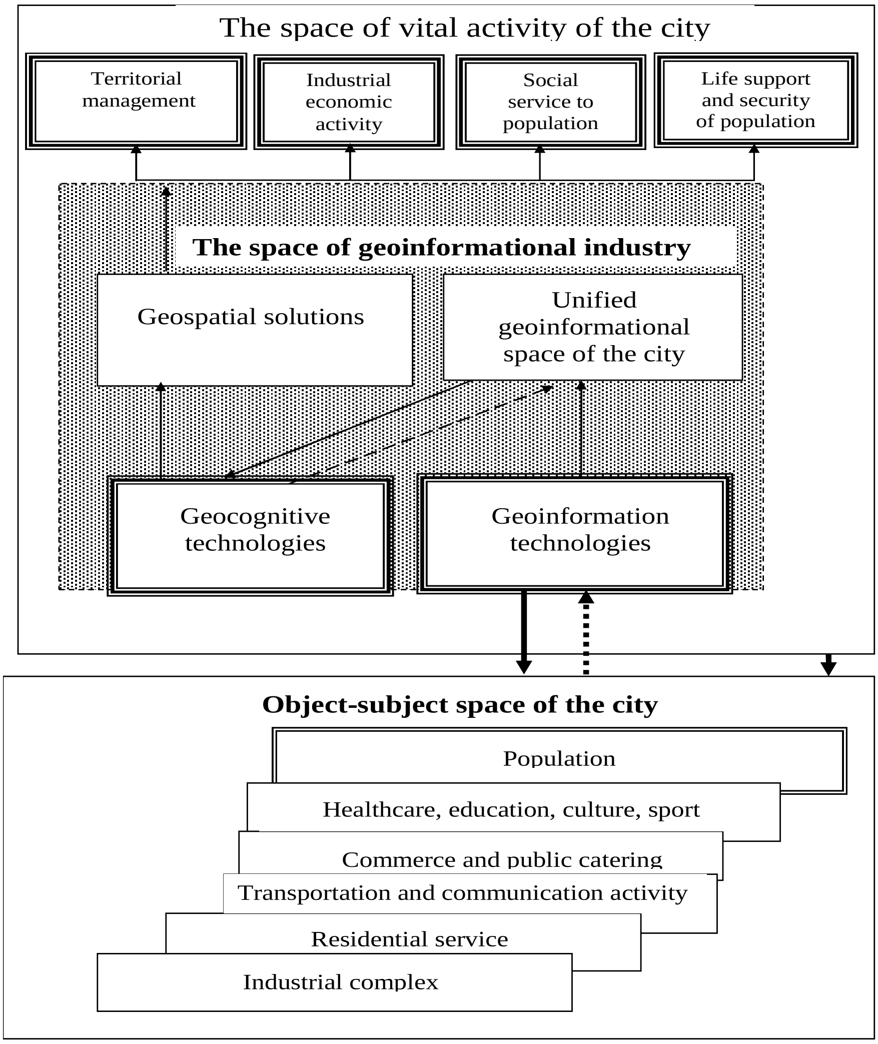

Fig. 3. Geo-information industry in the structural and functional model of "Smart City"

Management decisions are developed on the basis of preliminary modeling of activities, rational use of the territory, primarily lands, searching for optimal options for spatial solutions and predicting their consequences. The project will provide solutions to a number of spatial problems of the upcoming sixth technological order related to "big challenges".

A fragment of the structural-functional model of the system being developed, compiled by the means of the CA ERWIN process modeler, is shown in Figure 4.

The project envisages the use of basic advanced technological components: high-precision satellite positioning and navigation of GPS / GLONASS, remote sensing of the Earth from space, aircraft, unmanned aerial vehicles and ground-based laser systems, digital 3D-4D modeling, monitoring of resource base based on unified spatial infrastructure data.

The main technological blocks of the project are:

- geoinformation system for the preparation of optimal solutions for the management of the agro-industrial complex of the region, using the methodology of parametric estimation of the condition of the territory and lands of farmland, forecast modeling, thematic queries and development scenarios;
- innovative management system for transport and logistics complexes and infrastructure facilities in the region;
- 3D - and BIM-technologies for design and construction of buildings, structures, industrial facilities, etc.;
- system of optimal solution preparation for the spatial development of the region, including zoning and functional zoning of the territory, predictive modeling; long-term planning of the rational use of the territory, monitoring of the territory use as a result of the adopted geospatial solutions;
- tools for effective use of natural-resource geospatial data by specialists of territorial administrative structures on the basis of geospatial modeling and analysis of the natural resources state;
- system for substantiating geospatial solutions for the rational use of natural resources based on inventory and assessment of natural resources, planning of rational nature management, monitoring of the results of geospatial solutions;
- system of high-precision satellite positioning of zones and facilities in the region, including the online service for the automated processing of GNSS measurements, and the market for positioning services;
- technological complex of remote sensing of the Earth (RS) and geomonitoring of the territory of the region, including:

  - bank of remote sensing materials;

  - center of unmanned aerial systems, with the functions of training pilots, maintenance and metrological support;

  - training and consulting center for remote sensing;

  - scientific and methodological center for the development of technological solutions for the processing of remote sensing data in the interests of territorial management, economic sectors and the population;
- unified geoinformation space for the management of the territory and rational use of natural resources, including the spatial data infrastructure (SDI) of the region, a system for collecting, accumulating and updating geospatial information (including VGI, obtained with a crowdsourcing method, with the participation of wide layers of the population [17]); a telecommunication system, providing a wide range of users with geospatial data;
- geospatial engineering system that provides the entire range of services in the sphere of spatial development and optimization of the use of the territory, including lands and other natural resources of the region;
- system of specialized training and personnel support for the project.

III. CONCLUSIONS

Thus, modern global changes in productive forces and production relations lead to the development of the digital economy, which in turn generates revolutionary changes in the technological sphere as well as in geospatial activities.

Firstly, the importance and role of geospatial data, technologies and systems in the economy and the vital activity of the population are sharply increased. This is due to the general trend of the post-industrial era, manifested in the strengthening of the virtual component of the emerging hybrid world, a significant part of which is the geo-information industry.

Secondly, to replace the classical geoinformation technologies, oriented toward determining the spatial position of real objects of the surrounding world, cognitive technologies are being developed aimed at the formation of spatial knowledge and virtual administrative influences on real objects. In this regard, there is a need to introduce a new concept - "geocognitive technologies" as a special class of cognitive-information technologies associated with the perception and use of geospatial

Thirdly, in spatial processes, along with the subject (the person owning a set of appropriate geoinformation technologies), the objects of management, which acquire the properties of the subjects, begin to actively participate.

Fourthly, in connection with the new task of ensuring spatial interaction of people, animals and things, there is a need to create, to maintain and to use the appropriate single geoinformation space as an information foundation for practically all human activities.

References

[1] http://voprosik.net/chto-takoe-cifrovaya-ekonomika/

[2] V.P. Kupriyanovsky, S.N.Yevtushenko, O. N. Dunayev, G.V. Bubnova, V. I. Drozhzhinov, D.E. Namiot, S.A. Sinyagov, "Government, industry, logistics, innovations and intellectual mobility in digital economy", *Modern information technologies and IT education.* Cognitive and information technologies in digital economy, vol. 13, no. 1, pp. 74-96, 2017.

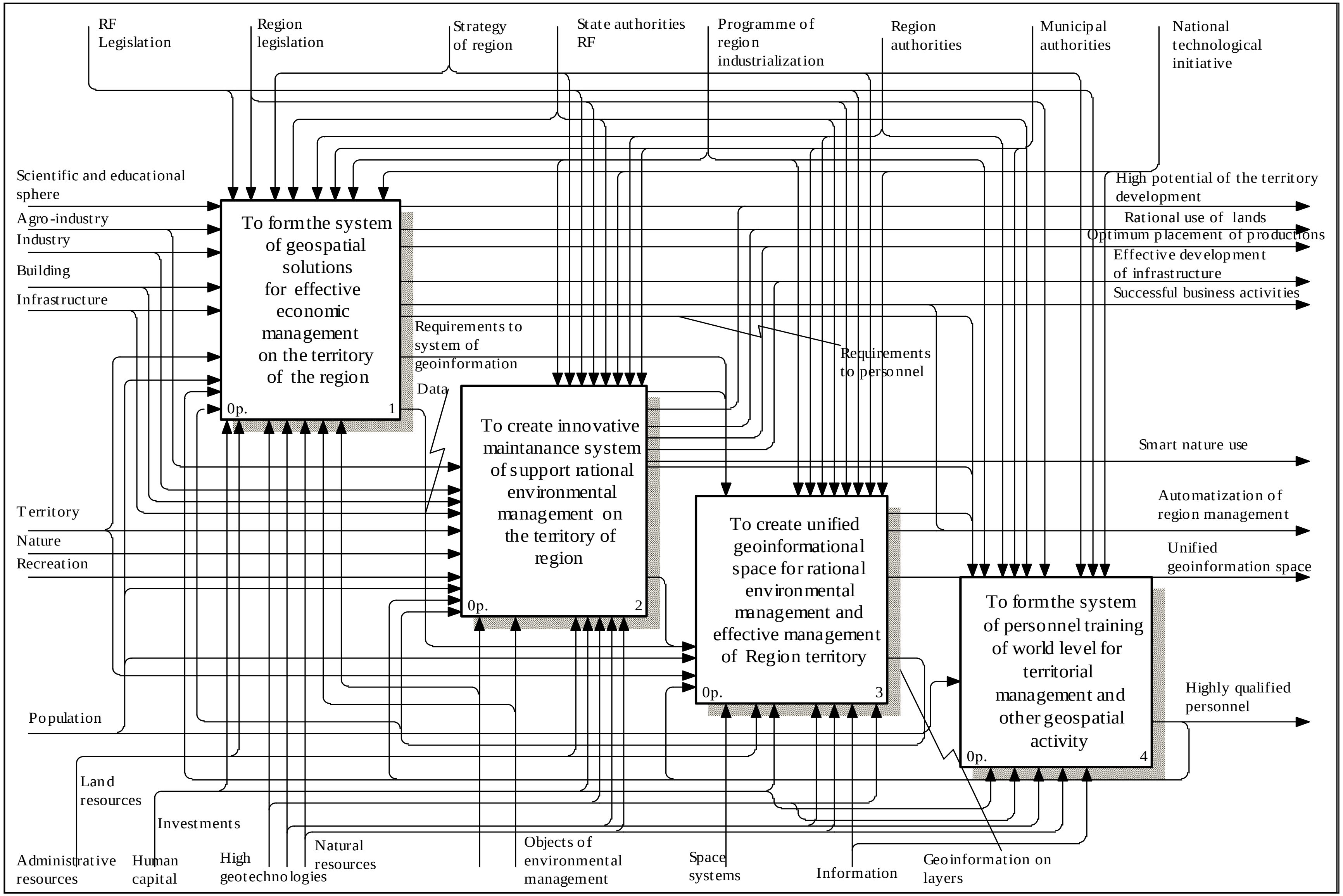

Fig.4. Fragment of structural functional model of open high-technology system for territory management of region ("Smart region")

[3] K.D. Thoben, S. Wiesner, T. Wuest, "Industrie 4.0" and Smart Manufacturing–A Review of Research Issues and Application Examples ", *Int. J. of Automation Technology*, vol. 11, no. 1 , pp. 4-16, 2017.

[4] C. Loebbecke, A. Picot, "Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda", *The Journal of Strategic Information Systems*, vol. 24, no. 3, pp. 149-157, 2015.

[5] A Botta, W De Donato, V Persico, A Pescapé, "Integration of cloud computing and internet of things: a survey", *Future Generation Computer Systems*, vol. 56, pp. 684-700, 2016.

[6] N.R. Vajjhala, E. Ramollari, "Big data using cloud computing-opportunities for small and medium-sized enterprises", *Eur J Econ Bus Stud.*, vol. 1, no. 4, pp. 129-137, 2016.

[7] A. Berisha-Shaqiri, M. Berisha-Namani, "Information technology and the digital economy", *Mediterranean Journal of Social Sciences*, vol. 6, no. 6, pp. 78-83, 2015.

[8] E.P. Istomin, A.G. Sokolov, V.M. Abramov, A.A. Fokicheva, N.N. Popov, "Clusters within geospatial information management for development of the territory", *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management*, SGEM, Bulgaria, vol. 1, pp. 601-608, 2016 [16th International Multidisciplinary Scientific GeoConference SGEM 2016].

[9] D.V. Lisitsky, "Cartography in the era of informatization: New problems and possibilities", *Geography and Natural Resources*, vol. 37, no. 4, pp.296-301, 2016.

[10] G.G. Malinetsky, S.K. Manenkov, N.A. Mitin, V.V. Shishov, "Cognitive call and information Technologies," *IPM Preprints of M.V.Keldysha*, no. 46, 28 p., 2010. URL: http://library.keldysh.ru/preprint.asp?id=2010-46

[11] I.V. Chernikova, "Cognitive Science & Cognitive Technology in the Mirror of Philosophic Reflexion", *Epistemology and Philosophy of Science*, vol. 27, no. 1, pp. 101-117, 2011.

[12] T. Redondo, "The Digital Economy: Social Interaction Technologies-an Overview", *IJIMAI*, vol. 3, no. 2, pp. 17-25, 2015.

[13] S.B. Letaifa, "How to strategize smart cities: Revealing the SMART model", *Journal of Business Research*, vol. 68, no. 7, pp. 1414-1419, 2015.

[14] R.K. Kummitha, N. Crutzen, "How do we understand smart cities? An evolutionary perspective", *Cities*, vol. 67, pp. 43-52, 2017.

[15] L. Živković, S. Marani, S. Berk, K. Dežman, "Towards a monitoring information system for territorial attractiveness and policy management in South East Europe", *Geodetski Vestnik*, vol. 59, no. 4, pp. 752-766, 2015

[16] F. Würriehausen, "Semantishe Interoperabilität heterogener GIS-Daten im Kontext von INSPIRE", *Gis Science*, Wichmann Verlag, vol. 29, no. 2, pp. 35 – 47, 2016.

[17] D. Demetriou, M. Campagna, I. Racetin, M. Konecny, Integrating Spatial Data Infrastructures (SDIs) with Volunteered Geographic Information (VGI) for creating a Global GIS platform, In: G. Foody, L. See, S. Fritz, P. Mooney, A.M. Olteanu-Raimond, C.C. Fonte, V. Antoniou, Mapping and the Citizen Sensor, London, Ubiquity Press, pp. 273–297, 2017. DOI: https://doi.org/10.5334/bbf.l. License: CC-BY 4.0