www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC Gestão, Inovação e Tecnologias

Smart Region Conceptual Model: Evolution of Approaches, Architecture, Stratification

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Abstract
Relevance of the work is stipulated by the fact that currently, under the influence of the Fourth Industrial Revolution, digitization and convergence of technologies, the previously established paradigm of sustainable development is transformed into smart sustainable development at all levels including regional. The aim of this article is to develop a conceptual model of stratified architecture of smart region on the basis of analysis, generalization, and systematization of scientific investigations and established regional practices of formation, institutionalization and implementation of new forms of spatial development of territories under conditions of digital transformation of economy. The empirical base of the research is presented by laws and regulations of national and regional level in the sphere of social and economic, spatial development and digitization, as well as by the rating data of innovative development of entities of the Russian Federation by Higher School of Economics. The methodological base of the research includes historical and evolutional, and ecosystem approaches, dialectic, categorial, subject–object, retrospective and monographic methods, terminological, comparative, and content analysis of scientific publications and empirical sources, methods of generalization, typology, classification, and systematization, principles and approaches of system engineering in building digital system architectures of various objects. In the course of the research, the genesis, evolution of successful practices, problems and discussion issues of implementation of new forms of spatial development have been generalized and analyzed in the context of Smart Sustainable Development; the architectural stratified model of smart region has been proposed combining a set of basic principles of its technological organization implemented in the form of digital technologies, interrelation of the technologies with each other and ambient environment. It has been concluded that formation and development of smart region model with accounting for all considered factors should be based on modern methodological achievements of system engineering allowing to consider smart region as a complicated architectural stratified sociotechnical and economic system, its practical implementation is significantly influenced by established traditions of state and regional management as well as interaction of state with population and business.

Received: 13.05.2021 – Accepted: 04.06.2021

Key-words: Smart City, Smart Region, Digital Economy, Spatial Development, Concept, Model, Architecture, Stratification.

1. Introduction

Under the influence of global synchronization and convergence of various areas of science and engineering, conversion from individual to network and cluster types of spatial development, widespread implementation of smart solutions, the existing paradigm of sustainable development is transformed into Smart Sustainable Development. The fourth industrial revolution dictates the concept of Smart Sustainable Development (Girard, 2013; Martin et al., 2018) based on human capital, innovations, and digital end-to-end technologies. The digital transformation provides opportunities of inclusive economic growth for industries, territories, and states, while simultaneously generating numerous challenges related with new forms of interaction of economy, society, and technologies. This is confirmed by explosive growth of the number of scientific publications in the considered field, in social and engineering sciences, in Russia and abroad, which evidences the necessity of integrated studies in this area.

The aim of this article is to develop a conceptual model of stratified architecture of smart region on the basis of analysis, generalization, and systematization of scientific investigations and established regional practices of formation, institutionalization and implementation of new forms of spatial development of territories under conditions of digital transformation of economy.

Accordingly, two interrelated ussies were resolved:

1) the genesis, evolution of successful practices, problems and discussion issues of implementation of new forms of spatial development were generalized and analyzed in the context of Smart Sustainable Development: from smart cities (Dierwechter, 2013; Fernández Maldonado, 2012) to smart villages (Sutriadi, 2018), smart regions (Colantonio & Cialfi, 2016; Morandi et al., 2016; Rolando & Djordjevic, 2013; Mikki et al., 2014; Blanutsa, 2018);

2) on the basis of the works (Kolbanev et al., 2020; Vorobieva et al., 2019; Verzun et al., 2018), the architectural stratified model of smart region was proposed combining a set of basic principles of its technological organization implemented in the form of digital technologies, interrelation of the technologies with each other and ambient environment.

Received: 13.05.2021 – Accepted: 04.06.2021

The theoretical provisions and conclusions formulated in the work reveal lacunas and determine prospects of future studies in this area. The obtained results can be used upon development and updating of strategic programs of federal, industrial, macroregional, regional and local level.

2. Methods

The empirical base of the research was presented by laws and regulations of national and regional level in the sphere of social and economic spatial development and digitization, including National Technology Initiative (n.d.); the Concept of implementation of smart digital technologies in Ulyanovsk Oblast for the years 2017–2030: Smart Region (2017); Smart Region concept in Sverdlovsk oblast (2018); Smart Kuban: Future Leaders (Passport of regional program, 2019); Strategy of social and economic development of Tatarstan up to the year of 2030 (Law of the Republic of Tatarstan, 2015); as well as by Rating of innovative development of entities of the Russian Federation by Higher School of Economics (Abdrakhmanova et al., 2020).

The methodological base of the research included historical and evolutional, and ecosystem approaches, dialectic, categorial, subject–object, retrospective and monographic methods, terminological, comparative, and content analysis of scientific publications and empirical sources, methods of generalization, typology, classification, and systematization, principles and approaches of system engineering in building digital system architectures of various objects.

3. Results

While aiming at terminological description of digital transformation of spatial development and management mechanisms of not only urbanized but also rural areas of Northern Italia from Milan to the Po Valley, searching for new mutual equilibrium between city and region, European scientists–regionalists had to expand theoretical reference apparatus from the smart city concept to the smart city–region or just the smart region. European Council of Spatial Planners (ECTP) proposed a new vision of European cities in the 21st century based on development of polycentric urban networks completely indifferent to the traditional national and administrative boundaries, thus, a smart region could be organized as a local urban network (Fernández Maldonado, 2012).

Considering examples of successful European smart regions, the Interreg projects should be mentioned at first (Bird, ICT4SMEs and LoG-IN), developed from 2002 to 2007 by the cities and regions in Northern Europe (Belgium, Germany, Denmark, the Netherlands, Sweden, and Great Britain). They promoted development of e-services, e-learning, and e-management by implementation of broadband communications (Morandi et al., 2016). The SmartRegions pilot projects guided from 2010 to 2013 by agencies, research institutes and companies from eight European countries (Finland, Norway, Germany, Austria, the Netherlands, Poland, Romania, and Spain) in the frames of Intelligent Energy Europe (IEE) commission were established with the aim of development of knowledge networks and achievement of target performances of energy efficiency of Europe for the years of 2016 and 2020 (Morandi et al., 2016). While combining fourteen adjacent municipalities, Comunità Montana Vallo di Diano project (Italy) promotes development of unified system of strategizing aimed at improvement of resource mobility at local level, economic productivity, as well as conversion to sustainable management of natural and human resources (Associazione Nazionale Comuni Italiani. Osservatorio Nazionale Smart City, 2014; Morandi et al., 2016). Created by six adjacent municipalities, Unione dei Comuni della Romagna Faentina project (Italy) promotes development of inclusive, smart and sustainable community. It assumes adoption of schedule for energy production and ambient environment, creation of Hi-Tech park, provision of free Wi-Fi for city spaces, as well as implementation of e-management based on open data (Associazione Nazionale Comuni Italiani. Osservatorio Nazionale Smart City, 2014; Morandi et al., 2016). Mantova Smart Region project (Italy) was launched in 2012 with assistance from the Polytechnic University of Milan. Its essence is in experimental integration of digital infrastructures and services with cultural, ecological and landscape heritage, as well as in implementation of an innovative approach to supramunicipal management (Morandi et al., 2016). Therefore, it is obvious that European countries are characterized by transboundary approach in formation of smart regions, which can be attributed to purposeful policy of EU Member States regarding provision of conditions for transboundary data exchange among the countries and equal access to it for all EU citizens at supranational level.

V.I. Blanutsa (2018) in the work on identification of territorial structure of future digital economy of Russia attracts attention to obligatory usage of interregional (transregional) approach in determination of boundaries of smart regions. Taking into account the slow response of the existing system of migration and agglomeration economy, he assumed that the future territorial structure

would be presented by smart urban agglomerations and regions. The attention is focused on the fact that the existing in Russia euphoria regarding creation of smart cities and regions is not supported by analysis of territorial structure of digital economy; thus, the ubiquity of new technologies is unreasonably declared. Herewith, there is no scientific substantiation that the borders of digital (smart) agglomerations and districts run along the boundaries of administrative division of Russia. However, the lack of studies on substantiation of borders of digital regions is not only the Russian problem. For instance, Helsinki Smart Region combined 26 municipalities in the south of Finland (Mikki et al., 2014), and the smart regions in Italia were administrative divisions of the country, the respective statistic data were used for determination of the degree of their smartness and combination into clusters (Colantonio & Cialfi, 2016). Such situation with digital agglomerations and regions was caused by the lack of exact and clear criterion of delimitation.

Asian countries, such as South Korea, Japan, Singapore, with their concepts of Smart Society 5.0 and Smart Nation, are prominent representatives of the so-called engineering approach, which is determined by initial ubiquitous informatization of these countries, distribution of data networks, centralization of governmental systems and information resources, and reduction of digital gap. However, for the Russian conditions, the experience of China, India, Indonesia is more attractive, since they are characterized by differentiation of economic space and combination of urbanized and rural areas.

The Indonesian researcher (Sutriadi, 2018) defines the smart region as an innovative approach to sustainable planning at regional level, which promotes development based on knowledge achieved by continuous learning. Peculiar attention is paid to harmonization of development of national economy and preservation of natural resources. Since Indonesia is characterized by combination of urban agglomerations and rural areas, in his work (Sutriadi, 2018) the smart territories are presented in the form of hierarchical technological and innovative concept: smart city–smart village–smart region, aiming at sustainable development. The researcher highlights the following effects of implementation of the smart region concept:

occurrence of synergy between regional physical infrastructure and regional telecommunication system;

replacement of physical logistic flows with virtual ones;

increase in competitiveness and sustainability of region due to development of regional researching centers;

development of regional communication infrastructure (automobile, rail road, water, and power engineering);

transformation of regional policy with more significant role of public discussion and actions;

arrangement of contacts among key regional stakeholders.

As for the North Atlantic states, the experience of Seattle attracts interest with regard to transition from smart city concept to smart city–region. Reorientation of municipal agencies of Greater Seattle to the policy of redistribution aimed at growth promotion improves both the city ability to sustainable development and to its competitiveness. In particular, this refers to development of transport plans integrated with new policy of distribution and promoting more sustainable growth of the region (Dierwechter, 2013).

The management of Seattle smart city–region is performed as follows:

at local level: municipalities and districts, which coordinate their plans with general plans and strategies;

on a wider scale: Washington state, which approves official regulations and, hence, determines strategic targets;

Puget Sound Regional Council (PSRC), which has the opportunity to integrate the policy in the field of land management, transport, environment, social sphere and economy.

President Barack Obama's administration supported the municipal regionalism by the policy aimed at integration of investments into economic development, land management and transport in the frames of US cities–regions. However, it was mentioned that the investments into the Seattle public transport at initial stages were profitable mainly for the economic centers of cities–regions and not for their periphery. Therefore, despite the orientation of targets at social equality and environmental stability, the political stability of growth of the cities–regions was not unambiguous. Despite certain difficulties of Seattle in provision of real smart growth (based on integration between land management and transport system by means of transit hubs) and the fact that this smart city–region, probably, does not use the most advanced opportunities of ICT, in terms of methodology, the regional prospect of this proposal makes it an interesting strategy, which can stimulate conversion from smart cities to smart regions (Dierwechter, 2013).

The Russian academic thought and regional managerial practices are developed in a similar trend, formulating the main provisions and principles of formation of smart regions as continuation of smart city strategies. In particular, in (Kubrak, 2020) on the basis of systematization of

implementation of the smart city concept and best managerial practices of urban environment and suburban areas in the frames of national projects "Housing and comfortable urban environment", "Digital economy of the Russian Federation", "Ecology", it is proposed to expand the smart city concept to the smart region concept. In the work (Tebekin & Egorova, 2019), on the basis of analysis of the dynamics of Russian urbanization, it was established that significant portion of social and economic problems of development could not be completely solved in the frames of the smart city concepts, it should be solved at other hierarchical levels of management in the frames of the smart region and smart state concepts.

The ambitiousness of Digital Economy national project, approved by the Russian Government, and official announcement at initiation of the reform of governmental management dictate the requirements to searching for a new model of regional management and development on the basis of integrated implementation of digital technologies into all active spheres of economy and society. Such changes are applied in numerous regions, thus allowing to analyze and to generalize the established practices in the frames of previously revealed approaches (Lyshchikova et al., 2019).

Technological approach was initially presented by the federal pilot project "Smart City. Successful Region", initiated by the Center of Strategic Developments. This federal innovation project is scheduled up to 2022. The selection criteria of the subjects were as follows: high innovation potential, population, existence of a major city, no conflicts between regional and municipal authorities. The proposed amount of funding for implementation of the pilot project in three selected subjects, Voronezh oblast, Yaroslavl oblast, Samara oblast, can amount to RUB 21.8 billion. The aim of the pilot project is implementation of the advanced managerial technologies into territorial spatial development.

Samara oblast as one the largest Russian urban agglomerations, initiating active structural and spatial transformations, was included into the federal program "Smart City. Successful Region" as a pilot site. Theoretical and implemented models of smart cities cover all trends of modern urbanization: informatization, democratization of society, clusterization, gentrification, digitization, being the base of fundamental models of urbanization in the 21st century. One of such models, known as "the triad of development agents", is being analyzed at present by the scientific society of Samara region. In the frames of this pilot program new approaches of Samara development as a smart city are proposed. The basis of social and spatial activity in the model is comprised of smart

university, smart park–works, and smart city (Akhmedova et al., 2018; Akhmedova & Vavilonskaya, 2019).

In 20 Russian subjects (including Nizhny Novgorod oblast, Pskov oblast, Tyumen oblast, Primorsky krai, Nenets Autonomous Okrug), the pilot projects have been implemented in the frames of contracts of cooperation with PAO Rostelecom in the scope of the Smart region program since 2018. This program assumes creation of conditions for implementation of information decisions into various spheres of regional activities, promoting formation of modern communication environment, development of information society, transformation of federal and municipal management, and their integration on the basis of platform decisions, safe and comfort living in the regions, improvement of quality of living (RBK, 2018).

Prominent representatives of economic approach to formation of the smart region concept are Krasnodar krai and Tatarstan. In Krasnodar krai in September, 2019, the regional program "Smart Kuban: Leaders of the Future" was approved, which is aimed at formation of territory of smart economy oriented at realization of potentials of young talents and entrepreneurs, thus providing global engineering leadership of Russia. The program assumes development of the system of federal management oriented at human and providing sustainable growth of quality of living, comparable with medium level of countries in the Organization for Economic Cooperation and Development (Passport of regional program, 2019).

In June 2015, Tatarstan adopted the Strategy of social and economic development up to 2030, which stipulates formation of smart economy: development of smart and environmentally safe technologies, development of smart environments, smart systems, and smart productions: transport systems, power supply systems, production systems, houses, shops, cities, etc. (Law of the Republic of Tatarstan, 2015).

Some initiatives on formation and development of smart economy exist in other Russian regions. For instance, in the work (Baulina et al., 2018) the measures are developed on formation of smart economy of post-industrial type as exemplified by Volgograd region. The model of implementation of smart economic potential of Volgograd oblast and its center is based on the integrated approach: evolutional shift and structural transformation. The authors in (Detter & Tukkel', 2018) declare that the improvement of local innovative ecosystems and their infrastructure should be aimed at provision of flow of R&D initiatives, required for sustainable development of Russian Arctic zone. Digitization of innovative infrastructure is able to activate the innovative processes

without localized block of knowledge generation due to new opportunities of search and glocalization of smart engineering solutions. The presented provisions formulate the concept of spatial development of Russian Arctic regions: smart cities–smart region. In this context, the concept of development of innovative potential of Arctic regions is comprised of digitization of local innovative infrastructure, development of human potential, as well as mastering the smart city technologies aimed at improvement of quality of living in Arctic regions. Formation and expansion of innovative infrastructure provide new content for institutional, economic, legal, and cultural space of region, make it smart, transform potential into capitalization. Digitization of interrelations inside regional and local innovative systems allows to eliminate territorial and competence limitations and to be involved into global technological processes. Digitization of local innovative infrastructure makes it really open, allows to involve new knowledge and technologies, most suitable for artic specificity. Digitization of ecosystem will improve competences and intellectualization of regional population, development of their capabilities to meet emerging challenges and to provide decent future (Detter & Tukkel', 2018).

According to the researchers (Artemova & Nurmukhametov, 2019), the programs of smart regions should have individual status and not be absorbed by regional strategies of social and economic development. Orientation only at large cities and not on regions could be a significant obstacle for this trend. In particular, digital inequality between cities and minor settlements can increase. Therefore, the integrated concepts of smart region were adopted in Ulyanovsk and Sverdlovsk oblasts for good reason. While substantiating this position, the Concept of development of smart region in Sverdlovsk oblast states that the Russian specificity of spatial development assumes high distances between the centers of economic activity, existence of remote areas in the Federation subjects, which results in significant inequality in access to infrastructure and services. And transition to regional positions allows to displace the focus of economic policy from the municipal level or the level of certain agglomeration to intermunicipal and regional level. The Concept of development of smart region in Sverdlovsk oblast was adopted in 2018. Its main aim is the development of human capital, improvement of quality of living and increase in competitiveness of economy by means of systematic implementation of services and decisions supported by the most advanced achievements of digital technologies allowing to solve the most relevant issues of the citizens at a new level.

In 2017 the concept of implementation of intelligent digital technologies was adopted in Ulyanovsk oblast: Smart region for the years of 2017-2030, assuming acceleration of economic development of territories and improvement of quality of living on the basis of implementation of information and communication technologies into various spheres; development of digital economy, production and application of innovations in the frames of regional specialization, creation of relevant infrastructure and cultivation of competences.

Summarizing the analysis of studies and regional practices of development and implementation of the smart region concepts, a set of important conclusions can be obtained. Gradual increase and displacement of accent in Russian practice from technocratic approach to European complex (co-evolutional) variant should be stated. This is confirmed by the fact that in October, 2019 the Council for Development of Digital Economy at the Federation Council proposed to create a new federal project "Digital Region" in the frames of the national project "Digital Economy of the Russian Federation"', assuming creation of information systems to solve the problems of all regional territories, including rural areas. In March, 2020 the new initiative was approved by Prime Minister Mikhail Mishustin, who mentioned the necessity to consolidate budgets and to synchronize digital projects in regions. It must be agreed that there is certain fragmentation of digital initiatives in regions together with duplication and intersection of regional and federal projects. For instance, Ulyanovsk and Sverdlovsk oblasts participate in pilot projects of PAO Rostelecom, and simultaneously they developed and adopted their own concepts. At the same time, there exist requests from regions, the necessary potential of digital and innovative technologies has been accumulated so that to provide maximum social and economic, and managerial synergetic effect of their implementation (Table 1).

Table 1 - Leaders of rating of innovative development of subjects of the Russian Federation: structural decomposition of index (Abdrakhmanova et al., 2020)

Rank	Integral index	Index of social and economic conditions of innovative activity	Index of scientific and engineering potential	Index of innovative activity	Index of export activity	Index of innovation policy quality
1.	Moscow	Moscow	Tomsk oblast	Tatarstan	St. Petersburg	Tatarstan
2.	Tatarstan	Tatarstan	Ulyanovsk oblast	Chuvashia	Moscow	Moscow
3.	St. Petersburg	St. Petersburg	St. Petersburg	St. Petersburg	Nizhny Novgorod oblast	Novosibirsk oblast
4.	Tomsk oblast	Tomsk oblast	Nizhny Novgorod oblast	Tomsk oblast	Smolensk oblast	Tomsk oblast
5.	Nizhny Novgorod oblast	Samara oblast	Moscow	Mordovia	Tula oblast	Kaluga oblast
6.	Moscow oblast	Khabarovsk krai	Moscow oblast	Penza oblast	Murmansk oblast	Nizhny Novgorod oblast
7.	Sverdlovsk oblast	Sverdlovsk oblast	Ivanovo oblast	Moscow	Novosibirsk oblast	Moscow oblast
8.	Novosibirsk oblast	Yamalo-Nenets Autonomous Okrug	Novosibirsk oblast	Nizhny Novgorod oblast	Leningrad oblast	Mordovia
9.	Chelyabinsk oblast	Chelyabinsk oblast	Novgorod oblast	Lipetsk oblast	Tatarstan	St. Petersburg
10	Kaluga oblast	Khanty-Mansi Autonomous Okrug–Yugra	Sverdlovsk oblast	Krasnodar krai	Lipetsk oblast	Samara oblast
11.	Samara oblast	Tyumen oblast	Tyumen oblast	Belgorod oblast	Rostov oblast	Sverdlovsk oblast
12.	Krasnoyarsk krai	Omsk oblast	Bashkiria	Moscow oblast	Omsk oblast	Chelyabinsk oblast

The rating of innovative development is based on ranking of the subjects of the Russian Federation in descending order of Russian regional innovation index (RRII) for 2017. The 2017 rating of the subjects of the Russian Federation was headed by Moscow. This position, held from 2008 to 2014, was regained. The top three– Moscow, Tatarstan, and St. Petersburg – are the most popular (in the ratings of 2012, 2014, and 2015). The Russian regions are characterized by

heterogeneous development of various aspects of innovations, demonstrating significant diversity in this regard. As a consequence, the final index is the smoothed estimate equalizing different constituents of innovative development and hiding them at the same time. Therefore, the rating developers supplement the RRII data with the information for certain subject subindices, characterizing social and economic conditions of the innovative activity, R&D potential, export activity, quality of innovative policy of the regions (Abdrakhmanova et al., 2020).

In (Bauer, 2019) the basic term for smart activities is defined as an integrated approach and, thus, ability to innovations. Herewith, it is mentioned that the urban and regional development is not just a technical term, since in addition to all economic and scientific issues, the attention is focused on a human with respective demands. Therefore, the term 'smart region' implies integration and combination of already existing various systems on engineering and administrative platforms. Herewith, its main objective is to provide centralized data collection for combined use of resources in all locations. Therefore, smart region becomes a region of the future. In this regard, it would be appropriate to develop and to include in the 2020 rating of innovative development of the subjects of the Russian Federation the index of readiness for the future, which is the quality estimate of strategic management at regional level. It is calculated by six indicators: the range of planning of regional strategies; engineering orientation of regional strategies; published information in mass media about successes of the region in the spheres of R&D, innovative, and industrial development; thematic diversification of regional strategies; closeness of regional news agenda to information field of developed countries; correspondence of regional strategic agenda to the content of federal strategies. The first rating group in terms of the index of readiness for the future includes Belgorod oblast, Moscow, Moscow oblast, Nizhny Novgorod oblast, Novosibirsk oblast, Penza oblast, Primorsky krai, Crimea Republic, Samara oblast, St. Petersburg, Sverdlovsk oblast, Tambov oblast, Khanty-Mansi Autonomous Okrug–Yugra, Chelyabinsk oblast, and Chuvashia (Abdrakhmanova et al., 2020).

The analysis of managerial practices makes it possible to conclude that the efficient implementation of the smart region concept is prevented by increasing contradiction between individual and general approaches to its creation. On the one hand, there is an increase in the number and scope of funding of local tasks, development and implementation of digital technologies, pilot projects, and startups. On the other hand, insufficient attention is paid to the development of integrated system approach to formation of the smart region concept as an integer engineering project using generalized and standardized models and architecture. We believe that this target can be

achieved by combination of diversification and unification of smart region models in the frames of single concept and architecture. For instance, in (Apatova & Korolev, 2017) the elements of innovative region structure are analyzed, which are required for development of digital economy, including information and researching infrastructures, infrastructures of digital space of confidence, institutional environment and smart region, as well as their constituents, the role of engineering constituent is shown: digital platform, its capabilities in regional development.

With accounting for the aforementioned, the smart region model should be considered as a digital system of mesolevel. From this point of view, the smart region model should be based on architectural approach, which allows to observe all fundamental engineering tasks to be solved upon building new models of activity of regional subjects under the conditions of digitization of economy. Architectural models of digital information systems are always characterized by level-based (stratified) presentation. On the basis of the works (Kolbanev et al., 2020; Vorobieva et al., 2019; Verzun et al., 2018), devoted to the architecture of digital economy in total, let us propose the following conceptual presentation of the smart region architecture (Table 2).

Table 2 - Architectural model of smart region: strata and technologies

No.	Levels (strata) of architecture of smart region	Technologies
Infrastructural levels		
1.	Real and virtual sources of data on social and economic objects and processes of region	Electronics, photonics, radio engineering, quantum, optical, NBICS and other technologies of regional data conversion
2.	Networks of storage, distribution, and processing of data on social and economic objects and processes of region	Technologies of creation of regional and interregional cyberspace for provision of interregional information interaction
3.	Cloud, fog, and dew computing	Technologies of vertical distribution of regional data among the pools of regional, interregional, and national resources of storage and processing and points of data occurrence and use
Subject-oriented levels		
4.	Management of regional data, structures and analysis of regional data	Technologies of management of regional data, formation of logical structures of regional data
5.	Regional digital platforms and applications	Technologies of creation of information space of region for coordination of market interactions of regional

		manufacturers and consumers of goods and services
6.	Ecosystem of regional digital platforms	Partnership providing interaction of regional digital platforms on the basis of scientific and engineering standards and security guaranties
7.	Hi-tech and digital markets and business models	Technologies of global, national and regional hi-tech digital markets

The proposed smart region architecture is presented in the form of stratified hierarchical model, comprised of two groups of levels (strata): infrastructural levels and subject-oriented levels. As in architectural models of other digital systems, the interrelations of neighboring strata are characterized by hierarchical subordination. The technologies of three bottom strata jointly form infrastructural engineering level of the smart region model. At the first level, the technologies are located forming digitization of natural analog social and economic processes in the region and their presentation in the form of digital signals. The second level corresponds to the technologies of regional and interregional cyberspace. Here the conditions are created for interaction among the sources of digital data in time, space, and by data processing. The third level combines the technologies of storing and processing of regional data, vertically distributed between the pool of regional, interregional, and national resources of storage and processing and points of data occurrence and use. Their main aim is the organization of services of storing, distribution and processing of data by final regional customer.

Combination of the technologies of the four top strata form the subject-oriented levels of architectural model of smart region. The fourth level contains technologies of such structures of regional data, which allow to build efficient algorithms of analysis of regional data and extraction of information from them, to impart new system properties to regional digital data obtained from infrastructural levels, adding new metadata increasing the extent of organization of data resources of the region in total. The fifth level is comprised of the technologies of regional data space (cyberspace) for coordination of market interrelations between regional manufacturers and consumers of goods and services. These are the technologies of creation of regional digital platforms on the basis of open protected interfaces for information interaction between regional subjects and external environment; provision of virtual sites for communication of participants in regional market; commercialization of innovative development and business ideas during integration of virtual, material, and managerial

activities upon production, distribution, exchange and consumption of goods. The sixth level is comprised of the technologies aimed at creation of ecosystem of regional digital platforms: partnership providing interaction between regional digital platforms on the basis of scientific and engineering standards and security guarantees based on both engineering principles (network, open technologies and open data) and economic principles (strategic partnership, co-creativity and co-competition). The seventh level is comprised of the technologies of global, national, and regional hi-tech digital markets, based on the principles and methodology of smart specialization. The list of markets and criteria of their selection are formulated in the Governmental program of development of challenging industries in Russia, which in the nearest 20 years can become the base of world economy: National Technology Initiative.

4. Discussion

A set of the most important factors can be highlighted, due to which the conventional methods of development of complicated systems are inadequate for formation of smart region model.

The involved parties participating in development of smart region are numerous and highly heterogeneous. They refer to various governmental, social and economic institutions, they have different powers or no powers at all, they have different goals, operate in different subject spheres with divergent discourses. This becomes the reason of different and sometimes contradictory approaches to smart region concept, which complicates the opportunity to agree on the principles of interaction and requirements for the model, forcing their unjustified ignoring or excessive simplification.

The number and composition of participants in the smart region model are comprised of indefinite range of subjects referring to different spheres of economic activity and state management, society layers, social groups. It is in fact impossible to account for and to systemize the demands of total range of subjects regarding the use of functional opportunities of the smart region model and to measure their satisfaction. This creates preconditions for various voluntaristic decisions and speculations.

The composition of information systems and technologies included into the architecture of smart region is not precisely defined and subjected to permanent changes. They can solve wide range of intradepartmental and interdepartmental, regional and interregional, industry and interindustry

tasks. While developing the smart region model, information systems are combined into a single complex. These systems were developed, as a rule, for independent operation in order to achieve specific targets and solution to specific tasks; mostly, they do not have mechanisms providing their interaction with other information systems. Subjects of information system management perform their functions or exercise powers. Involvement of information system into the smart region model can result in conflict of interests, for instance, competition for resources. And changes in single information systems during their lifecycle can result in incompatibility with other information systems of the smart region.

5. Conclusion

Digitization of regional economy is directly related with support of innovations, transformation of system of regional management and development of the model of smart or digital region. The new (digital) stage of development of regional economy is characterized by its peculiar features, which should be clearly formulated in the context of scientific and practical achievements both in the sphere of development of smart regions and in the sphere of regional digitization in total.

The experience of development of smart regions, development of governmental pilot projects in this area makes it possible to state that the issues of development of smart regions are in the scientific, technical and methodological field. The greatest difficulties in this sphere are caused by high complexity of smart region model, as well as its susceptibility to changes stipulated by reformation of state and regional management and evolution of social and economic relations. In particular, significant influence is exerted by rapid development of information and communication technologies, which not only provides new opportunities for development of regional economy and management but also generates new challenges and overestimated expectations of regional community.

The formation and development of smart region model with accounting for all considered factors should be based on modern methodological achievements of system engineering allowing to consider smart region as a complicated architectural stratified sociotechnical and economic system, its practical implementation is significantly influenced by established traditions of state and regional management as well as interaction of state with population and business.

Acknowledgements

This work was supported by the Grant of the President of the Russian Federation (project No. MC-23.2019.6): 'Smart region' as an interdisciplinary concept of sustainable spatial development.

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Received: 13.05.2021 – Accepted: 04.06.2021