Innovative Types of Buildings and Materials Reorganization as Systems in the Cyberphysics of Techno-Science

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Abstract. The study dedicates to innovative types of construction reorganization such as renovation, reversal, recombination, retreatment, which have been implementing in varying degrees in construction practice. The objects of study are innovative types of buildings and materials reorganization as cyberphysical systems. The task of the study was to analyze the modern scientific and technological development of society as the techno-science domain area, then to determine a place of cyberphysics in the environment of techno-science and present an interaction analytical model of cyberphysics, techno-science and the complex of innovative types of buildings and materials reorganization. An infographic modelling as a particular consideration level of objects in the techno-science domain area has been used as a method in the study. Conclusions of the study show that the correct interaction infographic model is based on the theory of multipoint logics. Currently, the most relevant model for innovative type of construction reorganization for the housing and communal complex of the Russian Federation is a model of renovation. Foreign and domestic open scientific publications on the subject are summarized in the present study.

1. Introduction

In the publications of foreign and domestic researchers, the specifics of society modern scientific and technological development are increasingly referred to the space of techno-science. The term “techno-science” (Bachelard G, La materialisme rationel, Paris: PUF, 1953) appeared as a result of discussions by prominent philosophers of the fifties of the twentieth century (Ellul J, 1954; Snow ChP, 1959; Simondon G, 1969, etc.). The term and concept of "techno-science" was established in the last thirty years of the last century in numerous publications, which show that the man-made human habitat is increasingly turning from the field of application of scientific knowledge into the space of its natural development. Different areas of intellectual activity interact in this space according to the principle of synergy, when new ideas and developments in one of them create incentives and conditions for the development of all others (Latour B, 1987; Pickering A, 1995). Among the components of techno-science are artificial intelligence, philosophy of consciousness, psychology, neurophysiology, and a number of others (the space of techno-science is denoted by the collective abbreviation NBIC as NBIC-Convergence: nano-bio-info-cognitive). Innovative technologies of building reconstruction as
well as the creation and implementation of new materials belong to the space of techno-science in construction. There are three levels of consideration of objects in the space of technical science: analytical, deconstructive and infographic modelling (imaging).

The authorship of the term “Cyber-physical System” is attributed to Gill H. (US National Science Foundation, 2006), and its content and popularity in Germany was provided by Industry 4.0 programme, which set the task of modernizing the country’s manufacturing industry on new principles. At first, cyber-physics meant technical systems with built-in computing tools, where a person used different channels of information transfer in design and control processes. In Russia, the circle of problems of cyber-physics included the provision of its own system state space and the study of its parameters. The task was put to create an apparatus for infographic modelling, which could become the basis for technical regulation in certain segments of innovative technologies for reorganizing construction.

Parameters of the modern Russian construction industry differ significantly from its Soviet and "perestroika” development periods. Reconstruction of construction objects and new construction of the Soviet period had approximately a ratio of 80:20 in terms of the volume of construction and installation work being carried out (SMR). At the same time, the volume of financial expenses for the reconstruction of the object was about 70% of the cost of new construction of a similar structure. There is new construction is dominating in modern Russia. The volume of construction and installation work in 2005 amounted to 1,754.4 billion rubles (or 113.2% compared to 2004), and its amounted to 6148.4 billion rubles in 2015 (or 95.2% by 2014) at a comparable circle of economic entities of the Russian Federation. At the same time, investments in fixed assets aimed at the development of construction increased from 129.5 billion rubles in 2005 to 448.7 billion rubles in 2015. The level of profitability in construction practically did not change over the years (3.9% in 2005 and 3.8% in 2015) [1, p.10, paragraph 1.1.].

Despite of the official open data lack on this issue, its comparable reliability is extremely low, because since 2013, Russia is introducing an international methodology for assessing housing services and materials and assessing the consumption of fixed capital on the basis of its current cost.

A number of authors are trying to justify the decline in the growth rate of construction in Russia [2]: - economic recession due to the negative impact of sanctions; - increase in the cost of imported building technologies and materials; - a decrease in the number of domestic and foreign investors in the construction industry of Russia due to the rigid foreign policy of sanctions; - a decline in the result of sanctions on the purchasing power of the population of Russia.

There are numerous publications of foreign and domestic researchers regarding to analysis of the problems of formation and evaluation of innovative types of reorganization of buildings and materials as cyber-physical systems in engineering areas of activity (in particular in the construction industry), as well as in reorganization and its efficiency as a fundamental process of development of activities in key sectors of the economics (Ott E, Grebogi C, Yorke G [4], Law J., Bijker WE [5], Boccaletti S, Grebogi C, Lai YC et al [6], Clarke EM, Grumberg O, Jha S, Lu Y, Veith H [7], Rabitz H [8, 11], Xiao JH, Hu G, Gao JH, Bhuiyan MZA, Wu J, Wang G, [9, 20], Boccaletti S, Pecora L, Pelaez A [10], Sontag E, Kholodenko BN, Kiyatkin A, Bruggeman F, Westerhoff H, Hoek J [12], Macnaghten P, Kearnes M, Wynne B [13], Cataldo A, Lee EA, Liu X, Matsikoudis E, Zheng H, Seshia SA [14, 17], Nordmann A [15], Huang HM, Tidwell T, Gill C, Lu C, Gao X, Dyke S [16], Hackmann G, Guo W, Yan G, Sun Z, Lu C, Dyke S [18], Dragos K., Smarsly K [19], Yuan X, Anumba CJ, Parfitt MK [21], Fradkov AL [22], Stolyarova OE [23], Yudin BG [24], Andreev AL [25], Jastreb NA [26], Zaborovsky VS, Lukashin AA, Mulyukha VA [27], Tolstova K., Chulkov VO [28], Losev KYu et al [29], Losev KYu, Chulkov VO, Chulkov GO [30, 31] and others.).

2. Methods
The result of the impact of objective factors of social development (the progress of cyber-physics and techno-science) and of subjective international political influences (not decreasing heat of foreign sanctions) is the forced development of the domestic construction industry in the context of continuous
Reorganization. The main method of scientific research of the reorganization space was chosen visual-shaped infographic modelling of organizational and technological features of the reorganization of buildings and materials in the cyber-physics of space techno-science. The infographic model of the basic reorganization cycle is shown below (Figure 1).

**Figure 1.** Infographic model of the basic cycle of reorganization [3].

Note. The model shows: - stages of reorganization (De - device, Di - disorganization, Re - reorganization, Co - co-organization); - interactions of these stages, which are represented by either a line with two arrows or a pair of oppositely directed one-way arrows (called impacts); - results of impacts and interactions (for example, Di → De - the result of the impact of stage Di on stage De).

Figure 1 shows two pairs of stages, which are opposite in their development trends, but closely interrelated (De and Re, Co and Di). These are the irreversible nonequilibrium development processes (antonyms) of any open system, the stages of its evolutionary or volitional (forced) reorganization. The structure of each stage of the basic cycle of reorganization is of the same type (Table 1).

**Table 1.** The structure of the phase of the basic cycle of reorganization [3].

| Stage of the basic reorganization cycle | For each stage its own goal, tasks and methods for solution is determined |
|----------------------------------------|--------------------------------------------------------------------------------|
| A common component for all stages of the basic cycle is the process of interaction between the restructuring R and the composition C: R ↔ C | The quality of the implementation phase as the proportion of R and C in the process of interrelation R ↔ C |

At each of the stages of reorganization, the ratio of R and C in the process of interconnection R ↔ C is different (Figure 2).

At stage De, the share of restructuring is small. Disorganization raises it to 90%, but during reorganization Re it decreases again to 15-20%.
Figure 2. Change in the share of restructuring at different stages of the reorganization cycle (Golubeva NN, 2003).

3. Discussion
The most studied is the stage Re (construction reorganization). The complex of construction reorganization types is shown in Figure 3.

Figure 3. Complex of types of construction reorganization (Chulkov VO, Kuzina ON, 2007)
As a formal criterion for distinguishing and systematizing the varieties of the construction reorganization, the volume of the used part of the initial functional resource \( FI \) (as a percentage) was chosen. \( FI \) is originally defined in the construction object reorganization project.

The meaning of this functional resource is its own for each type of construction reorganization. For example, in case of retreatment (using mounted systems for finishing rooms and facades of structures), such a resource is the area of the surface to be trimmed.

Since, for retreatment, the surface that requires finishing, in most cases is from 90% to 100% of the entire surface of the room (or the facade surfaces of the external walls of the building or structure), we accept \( FI > 90\% \).

According to the statistical studies results of modern Russian construction enterprises and organizations activities, the approximate \( FI \) values were determined for each of the above-mentioned types of construction transformations.

The \( FI \) values given in Figure 3 are not normative, but they define a region of all sorts of new innovative types of construction reorganization reasonably arising for meeting construction needs.

Such needs are produced by: - representatives of state and private forms of business, joint ventures, corporations and holding companies, associations; - market conditions for construction products; - innovative construction technology; - numerous participants in construction (investors; developers; developers; customers; designers; managers; contractors; suppliers; transport, operating and research organizations); - owners and users of buildings and construction structures.

A typical activity technology (algorithm) in the formation of an innovative type of construction reorganization: - by initiative or as a result of scientific research, a local component of a known type of construction reorganization is identified; - give this component the status of a new separate type of construction reorganization; - form the directive and administrative documentary support for a new separate type of construction reorganization; - make a type of construction reorganization a multivariate object of business activity; - form the diversity of its organizational and technological varieties; build models of the structure of a variety of construction reorganization; - normalize the processes of activity, the indicator and the quality levels of the results of a new separate type of construction reorganization.

For example: - the well-known local component of the reconstruction “fit out”, when it's needed could be transformed into an independent kind of reorganization “recomponation”; - the local repair component “restoration of the initial state”, if required, transforms into an independent kind of "reversal conversion", etc.

4. Results

Summarizing what has been said, it can be argued that the interaction of the cyber-physics Cph, the techno-science Tsc and the complex of innovative types Cit of reorganization of buildings and materials is advisable to represent the most studied model of the theory of multipoint logics - a three-point or triad (Figure 4).

![Figure 4. The triad of interaction of cyber-physics, techno-science and a complex of innovative types of reorganization of buildings and materials (model authors of the article, 2019).](image-url)
Note. The loading of the interaction of the two components of the triad by the control action of the free component is conventionally indicated ▼.

5. Conclusions
The synergistic effect of the development results interaction of techno-science and cyber-physics in the society, combined with the constant glow of foreign sanctions, has formed a steady mode of continuous reorganization in domestic construction. This situation should be studied in order to manage it.

As a method for studying dynamically changing reorganization space the authors of the article have chosen method of visual-figurative infographic modelling of buildings and materials reorganization in the cyberphysics of techno-science, concentrating on its system organizational and technological features. Using the theory of multipoint logic and the practice of infographic modelling, infographic models of building reorganization were proposed at four stages of this process (device, disorganization, reorganization and co-organization). Currently, the most studied stage of construction reorganization, the original models and quantitative estimates of different types of which are discussed in the article. At the moment, the most relevant type of modern construction reorganization for the housing and communal complex of the Russian Federation is renovation.

A further direction of the construction reorganization study, the authors consider revealing new innovative types of such reorganization with the subsequent study of its typical properties and characteristics.

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