

Qualitative multifactorial analysis and evaluation of options for urban development solutions

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Abstract. The development of ‘Smart City’ concept in the information society required the development of ‘artificial intelligence’ expert-analytical networks, new technical opportunities provided for the development of network expert professional analytical (situational) centers. This article considers the development of an invariant environment for the intensification of the group interaction of various specialists in the process of creating and evaluating solutions for weakly structured problem situations. A system-technical information processing solution has been developed, that takes into account the peculiarity of the thought-activity in the form of representation of graphic and analytical components of the weakly structured problem situation of the interdisciplinary subject area on a single screen. In particular: due to distribution of the thought-activity of various roles during the ‘Electronic brainstorming table’ in the group session: ‘Director’, ‘Stagehand’ and ‘Experts’. At the same time, a ‘Stagehand’ (Urban developer) is a mediator or communicator who has the skills of using the stagehand support environment for the ‘Strategic techno-theatre’ (STT) solutions, ‘Experts’ (representatives of ‘Power’, ‘Business’, ‘Society’ and specific ‘Individuals’). The use of the developed software allows accounting for and generalizing the interests of various urban development stakeholders in the use of the ground, underground and above-ground territory. The obtained technical solution can be used by both state and municipal authorities for the formation of urban development policies and the implementation of joint projects, as well as other projects of stakeholders.

1. Introduction

The scope of this study is within the emerging concept of ‘Smart City’. The company ‘Navigant Research’ identified five main components of a ‘Smart City’: 1) Smart Technologies and Infrastructure for Energy, 2) Water, 3) Transportation, 4) Buildings, 5) Government: Business Drivers, City and Supplier Profiles, Market Analysis, and Forecasts [1].

Among the various named areas of the ‘Smart City’ concept, urban planning is the connecting link for all of them. In the 21 century, ‘Smart Cities’ are considered as a model of urbanization [2]. In the modern information society, the role of information modeling increases for urban development of the living environment: expert-analytical networks of ‘artificial intelligence’, new technical possibilities for finding a compromise at the pre-project stage of urban development. Such planning underlies the



group session of the thought-activity of the pre-launch and start of various network expert professional analytical centers: Smart Energy, Smart Water, Smart Buildings, Smart Government, Smart Transport.

In Russia, the field associated with analytical (situational) centers for urban development has been studied in the works following the scientific school of organizational activity games and the system-thought-based methodology by G P Shchedrovitsky and the scientific school of organizational management and methodology of the information systems and conceptual analysis development by S P Nikanorov. These are the works of O S Anisimov, E P Grigorjev, O A Zhirkov, A A Zinovjev, V E Lepsky, V A Lefevr, G G Malinetsky, A N Raykov, A V Shevyrev [3].

To achieve a compromise and consensus among the stakeholders in urban development 'Power', 'Business', 'Society', 'Individual' (hereinafter - PBSI) [4], the reflection is fundamental for the study and construction of social systems (models). Examples of reflexive management, known from N Machiavelli's works, J Soros publications, Chinese stratagems, used by business consultants, are quite popular. However, the possibilities of formalized reflexive analysis are practically not mastered in applied modern urban development of 'Smart City'. In the global trend of direct influence of scientists on decision-makers reducing, the role of reflexive methods for ensuring such influence will increase. In Russia, interest has recently increased to a civilized form of dialogue with consumers to create a comfortable environment and achieve win-win in terms of public-private and city authorities-private partnership compromise among stakeholders in urban development activities - four subjects of urban development. Error price in the creation of a 'Smart City' is not comparable to the costs of analysis of urban planning decisions at the pre-stage using modern information and communications means, including the stagehand environment of 'Strategic techno-theater' decision support (hereinafter - the software STT or STT) [5]. 'Figure 1 presents STT software screen examples.

2. Methods and Materials

The research is based on the method of T Saati, the methodological development of G P Shchedrovitsky and S P Nikanorov, approaches to evaluation and assessment of weakly structured problem situations in situational centers by O S Anisimov and E P Grigorjev [3], as well as the block diagram of decision-making in the stagehand environment of 'Strategic techno-theater' (STT) [5]. T Saati's method of analyzing hierarchies and the method of interactive visualization of multifactorial spatial data in analytical systems were used at the situational center of the Situation Room in the Presidential Executive Office of Russian Federation, the Russian Academy of Public Administration and the MGIMO University [3]. However, these methods were not applied for a comprehensive urban development analysis of all subjects of urban development PBSI relations on the territory.

The design experiment was carried out in the educational process of the National Research University of Moscow State University of Civil Engineering in Department of Urban Development. The study used hypothetical multifactorial data of the territory, characterizing the problem of conflicts of stakeholders in urban development, conflicts in the planning of an object of capital construction (using the example of a multi-storey apartment building). Also, STT was tested in a scientific study, which was carried out based on actual data on disturbed territories as a result of coal mining activities in the Kuzbass (as an example, involvement in the urban development reuse of such areas).

Public cartographic data of Open Street Map was used. Information about the location of coal basins is taken from public sources (GIS Atlas 'Nedra Russia'). To create visual information layers of a problem situation, the geographic information system ArcGIS (ArcInfo) is used. Urban development data (multidimensional data) includes information about various objects (territories of different levels of planning, forecasting and design) by different subjects of urban development relations, which have certain, probably mutually exclusive interests in the use of ground, underground and above-ground territory. The basis for the actions of a 'Stagehand' (urban developer-mediator or communicator possessing the skills of using the stagehand environment STT solutions support) is a study of the problem situation. The analysis of the weakly structured situation under consideration, which begins with the creation of a list of relevant factors that characterize this problem for interested stakeholders

in urban development, their aggregation and the formation (forecasting) of scenarios of future processes. As the first iteration, the ‘Experts’(representatives of PBSI - physical or legal entities having legal relations to specific land plots in respect of which options are being considered for urban development) offer lists of relevant (important) text factors for them.

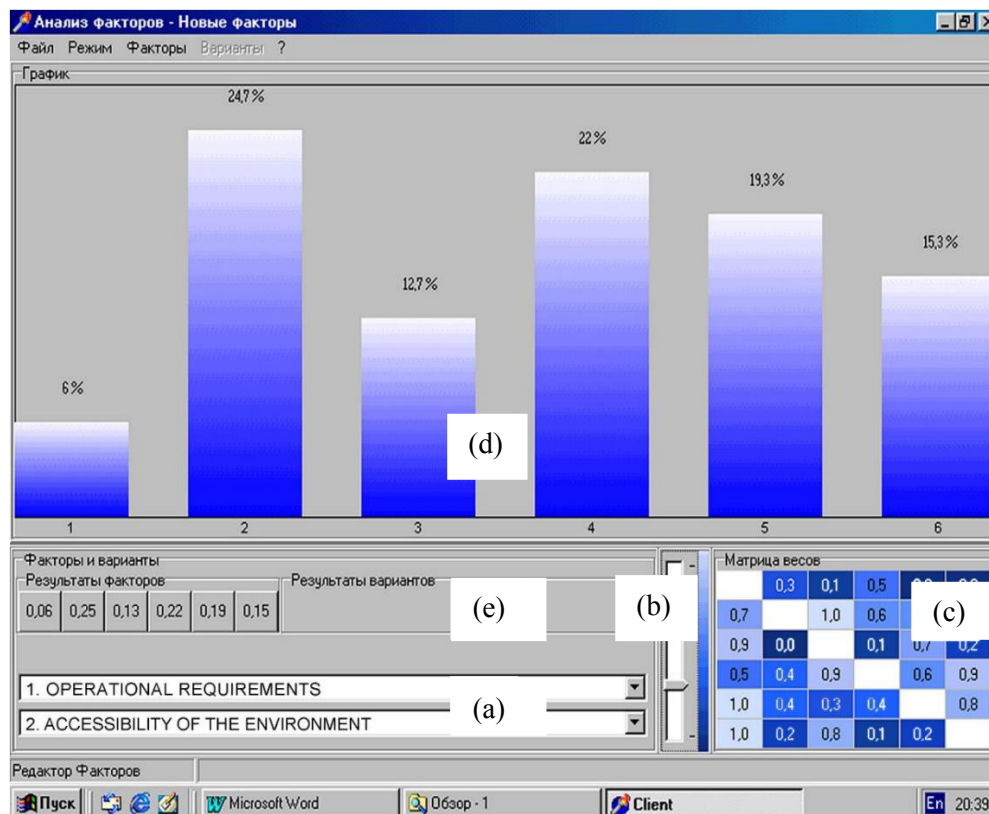


Figure 1. STT software screen (an example of an urban-planning solution evaluation by an ‘Expert’): (a) relevant factors of the problem situation or options of urban development decisions, hereinafter the factors (options), (b) the slider for pairwise comparisons of factors (options) among themselves, (c) the results of pairwise comparison of factors (options) in the form of a matrix, (d) the result of pairwise matching of the relevant factors (options) in the form of a histogram, (e) an interactively visualized indicator of the relevant factors (options).

‘Stagehand’ (Urban developer) prepares visual information layers of significant relevant (important) options of the problem situation. The urban developer makes the necessary studies and prepares options for the map-schemes for the territorial object being developed; taking into account the identified and justified type of urban planning unit, its urban development boundaries, which are necessary for selecting the type (kind) of urban development documentation. The conceptual foundations and methods of the mentioned urban planning for the use of territories are set forth in the research paper of the Russian Academy of Architecture and Construction Sciences (RAASN) under grant 3.3.4 for 2015-2016.

The ‘Director’ (the person making the decision) in the STT analyzes aggregated text factors and graphical options that have a significant impact on the adoption of an urban development solution. Values (text factors and graphic image options) are shown in Figure 1 (e).

3. Results

The article presents the first results of a project experiment on the generalization and systematization of the informational modeling process of expert group interaction in various fields of activity in the process of creating and evaluating solutions for weakly structured problem situations in various subject areas. The problems of the subject area are identified: urban development, which is interdisciplinary and includes information (multifactorial data) of various stakeholders of urban development activities: 'Power', 'Business', 'Society', 'Individuals' (PBSI).

The modified software module includes: The 'Electronic brainstorming table' to support group interaction of experts and an interactive problematizer for visual shaping of solutions to the problem situation. In the process of playing a game interaction session with group support of decisions (in the case of software and hardware interactive cooperation of decision-makers on the common means of displaying information), the director 'gives the floor' to each of the persons of the stakeholder group in accordance with the scenario or as necessary in the process of the game session.

'Experts' (subjects of urban development) estimate the relevant factors together with the 'Stagehand' (urban developer) and a special analyst during the gaming session in the STT studio at the electronic table for the brainstorming support, receiving ratings of the factors that are further used in assessing options for solutions of a problem situation.

At the same time, the urban developer visualizes various options of urban development decisions, which have gained the most weight among the generalized factors expressed by 'Experts'. Common for the design experiments outlined in the article (for an object - a multi-storey apartment building; for the territory - the coal mining area) is that the analysis of the problem situation begins with the shaping (forecasting) scenarios of future processes and making lists of actual (important) factors that characterize this urban development situation. As a first iteration, the 'Experts' propose lists of actual (important) factors for each group of 'Experts'.

3.1. Basic principles of informational modeling of the Urban Development System in the form of expert-analytical network 'artificial intelligence'

The qualitative result of the initial data and materials study and its legitimate formalization at the decision-making level are aimed at accelerating (by factors) the creation and evaluation of urban development solutions. A system-technical information processing solution has been developed that takes into account the peculiarity of the thought-activity in the form of representation of figurative and analytical components of the weakly structured problem situation of the interdisciplinary subject area on a single screen. In particular: due to the distribution of various roles at the 'Electronic brainstorming table' during the group session of the thought-activity: 'Director', 'Stagehand', 'Experts'. The modified software module includes: The 'Electronic brainstorming table' to support group interaction of experts and an interactive problematizer for visual shaping of solutions to the problem situation. In the playing process of a game interaction session with group support of decisions (during software initialization and hardware interactive cooperation of decision-makers on the common means of displaying information), the 'Director' gives the 'floor' persons of the stakeholder group in accordance with the scenario or as necessary in the process of the game session.

'Experts' (subjects of urban development) estimate the relevant factors together with the 'Stagehand' (urban developer) and a special analyst during the gaming session in the STT studio at the electronic table for the brainstorming support, receiving ratings of the factors that are further used in assessing options for solutions of a problem situation. At the same time, the urban developer visualizes various options of urban development decisions, which have gained the most weight among the generalized factors expressed by 'Experts'. Common for the design experiments outlined in the article (for an object - a multi-storey apartment building; for the territory - the coal mining area) is that the analysis of the problem situation begins with the shaping (forecasting) scenarios of future processes and making of actual (important) factors list that characterize this urban development situation. As a first iteration, the 'Experts' propose lists of actual (important) factors for each group of 'Experts'.

3.1.1. The first problem situation: conflict related to the placement of the capital construction object. In this problem situation, the following scenario is considered: in view of the spatial and temporal urban development in the micro district of city N, it is planned to build a multi-storey apartment building on the outskirts of the forest area adjacent to the given territory. The aim of the research and compilation of the stageholder model is to analyze the reaction of all participants of urban development activity to the erection of the object of capital construction. For the investigated object, factors for each group of 'Experts' ('Power', 'Business', 'Society', 'Individuals') were hypothetically revealed. In the article, only relevant factors proposed by the 'Experts' of the 'Society' group (regional, local, local communities, for example: 'Society for the Protection of the Historical Heritage of the City of N', ecological community 'Greenpeace'): 1) Operational requirements, Figure 1 (a); 2) accessibility of the environment, Figure 1 (a); 3) organization of sustainable urban communities; 4) reconstruction of the network of transport routes and organization of new transport route; 5) preservation of historical heritage; 6) preservation of the natural landscape in vicinity of the territory. An interactive visualized indicator of the relevant factors of the problem situation in the form of histograms is presented in Figure 1 (d).

3.1.2. The second problem situation is: conflict involvement in the urban development reuse of territories. The presented example (the study examines one type of different typological units of the urban development as the area of coal mining) illustrates the operation of the first phase of the STT module as the stageholder work at the 'Electronic brainstorming table'. The problem of multifactorial analysis and qualitative assessment of the territory options is more complicated than the possibilities described earlier for the first phase of the STT work for the capital construction object. The authors formed a training and demonstration complex using information layers (map-schemes) based on actual data from the GIS environment. Multivariate analysis and evaluation of pre-project urban development options in the second phase of STT are illustrated by the example of involvement in the urban development reuse of the territory previously used for coal mining activities in Kuzbass.

In particular, there is a pairwise comparison of the relevant option chosen by the 'Stagehand' in the STT module (interactive visualized change of the solutions (options) of urban planning see Figure 1 (e)): 1) The impact of the social and economic attraction of the settlement (zones from settlements in km according to table data); 2) Transport accessibility of the settlement (isochron availability lines, hour); 3) The distance of the disturbed zone from populated areas; 4) Level of industrial coal reserves (billion tons); 5) The duration of coal mining (years); 6) Location of disturbed areas (in meters above ground level for open and underground coal mining).

The selection of these factors minimizes the options for decisions of urban planning of the previously formed factors of PBSI (similar to the previously described example of an object - a multi-storey apartment building).

The result of the pairwise comparison of the options is the weight matrix and the histogram of the factors or options significance, taking into account the peculiarity of the thought-activity in the form of representation of visual and analytical components of a weakly structured problem situation on a single screen.

4. Discussions

Nowadays, there is a tendency in the urban planning of previously mastered urbanized territory, i.e. renovation and revitalization of objects and land plots functions. It is proposed to search for a compromise between stakeholders in the urban development activities PBSI using the STT method in the information system (urban development system - information modeling concept).

The developed STT software can be used to process an unlimited amount of data (different interests of stakeholders in urban planning representatives). Filling of factors in the STT software by the subject can be carried out directly at the location of the planned object (land plot) or remotely, incl. online. In some cases, it is possible to use STT software in a special vehicle with computer equipment.

To work out the hypotheses, a town developer (stageholder) can attract specially selected representatives of urban development stakeholders to a situational center to conduct a brainstorm (for testing or working out urban development hypotheses).

At the present time STT software has a Russian user interface. Developers can adapt the STT software interface, including for Mobile Networks, for using in any convenient language.

5. Conclusions

The outcome of the research was the formulation of the basic principles of employing the informational modeling concept of ‘Smart City’ as an urban development system in the form of an ‘artificial intelligence’ expert-analytical network to achieve compromise between urban development stakeholders. The use of the developed STT software allows accounting for and summarizing the various interests of the urban development subjects using advanced information and communication tools, including support for decision-making in the field of ‘Strategic techno-theater’ as STT. The STT software can be part of the Building Information Modeling (BIM) technology, which facilitates collaborative processes in architecture, engineering, construction and facility management (AECFM) industry.

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