Conception of the operational information model of smart city control system

Olga Kuzina*

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

Abstract. The article contains the BIM-models cycle, background and basic principles of creation the operational information model of smart cities control system with tools for performing the rule check, sequence of E-BIM model use. For the development and implementation of the operational information model of smart cities control system in the construction industry, it is necessary not only to determine the basic levels and parameters of choice when taking into account solutions from the organizational and technological documentation, but also to build the architecture of application software to ensure the operation of the control system at all subsequent stages of the life cycle of the smart object. It is important to determine the main factors affecting decision-making and parameters of formation of input and output data for modeling each stage of the life cycle of the object, as well as technical and economic indicators of the information model by stages [1,2].

1. Introduction

When designing automated control systems use cybernetic interpretation of the "system" definition. This is explained by the definition of control as a probabilistic information process with extensive use of mathematical models and computer tools adopted in cybernetics.

Complex dynamic systems are sets of interrelated variables, which can be sets of characteristics or properties of the objects considered in the system.

When developing automated control systems, it is necessary to comply with a number of principles that ensure the achievement of the goals of the system.

To create operational control system, it is necessary to rely on the following principles: the principle of new tasks (inclusion fundamentally new tasks in each of the functional subsystems, the solution of which is possible only in the conditions of using modern software); the principle of the first head; the principle of system (integrated) approach; the principle of document flow automation; the principle of unified information database; the principle of tasks complexity and work programs; the principle of one-time input and accumulation of information; the principle of maximum reasonable typing of design solutions; the principle of the system continuous development.

* Corresponding author: KuzinaON@mgsu.ru

Multivariance and complexity of the exploitation models development to control the facilities, as well as methods of organization of operation and its maintenance leads to the emergence of many optimization problems, the solution of which allows to open and use significant reserves to improve the efficiency of each engineering system work and the total object.

Using information and communication technologies help to solve the following main problems of modern smart cities:

1. Ensuring efficient and optimal use of data, information and all types of resources.
2. Automation of production processes, decision-making processes in the event of deviations from the planned indicators.
3. Complex systems formation for interaction of production and social processes.
4. Ensuring information interaction between people as a mean of communication and information transfer.
5. Development of education system, system of knowledge accumulation and information culture of the society.
6. Predictive analysis of the industry development, forecasting of engineering systems, risk assessment and calculation of the probable consequences of adverse circumstances.

Operational information model of smart city control system based on the information model of the building obtained at the construction stage (C-BIM). And then C-BIM model develop into E-BIM model, which later become useful for the stage of the building lifecycle – RE-BIM. The content of that model is shown at the table 1[3,9].

Table 1. Input and output data for modelling E-BIM and RE-BIM stage of life-cycle

	E-BIM	**RE-BIM**
Input data	N-D model	N-D model+
Final document	Report of the object inspection	Put into operation the system and object (permission)
Model type	N-D model+	N-D model++
Technical and economic indicators	TEI_3	TEI_4

The N-D model is a multi-dimensional model that takes into account all operational activities on the construction site at any given time;

N-D model+ is a multi-dimensional model taking into account the data on the results of monitoring the work of engineering systems of the building, operating costs and the results of inspection of the building and systems for further reconstruction;

N-D model++ is operational a multi-dimensional model taking into account data on the project and the fact of performance of works on reconstruction of the object (reconstruction/ renovation/ retrivation/ reversation/ rekombination/ restoration/ rehabilitation/ recycling/ reequipment);

TEI 3 (technical and economic indicators) -building volume of the building, the total area, the cost of construction, the power of the object, the cost per m2 and m3, the cost of CMP and equipment, the duration of construction, the length of engineering networks, power supply devices, energy demand, total labor intensity, average output per 1 person per day, the average number of workers, payback period, performance of all engineering systems of the building, tariffs for electricity, heat, water, sewerage, gas, etc.

TEI 4 - building volume of the building, the total area (possibly modified), the estimated cost of reconstruction, the power of the object, the cost per m2 and m3, the cost of construction and equipment, the duration of reconstruction, the length of engineering networks (possibly changed), the power of power supply devices, the need for energy, the total complexity of the reconstruction, the average output per 1 person per day, the average

number of workers, payback period, the performance of all engineering systems of the building, etc. [3,9]

2. Methods

To create the conception of the operational information model of smart city control system it is necessary to solve following tasks.

Task 1. The identification of alternative technical systems that implement the goals and objectives (industry related).

Input information: tasks and criteria, general requirements for the technical complex (product), the composition of the complex and the requirements for subsystems, the approximate terms of use, the data of scientific and technical information.

Output: principles of design solutions, the required technology and materials, the required solutions and scientific and technical problems, the tree of alternative versions of the technical complex with an assessment of the existing state of availability for each of the options and an assessment of the probability of creating a technical complex to given estimated time.

Task 2. Full assessment of alternative complexes of this purpose and selection of the complex according to the criterion 'Cost-effectiveness'.

Input information:

1. Product characteristics (for each alternative complex): static characteristics (product design specifications, weight, geometric dimensions), dynamic characteristics of the product in different operating modes.

2. Characteristics of the product life cycle: the required volume of production exploitation works for the complex; a calendar date of completion of research, development, production and operation; the duration of the stages of development and production (standards of the times); the economic parameters for life-cycle stages of complex (cost standards).

3. Criteria and models of the target effect.

4. Model and cost-effectiveness criteria.

Output information:

Evaluation of the cost-effectiveness criterion for each alternative complex; comparative characteristics of alternative complexes for different parameters; justification of the proposed complex for this purpose [4].

For this purpose it is necessary to create special software which could provide decision making on each level.

The composition of the system-wide mathematical and software automated control system operation of the object is divided into 4 subsystems: message analysis system, information support system for task solving, organization system for task solving, automatic office management system.

Message analysis system (input system) is intended for determination incoming information processing modes and providing necessary dialogue between users and technical means. The mode of such messages processing should be determined by the system on special features of messages.

To perform these functions, the message analysis system has 5 blocks.

Block Manager is designed to ensure the joint operation of all units of the message analysis system in accordance with the type of message, the configuration of the system in accordance with the allocated resources, the implementation of communication with other systems of mathematical support.

Tasks of syntactic and semantic analysis blocks — the allocation of individual sentences of messages, checking the correctness of their construction, their distribution, in

order of importance, the formation of the summary rules of their analysis, the definition of input and output parameters of the message, the formation of signals in the block dialogue about anomalies identified during the syntactic and semantic analysis.

The block of the list of works formation is intended for determination of the message processing possibility (transition - from input parameters of the message to output), determination of optimum ways of processing, creation of the list and sequence of works with their necessary description and formation of output arrays structure with their description, formation of signals in the block of dialogue about reception of the message in processing or about impossibility of its processing.

The block of dialogue with the user should provide formation and delivery to the user of signals about acceptance of the message in processing or impossibility of its processing, about the anomalies revealed during the syntactic and semantic analyses, the analysis of additional (secondary) messages of the user, addressing them in other blocks of system and formation of the corresponding signals to the user about implementation of its additional messages.

Information support system for task solving. The system is designed to organize the storage of information and provide the necessary information to solve all calculation and information problems.

To reduce the volume of operations for the preparation and input of information into the system, eliminating unnecessary duplication of work and information, reducing the required amount of memory and unification of mathematical support, it is necessary to strive to create a single array (fields) of information to solve all problems of automated control systems. According to the efficiency of use and physical storage of information single arrays (fields) can be divided into levels: permanent information; operational information required to solve a set of tasks of one stage of management; current, information needed to solve a specific problem.

The basis for the creation of single arrays (fields) of information for different tasks is the creation of a common information language, providing a description of each item of information, non-location characteristics of the information, possibility of differentiation of recurring and non-recurring characteristics.

The information support system in the course of its operation must ensure:

- reception, placement and storage of information;
- search on information fields and selection of information necessary for solving specific tasks;
- processing of selected information, editing and formation of response information arrays (fields) in the form necessary for solving specific tasks.

For performance of the specified functions in system 7 blocks are provided. In addition, libraries of standard procedures, placement optimization blocks, information in different level storages, information security, statistics collection can be included in the system.

The block of information requests analysis performs the functions of perception, semantic analysis of the request, determining the optimal way of its processing.

Blocks of formation, updating and maintenance of information arrays (fields) should ensure the compilation of information record structures, the establishment of semantic (associative) links, the compilation of addresses, the location of records, the organization of new data or changes to existing records, the elimination of obsolete records.

The information retrieval unit should provide the determination of the location addresses necessary for solving a specific task of information, the selection of information from the corresponding information files, the organization of the primary grouping of information in accordance with the requirements of a specific information request.

The block of formation of response arrays is designed to determine the form of the response array, which is necessary for solving a specific task, selecting and arranging

information in the necessary order, selected and grouped by the search unit, including standard library procedures into operation, which are not explicitly in the main information arrays.

Organization system for task solving is intended for direct management of programs set work of special mathematical support at the solution of information and settlement tasks.

In the course of functioning this system should provide:

- specific planning of computational work required to solve this problem;
- determination of the necessary system resources to solve the problem;
- timely inclusion in the work of some programs of special mathematical support;
- monitoring the progress of the task and its logging;
- processing and maintenance of additional consumer instructions received in the course of solving the problem;
- definition of capabilities and management of parallel solution of several tasks;
- modify the plan of solving the problem and the redistribution of computational efforts in the case of changing the allocated resources.

To perform these functions in the system of organization of task solutions there are 5 blocks.

Block-manager is designed to ensure the joint operation of all the blocks of the system for solving problems, setting the system to work in the mode corresponding to the allocated resources, communication with other parts of the system of mathematical support.

Unit planning provides the definition of the resources required to solve the problem and the formation of the corresponding application, the planning work on the solution of tasks when selected: resources, reallocation of work, if you change the allocation of resources, formation of accesses to the information management system to obtain the necessary for the decision of tasks of information.

Maintenance unit library design and information tasks of the special mathematical software maintains a library catalogue searches and a call to the required programs, should maintain and update the library and directory.

The control unit ensures the development of the plan of computational work, timely connection to the necessary programs, the formation of appeals to the exchange unit in the case of joint work of several programs.

The exchange unit organizes the joint work of several programs, processing of additional consumer instructions received in the course of solving problems, monitoring the use of allocated resources and the time of return of free resources.

Automatic office management system is designed for registration and accounting of all appeals to the system, differentiation of access to information and tasks.

In the operation of the automatic record keeping should allow for the automatic:

- identification of the subscriber who has applied to the system for input, output of information or solution of this or that task;
- check the rights of the subscriber to input, the output of this information, and that the solution of a particular problem;
- the permit input, output information and the solution of the problem or a signal of disloyalty of circulation;
- definition of the classification of the newly generated information (the solution of task or generalization of individual messages) on the right of cecrecy;
- registration of all requests for input, output information, problem solving with indication of subscribers, time entered or issued information.

To perform these functions, the automatic office system is built of 6 blocks.

The dispatcher provides the joint functioning of all the blocks of the system in all modes: applications for inputting, outputting information and solving problems from

individual external subscribers, technical personnel of the facility, other automated objects of the system, other tasks solved in the system, etc.

The unit for checking the loyalty of a request based on special characteristics of calls (names or numbers of subscribers, various digital, light codes, especially voices, etc.) identifies subscribers and checks their right to Enter, output information and solve problems.

The classification (establishment) block of the newly formed information column automatically, based on a meaningful analysis, determines the right (security classification) of different subscribers to use information, which is a synthesis of individual messages or the result of solving problems.

The unit for accessing information should automatically form special program measures that prohibit access to information and tasks without the permitting commands of the loyalty checker unit, and organize access to information and tasks with such permissions.

3. Results

Analysis of the system-wide functions, the software of the operational information model of smart city control system (OIMCS) and its objects shows that the composition and structure of these systems extremely strongly depend on the nature and characteristics of the tasks being solved. In those cases when in OIMCS or on object the defining value have information tasks, the systems of the analysis of messages and information support up to association of these systems in one automated information system receive the greatest development.

If in the OIMCS or the object of determining importance are complexes of interrelated computational problems, all three systems of the system-wide part of the mathematical support can merge into one system of complexing problems.

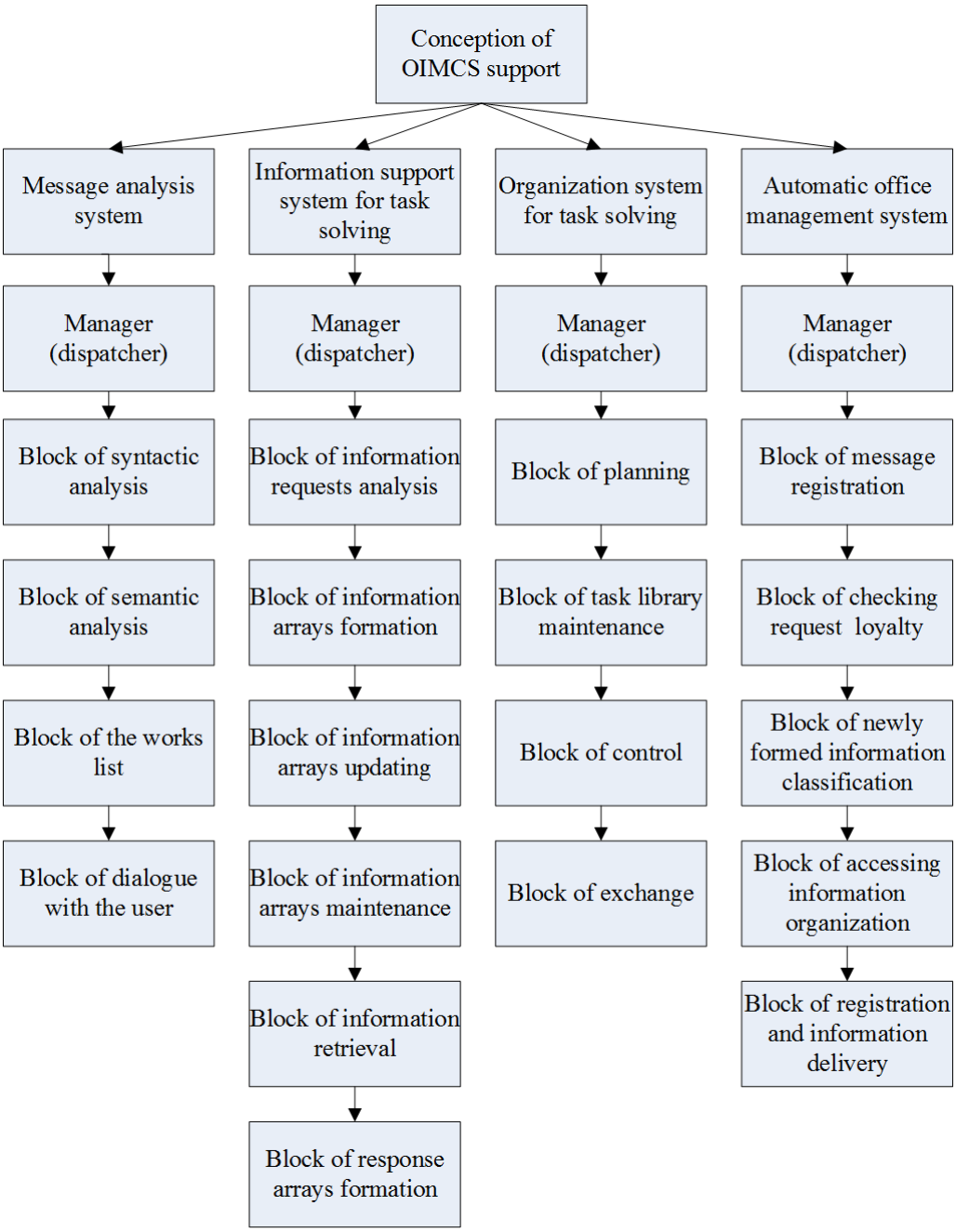

Fig. 1. Conception of control system in the operational information model

4. Discussion

For effective management of smart house it is necessary to take into account a number of features of this type of activity. Control system has a limit defined within the specified service requirements in a confined space. This system is conventionally closed, formed for

each object individually depending on the size and structure of the needs at each individual time. The functioning of such systems is associated with the development of infrastructure, spatially limited by both physical and organizational and functional boundaries [5,6].

The main objectives of the smart city management system are to ensure sustainable development of urban infrastructure, improvement of the urban environment, ensuring a given level of comfort and safety of living.

The enterprises rendering services in management of the building are not producers of these services therefore there are difficulties in the sphere of the organization, distribution, calculation and the accounting of the rendered services, cost of the rendered services. In this regard, the management companies make mutual settlements with the supplier organizations: electricity (power plant), natural gas, thermal energy, water supply and sanitation. The formation of the information model of the building at the stage of operation, taking into account all current indicators, is necessary for the implementation of an integrated approach to the effective functioning of the building systems.

To build an effective management system at the stage of operation services it is necessary to understand that the operational model is a multi — level system of various industries, united by economic and social goals and objectives to meet the needs of the user, to ensure the level of comfort of living in the existing environment [6].

There are three types of needs for operational control system: management services of life support systems (because of cease functioning or failure of systems can lead to emergency situations); management of the user's daily needs (classification criterion-a factor of service delivery time); management of needs upon occurrence of problems (the classification criterion is a factor of the need for the provision of services) [6].

Offered conception could help to provide all the function of facility management at three levels.

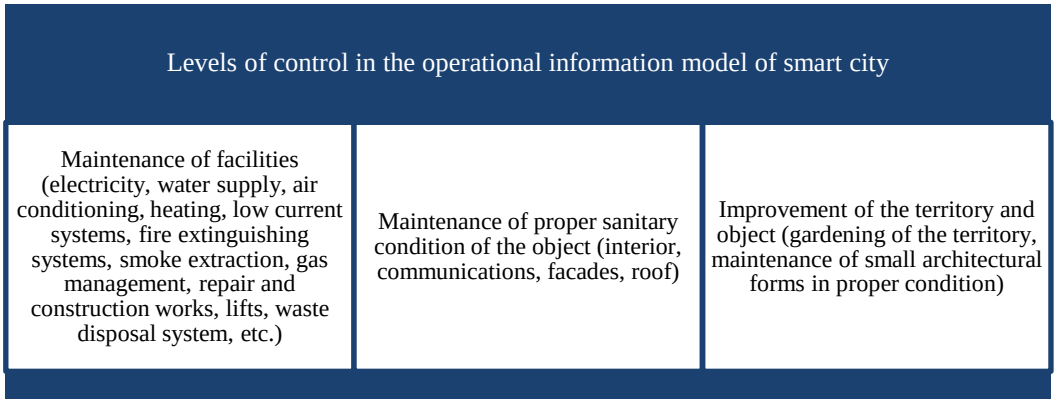

Fig. 2. Levels of control in the operational information model of smart city

5. Conclusion

In order to implement the above, it is necessary to develop appropriate software to take into account all the requirements that affect the final decision.

The main elements of such a system should be:

1. Data warehouse containing data of official statistics reports, goals and requirements of the customer to the project under consideration.

2. Software modules for collecting information, importing data into the repository by both automated and manual input depending on the required information and its source, modules for calculating performance indicators and comparing options.

3. Analytical subsystem of legislation, standards depending on the territorial division, analytical information on the region of transport infrastructure, suppliers of materials and equipment, etc.

4. A planning subsystem for predicting the results of selected solutions, based on the calculations of local problems, which performs calculations in the form of comparison.

5. Means of visualization of the obtained multifactor parametric models. Means of display of initial data at the stage of information input, results of changes of the main criteria depending on the chosen decision for each parameter, results in General on object. Generation of reports in various formats.

6. The administrative subsystem is necessary to ensure information security (taking into account the differentiation of access rights to information, the order of use of data libraries), to work with database servers [7].

The creation of an information system for managing the operation of buildings and their infrastructure will allow:

-improve the efficiency of design, construction, operation on the basis of predicting the behavior of the building system and its infrastructure;

- to organize rational management of the project implementation by increasing the level of operation planning at the initial stages of design and increase efficiency in the implementation of tasks;

- build a predictable financing system for the facility throughout the life cycle of the building, simulate changes in infrastructure projects;

- reduce time for preparation and execution of works, labor costs for operations on search and processing of data for decision-making;

- provide the proper level of security in operation of life support systems in smart city [7,8].

Software based on the technology and methods of artificial intelligence should be developed in the construction industry. This will allow to optimize the management system, to make decisions with the highest quality, to minimize the time spent on finding solutions, as well as to control the implementation of state tasks, to reduce the risks of the construction industry as a whole [9].

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