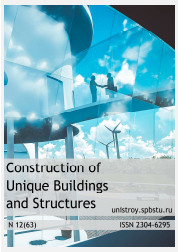
Строительство уникальных зданий и сооружений. ISSN 2304-6295. 12 (63). 2017. 7-19



Construction
of Unique Buildings and Structures

journal homepage: www.unistroy.spbstu.ru

Monitoring of the construction site using an information model

O.S. Grishina [1]*, A.V. Savchenko [2], A.P. Marichev [3], E.S. Zalata [4], M.V. Petrochenko [5]

[1-5]*Peter the Great St. Petersburg Polytechnic University,29 Politechnicheskaya St., St. Petersburg, 195251, Russia*

Article info

scientific article

doi: 10.18720/CUBS.62.1

Article history

Received: 08.11.2017

Keywords

Information model;
4D BIM;
4D modeling;
4D BIM tools;
work schedule;

ABSTRACT

BIM technologies are an integral part of the modern building process. In order to approach the complex implementation of BIM, it is necessary to use not only the 3D modeling process. The next step is to generate a 4D model based on the 3D model and work schedule. Russian construction companies implementing BIM are beginning to implement 4D models not only during the design phase but also during the construction phase. This article shows the principle of control of the construction site due to the information model. The most common software applications are identified. Their main characteristics are clarified and also in what situations the software applications can be used to organize the most effective work.

Content

1. Introduction 8
2. 4D Information modeling 8
3. 4D BIM tools 10
4. Results and discussion 10
5. Conclusions 15

Contact information:
1* +79118372393, olgasergeevna2009@yandex.ru (Olga Grishina, Student)
2 +79111153597, ya.int@yandex.ru (Alexey Savchenko, Assistant)
3 +79215870750, lexa-ap94@yandex.ru (Alexey Marichev, Student)
4 +79214078184, ekaterinazalata@gmail.com (Ekaterina Zalata, Student)
5 +78125529460, mpetroch@mail.ru (Marina Petrochenko, Ph.D., Senior Lecturer)

1. Introduction

Increasing of the requirements for effective construction management [1-5] leads to the implementation of the recently developed BIM-technologies, including the 4D management tool [6, 7]. This tool allows to create an integrated model, analyze the process of virtual building of an object, eliminate space-time collisions during the design phase, as well as supervise the execution of assembly works during actual construction [8-10], which is excluded in the traditional approach to the construction process [11]. The use of 4D modeling improves the interaction between the participants of the construction project, also improves the quality of the work following the deadlines and minimizing the additional costs [12, 13]. But the process of realizing this technology in real projects is still complicated and requires its detailed elaboration.

At present there are no BIM standards in Russia that contain information about 4D modeling. Each organization that implements an information model in the life cycle of a building creates its own system for implementing and using BIM-technologies, in particular 4D modeling. In this regard each organization develops its own principles for the 4D model development. At the moment, during 4D modeling, the model is checked for intersections and spatio-temporal collisions due to the assembly of the model from separately executed project sections and the work schedule [14, 15]. In most cases the obtained information model is not used on the construction site to monitor the actual construction process, which is also implied in the 4D modeling [16]. In the UK in 2013 a conducted study showed that BIM was most common in the design and pre-construction stages, and in construction and operation - less often [17]. In Russian companies BIM currently has a lower maturity level than in the United Kingdom at the time of the previous study (for example, this is indicated by the lack of BIM standards established by the Russian legislation, while the first standard was introduced in the UK in 2009 year). The use of the 4D informational model is voluntary and is not accepted by most builders as an effective management tool during the construction phase. This leads to inefficiency of the process. Therefore, the concept of an integrated approach inherent in BIM [16, 18-21] is not fully realized at the moment.

In addition to the lack of approved principles of control of the construction with the help of the information model there is insufficient information on how to create and implement the 4D model. Along with foreign programs there are Russian analogues which have not been sufficiently studied and therefore are applied to a lesser extent.

The purpose of this paper is to investigate software applications that provide the 4D modeling process. To do this it is necessary to identify the most used programs among Russian companies with the help of the survey. With the help of theoretical analysis identify and compare the characteristics of these software applications; find out in which situations they can be used to organize the most effective work.

2. 4D Information modeling

Building SMART (2010) defines BIM as follows: “The building information model (BIM) is a set of information that is structured in such a way that the data can be shared. A BIM is a digital model of a building in which information about a project is stored. It can be 3D, 4D (integrating time) or even 5D (including cost) – right up to ‘nD’ (a term that covers any other information)”.

4D BIM requires a connection of the construction plan with the 3D model [16]. It is possible to create 4D models both for the whole project or for its separate parts presenting the project as separate moments of time. In this case any adjustments of the plan or 3D model are reflected in the visual model itself [16].

According to Koo and Fischer [22], in 4D Models the temporal and spatial aspects of the project are closely interrelated. These aspects allow users to view the construction process, improve the understanding of the construction schedule and identify errors before commencing construction work. Other benefits reported by Eastman et al. [16] include improved communication, simplified logistics management, comparison of execution plans and monitoring of construction progress. Olde Scholtenhuis et al. [23] believe that the 4D coordination process allows us to focus on operational interdependence, identifying potential conflicts, elaborating strategies, building awareness, detecting errors and taking corrective measures. The advantages of using 4D modeling tools in comparison with traditional tools are described in the studies [24-26].

Thus, due to the use of 4D modeling we have:

- Optimization of construction work schedules (optimization of deadlines, comparative analysis of project implementation options, development of an optimal construction scenario, identification of spatio-temporal collisions in calendar planning).
- Transfer of the 4D informational model to the construction site.
- Fixation of the actual work performed (daily automated time control, quality control of the work performed, continuous monitoring of the implementation schedule of the project).

- Up-to-date information about the progress of construction in a single information model (identifying the deviation of actual construction from planned in the early stages, minimizing the risk of failure to meet construction deadlines).
- Automated reports on the progress of construction.

4D informational model at the construction stage is used by the general contractor (for direct control of construction and installation works and issuing tasks corresponding to contractors), the general designer (as a means for author supervision), technical supervision bodies (to monitor the quality of work performed) and also by the customer (to monitor the current state of construction and deviations from planned implementation dates).

The information model of the building is the real basis for monitoring the progress of the construction. Information model for builders is:

- One tool for coordinating project participants.
- Orderly structure of data about the construction site.
- Minimization of errors in the evaluation of construction documentation.
- Timely identification of spatial and planning conflicts.
- Preparation of bill of quantities.
- Access to the 5D-6D construction model.

The principle of control of the construction site due to the information model:

1. The design phase:
    a. Creation of 3D information model. Performed by the designer.
    b. Connection of all sections of the information model into the composite model. Performed by the designer.
    c. Checking the composite information model on collisions using visual modeling (performed by the designer):
        i. The element intersections that can be formed when assembling all the sections into one model are analyzed. When collisions are detected, design solutions are revised (for example, crossing the duct with a wall without a special hole in the wall).
        ii. Space-time collisions are determined by comparing the construction schedule and 3D model (4D modeling).
    d. Transfer of the model to the construction site with an increase in LOD.
2. The construction phase:
    a. Test the model. Performed by the General Contractor / VET Engineer.
    b. Comparison of actual construction and design solutions. Performed by General contractor / VET Engineer.
    c. Making the necessary adjustments to the information model using mobile applications during construction. Performed by the General Contractor / VET Engineer.
    d. Field verification through modeling:
        i. Performing regular laser scanning to ensure that the model will be adjusted in accordance with the actual object being built. In addition, laser scanning helps to record MEP components that are hidden after construction, and make appropriate changes.
        ii. Making the necessary adjustments to the information model using mobile applications.
    e. Formation of executive documentation. Performed by the General Contractor / VET Engineer.
    f. Getting the As-built[6] model. The model can be used for early facility management[7]. Performed by the General Contractor / VET Engineer.
3. Transfer of the received model to the Customer. Performed by the General Contractor.

[6] As-built model – “a model consisting of documentation, non-graphical information and graphical information defining the delivered project” [27].

[7] Facility management (FM) – “a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology” (the definition of FM provided by the International Facility Management Association IFMA).

3. 4D BIM tools

Variety of tools allows to select 3 groups for the 4D model [16]:

1. Manual method using 3D or 2D tools.

The construction process is displayed using visualized animation of the construction schedule in a third-party program. Animations are attractive for marketing but inefficient as a means of planning. The main reason is the manual production of animations with limited capabilities for changing, updating and scheduling real-time scenarios. Each time the schedule details are changed, the scheduler must create a new set of animations to manually synchronize the 4D image with the construction schedule. As a consequence - the use of this method is possible only at the initial stage of design (the concept of the project).

2. Built-in 4D features in a 3D (BIM Tools with 4D Capability).

The construction process is displayed using the 4D imaging tools built into the 3D program. This method can generate 4D images but there is no direct coordination with the construction schedule.

3. Import 3D and schedule to 4D tool.

The construction process is displayed by integrating the 3D BIM model and the construction schedule from the scheduler in a separate program.

The most common option is to use the last group. In this paper, an analysis of several programs from this group is presented, the results are summarized in Table 1.

4. Results and discussion

A study was conducted on the use of BIM-technologies, in particular the use of the 4D model among construction companies of St. Petersburg, Leningrad region, Moscow and Moscow region.

Among the companies surveyed there were both Russian companies that had been long implementing BIM, as well as companies just starting the implementation of BIM. Development, design, general contracting companies and engineering companies took part in this survey, see Fig. 1.

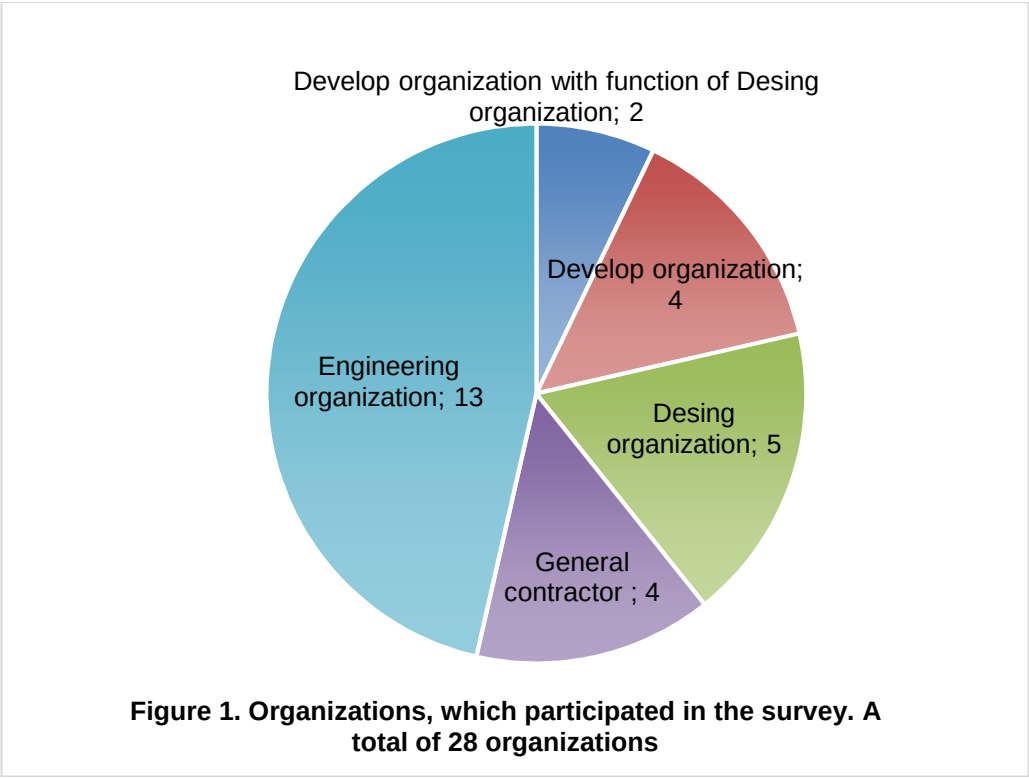


Figure 1. Organizations, which participated in the survey. A total of 28 organizations

Initially the criteria of selection adverted to the application of BIM in the organization. The next question was related to the using of 4D BIM technologies. Most of the companies gave a negative response because their level of implementation of BIM is not enough to use 4D technology. At the same time some companies do not use 4D due to lack of demand from the Customer for this technology. Among the remaining companies the survey showed that the most common software applications to get 4D model were Navisworks, Synchro, SOMOX.CMR, see Fig. 2.

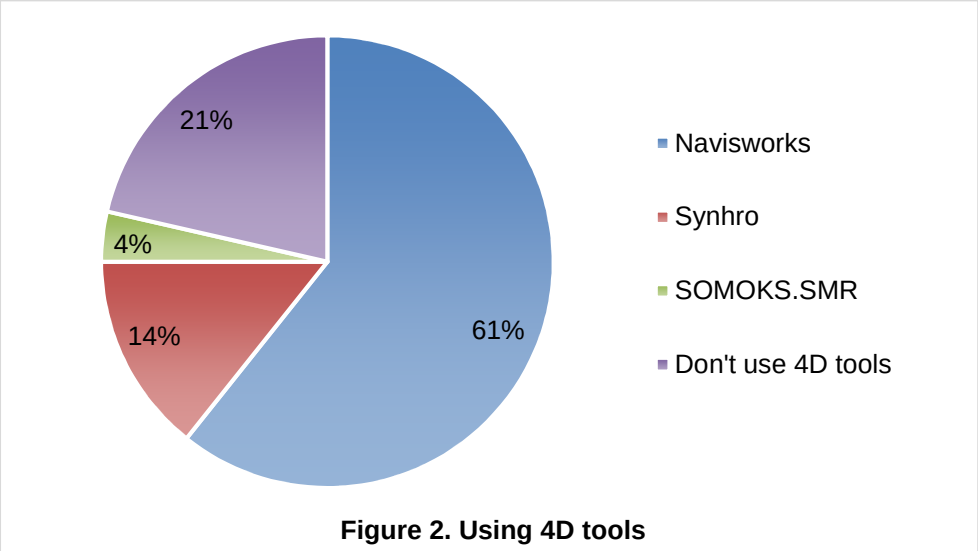


Figure 2. Using 4D tools

Characteristics of these common software applications were examined. The results are summarized in Table 1.

Table 1. General information of Navisworks, SOMOKS. SMR, Synchro

Software applications	Definition	Phase of the project	Software solutions
Navisworks	A solution for the examination of architectural and construction projects which allows to fully control the results. It checks models and data, which is coming from all participants in the design process.	Construction documents, preparation for construction, construction.	1. A software application for Personal Computer. 2. Consists of several separate products (Review, Simulate, Manage, Freedom). The most complete NavisWorks Manage[8] solution is considered.
SOMOKS. SMR	The software complex for automation of the planning, control and monitoring of installation and construction work with the reference to the activity based network which was designed for efficient 2D-6D planning and construction of objects of any complexity.	Construction documents, preparation for construction, construction.	1. Information portal, access via the Internet. 2. Mobile application for the Customer.
Synchro	A solution for the synchronize the three-dimensional model of the object with the work schedule. As a result, a model is obtained that contains information about the duration, labor and cost of construction and installation works, including information on temporary structures and the management of construction equipment.	Construction documents, preparation for construction, construction.	1. A software application for Personal Computer. 2. Consists of several separate products (Synchro PRO, Synchro Workgroup Project, Synchro SITE). 3. Synchro SITE is for mobile devices. Synchro PRO is considered.

[8] With the use of the NavisWorks Manage with ReCap 360 (a specialized tool for desktop and cloud solutions designed to create a 3D model from photographs and scanning data) and BIM 360 Glue the functionality of the program is extended.

Table 2. Formats of Navisworks, SOMOKS. SMR, Synchro

Software applications	Supported format	The final model format
Navisworks	Some CAD systems have built-in export commands to the NavisWorks format (.nwc), for others it is possible to use industrial data exchange formats, such as IGES, SAT, IFC and a number of others.	1. .nwc – a file with this extension is created by default when a model is transfered from a third-party program. 2. .nwf - a file with this extension only saves a list of pointers to currently loaded files, also the scene environment, the current view, the results of conflict checking and selected viewpoints (including comments) 3. .nwd – all loaded models, scene environment, current view and selected viewpoints (including comments) are saved in one file. A composite model can be passed to all interested participants. Export of work schedules in .xml,.PP and .xer formats.
SOMOKS. SMR	Import of models from most popular CAD formats.	Export of work schedules in .xml and .xer formats.
Synchro	Import and synchronization with most of the leading programs for developing 3D models in common formats: DWF, DWG, DXF, HSF, IGES, STEP, CATIA V4/V5, SolidWorks, ProEngineer, Parasolid, Google SketchUp. Import from Bentley MicroStation ™ and 3D Studio Max ™ is implemented through plug-ins that export to an HSF file.	1. File exort (Autodesk (.DWF, .DWFX), Autodesk FBX (.FBX), Collada (.DAE), HOOPS Stream File (.HSF), VRML '97 (Only geometries, Beta-version WRL), 3D PDF (.PDF, .PRC). 2. Export of work schedules in .xml, PP and .xer formats.

Table 3. General principles of operation of Navisworks, SOMOKS. SMR, Synchro. Part 1

Software applications	3D model formation	Creation and management of 3D objects	Creation of work schedules
Navisworks	1. Individual models are formed for the design sections / for individual parts (depending on the requirements). 2. Import of these models to Navisworks. 3. Creation of a general composite model to identify intersections. 4. Synchronization from updated versions of the model.	Management.	1. Import of work schedules from the planning programs Oracle Primavera, MS Project, Asta PowerProject. 2. Adding new tasks in this program.
SOMOKS. SMR	1. Individual models are formed for the design sections / for individual parts (depending on the requirements). 2. Import of these models to SOMOKS.SMR. 3. Creation of a general composite model.	Management.	1. Import of work schedules from the planning programs Oracle Primavera, MS Project. 2. Adding new tasks in this program
Synchro	1. Individual models are formed for the design sections / for individual parts (depending on the requirements). 2. Import of these models to Synchro. 3. Creation of a general composite model to identify intersections. 4. Import of machines and mechanisms for construction. 5. Synchronization from updated versions of the model.	Creation of simple geometry to represent projects not contained in the imported model and management.	1. Import of work schedules from the planning programs Oracle Primavera, MS Project, Asta PowerProject. 2. Adding new tasks in this program. 3. Synchronize from updated schedules. 4. Analyzing "what-if" scenarios. 5. Assignment of human, material, equipment and space resources to tasks.

Table 4. General principles of operation of Navisworks, SOMOKS. SMR, Synchro. Part 2

Software applications	Intersections and collisions. BIM Coordinator Functions	4D model formation
Navisworks	1. Designers do not have access to the entire composite model. Intersections of elements are eliminated after check of the model by BIM coordinator. 2. The module "Clash detective": 2.1. Automatic check of the model for intersections between the models of different sections. 2.2. Setting rules for checks. 2.3. Intersection mapping of elements with color highlighting. 2.4. The camera types can be saved, organized, made available to other users, exported and included in reports. A model with saved viewpoints can be opened in many source CAD systems. 2.5. The check of spatio-temporal collisions occurs after 4D model was created. The main task of this check is to identify inconsistencies in the virtual construction of an object. The functions of the BIM coordinator are assembly of the model including 4D and control of the model for intersections and spatio-temporal collisions.	1. If names of the elements are organized in the 3D model they will be displayed in the tree's structure in this program. 2. Manual binding of 3D elements to the work schedule.
SOMOKS. SMR	1. There is no module to check for intersections between the models of different sections[9]. 2. The check of spatio-temporal collisions occurs after 4D model was created. The functions of the BIM coordinator are assembly of the 4D model, control of the model for spatio-temporal collisions and issuing of weekly-daily assignments.	1. If names of the elements are organized in the 3D model they will be displayed in the tree's structure in this program. 2. Creation of links "3D-KSP": - Automatically by attributes. - Manually. - Import. 3. Optimization of the sequence of works (for example, the selection of consecutively erected columns, their bundle. The result is a sequential display of the construction of columns).
Synchro	1. Intersections of elements are eliminated after check of the model by BIM coordinator. 2. The check of spatio-temporal collisions occurs after 4D model was created. The functions of the BIM coordinator are assembly of the model including 4D and control of the model for intersections and spatio-temporal collisions.	1. If names of the elements are organized in the 3D model they will be displayed in the tree's structure in this program. 2. Manual binding of 3D elements to the work schedule. 3. Optimization of the sequence of tasks due to "Link type" between constructed elements.

[9] The composition of the modules in SOMOKS.SMR is extensible. Based on the customer's tasks additional modules can be developed and some of the basic set can be excluded from the system. Thus the customer has the ability to influence the final cost of the product.

Table 5. Interactive methods of data representation of Navisworks, SOMOKS. SMR, Synchro

Software applications	Simulation of the construction process	Synchronization with the current construction process	Information about the readiness of the object
Navisworks	1. The interconnection of the model elements to the Gantt chart in the work schedules is formed with the "Timeliner" module. 2. Visualization of the progress of construction and installation work in a 3D model using color schemes to display the processes of lead advance / lag.	Data input through the application for the mobile device BIM 360.	A summary of the readiness of the total amount of work can be displayed.
SOMOKS. SMR	1. The interconnection of the model elements to the Gantt chart in the work schedules is formed with the "Player" tool. 2. Visualization of the progress of construction and installation work in a 3D model using color schemes to display the processes of lead advance / lag.	Data input through the application for the mobile device.	The percentage of completion in the module "Work orders" can be displayed (see next issue).
Synchro	1. The interconnection of the model elements to the Gantt chart in the work schedules is formed with the "Timeline" tool. 2. Visualization of the progress of construction and installation work in a 3D model using color schemes to display the processes of lead advance / lag. 3. Zoning of the construction site, allocation of work fronts and modeling of the object flow. 4. Enlarged modeling of the territory for visualization and analysis of the construction site: existing buildings and structures, green spaces, road traffic, cars, household towns, construction equipment, etc. 5. The ability to put machines and mechanisms on certain coordinates which are added / removed through the Gantt chart.	Data input through the application for the mobile device Synchro SITE.	The schedule of the done volume of work.

Table 6. Information of Navisworks, SOMOKS. SMR, Synchro

Software applications	The interaction of participants in the construction	Main tasks to be solved
Navisworks	1. Conflicts that were obtained during checks on the intersections of elements are displayed with highlighting by color. 2. Export of the conflict data in the form of reports in the "Clash detective" module to the corresponding construction participants for their correction. 3. Updating the model, changing the status of the conflict. 4. The solution of spatio-temporal collisions due to the adjustment of the schedule.	1. Creation of the composite model at the design stage. 2. Checking for intersections and collisions and managing them. 3. Creation of remarks and transferring for finalization. 4. Creation of a 4D model. 5. The ability to see the construction of an object with the lead / lag by entering the actual construction dates during the construction phase.
SOMOKS. SMR	1. The solution of spatio-temporal collisions due to the adjustment of the schedule. 2. The module "Work orders" generates in an automatic mode weekly-daily	1. Creation of the composite model at the design stage. 2. Checking for intersections and collisions and managing them. 3. Creation of remarks and transferring for finalization. 4. Creation and transferring of weekly-daily assignments and

	assignments for workers at the construction site. 3. The ability to monitor their implementation when data is received via a mobile device.	reports to interested participants. 5. Creation of a 4D model. 6. The ability to see the construction of an object with the lead / lag by entering the actual construction dates during the construction phase.
Synchro	1. The solution of spatio-temporal collisions due to the adjustment of the schedule. 2. Creation of a collision report with the “Reports” tool.	1. Creation of the composite model at the design stage. 2. Checking for intersections and collisions and managing them. 3. Creation of remarks and transferring for finalization. 4. Creation of a 4D model. 5. The ability to see the construction of an object with the lead / lag by entering the actual construction dates during the construction phase. 6. Modeling the logistics of the construction site, rational use of the territory. 7. Allocation of work fronts, distribution of workplaces, so that workers' brigades do not intersect and some sections of the site are not overloaded. 8. Visual modeling of work flows. 9. Visual comparison of organizational and technological solutions.

5. Conclusions

The most common software applications among the companies surveyed are Navisworks, Synchro, SOMOKS.SMR. Analysis of the characteristics of these programs led to the following results.

Navisworks is convenient when working with a 3D model during the design phase. Its main advantage is the automated analysis of the intersections of model elements and the output of conflicts in the form of reports for their solution by the relevant project participants. Visualization is a side function.

Synchro is convenient for planning construction projects and managing the process of their construction. The Synchro solution allows you to correlate project information in the form of 3D models with the project's calendar-network schedule, its resources, costs and supply chain management. Visualization is the main function.

The analogue of foreign programs SOMOKS.SMR is convenient when working with the 4D model during the design and construction phases. There is no analysis of the intersections of the elements but finding of space-time collisions is possible. The main advantage of this program is the assignment of weekly-daily tasks for workers at the construction site and the possibility of their control.

As a result, for effective use of software applications you need to determine the task that you need to focus on. If this is a check for intersections at the design phase then Navisworks is more suitable. If you need to focus on the construction phase then you must choose SOMOKS.SMR or Synchro. It is also worth noting that some programs work more efficiently if you organize collocations of these program.

References

[1] Strategiya innovatsionnogo razvitiya Rossiyskoy Federatsii na period do 2020 goda (utverzhdena rasporyazheniyem Pravitelstva Rossiyskoy Federatsii ot 8 dekabrya 2011 g. №2227-r «Ob utverzhdenii Strategii innovatsionnogo razvitiya Rossiyskoy Federatsii na period do 2020 goda»).

[2] Protokol zasedaniya Pravitelstvennoy komissii po vysokim tekhnologiyam i innovatsiyam ot 3 avgusta 2010 g. №4.

[3] Metodicheskiye materialy po razrabotke programm innovatsionnogo razvitiya aktsionernykh obshchestv s gosudarstvennym uchastiyem, gosudarstvennykh korporatsiy i federalnykh gosudarstvennykh unitarnykh predpriyatiy (utverzhdeny rasporyazheniyem Minekonomrazvitiya Rossii ot 31 yanvarya 2011 g. №3R–OF).

[4] Metodicheskiye materialy po razrabotke pasportov programm innovatsionnogo razvitiya aktsionernykh obshchestv s gosudarstvennym uchastiyem, gosudarstvennykh korporatsiy i federalnykh gosudarstvennykh unitarnykh predpriyatiy (odobreny resheniyem Rabochey gruppy po razvitiyu chastno-gosudarstvennogo partnerstva v innovatsionnoy sfere pri Pravitelstvennoy komissii po vysokim tekhnologiyam i innovatsiyam ot 15 noyabrya 2011 g., protokol №43–AK).

[5] Chetverik N. P. Otsenka effektivnosti innovatsiy na etape proyekta // Nauka i bezopasnost. 2014. No. 2(11). Pp. 2-33.

[6] Jacobi J. 4D BIM or Simulation-Based Modeling. Structure Magazine. 2011. Pp. 17-18. Nomer zhurnala.

[7] Liao, Y. F., Hsieh, S. H., Kang, S. C., Chen, C. S., Yang, C. T., Chi, H. L., Chi, W. C. and Yu, C. H. Development and application of 4D construction simulation tools. Proceedings of The Fourth Civil Engineering Conference in the Asian Region (CECAR), 2007.

[8] Singh, V., Gu, N. and Wang, X. A Theoretical Framework of a BIM-Based Multi-Disciplinary Collaboration Platform. Automation in Construction. 2011. No. 20. Pp. 134-144.

[9] Alcínia Zita Sampaio. BIM as a Computer-Aided Design Methodology in Civil Engineering. Journal of Software Engineering and Applications. 2017. No. 10. Pp. 194-210.

[10] Marko Paavela, Kristo Karjusta, Jüri Majaka. PLM Maturity model development and implementation in SME. Procedia CIRP. 2017. No. 63. Pp. 651-657.

[11] Wang, X. Extending Building Information Modelling (BIM): A Review of the BIM Handbook. Australasian Journal of Construction Economics and Building. 2012. No. 12. Pp. 101-102.

[12] Nesterov I.V. Informatsionnoye modelirovaniye v stroitelstve. SAPR i GIS avtomobilnykh dorog. 2014. No. 2(3). Pp. 33-36.

[13] Douglas M. Brito, Emerson A. M. Ferreira. Strategies for representation and analyses of 4D modeling applied to construction project management. Procedia Economics and Finance. 2015. No. 21. Pp. 374-382.

[14] Sheryl Staub-French, Atul Khanzode. 3D and 4D modeling for design and construction coordination: issues and lessons learned. ITcon. 2007. Vol. 12. Pp. 381-407.

[15] Yashchenko A.A. Primeneniye 4D modelirovaniya v kalendarnom planirovanii na baze tekhnologicheskoy platformy BIM. Sbornik trudov Vosemnadtsatoy Mezhdunarodnoy mezhvuzovskoy nauchno-prakticheskoy konferentsii studentov, magistrantov, aspirantov i molodykh uchenykh. Stroitelstvo - formirovaniye sredy zhiznedeyatelnosti. Moskva, 2015. Pp. 715-718.

[16] Eastman C., Teicholz P., et al. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. Hoboken, New Jersey, Wiley, 2011. 490 p.

[17] Eadie, R., Browne, M., Odeyinka, H., McKeown, C., McNiff, S. BIM Implementation throughout the UK Construction Project Lifecycle: An Analysis. 2013. Automation in Construction. No. 36. Pp. 145-151.

[18] Eastman C., Fisher D., Lafue G., et al. An Outline of the Building Description System. Institute of Physical Planning, Carnegie-Mellon University, 1974. 23 p.

[19] Azhar, S., Hein, M. and Sketo, B. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. Leadership Manage. Eng. 2011. No. 11(3). Pp. 241-252.

[20] Tardif, M. and Smith K.D. Building Information Modeling: A Strategic Implementation Guide. John Wiley & Sons, Hoboken. 2009. 216 p.

[21] Azhar, S et al. Building information modeling (BIM): now and beyond. Australasian Journal of Construction Economics and Building. 2012. No. 12 (4). Pp. 15-28.

[22] B. Koo, M. Fischer, Feasibility study of 4D CAD in commercial construction. Journal of const. Eng. & Manage. 2000. No. 126 (4). Pp. 251-260.

[23] Olde Scholtenhuis, L., Hartmann, T., and Dorée, A. Comparing Mindfulness in Manual and 4D-Supported Coordination Practices. In: Proceedings of Construction Research Congress. Atlanta, USA, 2014. Pp. 160-168.

[24] Hsieh, S.H., Chen, C.S., Liao, Y.F., Yang, C. T. and Wu, I.C. Construction director: 4D simulation system for plant construction. Proceedings of the 10th East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-10). Bangkok, Thailand, 2006.

[25] Tsai, M. H., Kang, S. C., Hsieh, S. H., Kuo, C. H., Pei, T. J. and Yeh, K. C. Experiences on study of setting-up a 4D construction management tool in a high-rise construction project. Proceedings of 12th International Conferences on Computing in Civil and Building Engineering & 2008 International Conference on Information Technology in Construction (ICCCBE XII & INCITE 2008). Beijing, China, 2008.

[26] Dawood, N., and Mallasi, Z. Construction Workplace Planning: Assignment and Analysis Utilizing 4D Visualization Technologies. Computer-aided Civil and Infrastructure Engineering. 2006. Vol. 21, Is. 7. Pp. 498-513.

[27] PAS 1192-2:2013: Specification for information management for the capital/delivery phase of construction projects using building information modeling (BIM). BSI, UK. 2013.

Контроль строительной площадки с помощью информационной модели

О.С. Гришина [1]*, А.В. Савченко [2], А.П. Маричев [3], Е.С. Залата [4], М.В. Петроченко [5]

[1-5]Санкт-Петербургский политехнический университет Петра Великого, 195251, Россия, г. Санкт-Петербург, Политехническая ул., 29.'

ИНФОРМАЦИЯ О СТАТЬЕ	ИСТОРИЯ	КЛЮЧЕВЫЕ СЛОВА
doi: 10.18720/CUBS.62.1	Подана в редакцию: 08.11.2017	Информационная модель; 4D BIM; 4D моделирование; 4D BIM инструменты; график производства работ;

АННОТАЦИЯ

BIM-технологии – неотъемлемая часть современного строительного процесса. Для того, чтобы приблизиться к комплексной реализации BIM, необходимо использовать не только процесс 3D моделирования. Следующий шаг – генерация 4D модели на основе 3D модели и графика производства работ. Российские строительные компании, реализующие BIM, начинают внедрять 4D модели не только на этапе проектирования, но и на этапе строительства. В данной статье показан принцип контроля строительной площадки за счет информационной модели. Определены наиболее распространенные программы, обеспечивающие данный процесс. Выяснены их основные характеристики, а также ситуации, при которых их использование способствует организации наиболее эффективной работы.

Контакты авторов:
1* +79118372393, olgasergeevna2009@yandex.ru (Гришина Ольга Сергеевна, студент)
2 +79111153597, ya.int@yandex.ru (Савченко Алексей Владимирович, ассистент)
3 +79215870750, lexa-ap94@yandex.ru (Маричев Алексей Павлович, студент.)
4 +79214078184, ekaterinazalata@gmail.com (Залата Екатерина Сергеевна, студент)
5 +78125529460, mpetroch@mail.ru (Петроченко Марина Вячеславовна, к. т. н., ст.преподаватель)

Reich E.V., M. Lima, Strelets K.I. Efficiency of applying sustainable technology of bubbledeck technology in concrete in Russia / Рейх Е.В., Лима М., Стрелец К.И. Эффективность применения экологически устойчивой технологии пустотных бетонных плит с пластиковым заполнителем в России ©

Литература

[1] Стратегия инновационного развития Российской Федерации на период до 2020 года (утверждена распоряжением Правительства Российской Федерации от 8 декабря 2011 г. №2227-р «Об утверждении Стратегии инновационного развития Российской Федерации на период до 2020 года»).

[2] Протокол заседания Правительственной комиссии по высоким технологиям и инновациям от 3 августа 2010 г. №4.

[3] Методические материалы по разработке программ инновационного развития акционерных обществ с государственным участием, государственных корпораций и федеральных государственных унитарных предприятий (утверждены распоряжением Минэкономразвития России от 31 января 2011 г. №3Р–ОФ).

[4] Методические материалы по разработке паспортов программ инновационного развития акционерных обществ с государственным участием, государственных корпораций и федеральных государственных унитарных предприятий (одобрены решением Рабочей группы по развитию частно-государственного партнерства в инновационной сфере при Правительственной комиссии по высоким технологиям и инновациям от 15 ноября 2011 г., протокол №43–АК).

[5] Четверик Н. П. Оценка эффективности инноваций на этапе проекта // Наука и безопасность. 2014. № 2(11). С. 2-33.

[6] Jacobi J. 4D BIM or Simulation-Based Modeling. Structure Magazine. 2011. Pp. 17-18. Номер журнала.

[7] Liao, Y. F., Hsieh, S. H., Kang, S. C., Chen, C. S., Yang, C. T., Chi, H. L., Chi, W. C. and Yu, C. H. Development and application of 4D construction simulation tools. Proceedings of The Fourth Civil Engineering Conference in the Asian Region (CECAR), 2007.

[8] Singh, V., Gu, N. and Wang, X. A Theoretical Framework of a BIM-Based Multi-Disciplinary Collaboration Platform. Automation in Construction. 2011. No. 20. Pp. 134-144.

[9] Alcínia Zita Sampaio. BIM as a Computer-Aided Design Methodology in Civil Engineering. Journal of Software Engineering and Applications. 2017. No. 10. Pp. 194-210.

[10] Marko Paavela, Kristo Karjusta, Jüri Majaka. PLM Maturity model development and implementation in SME. Procedia CIRP. 2017. No. 63. Pp. 651-657.

[11] Wang, X. Extending Building Information Modelling (BIM): A Review of the BIM Handbook. Australasian Journal of Construction Economics and Building. 2012. No. 12. Pp. 101-102.

[12] Нестеров И.В. Информационное моделирование в строительстве. САПР и ГИС автомобильных дорог. 2014. № 2(3). С. 33-36.

[13] Douglas M. Brito, Emerson A. M. Ferreira. Strategies for representation and analyses of 4D modeling applied to construction project management. Procedia Economics and Finance. 2015. No. 21. Pp. 374-382.

[14] Sheryl Staub-French, Atul Khanzode. 3D and 4D modeling for design and construction coordination: issues and lessons learned. ITcon. 2007. Vol. 12. Pp. 381-407.

[15] Ященко А.А. Применение 4D моделирования в календарном планировании на базе технологической платформы BIM. Сборник трудов Восемнадцатой Международной межвузовской научно-практической конференции студентов, магистрантов, аспирантов и молодых ученых. Строительство - формирование среды жизнедеятельности. Москва, 2015. С. 715-718.

[16] Eastman C., Teicholz P., et al. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. Hoboken, New Jersey, Wiley, 2011. 490 p.

[17] Eadie, R., Browne, M., Odeyinka, H., McKeown, C., McNiff, S. BIM Implementation throughout the UK Construction Project Lifecycle: An Analysis. 2013. Automation in Construction. No. 36. Pp. 145-151.

[18] Eastman C., Fisher D., Lafue G., et al. An Outline of the Building Description System. Institute of Physical Planning, Carnegie-Mellon University, 1974. 23 p.

[19] Azhar, S., Hein, M. and Sketo, B. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. Leadership Manage. Eng. 2011. No. 11(3). Pp. 241-252.

[20] Tardif, M. and Smith K.D. Building Information Modeling: A Strategic Implementation Guide. John Wiley & Sons, Hoboken. 2009. 216 p.

[21] Azhar, S et al. Building information modeling (BIM): now and beyond. Australasian Journal of Construction Economics and Building. 2012. No. 12 (4). Pp. 15-28.

[22] B. Koo, M. Fischer, Feasibility study of 4D CAD in commercial construction. Journal of const. Eng. & Manage. 2000. No. 126 (4). Pp. 251-260.

[23] Olde Scholtenhuis, L., Hartmann, T., and Dorée, A. Comparing Mindfulness in Manual and 4D-Supported Coordination Practices. In: Proceedings of Construction Research Congress. Atlanta, USA, 2014. Pp. 160-168.

[24] Hsieh, S.H., Chen, C.S., Liao, Y.F., Yang, C. T. and Wu, I.C. Construction director: 4D simulation system for plant construction. Proceedings of the 10th East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-10). Bangkok, Thailand, 2006.

[25] Tsai, M. H., Kang, S. C., Hsieh, S. H., Kuo, C. H., Pei, T. J. and Yeh, K. C. Experiences on study of setting-up a 4D construction management tool in a high-rise construction project. Proceedings of 12th International Conferences on Computing in Civil and Building Engineering & 2008 International Conference on Information Technology in Construction (ICCCBE XII & INCITE 2008). Beijing, China, 2008.

[26] Dawood, N., and Mallasi, Z. Construction Workplace Planning: Assignment and Analysis Utilizing 4D Visualization Technologies. Computer-aided Civil and Infrastructure Engineering. 2006. Vol. 21, Is. 7. Pp. 498-513.

[27] PAS 1192-2:2013: Specification for information management for the capital/delivery phase of construction projects using building information modeling (BIM). BSI, UK. 2013.

Grishina O.S., Savchenko A.V., Marichev A.P., Zalata E.S., Petrochenko M.V.Monitoring of the construction site using an information model. Construction of Unique Buildings and Structures. 2017. 12(63)., Pp. 7-19.

Гришина О.С., Савченко А.В., Маричев А.П., Залата Е.С., Петроченко М.В., Контроль строительной площадки с помощью информационной модели, Строительство уникальных зданий и сооружений, 2017, №12 (63). С. 7-19.