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Agile PM and BIM: A hybrid scheduling approach for a technological construction project

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Abstract

This paper introduces synthesis of the Agile Project Management and Building Information Modeling in construction industry and its practical application with the accent on economic incentives of their implementation as the most significant factor. The executed synthesis of both concepts' features leads to the representation of the general process of integration, thereby the general development of integrated product and process model for addressing the on-site management phase of a construction project. That is when Building Information Modeling technology plays a key role in Agile method not only as the technological container for information model of a construction project, but as a new construction approach bringing in the additional benefits described in the literature.

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Keywords: Activity overlapping; Agile Project Management; Building Information Modeling; Hybrid Scheduling Approach

1. Introduction

The effort of shortening construction project duration usually increases the complexity of the project, creating real problems for the project team. The main problems arise in the relationships between the project's phases and reactions to changes during the project period. Also most overlapping techniques - such as concurrent engineering, parallel engineering, phased construction, fast-tracking, flash-tracking, and agile project management - reduce the time from the start of construction of separate parts of the project to completion [1,2,3,4,5]. This happens because the reduction of the investment process duration in the construction process is the major component in the whole

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control system. First, the changes and instability in the market conditions together with the exposition of considerable funds for the project represent a great risk for the Investor. Secondly, the reduction of the project realization terms involves the reduction of the period of a recoupment and improvement of some other indicators of economic efficiency of the projects.

Naturally, the Investor is interested in a faster start of the project operation for an earlier return on investments and subsequent receipt of the profits. Designers and Contractors are also guided by the similar reasons. Therefore all used guidance systems are subordinated to the idea of acceleration of turning of the capital. The integral purpose of schedule compression techniques consists in the decrease or the reduction of the project duration. In such projects in which schedule compression techniques and BIM processes and tools have been simultaneously involved, the Investor and the General Contractor can achieve considerably important economic advantages. The reason for the usage of schedule compression techniques is clear enough and is supported by the possible economic gain [6]. The reason that BIM is used in our case is the requirement for the optimization of existing project delivery. To be more exact the project requirement was for higher quality in design/construction and the elimination of rework [7,8] (Figure 1).

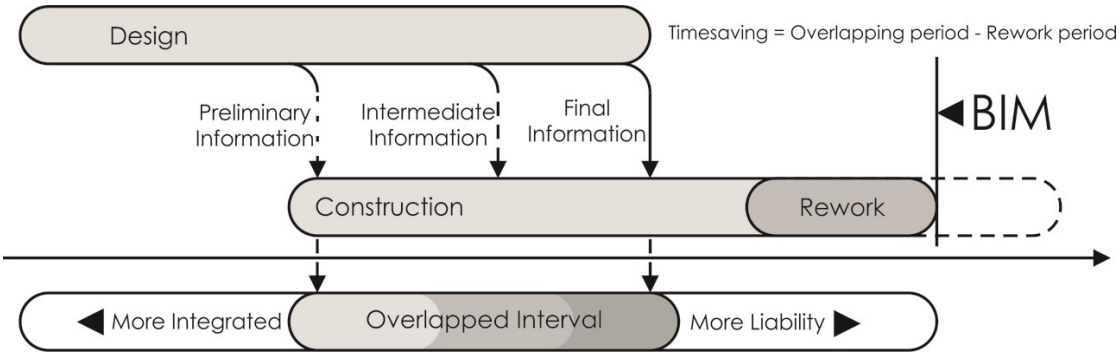

Figure 1: The role of BIM in the mechanism of activity overlapping. Source: Own elaborations.

In this paper, we present a real world concept of compressing the project schedule by running design and construction phases simultaneously based on an Agile approach for the schedule compression. By contrast to traditional approaches, Agile's approach assumes that the detailed design specification can be improved with intensive Investor, Designers and General Contractor collaboration during the process. This approach requires two kinds of plans: longtime (complete project realization) and short-time (iteration) plan [9].

Building Information Modeling technology plays a key role in the Agile method not only as technological container for information model of construction project [10,11], but as new construction approach bringing together the other additional benefits described in the literature [12,13,14]. As a consequence, during project planning phase, these two methods collect the essential information inside Building Information Models for the longtime plan (i.e. design features allocation to the stages). After project planning is finished, the Building Information Model only collects more detailed information on the design features of the next iteration of the given project realization stage to stage the short-time plan.

2. Synthesis of the approaches towards an integrated product and process model

Agile and BIM definitely have things in common. It will be logical to use the best practical experience of both concepts not only for fast-tracking a project but for profound mapping-out and monitoring of the whole process of integrated construction model and each stage of preconstruction, design, construction and post construction studies.

In this case, it is possible to describe BIM as a main link that forces Agile to work out in construction industry with the full-scale output. The associative communication between Agile and BIM is explained by natural life cycle of any building project, its main goals and its high technological level. The detailed information necessary for construction studies - as e.g. used building materials, engineering systems, etc. - allows minimizing economic and labor expenditures during building, maintenance of an object and after the life cycle's termination. Figure 2 presents some general goals for BIM and Agile which design participants can share, using these two approaches.

Both Agile and BIM's tools and techniques can be grouped into two broad categories which are interrelated: organizational and technological. Organizational enablers provide the framework for people and machines to work 'concurrently'. This includes: facilitating the work of multidisciplinary teams, involving all relevant parties in the product development process, and managerial/technological support for organizational team and individual levels of working [3,5,6]. The condition precedent for all these changes is the maturity of network/software technologies providing sharing of BIM interdisciplinary model [12].

Technological enablers facilitate concurrent working within organizations. They include all the Information and Communications Technologies (ICTs) and software required for integration, concurrent working, communication and collaboration [10,14]. The synchronous information interchange is produced on the basis of an information model in the documented form. It creates conditions for all-round, unified, capable to sharing information models that also include business analysis, principles of economical building, and a policy of green building and accounting of the whole life cycle of a building object [8,12].

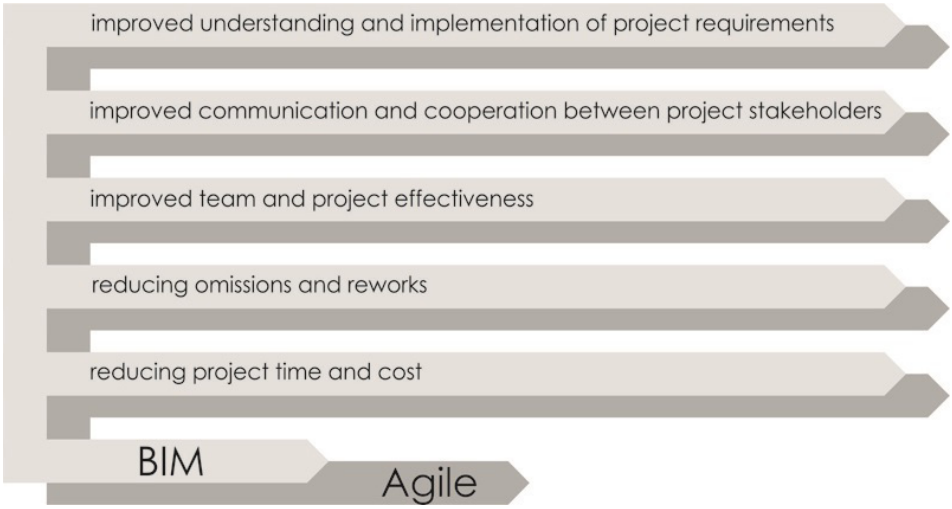

Figure 2: The common goals of Agile and BIM methodologies. Source: Own elaborations.

The executed synthesis of the features of the two concepts (Table 1) leads to the representation of the general process of integration. The purpose of integration is to create a process model for addressing the on-site management phase of a construction project. Both approaches for the construction project realization which have been considered in this analysis contain one or several of these physical, logical and process entities. They may not often be located in a top level hierarchy. Out of these basic subjects, various models are included into the objects, such as cost, time and quality that are less universally accepted, and can equally belong to the highest level. Another approach is to accept the simple connection between the products and the processes by means of their integration so that the processes correspond to the certain products.

Table 1: Synthesis of two approaches. Source: Own elaborations.

Issue	Agile	Building Information Modeling
Concept	scheduling technique	building information model technology solution project management approach
Main principles	overlapping the project design and construction phases	creating information model team collaboration effective communication
Aim	reduction of the project time	elimination of omissions and rework
Method and practices (example)	product development (concurrent engineering) project execution (fast track, design-build)	
Practical contribution	construction starts prior to all information is available	Earlier involvement of all key participants

Table 2: Comparative advantages of BIM. Source: Own elaborations.

Process Overlapping Advantages	Process Overlapping Disadvantages	BIM Benefits
Capability of ordering long lead items during the early phases of a project	High possibility of misunderstanding between the owner, designer, and the contractor	Earlier collaboration of multiple design disciplines
Expedition of the construction process	Propensity to an increased number of errors from the designer	Discovery of Design Errors and Omissions before Construction and Automatic Low-Level Corrections
Increasing of productivity by speeding up the construction process	Total cost of the project is unknown	Extraction of Cost Estimates during the Design Stage
Cost minimization of overruns	Coordination of all trades can be more difficult	Earlier Collaboration of Multiple Design Disciplines and Use of Design Model as Basis for Fabricated Components
Positive cash flow would start sooner for an owner	Potential for more change orders to correct errors or to change to more advantageous designs	Easy Verification of Consistency to the Design Intent and Synchronization of Design and Construction Planning
Can avoid winter or other adverse weather conditions	May have to obtain various municipal approvals and more permits then what would normally be required	Earlier and More Accurate Visualizations of a Design
Can save on inflationary cost of materials, products, and equipment	Contract with the owner has to be clearly defined: • Percentage of construction documents completed • Allowances • Contingency amount and who owns it	Improved Collaboration Using Integrated Project Delivery
Can obtain critical subcontractors early in the process	Incomplete drawings and specifications are incrementally released for bidding, governmental review, and construction	Generation of Accurate and Consistent 2D Drawings at Any Stage of the Design

3. Baseline schedule development approach

Success in the BIM delivery approach required understanding what Building Information Modeling technology means. One must also know how to create BIM teams, and how BIM teams collaborate, cooperate, and function in various situations, particularly for projects employing Schedule Compression Techniques [14,15]. The different life-cycle phases of a construction project can be divided into eight parts. It can be separated to nine main processes, which are: inception and project definition, outline design, structural engineering and analysis, property specifications, cost management, procurement and supply, fabrication, assembly and erection and finally facility management [17]. To simplify the following analysis this paper shortcuts this number of processes for all types of projects: Initializing Process, Planning Process, Controlling Process, Executing Process, Closing Out Process.

The Figure 3 illustrates the classical project realization cycle. This type of relationship between most processes is also known as a finish-to-start dependency, meaning that the predecessor activity must be completed before the start of second successor activity and any change in project may cause rework. The farther into the construction life cycle the project progresses it is often when some issues are discovered, or changes happen. These changes cause the biggest impact on the budget and schedule. When problems arise they can drive a replanning of the project schedule and a re-estimation of costs to complete the project [4].

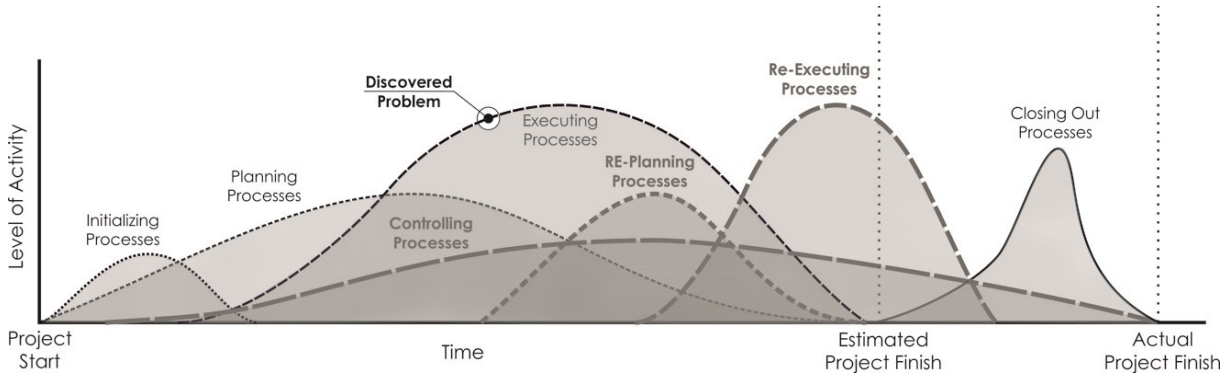

Figure 3: Replanning of the classical construction life cycle. Source: Own elaborations.

The baseline schedule development approach will be used as the basis of Agile and BIM. Concurrent construction approaches are to break up the long main project life cycle into small sets of dependent activities - Overlapping Activities. Overlapping Activities should consist from semi-independent activities with a specific degree of overlapping capacities. Interdependent activities which must be overlapped for information exchange and to progress. The length of the Overlapping Activities are dependent on the project conditions such as the complexity of the project, total duration, and the team. At this point, changes and adjustments will not create rework (i.e. extra cost and time), i.e. an increase in the duration of the successor Overlapping Activities compared with their normal duration. It doesn't mean that the rework might ever happen. If a problem is discovered it can be rolled into the next and subsequent Overlapping Activities' planning sessions and into the schedules and would not require a major re-plan of the entire project. The Figure 4 demonstrates the process described above. Normally, because there is a completed part of the project after each Overlapping Activity, problems are discovered earlier in the project development process. Investor, Designers and General Contractor provide feedback after each Overlapping Activity for the purpose to re-vector the project realization efforts before major cost and schedule have been expended.

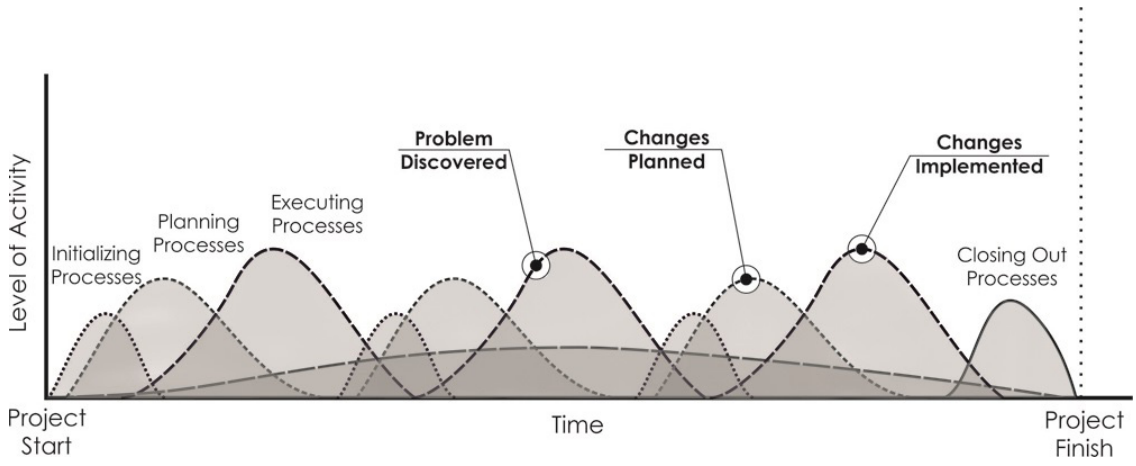

Figure 4: How requirements changes are handled in the agile process. Source: Own elaborations

4. A Tentative Estimation of Changes Connected with a Hybrid Scheduling Approach

The scale of changes of the construction companies connected to application of Agile and BIM in hybrid scheduling approach can begin from insignificant and reach the most cardinal ones. Figure 5 shows four types of structural changes of the construction organization, aspiring to pass to BIM-based concurrent construction approach: automation, rationalization, reengineering and paradigm change. Each type of change corresponds to a certain risk level [14].

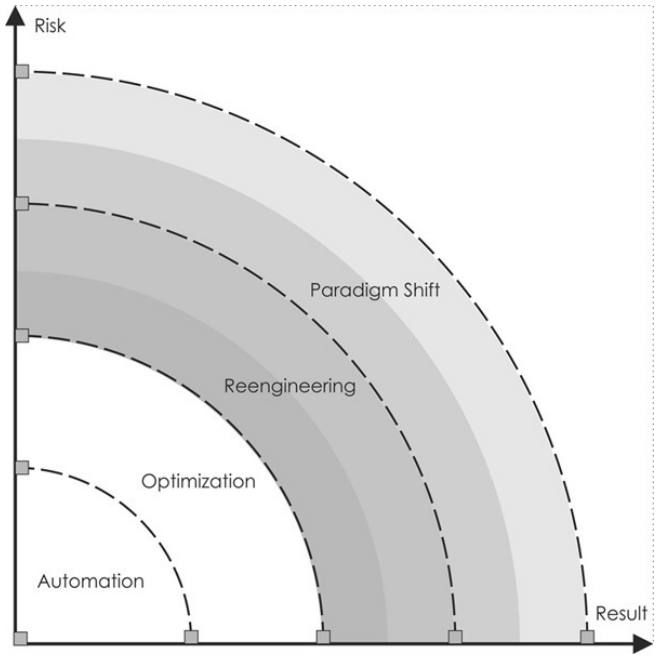

Figure 5: The scale of structural changes connected to application of a hybrid scheduling approach. Source: Own elaborations

The new hybrid scheduling approach presumably will lie between Reengineering and Paradigm shift areas. Reengineering essentially consists of process analysis, simplification and remodeling. Reengineering implies radical revision of workflow and business processes of building products' production. Using BIM, organizations can refine the production to increase the rate and quality of performance of their operations and services; organizations can also lower the costs through that [12]. The primary goal of Reengineering of projecting and building processes is reorganization of labor processes on a building site and beyond its limits. The procedure of Reengineering is more difficult than Optimization procedures since it opens a new vision of how implementation processes of the building project should be structured.

New approaches in project delivery can radically change the structure of the whole organization, changing a company's methods, or even directions of its activity [9,16]. Such radical changes of a company's activity is called a Paradigm shift. A paradigm shift not only implies a revision of procedures and processes, but also the character of the company itself.

World experience shows that passage to BIM demands organizational-structural changes in the design team [7]. Hybrid scheduling approach brings even more serious changes to the approach of implementation of the integrated product and process model and it is impossible to get rid of reengineering separate productions (as BIM itself implies implementation of new rules of creation, actualization, back up and information processing), not mentioning decision making processes. With the help of Agile in construction based on BIM, it is possible to reach a sharp increase design operation efficiency. It principally creates new business processes sharply raising efficiency of activity of all construction stakeholders. The distinctive feature of reengineering processes is a cardinal change of processes, instead of their step-by-step improving.

Reengineering processes are implemented in three stages:

- modeling and analysis of existing building processes;
- reconsideration and development of principally new building processes;
- implementation of new processes.

For effective reengineering, it is necessary to have an extensive strategic vision of results which are necessary to be achieved [14,16].

Until now, many building companies have been focused on acceptance of BIM technologies with which they can refine industrial and economic indexes. With the creation of an integrated product and process model, there is a need of reorganization of the organization's key business processes, both exterior and internal. Thus reconsideration of duties, responsibilities, tasks of employees, material, financial and information flows, document circulation, and also corporate culture as a whole is required.

5. Conclusion

The main focus of the work is focused on the practical application of the newest technologies and approaches in construction industry with the accent on economic incentives of their implementation as the most significant factor. It is expected that the integrated product and process model will facilitate improvements in the construction process, particularly with respect to: collaborative design, project coordination, reduction in project duration, reduction in costs, reduction in claims and disputes and improvements in product quality. The generic model will be applicable to different European countries, out of which many have similarly fragmented construction industry markets. A hybrid scheduling approach necessary overestimates the main contractual relationships, risk-allocation models and procedural flows. A principal condition for solving the given tasks is the necessity of the analysis of non-traditional pyramid-shaped organization and realization of the alternative form of the organization which encourages an open dialogue and minimizes parting layers in an information flow.

The introduced methodology of synthesis of Agile and BIM was already implemented in practice and has already proved its applicability and effectiveness. This methodology was integrated into the current practice of Group of Companies in Russia. This Group of Companies is a construction and installation Holding Company performing design and construction of large-scale industrial projects of power-producing industry (oil & gas processing, transportation and storage facilities), power industry and metallurgy industry. Because of an enormous potential for the investment projects in the oil & gas industry and because of its high interest in intensification of works, this company already started to test the implementation of BIM. The introduced innovative method of design was mentioned in tender documentation and will go through approbation within a pilot project on delivering groundbreaking oil and gas at the extensive Sakhalin-2 construction project.

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