4th International Workshop

WHEN SOCIAL SCIENCE MEETS LEAN AND BIM

28th & 29th January 2016

Financially supported by the Innovative Design Lab
School of Art Design and Architecture
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4th International Workshop
When Social Science meets LEAN and BIM

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Yufan Zhang

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Forward

Lean construction and Building Information Modelling (BIM) are important means of on-going change and improvement in the construction industry. However, the achievement of the proposed benefits from both approaches needs to appropriately consider business processes and environment, which are highly influenced by social phenomena. Thus, there is a clear need and opportunity for a social science perspective in this context.

Historically, the field of management, understood as social science, has dissociated itself from concerns related to design and production. Furthermore, it can be argued that the current on-going transformation has been somewhat fragmented, and as such it provides a challenge for social science oriented research.

The current changes in industry through new processes and the use of technology is also a major opportunity for social science researchers to observe social and psychological phenomena such as creativity, problem-solving, collaboration, co-design, commitment and trust, which may lead to improved methods and models of management. The evolving technological and business landscape provides many interesting puzzles and contradictions for researchers to study.

In view of these issues, the ambition of the workshop is to discuss and clarify the following: What are the important social science research questions in relation to Lean and BIM? Which social science approaches and methods are effective and useful in this context? How can we reconcile the apparent contradictions between technological, sociological and psychological viewpoints to design and construction activities?

Thirty-two abstracts from ten countries are part of this publication. The workshop itself included two key note speakers and a total of 27 presentations.

All abstracts submitted have been undergone a double review process. We would like to thank all authors for their contribution.

About the Innovative Design Lab

The Innovative Design Lab (IDL) is an interdisciplinary research centre/laboratory at the University of Huddersfield. The lab conducts theory based and applied research generally into product design, and especially in the built environment, pushing the impact of design thinking and practice to new areas. It cuts across the areas of architectural design, construction management, interior design, new product development, engineering, social sciences and healthcare.

Our research focuses on solving real world problems through design innovation, mobilising the underlying theories as well as the enabling processes and technologies needed to deliver value to users and the society at large.

Our research is developed closely with diverse public and private sector organisations to propose novel solutions to design challenges and project based problems. We offer Undergraduate, Masters and PhD programmes that are future focused and informed by the state of the art in research and practice.

Vision
Our vision is for increasing the value of design whilst reducing costs, enabling the society to benefit from high quality environments and products that are supportive of users needs and activities. This vision will be achieved through scholarly research and industrial engagement. More specifically, the potential of design innovation, collaboration, co-design and lean strategies to improve design and production processes and products will be examined.

Objectives

* To advance theory and methods of design and of cognate areas
* To undertake solution-driven research with a global reach, addressing current challenges and enabling ideas to flow across disciplinary boundaries
* To produce outcome driven, internationally leading research outputs of relevance, impact and rigour
* To become an external relations centre for strategic partnership building, developing networks for collaboration in research and teaching, sharing expertise nationally and internationally

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Keynote speakers

Prof. James Barlow

Chair in Technology and Innovation Management
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James Barlow has held a Chair in Technology and Innovation Management (Healthcare) at Imperial College Business School since 2003. Since September 2013 he has also been Associate Director of Research and Evaluation for Imperial College Health Partners. He was co-director of the Imperial College's Innovation Studies Centre from 2003-2006. From 2006-2013 he led HaCIRIC, a major programme of research on the adoption, implementation and sustainability of innovation in healthcare infrastructure systems.

James was educated at the London School of Economics (BA and PhD) and has previously held appointments at the Science Policy Research Unit (SPRU, University of Sussex), the Policy Studies Institute and the University of Westminster.

Much of James' research and practice has been on the development and introduction of complex healthcare technologies, as well as organizational and financial innovations such as public-private partnerships. He has published widely and has been a member of many expert panels on healthcare innovation, both in the UK and internationally.

He is a member of the executive for the NIHR Northwest London CLAHRC and the Dept. of Health Policy Innovation Research Unit. In September 2014 he was appointed President of the International Academic for Design and Health.

James has worked extensively with companies involved in the healthcare sector, including pharmaceuticals, medical devices, ICT and construction. He has been a member of healthcare advisory boards for UK companies, and currently sits on the advisory board for Guy's and St Thomas' Hospital Charitable Trust and. For more information see www.james-barlow.com and www.imperial.ac.uk/people/j.barlow.

Global Health Challenges, The Built Environment And Disruptive Innovation. Why We Need To Reset The Agenda

James Barlow

Healthcare providers, payers, governments and the public are facing a ‘perfect storm’ of escalating demand, rising expectations and concerns to control public expenditure. And in many parts of the world, there are significant challenges in providing access to affordable care and meeting the requirements of the UN Sustainable Development Goals. Countries around the world are trying to redesign their healthcare systems – adopting new financial models, attempting to shift from a ‘sickness’ to a ‘wellness’ paradigm, reforming the organisational architecture of health systems by placing primary care more centrally, and finding new ways of involving the private sector through PPPs. There is much interest in ‘disruptive innovation’ – cheaper, simpler organisational and technological solutions, emphasising the importance of individuals taking more responsibility for their care. So where does the built environment sit within this agenda? Around $400bn a year is spent globally on the built infrastructure for healthcare, as much as on medical devices. But much of this is on replicating out-dated hospital-centric approaches. Using the latest ICT and diagnostics technologies developing countries can leapfrog to 21st century models of healthcare which are able both to improve access and reduce costs. The built environment industries have a key role to play, but this will require new thinking to deliver more adaptable and affordable buildings.

Keynote speakers

Prof. Arto Kiviniemi PhD, MSc Arch

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Dr Arto Kiviniemi, Professor of Digital Architectural Design at the School of Architecture in the University of Liverpool, has developed integrated Building Information Modelling (BIM) both in Finland and internationally since 1996. In 1997 Tekes (Finnish Funding Agency for Technology and Innovation) invited Arto to lead the national R&D programme “Vera – Information Networking in the Construction Process 1997-2002”. The programme created the foundation for Finland’s position as one of the leading countries using BIM in the industry. In May 2010 Arto moved to UK and worked first as a Professor at the School of Built Environment in the University of Salford until he moved to his current position at the University of Liverpool in September 2013.

Internationally Arto’s main activities have been related to the International Alliance for Interoperability, now known as building SMART International, where he has acted as the Chairman and Deputy Chairman of the International Council and Executive Committee and as the Chairman of the International Technical Management Committee. Currently he is a member of the International Technical Advisory Group.

Arto has presented 140+ keynote and invited lectures in international seminars and conferences around the world since 1996. For his international merits in developing integrated BIM Arto received the FIATECH CETI Outstanding Researcher Award in March 2009 and the Order of the Knight of White Rose of Finland in December 2012.

Built Environment And Our Digital Future

Arto Kiviniemi

AECOO (Architecture, Engineering, Construction, Owning and Operating) industry has traditionally been notoriously conservative and slow to change. However, we are now reaching the point where the changes in technology and our business environment are forcing also AECOO to change. If the traditional players will not adapt to the situation, there will be new companies and business models the same way as we have seen in other industries.

The focus is now moving from design and construction of individual buildings to the built environment and lifecycle values; complex networks of infrastructures, buildings, services and users. Emerging Smart City initiatives are combining new technologies into the fabric of cities and data is becoming more and more valuable asset and moving from the monolithic software into distributed resources which can be accessed and utilised on any platform and with any application. Also the production methods are moving from labour intensive, manual methods into robotics, 3D printing and other automated processes, which in turn is increasing the value of data and design for production.

However, a crucial part of the change is the need of developing procurement, business and contract models. With the new technologies the built environment is becoming more and more complex and requires intensive collaboration, but the traditional procurement of fragmented services does not encourage into collaboration. Thus, it is critical that the clients will move to service models where the total lifecycle cost and functionality of the solutions is more important than the lowest price of each individual service package.

Abstract

Integrating Design And Production In Construction Projects

Clarissa Biotto [1*]
Patricia Tzortzopoulos [2]

The lack of integration between design and production causes many problems in construction projects, i.e. design errors, rework, change orders, construction delays, lack of constructability, between others.

The integration between design and production in the construction industry is challenging, as there are different companies with different knowledge, sometimes with conflicting goals executing these processes. Furthermore, there is fragmentation in decision making between design and production, which increases the complexity of construction project management.

Recently, researchers are applying lean thinking in design management in order to improve the performance of construction projects. The application of Last Planner System (LPS) in the design stage has proved to improve workflows and reduce waste. However, waste is still common in the interface between design and production.

Therefore, there is a need to integrate the processes of design and production in order to improve the performance of architectural, engineering and construction projects. In the literature, different researchers address some elements of integration and its main barriers, for example, the use of BIM tools, multidisciplinary teams, relational contracting, planning and control, between others. However, there is still a need to further understand such integration and how to best enable it in practice.

This research aims to develop a model to integrate design and production in construction projects. As this research aims to develop a solution to a problem, the research method is design science research. The integration model will be developed and assessed according to results from implementation in case studies.

Keywords: integration, design, product, production, management

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Use Of BIM And Lean In Construction By A Consulting Firm From Brazil

Clarissa Biotto [1]
Bruno Mota [*2]

SIPPRO is an innovative company engaged in the construction industry, specialized in construction management, budgeting, production planning and control integrated with information technology and BIM. The company is located in the city of Fortaleza, state of Ceará, in Brazil, but has projects developed in other five Brazilian states. The company develops works in Lean Construction since 2012 and in BIM tools since 2013. Also, the company has a strong relationship with the academy, publishing papers in important events, such as the IGLC.

This presentation aims to address the main results from the lean consulting activities. It will be presented cases of lean construction implementation, in which is possible to visualize the use of line of balance as a tool to plan the long-term of construction projects, as well, the variations in the application of the look-ahead plan as a medium-term for constraints removal and weekly planning. In addition, it will be presented the application of lean concepts to reduce wastes, plan physical flows and apply lean tools such as kanban and andon, in some cases integrated into IT systems.

About BIM implementation, it will be possible to visualize the use of BIM 3D models to develop the clash detection of different disciplines of design (architectural, structural and MEP) in order to avoid construction errors. The company has also implemented 4D BIM models to support the construction planning and control on sites. 5D BIM models were used by extract quantitative amount to develop a more accurate construction project budget.

The qualitative results of the implementation of Lean and BIM by the consulting company were: waste reductions, increase information transparency from production planning and control (PPC), fulfil expected deadlines and costs, and integration of the various sectors of the company through the PPC. As quantitative results, it was obtained an average savings of 10% over the cost of construction of the building.

Keywords: Lean Construction, BIM, Integration, Management, IT.

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Lean Production And Transaction Cost Economics

Nigel Blampied *

This review paper is part of a research project into the potential application of Lean in public agencies, with a particular focus on the potential development of Lean processes for pavement rehabilitation and preventive maintenance on public highways. The paper stems from a qualitative review of literature in the field of Lean production alongside literature in public organization theory. With public organization theory, I focus here particularly on literature on Transaction Cost Economics.

In recent years, two movements have challenged and begun to revolutionize thinking in the areas of production and economics respectively. Production is seeing a “Lean Revolution”, a movement to transform production and maximize value through systematic elimination of waste and removal of adversarial contracting relationships. This movement is founded on ideas that began in Japan and that have been championed by thinkers such as Taiichi Ohno, at Toyota Motor Corporation, and W. Edwards Deming.The Lean Revolution has affected projects both through the work of organizations such as the Lean Construction Institute and the International Group for Lean Construction, and through the development of techniques such as Agile project delivery.

At the same time that the Lean Revolution is challenging conventional wisdom in production, the world of economics is being challenged by a movement known as the “New Institutional Economics”, or “Transaction Cost Economics” (TCE). Six writers are most notable in the TCE school - Ronald Coase, Chester Barnard, Herbert Simon, Douglass North, Elinor Ostrom and Oliver Williamson, all of whom except Barnard received Nobel Prizes in Economics for this work.

The researcher found similar concepts in both sets of literature, although they are expressed in different terms. One example of such concepts is found in Koskela and Tommelein (2009) who criticize economics because it assumes that the internal organization of production does not count, assumes that there is no waste and assumes that ends are given and will be realized. Coase (1937) and Williamson (1996) express the same idea – that the key to economic analysis should be the transaction, which is internal to organizations. Their definition of and approach to “transaction costs” matches closely to the definition and approach to “waste” that is found in Ohno (1988) and discussed by Koskela and Tommelein.

In sum, this presentation will give an overview of the apparent common elements of Lean and of Transaction Cost Economics, explore common threads and connections between the two movements, and offer suggestions as to how each movement may contribute positively to the other.

Keywords: Lean production, Transaction Cost Economics, New Institutional Economics

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LAPID : Lean Guidance Tool For The Aviation Industry

Filippo Bosi *

Airport owners and the aviation industry in general are scarcely aware of Lean and its practices. Airport owners' internal design departments generally do not have the knowledge and organizational proactivity to achieve an integrated design process and to properly manage it, delivering the appropriate value to passengers, airlines and service providers. Integrated design development methodologies and integrated procurement are still not mandatory at the time of writing – in particular in Italy where the European Union Public Procurement Directive (EUPPD) has not been transposed – but the recent European regulations are pushing towards the adoption of lean, integrated design and integrated procurement methodologies to properly manage big infrastructure project development, complying with international requirements.

Since the aim of the design process is delivering value to both the airport owner and the airport users, the design process is critical in this direction. Building Information Modeling & Management (BIMM) technologies, being one of the Lean backbones, are often used in airport design activities but not integrated in the design process.

Lean Airport Project Integrated Delivery (LAPID) process methodology is accessible through a guidance tool that represents the framework for the application suite of design- supporting tools.

Lapid (לַפִּיד) in Hebrew means torch, a tool meant to illuminate, bring light and used to explore. Project participants are provided guidance tool to explore new possibilities of value delivery with the airport project. LAPID directs the design team and project participants in shaping the design process, using Airport Lean Design principles as references to foster value creation and avoid wastes in design activities.

To develop LAPID we used Design Science Research and Action Research. Design Science Research was used to produce a set of Common Practices-Lean Principles matrices (the artefact) that allowed to understand better the scientific and industrial problem and to develop a methodology to improve the quality of the design process, conveying more value with its final product. Action Research integration was aimed to address scientific problems and issues involving experts from the industry, introducing the researcher in the "community of practice".

The civil aviation industry and airport owners are the direct beneficiaries of LAPID integration in the practices. Indirect recipients are the other parties involved in the Airport supply chain: designers, con-

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struction companies and manufacturers of components and systems that can integrate the information model that is the backbone of the methodology. The recipients of the research and its products are:

* The scientific field of reference, which can further research and further develop its products;
* Stakeholders from the civil aviation industry;
* Managers interested in airport development methodologies and design verification.

LAPID provides a leaner and more consistent process methodology whose aim is increasing the value generated by the project for the airport owner, airlines and passengers, without binding the design team to rigid or standardized processes.

Every activity of the design process refers to the Lean pillars: Process, People and Technology. The aim of LAPID is connecting the three pillars.

LAPID's guidance capabilities can easily be used in design development activities, suggesting the preferred route to project participants.

In addition, LAPID in sided by a suite of design-supporting tools that feed BIMM tools - the backbone of Lean integration - enhancing the consistence and coherence of Project Information. LAPID and its toolsuite are a medium for close collaboration and integration that crosses normal company boundaries.

The different ALI tools, each fostering a different set of Airport Lean Design principles, support design and project development, enhancing Project Information control activities.

LAPID use and its integration in the practices implies a new vision for designers, based on an alternative set of priorities and objectives profoundly linked to Lean Mindset and efficietn Project Design & Management. Thanks to the use of supporting tools for project information generation, management and control the activities that don't generate "value" for the project are limited by the guidance tool, avoiding the waste of resources for the Design Team and delays in the project process due to redundant activities. LAPID integration will be finalized through an experimental interactive learning mean aimed to align the design cultures of the AECO Industry to the requirements of Civil Aviation Infrastructures, with the PhD Candidate as vehicle of specialist competencies and skills. This product will be aimed to both technical and non-technical profiles, fostering the integration of Lean mindset in the practices. LAPID could be the sparkplug for the Lean Revolution of Airport Design and its practices.

LAPID development is part of the doctoral research Airport Lean Integration (ALI), conducted by Filippo Bosi at the Dipartimento di Architettura of the Università di Firenze, Italy.

Keywords: Airport Design, Integrated Project Delivery (IPD), Lean Design, Information Modeling, Value Target Design

Exploring The Role Of BIM In Managing Knowledge In A Construction Project Delivery

Touria Bouazza [*1]
Chika Udeaja [2]
David Greenwood [3]

The construction organisations face challenges to stay afloat within the construction environment; these challenges could be summarised in an economic crisis, global competition, and rapid changes in industry structure. For this, the construction organisations must create value for their potential and existing clients; which is why many proponents in this area have identified Building Information Modelling (BIM) as a technology and a methodology that can create value within the supply chain (SC). BIM is considered by many researchers and experts as a technological tool that represents a building in a three dimensional digital model, and a platform where all parties involved can access and exchange information and data concerning the project. However, BIM is not only about technology, it encompasses other aspects such as the relationships between the stakeholders and the process of delivering a construction project. This research aims to develop a 'BIM-KM system' that uses BIM processes to manage tier 2 knowledge in a construction project delivery. It is anticipated that the management of unexploited knowledge using BIM will improve the decision making of the stakeholders. To achieve the aim above, the following objectives will be undertaken. The first objective is to establish the state of the art of Construction Project Delivery (CPD) process, and the current practices of managing knowledge in a project. The second objective will be to explore the BIM process in the construction project delivery, and determine the role that BIM can play in managing tier 2 knowledge. The third objective will identify the critical success factors of using BIM in managing unexploited tier 2 knowledge in a construction project delivery. The fourth one is to formulate a strategy for managing unexploited tier 2 knowledge in CPD using BIM. The fifth objective will develop a 'BIM-KM methodology' that uses BIM to manage unexploited tier 2 knowledge in a construction project delivery. Finally, the sixth objective will validate and test the methodology using BIM in a construction project delivery environment. In carrying out this research, a methodology will be set out to identify the framework to be developed by undertaking an in-depth literature review, and the use of mixed methods research through the use of case study and surveys. The main contribution of this research is to develop a methodology that uses BIM processes to manage unexploited tier 2 knowledge in a construction project delivery. It is also an-

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ticipated that the developed framework will be beneficial to the client and all the stakeholders because the management of the unexploited knowledge can have great ramification for the project delivery and performance. The presentation will describe a PhD work that is currently undertaken at Northumbria University supervised by Dr. Chika Udeaja and Prof. David Greenwood. This PhD work focuses on the role of BIM in managing knowledge in a construction project delivery. The presentation will discuss the background of the PhD student, followed by a short overview of her PhD topic and the motivation that pushed the student to undertake this research. The presentation will also discuss the research concept and strategy undertaken, and conclude with future works to be carried out over the next three years.

Keywords: Knowledge management, BIM, supply chain, construction industry, Construction project, Tier 2 supply chain, COBie

"A Knot" – The Construct To Bring Us "Beyond The BIM Utopia"?

Henrik Buhl [*1]
Nicolaj Hvid [2]
Michael Andersen [3]

In Denmark we are testing and getting experiences with Knotworking as a concept for teamwork in the design process. Building on discussions with our Finish colleges about their projects and theoretical development (Kerosuo et.al. 2015), their use of Activity Theory (AT) to understand and develop the collaboration and interaction in construction projects, as well as using AT for critical reflections on the utilization of BIM (Miettinen and Paavola, 2014), have made us curious about Knots and Knotworking as a construct based on Engeströms original thinking – From Teams to Knots (Engeström, 2008). Engeström describes Knotworking as an elusive and improvised phenomenon (p. 208). "The notion of a knot refers to rapidly pulsating, distributed, and partially improvised orchestration of collaborative performance between otherwise loosely connected actors and activity systems. Knotworking is characterized by a movement of tying, untying, and retying together seemingly separate threads of activity. The tying and dissolution of a knot of collaborative work is not reducible to any specific individual or fixed organizational entity as the center of control. The center does not hold…..The unstable knot itself needs to be mads the focus of analysis." (p. 194) "Knots that brings us beyond the models of stable, well-bounded institutions and teams" (p. 233) – The reason for this, for an abstract, long quote are that we think this understanding can help us to reflect the challenges and promises of BIM and how to implement and use BIM. Our ambition is critical reflections followed by creative ideas, based on the analysis made by Reijo Miettinen and Sami Paavola in their classic article: "Beyond the BIM utopia: Approaches to the development and implementation of building information modeling"(2014) – which is our reference when it comes to get an understanding of the difficulties with implementing BIM. We shall continue their discussion of the four elements of BIM Utopia, followed by ideas about BIM collaboration, Social BIM etc. – we hope our effort will bring in new perspectives on BIM, implementation and collaboration.

The starting point is our first experiences with developing the Danish Knotworking concept, we have worked with Knotworking as a concept to improve collaboration and use of digitized technologies – BIM and IPD. We do have confidence in Knotworking and the ideas behind, but we are not sure that our conceptual understanding brings us from "Teams to Knots".

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BIM/VDC is not just a tool, it is neither a platform, but it is an environment - what does it take to establish an environment? We look at how BIM/VDC /data may be the social glue in the construction process.

In the conclusion implications for Knotworking and Social BIM as drivers for implementing the potentials of BIM/VDC will be pointed out.

Keywords: Knotworking, activity theory, sociomateriality, collaboration, design, decision making, Integrated Project delivery, IPD

BIM & Lean For Nzeb Renovation: Design Opportunities For Regenerative Architecture

Gisella Calcagno *

Lean and BIM should represent two synergic and complementary game changers for the AEC sector, in order to design and manage a sustainable built environment, promoted by Europe.

Nowadays, urban transformation challenges are complex because of incoming pressures, such as climate change and growing population; thus, they require innovative and systemic design approaches, which can help to realize the regenerative sustainability potential.

Aligned with sustainable objectives, Lean philosophy requires a strong project management for all the building life cycle. Its practice in design process can be reinforced by computational approaches, like BIM, which allow the creation of informational models for cooperation.

This opportunity appears particularly profitable in urban regeneration, where decision-making is shared between various stakeholders, but common and challenging goals need to be achieved, regarding fundamental environmental and social aspects.

The re-design of the exhausted building stock will require strong and efficient technical retrofitting, in order to reach Nearly Zero Energy Building EU targets, but also the capability to re-shape spaces for a changing and growing society.

The informational and computational BIM contribution, basis of a knowledge-evidence based architectural project, guarantees efficacy in integrated design processes, but also improving the appliance, and understanding, of Lean principles in the building process. Furthermore, this can promote trust in building renovation investment, in its green and social potential and, finally, in architectural design. Reviewing the literature on BIM and Lean approaches, the objective of this study is to explore the potentialities of their integration in building renovation design process, depicting a changing role of architect, in the perspective of a regenerative turn in architecture.

Keywords: BIM, Lean, Nzeb renovation, regenerative architecture, design process

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Design Science Research In Lean Construction: An Analysis Of Research Processes And Outcomes

Carlos T. Formoso [*1]
Daniela D. Viana [1]
Iamara R. Bulhoes [1]

Design science (or constructive) research is a methodological approach concerned with devising artefacts that serve human purposes, which has emerged simultaneously in several fields of knowledge, including cost accountancy, information systems, and general management. This research approach aims to produce innovative constructions, intended to solve problems faced in the real world, and simultaneously make a kind of prescriptive theoretical contribution. It involves the construction of an artefact that solves a domain problem, and the knowledge produced must be assessed against criteria of value or utility. Due to its prescriptive nature, it seems to be highly relevant for the Lean Construction community. This paper discusses the research process and outcomes of a set of investigations that have implicitly or explicitly adopted a design science research approach: the development of framework for devising customisation strategies in house building, the development of planning and control model for ETO prefabricated building systems, and the conception and development of the Last Planner System. Moreover, the differences and similarities between the research strategies adopted in those studies and traditional social sciences research approaches are pointed out.

Keywords: Design science research, Prescriptive research, Research methodology, Implementation, Lean Construction

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Challenges To Manage Early Design Stage Information In A BIM Environment

Danilo Fernando de Oliveira Gomes [*1]
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It is well know that decisions made in the early stages of the design process impact on production and lifecycle. It is challenging to connect the abstract nature of early design decisions with the detailed information developed downstream. Therefore, there is a need to develop more integrated and collaborative design process. Previous research has discussed the need to bring the stakeholders that usually have been involved in later stages into the initial stages of design. This supports a more integrated environment for informed collaborative decision-making. However, while the majority of the research on BIM adoption and design integration seems to work in a clearer and structured route to engage in exchanging data and managing the integration process in later stages of design development, it seems that the development and communication of design decisions in early design stages remains informal.

Therefore, the research question is: Is there a need to structure information in early design stages differently to support detailed design information management in BIM?

The aim of this presentation is to discuss collaborative practices at early design stages, with a focus on the management of information, and how early design stages are affected by BIM adoption. Literature focusing on early design stages describing procedures to generate and manage design information is discussed. Also, studies on the implementation of BIM in multidisciplinary design practices are discussed, providing insights on their effects on design procedures.

As a result the barriers and limitations in current collaboration in early design stages and its relationship to BIM are discussed. Primarily, findings will help to frame the research problem more clearly and specify the remaining of the research design.

Keywords: Early design, Collaborative Design, BIM, Design Information Management, Design Team

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BIM Adoption In Large Government Construction Owner Organizations

Ury Gurevich [*1]
Rafael Sacks [2]

Building Information Modeling (BIM) is a complex business process that potentially allows facility owners to achieve better control over their projects and assets, offering benefits throughout the project lifecycle. Adoption of BIM processes across large business units with multiple outsourced suppliers, while they continue operating, is in itself a challenge. It is not clear how a construction owner's organization should manage the adoption process and how it needs to change in order to achieve the optimum results. This research explores the process of BIM adoption in large government construction owner organizations, focusing on the management, design and economic implications of implementing BIM procedures with a view to compiling recommendations for managed organizational change.

Over-dependence on technology, insufficient allocation of resources and time for training, lack of support, high costs of adoption and lack of collaboration are only a few of the roadblocks to Information Technology (IT) adoption that are cited in the general organizational literature (P. G. Bernstein & Pittman, 2004; Butler & Selbom, 2002; Chen, Crandall, & Yu, 2005). These are also true for BIM adoption (Ku & Taiebat, 2011). A recent market analysis (H. M. Bernstein, Jones, & Russo, 2012) reported that by 2012 72% of US design firms had adopted BIM technology; however, it pointed out that the depth of usage was as yet unclear. There was no attempt to measure their BIM level of maturity (BSI 2013). Many studies have focused on the adoption of IT by construction companies and on its impact on productivity (Ahmad, Russell, & Abou-Zeid, 1995; Love & Irani, 2004; Rivard, 2000), yet none of these have researched the adoption process and its social organizational effects, nor have they considered adoption in large government owner organizations.

The purpose of the research is to map the main steps and means (in context to the organization, technology, and the commercial & social relations) that a large construction owner should take for successful BIM adoption. Understanding how BIM processes should be implemented by large construction owners and how it affects the projects and their main participants will be the main contribution of this study.

The question's posed are:

* Does the BIM adoption process require or result in changes in formal and informal roles and behavior of key personnel?
* Does the adoption require or result in structural organizational changes?

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* How does BIM adoption affect the relationships with service providers (designers, consultants, contractors)?
* What are the implications of the changes on project outcomes?
* Can the organization leverage the BIM adoption process to filter service providers (designers and contractors) according to quality?
* Does the technology change the depth of the collaboration in the extended team (owner, designers, and contractors)?
* Who profits from BIM use and how?

In general, people tend to resist change (Folger & Skarlicki, 1999; Strebel, 1996). Over the years, a number of models for IT adoption have been proposed to overcome this and other obstacles (Davis, Bagozzi, & Warshaw, 1989; Taylor & Todd, 1995; Venkatesh, Morris, Davis, & Davis, 2003). These models will be used to analyze the BIM adoption process in selected case-studies. Empirical data describing the case-studies will be collected through interviews. Organizational hierarchy mapping, business process modeling (using BPMN) and the BIM maturity Index (BIMMI) (Succar, Sher, & Williams, 2012) will be used to document and analyze the case-studies.

The research comprises one major case study and a set of minor case studies. The major case study is being investigated using Action Research (Lewin, 1946), in which the first author is playing a leading role in his own organization's process of BIM adoption. This organization, the Engineering and Construction Dept. of the Ministry of Defence, is one of the biggest public construction owners in Israel; it employs more than 400 engineers and architects and has an annual construction budget of some £600m.

The first step in this major case study was to establish a pre-BIM adoption benchmark. The level of adoption and BIM maturity index was very low for the internal departments of the organization, as determined by inspection of the portfolio of projects and interviews with key personnel. A survey of the organization's external service providers (architectural and engineering firms) showed low levels of BIM adoption and maturity overall, with some notable exceptions (27% out of the 110 respondents; the survey was sent to a total population of 1,772 providers).

A departmental BIM guide has been developed and implementation is ongoing. The guide was based on a review of 15 leading BIM guidelines (Sacks, Gurevich, & Shrestha, 2015). BIM adoption is currently progressing within the framework of a work plan generated by a core group of advisors. Working teams have been established, and the adoption and the research are ongoing. The next steps in this case study are measurement of the changes over some two years, and interpretation of the results. The minor case studies include organizations such as the US Veterans Affairs Administration, US Army COE and three UK government agencies that are participating in the UK BIM task group. They are being investigated using in-depth interviews, questionnaires and case study write-up.

The main three fields of interest are management, design and economics. Each will be addressed separately and in relation to one another. Identification of the right implementation characteristics and compilation of a road-map for implementation can assist other owner organizations to achieve better and more organized implementation. Moreover, effective adoption of BIM by large construction owners in any given national or local construction economy is expected to have significant positive effect on the whole industry.

Keywords: Building Information Modeling, BIM Adoption, BIM Guides, Organizational Change, Social Impact.

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A Method For Historic Building Data Management Using BIM

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Even though BIM has been applied to preservation and maintenance of existing buildings, there is a knowledge gap in the BIM's adaptation to historic buildings. This research proposes the implementation of BIM, not only for the buildings' graphic survey, but also to make a complete management model. This management involves the entire life-cycle of the building, as well as the different stakeholders: owner, public agency, architect, archaeologist, surveyor, historian, restorer, user, etc. BIM is the best system to achieve this purpose because of standardization of historic constructive elements, internal data base for historic information, and representation of constructive phases. The model includes not only the geometry, but also the facilities and structure, maintenance, BIM families (historic, including deformities), etc. In conclusion, BIM is absolutely innovative regarding the analysis, research, documentation, and management of historic buildings; it also represents a huge progress in how the exchange of information occurs between the different professionals involved in architectural heritage. This research is part of the scientific project titled "The Design of a Database, Management model for the Information and Knowledge of Architectural Heritage" subsidized by the Spanish Ministry of Economy and Competitiveness.

Keywords: HBIM, BIM management, stakeholders in HBIM, HBIM method

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Structure And Agency: Key Considerations For Built Environment New Product Development

Michail Kagioglou *

The last 3 decades have seen significant developments in all aspects of process management in the Built Environment around the notion of New Product Development (NPD). Many aspects of NPD have been examined in detail, such as the design process, the front-end focus, construction as production, the notion of construction as a manufacturing process, etc. The overall notion of whole life cycle issues has also become stronger and the issue of delivering benefits rather than just tasks and processes have become more prominent over the last decade or so. In parallel to such developments technological innovations have in enabled, accelerated and in many cases radically changed the way that activities are undertaken and also what activities are undertaken. This interplay between process and technology is becoming more dynamic and more difficult to separate, hence necessitating the consideration of process and technology issues simultaneously. Lean and BIM can be seen as two such aspects where they can/should co-exist in any considerations of enactment of project and programme activity. In social sciences the space represented by the above will possibly fit around the notion of 'structure'. It is obvious that such 'structure' is of no relevance without the notion of action and the actors involved in both undertaking and enacting process and technology implementation within a specific context defined by projects and programmes. Therefore the notion of people is also fundamental in NPD. The incorporation of people, roughly speaking, is considered in social sciences under the general heading of 'agency'. Hence the fundamental consideration here is around 'structure and agency' and how these aspects are considered, categorised, understood and enacted within the context of NPD (by this we understand process/people/technology and the intersection of BIM/Lean and Social Sciences). Previous work has identified a number of key principles for successful NPD and this presentation will examine the validity and currency of these principles when considering 'structure and agency' and present an initial set of potential Social Sciences research issues and questions that might arise from such considerations.

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Expansive Uses Of BIM And Organizing BIM Coordination

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New occupational roles and tasks of BIM uses have emerged in organizations. Barison and Santos (2010) have identified different roles, tasks and individual responsibilities of BIM Specialists. For instance, BIM Facilitator and BIM Consultant assist professionals not yet skilled in operating BIM software programs, and BIM Analyst performs analysis on the BIM model. New occupational tasks are also identified under the label 'document control' dealing with document control and integration of data exercising different standards in assessing the quality of work (Jaradat, Whyte & Luck 2013). However, the boundaries of the roles and responsibilities are not clear in organizations. In addition, the tasks of BIM coordination seem to differ from a project to a project.

We study the organizing and coordination of BIM uses in Finnish construction projects. In which ways and by whom building information modeling is managed and coordinated in different projects? How the actors themselves see the roles, tasks and responsibilities? We have interviewed BIM specialists, project managers, head designers, and BIM coordinators (n=19) in the research project. According to our preliminary findings, there are two roles of organizing BIM coordination 1) to hire a BIM coordinator to assist the project management (e.g., the client's or the developer's BIM coordinator) and 2) to include BIM coordination to the tasks of a head designer or a developer. A coordinator is required to have good technical skills and an overall understanding of different requirements set for the BIM use. In some cases, a BIM coordinator is also expected to manage and organize BIM use and collaboration between different design disciplines. The roles, tasks descriptions and responsibilities involve also some tensions. A BIM coordinator represents typically some partner's viewpoint (the main designer's, the contractor's), and not necessarily the interests or requirements of the other participants. Although, the BIM coordinator has a responsibility of coordinating the work he or she does not have an official status in the project. Some interviewers reported that a BIM coordinator is supposed to conduct technical tasks and take care of the basic compatibility of models. Other interviewers thought the role should be developed to become a part of design work.

Keywords: coordination of BIM, BIM coordinator roles, BIM coordinator tasks

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Collaboration In Construction Projects - Why Is It Needed, What Does It Require?

Lauri Koskela *

Collaboration is generally viewed as a required element in construction projects. However, the discussion on collaboration tends to remain on a high abstraction level, and there is relatively little analysis, for example, on why collaboration is needed or what collaboration requires. The presentation gives an overview on our knowledge on these matters, based on prior literature but also providing new conceptual interpretations, informed by the time-honoured discipline of rhetoric.

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Information Management Of Life Cycle Of Highways And Roads From The Point Of View Of Maintenance

Manu Marttinen *

Information Management has emerged from the old times of storing information one's own bookshelf, towards a Meta Information based cloud computing services and Infrastructure Information Models. The highway maintenance – a very traditional field – is now seeking new ways to enhance Information Management than the dispersed portals and multiple Excel-sheets offers.

The current state of highway maintenance operations is more scattered than it used to be in past: the number of different actors working within maintenance has increased. Nowadays challenge is to handle vast amount of information, and make sure that every actor has the best, the same and the newest information to work with. The main goal of this research was to develop new Information Management ways to the maintenance field, assist with information sharing between different actors , and enable even Information Model -based maintenance and asset management in future by using visual interfaces and Meta Information -based cloud computing storages.

The research methods used were the literature research, expert interviews and research of studies done in past in Finland and in foreign countries. Thirty interviewees were selected to represent the maintenance area as widely as possible, and all interviewed shared the thought that this research is important. During this research, there was a workshop for interviewed people as feedback for the interview. With that feedback, it was possible to ensure that the quality of results was high. With all these methods used, it was possible to create the synthesis of the present Information Management process, and give some ideas to a more effective way of Information Management in future.

One result was that it is possible to ensure better information sharing between different actors by developing a system of "mapping of information" i.e. the guidelines of locating information with the visual interface. With that system it is possible also to ensure that the basic problem "my Excel vs. your Excel" no longer exists. Results also suggest that the current process of documenting maintenance plans and then maintenance works performed needs to be revisited towards longer periods of cycles. The main concern is to oversee the entire field of asset management and road maintenance by the Finnish Traffic Agency.

Keywords: Life Cycle, Information Management, Asset Management, Maintenance, Infrastructure Management, InfraBIM, Infrastructure Information Model, Building Information Model, BIM, Maintenance Model

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Soft Systems Methodology To Support Lean Geotechnical Design

Jason Le Masurier *

Broadly there are 2 approaches to design in geotechnical engineering:

Predefined design is an attempt to eliminate uncertainty by predicting ground conditions with (assumed) certainty before construction. This often leads to conservatism, over design and waste of resources, it is however the most common approach due to the traditional procurement approach of separation of the design stage from construction. If during construction conditions are found to be not as predicted, hasty redesign might be required leading to further waste of resources.

The Observational Method (OM) (Peck,1969) provides an alternative whereby designs can be modified during construction based on feedback from observation and monitoring of ground performance. The OM has been practiced for many years by innovative engineers and is far more efficient than predefined design. OM reflects many attributes of Lean Construction since it minimizes waste of materials, time, and effort in order to generate the maximum possible value.

OM requires integration of design and construction which has been facilitated over the past 20 years through new approaches to procurement. There is particular synergy between BIM and OM.

A danger with collaborative approaches to project delivery is that risks and responsibilities are shared more broadly and are not as clearly defined or understood as they are under familiar, traditional relationships. Under such circumstances uncertainty in the management process can lead to confusion of responsibilities, generating the potential for organisational and physical failure. An example of such a failure is the collapse of the tunnels under construction using OM, at Heathrow Airport. The enquiry into the tunnel collapse (HSE, 2000) found that it was the consequence of foreseeable cultural, organisational and management failures and said human failures were not identified and corrected. This suggests that in some projects human behaviour is a source of (soft) uncertainty in the OM design process that is as significant as (hard) uncertainty in the ground conditions.

The OM in its traditional application is systemic in terms of understanding and managing how all parts of a hard physical geotechnical system interrelate. The HEX collapse illustrates the need for a soft systems approach to deal with the human aspects of the process. Checkland (1981) offers a solution through Soft Systems Methodology.

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The Observational Method (OM) was both the subject of research and also provided a structure for the research method, using the generic perception-reflection-action loop (Le Masurier, 2001). As such it was action research. Perception was in the study of live construction projects and semi-structured interviews with key personnel. Reflection involved grounded theory (Glaser and Strauss, 1967) analysis of data from the interviews. From this analysis a new theory of the practical application of the OM was developed and made explicit in a generic process model. The generic model was then used in the action stage as the basis for developing a project specific process model to help ensure robustness of the process on a live application of an OM design (Chapman and Green, 2004).

The principles of the OM can be applied holistically to manage a range of construction project uncertainties, including human behaviour (Le Masurier et al 2006). A methodology is described to support applications of OM through the active design and management of the processes, carried out in conjunction with developing the BIM models. Associated with the process modelling methodology are a range of hard and soft performance indicators that represent the uncertainties in the processes. Measuring the soft KPIs requires the input of social scientists and some progress has been made in this area in developing quantitative measures for team integration on construction alliancing projects.

The increasing trend towards collaborative working and BIM means conditions for OM design are becoming more conducive, and applications of OM in ground engineering would be expected to increase.

Key words: geotechnical design, process modelling, soft uncertainties

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Contributions To Value Generation From Lean And BIM Studies In South Of Brazil

Luciana Inês Gomes Miron *

Over the past years the lean community has done research aimed at improving the generation of value in architecture, engineering and construction. Some of these researches are related to managing client requirements. Client requirements management consists of the identification and analysis of requirements, definition of priorities and making information available about the client's needs and preferences. The main set of client requirements management activities can be subdivided into three categories: (a) requirements capture - is related to the identification of "client body"; (b) requirements flow control - involved the monitoring, refining and fulfilling of client requirements during the project development process; and (c) value assessment - included measurement of the perceived value.

The purpose of this paper is to describe a sequence of clients' requirements management studies carried out at South of Brazil, which have brought contributions to value generation. Some of the techniques investigated in these studies are Building Information Modelling (BIM) and Laddering.

The use of BIM seems to be an alternative for supporting clients' requirement management, since it is capable of connecting different types of information to product models. BIM, among other things, aims to streamline processes, present construction information in an accessible and common way, reduce the possibility of missing or clashing information, ensure optimized project coordination, and facilitate simultaneous work of several professionals involved in the design and production of the project. One of the studies proposed a method to model the requirements of social housing projects' clients, supported by BIM. The main contributions of this method are concerned with the identification and structuring of generic requirements to support the decision making process in new housing projects.

BIM highlighted the need for clear definition and structure of requirements (in hierarchical levels) that can be used in software. Through the modelling of client requirements it is possible to provide, control, track and check the requirements with the design solutions adopted, and thus assist the decision making of the different stakeholders involved in the project.

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Laddering technique includes a number of data collection and processing that can be effectively used for generating hierarchical value maps - HVM. The HVM are a common output of a Means-end Chain (MEC) model originated from research in marketing area and widely applied. The MEC model connects the concrete attributes of a product/project (tangible attributes) with the emotional and personal values (abstract and intangible objectives). In construction context, other study demonstrated that a visual device, such as a HVM, can help decision makers involved in housing projects to understand the perceived value by the users. Another subsequent study proposed a method for evaluate the perceived value by the dwellers and technicians involved in the social housing provision in southern Brazil.

These clients' requirements management studies explored these newer approaches and represent an innovation for value generation in the development of construction projects. It also suggested that the use of techniques for capturing and controlling requirements has a positive effect in project development. Moreover, these techniques provide insights into the subjectivity of the client-supplier relationship in the value generation.

keywords: value generation, client requirements management, BIM, hierarchical value maps

Gamification And Building Information Modelling (BIM) Could Enhance Collaboration In Engineering Construction Project Management: A Critical Review Analysis

Petros Mitarakis [1]
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Over the past years, construction projects are challenged to enhance collaboration between the departments. The state of the art in construction is the use of BIM and Lean. Despite the fact that BIM and Lean are two independent strategies, there is a strong relationship between them which helps for a better working environment. Through literature review, BIM is referred as a way of thinking which provides to team members to understand in a better way a building through the use of digital model. On the other hand, Lean is based on the Toyota Production System and refers to the elimination of waste and continuous improvement for meeting the customers' demands. From the perspective of social sciences, Lean construction as a project based – production process. A primary requirement to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. Designing a production system to achieve the stated ends is only possible through the collaboration of all project participants (Owner, A/E, contractors, Facility Managers, End-user) at early stages of the project. This goes beyond the contractual arrangement of design/build or constructability reviews where contractors, and sometime facility managers, merely react to designs instead of informing and influencing the design. However, the problem with the collaboration is that there is no engagement of the employees. In order to tackle this challenge gamification could be a way forward. Gamification is a new well-known technique which focuses on a concept of applying game-design thinking to non-gaming situations. It is believed as one of the most promising methods of enhancing collaboration within a construction company or an organization, as it targets to improve communication and cooperation between the stakeholders and to make them more active. Many businesses already have invested in applications of gamification in order to engage participants to create a collaborative environment. However there are no indications that construction enterprises use gamification to engage stakeholders and thus to improve collaboration in BIM and Lean. This research is about understanding whether gamification could be embedded in BIM and Lean in order to enhance collaboration within construction projects and businesses significantly. Also, it is intended to present literature review (secondary data) to show interrelationships between Gamification, BIM and Lean to enhance collaboration .

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Negotiating On Uses Of BIM Within Construction Projects

Sami Paavola [*1]
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It has been maintained that the implementation of BIM challenges traditional, linearly and sequentially proceeding projects with more collaboration in all phases of the construction project (e.g. Succar 2009; Miettinen & Paavola 2012). Working “in silos” (Dossick & Neff 2010) need to be replaced with collaboration to encompass more parallel and iterative work with related tools (cf. Puonti 2004; Engeström et al 1997). This means that firms need to negotiate on the uses of BIM, and on the configuration of the tools used in different phases of the construction project.

We will present results of a study on coordinating and managing the uses of BIM in Finnish construction projects. The data is thematic interviews (n=19) of main actors responsible for the use of BIM in construction projects (BIM coordinators, BIM consultants, main architects, project managers). Our research focus is on how these experts talk about the needs for negotiations and agreements on different phases of the construction project. What are the means and tools of agreeing on the uses? Are there some specific phases or situations where the need for negotiations is especially important?

In our presentation we will analyze results on interviews which are still going on. On the basis of preliminary results it seems that most actors would like to see the construction process basically linearly. It means that the uses of BIM are agreed at the beginning of a certain phase of the project and then followed accordingly. Many of them report on using new BIM requirements developed in Finland at 2012. The actors see, however, also the need for a more intensive collaboration and communication in different phases of the projects. BIM consultants and experts are developing new means of doing collaboration and on agreeing on the uses of BIM. On the other hand, individual firms are developing their own means of supporting the BIM use, and have different outlooks on the ways of supporting the BIM use in their projects.

Keywords: BIM, parallel collaboration, negotiations, agreements

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Integration in Design and Construction: The Case of BIM-enabled SCM

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The integration of technologies and practices in Architecture Engineering and Construction (AEC) industry has been considered an innovative approach to tackling the fragmentation of the industry. The adoption of innovations, such as Building Information Modelling (BIM) has proliferated the recent years. BIM has been acknowledged for delivering benefits in the performance, collaboration and co-ordination of projects. However, the impact of BIM in inter-organisational settings has not been adequately studied. At the same time, Supply Chain Management (SCM), and Lean approaches have been associated with an inter-firm perspective and aim to reduce the interfaces among disconnected or loosely coupled parts of the construction Supply Chain (SC). The integration of SCM and Lean approaches with BIM could potentially increase the collaboration and integration of the various project actors. This PhD research aims at identifying the repercussions of BIM and SCM. In particular, it seeks to satisfy the following goals: (a) analyse their real-world combination, (b) develop a BIM-based SC modelling analysis tool, (c) identify the inter-organisational changes in BIM-enabled SCM and (d) propose a model for future BIM-enabled SC partnerships.

A mixed method approach was undertaken, to analyse the repercussions of the combination of BIM and SCM. The main method was case studies, which were occasionally complemented by modelling methods. The cases were focused on the Dutch construction market, given that the local AEC market presents a balanced mix of policy-driven BIM-roadmaps and emerging BIM practices. The case methods have been employed to achieve the goals above in the following phases:

a) Exploration case of real-world projects that engage in BIM and SCM to identify to what extent the two are compatible and their interdependencies in practice (via interviews, document analysis and live observation of joint meetings);
b) Scenario case of a potential conceptual fusion of the two topics (BIM and SCM) combining case research with modelling methods, and combines product-, process- and organisational models (in a graph-based model);

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c) Application case of the aforementioned conceptual model and further deep, interpretative case analysis of the emerging changing roles among the actors from BIM-enabled SCM (via document and project website analysis, interviews and modelling methods);
d) Validation (or credibility) post-hoc case analysis of the phases above (a, b, c) as to the construct, internal and external validity and potential appropriation in research and practice in the future (via interview and expert and user workshops).

Both inductive and deductive reasoning was followed, and both qualitative, and quantitative data have been collected and analysed. The potential impact of the study was outlined as to regional, i.e. cases in the Netherlands, societal and scientific relevance. This research used analytical and interpretative approaches and focused on the inter-organisational interfaces of BIM and SCM.

The combination of BIM-based technologies and SCM practices have been studied as an opportunity for the remaining and persistent AEC challenges pertinent to inefficiencies, poor co-ordination, information redundancies and waste. On one hand, object-oriented modeling, and particularly BIM, was suggested as a potential technology to regulate the information flows among the various project actors, given that the origins of BIM were found in the long-lasting efforts to standardise the building information through product modeling. On the other hand, many efforts on the standardisation of BIM have been developed, but from a top-down approach as to the delivery and the collaboration processes in the form of national mandates. The observed mismatch between the bottom-up and top-down strategies for the popularisation of BIM could be aligned by focusing on already structured (e.g. contractually-bound) multi-disciplinary environments and inter-organizational relations, e.g. by focusing on SCM and Lean.

The ultimate intended contribution of this PhD research is an analysis tool and a set of prescriptions for BIM implementation and diffusion from a middle-out level with the intention to inform and enrich the bottom-up and top-down BIM adoption and diffusion strategies, respectively. Eventually, BIM and SCM – being both holistic and integrative approaches – could be linked to the recent, or re-surfaced, discussions on the wider sense of sustainability as a strategy to reduce waste and increase efficiency. At the same time, the combination of BIM and SCM is relevant to the re-visited Systems Thinking, by considering the built environment as an open-ended – or circular – rather than a linear network.

Keywords: Building Information Modelling (BIM), case study, integration, partnership, Supply Chain Management (SCM)

Methods Of Overcoming Barriers To BIM Collaboration On A 70 Storey Development In Sydney

Matt Parkes *

In providing BIM Management and Tender and Construction Documentation services for Architectural and MEP on a prestigious new 70 storey tower mixed use development in Sydney, Australia, involving consultants from Australia, the UK and the USA, Atlas had to overcome a number of barriers (technological, contractual, psychological) in order to ensure the successful BIM collaboration by the whole team.

Keywords: BIM, collaboration, management

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Improving Transparency Behaviour In Construction Projects In Commonwealth Of Independent States (CIS) Countries Thru The Choice Of Contract And Building Information Modelling(BIM)

Jose Perez [1]
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The choice of an appropriate delivery method is one of the most critical decisions to be made with regard to a construction project. However decisions in construction projects largely lack of transparency thus opening the way for corruption which eventually results in significant cost and time overruns. Transparency as a behaviour in engineering, business and other social contexts implies openness, communication and accountability. The problem of achieving transparency in the construction industry remains high on the agenda, especially in the developing countries. The study focuses on the business environment and construction market of the Commonwealth of Independent States (CIS), specifically in Russia.

However the aim of this exploratory mixed method research is to critically assess the drivers for construction projects in CIS that overrun cost and delivery time.

The research design is based on the mixed method and follows an exploratory qualitative approach, with the information obtained in the course of a critical review of the available literature as well as through a questionnaire survey, participant observations and first-hand experience.

The uniqueness of the thesis is the attempt to link social science such as collaboration and transparency behaviour to overcome corruption challenge and introduce BIM and LEAN as way to overcome the challenge of corruption in CIS.

Keywords: BIM, DBF, DBB, Corruption, CIS.

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Degrees Of Alignment: Assessing Collaboration In Bim-Enabled Project Delivery Environments

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Facilitating collaboration amongst project stakeholders in the construction industry is one of the central tenants of Building Information Modeling (BIM). Collaboration, however, is a most complex and multifarious social phenomenon. In this paper, collaboration in the construction industry is investigated as the concerted and negotiated alignment between multiple actors from different social, mental and object worlds residing within a shared problem domain to fulfill a common motive. Through this conceptualization, we explore the notion of alignment, and the degree to which it is achieved in the context of a building project, as an indicator of the strength of collaboration amongst project team actors. The findings from a longitudinal research anchored in the design-sciences, employing a systematic combining process and involving multiple case studies conducted over a four year period are presented in this paper. We first define the notion of alignment across various domains to provide a robust conceptualization. We define various types of alignment and then explore the notion as an indicator of collaboration within the setting of a building project. We find that the transition to BIM-enabled project delivery is causing a shift in the various social, mental and object worlds of the various project actors residing within this problem domain: it's causing a shift in the alignments that are crucial to support collaboration. We posit that the degree to which project teams foster alignment is critical to ensuring strong collaboration amongst project team actors, especially in the context of BIM based project delivery. We discuss that furthering this notion of alignment in the construction industry is a useful and practical way to ensure that social and technical considerations are properly addressed to fully benefit from the adoption and implementation of BIM enabled project delivery. The key contributions of this work of the clear elucidation of the concept of collaboration in the context of the construction industry, the furthering of the application of design-science within the construction management research domain, the development of the notion of alignment as an indicator of strength of collaboration and a method to assess collaboration based on this notion of alignment.

Keywords: Collaboration, design-science, systematic combining, alignment, assessment

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Impact Of Changes On Project Participants' Psychology At Construction Stage: Problems And Potential Solutions

Noraina Md Rahim *

The presentation aims at shedding light on the negative impact of changes during construction. Not only changes affect cost and time, but they also influence the project participants' psychology and morale.

When a change is introduced, the construction flow will be interrupted and the progress will slow down. Based on findings, it is argued that also the change process itself can cause a project to delay leading to an overrun. Considering the complexity during the construction stage, a long process can lead to further disruption to site activities. This disruption in particular can degrade the project productivity and cause non-compensable damage to the contractor. Some strategies to catch up, for instance acceleration or overtime, may result in labor force fatigue, increasing level of mistakes and additional rework.

Taking lead from the construction project change literature, it can be suggested that the longer it takes to manage a change process, the more frustration and loss of motivation is caused to the project team. The principle of cycle time compression within the change process could be adopted in order to reduce the interruption. Such compression may be realized through the elimination of non-value added activities associated with the change impact. Finally, it is also argued that the application of Building Information Modeling could help in realizing the lean goal by providing object oriented, parametric, visual representation and collaboration tools as a communication medium.

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Knotworking In An Interior Décor Process

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These days, new buildings are being built at Aalborg University in Denmark, why interior décor processes are initiated. Planning the interior décor of Aalborg University is centralized at the Shared Service Center, where internal architects furnish the spaces and buy the selected furniture without consulting the end user (Teknisk Forvaltning, 2015).). But is it possible to make interior décor that fits the utilization of the building?
To improve the interior décor process and make the interior décor fit the utilization of the building, the initiated idea was to implement the different interested end users of the spaces to be furnished, why new methods were needed.

One method for integrating different actors in the same process at the same time is called Knotworking. In Knotworking 'knots' are pre-selected on the basis of the overall aspects of the specific project (Smith, 2010).). The pre-selected 'knots' determine which specific actors that have to be involved in the project for 'untying' the 'knots'. Knotworking has successfully been applied in different contexts such as the merge of public and university libraries in Finland in 2012 (Engeström et al., 2012) and the development of architectural building projects focusing on energy and cost calculations in 2013 (Kerosuo, Mäki, & Korpela, 2013).
A knotworking session lasting only one and a half day was performed to test if it was possible to adopt the principles of Knotworking in an interior décor process. For collecting data on the knotworking days, the following methods have been utilized: Participant observation, video records from 4 angles of the room, observation, notes and photo documentation. Document analysis and activity theory systems have subsequently been utilized to analyse the data.

At the knotworking session the pre-selected 'knots' were defined as the specific spaces to be furnished. To 'untie' the 'knots', the following actors were involved: The end-user being both the students, staff, cleaning staff, university caretaker, internal architects at Aalborg University and the furniture manufacturer. These actors had various interests in the specific spaces resulting in various reflections on the interior décor. The actors all gathered in the same room to solve the interior décor problems within the pre-selected spaces – the 'knots'. Knotworking as a method was applied to implement the actors in the process, while touchscreen and Oculus Rifts were utilized as tools to 'untie' the 'knots'. The Knotworking session resulted in a joint ownership of the interior décor and a mutual vocabulary

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concerning the interior décor. The presentation will describe how Knotworking were applied to the interior décor process, what happened before, under and after, and reflect upon if this method is applicable in future interior décor processes.

Keywords: Knotworking, Interior décor process, Public design process, Collaboration, Optimization, Joint ownership

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Combining Engineering And Social Science Concepts In The Analysis Of Lean Construction Practice

John A. Rooke *

Two Lean practices, the Last Planner System® and Visual Management will be analysed in terms of engineering and social science concepts respectively.

The engineering problem that Last Planner is designed to address is variability in construction project management. Against the conventional strategy of flexibility for addressing this, Ballard and Howell propose a strategy of production shielding, by building up a buffer of sound commitments. Process, resource and directive flows are mapped and short term commitment plans are formulated against quality criteria of: definition; soundness; size; sequence; learning. These plans must be approved by the last planner, usually a foreman, defined as the planner whose decisions results directly in production. Plan quality is measured using the Percentage Plan Complete measure.

When viewed from the perspective of the Last Planner System, construction projects can be seen to be a matter of achieving the necessary quality commitments from project participants. It is at this point that the engineering question gives way to a problem of managing human relationships. Drawing on the work of Searle and Flores, Macomber and Howell introduce Language Action theory to describe the linguistic activity necessary to achieve and maintain reliable commitments on projects. Searle has identified five types of illocutionary act: representative; directive; commissive; declarative; expressive. Building on these, Flores has further analysed the illocutionary activities necessary to induce, make, maintain and fulfil commitments.

Visual Management addresses the physical problem of facilitating communication. Grief has noted the existence of information fields, constituting the area from which a given piece of information can be immediately perceived. Galsworth has identified four types of so-called ‘visual tool’: indicators; signals; controls; guarantees. The presentation will demonstrate how Galsworth’s taxonomy of ‘tools’ can be mapped onto Searle’s taxonomy of illocutionary acts. It will be argued that these taxonomies are best regarded as an illocutionary grammar, thus integrating the analysis of key aspects of Last Planner and Visual Management under a single theoretical perspective.

The presentation will go on to explore the possibility that communication on construction projects (indeed, in organisations generally) can be comprehensively accounted for in terms of the physical (engineering) concepts of ‘flow’ and ‘field’ and the grammatical (social science) concept of the ‘illocutionary act’.

Keywords: Lean Construction; Last Planner; Visual Management; TFV; Language Action; Ordinary Language Philosophy; Information Flow; Visual Field; Illocutionary Acts

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Reducing And Eliminating Construction Defects Using Action Research (AR) In The Supply Chain

Martin Taggart *1
Lauri Koskela
John A. Rooke

The presentation is taken from ongoing PhD research, seeking the elimination and reduction of construction defects & rework in an SME main-contractor. Particularly, focusing on the ability of the supply chain to contribute in this endeavour, by problem solving and knowledge gathering to avoid future repetition. This question is considered within the problematic construction environment of the Republic of Ireland. Stakeholders in Ireland are currently emerging from a catastrophic economic crisis and populate an industry that is very fragmented, adversarial and largely SME in nature. This makes widespread diffusion of emerging vehicles for improvement, such as Lean and BIM very challenging. Adoption can however, provide competitive advantage, for those determined to overcome such barriers.

The presentation illustrates the development of the supply-chain ability to contribute to the generation of empirical problem solving solutions to defects that are often noted as being repetitive, from project-to-project and endemic in terms of the industry at large. The presentation demonstrates; (1) the extent of this problem solving ability, within the predominant Irish QA system, ISO9001. (2), supporting the ethos of the workshop, the presentation provides researcher insights about the practice and learning from using AR. This is an important contribution, as reportage of AR, as it is empirically applied to construction is still comparatively rare.

AR is unusual, in that its stated aim, is to intervene and positively change the status quo. Most other research approaches seek to better understand and describe the status quo, with any recommended changes as an additional option, following completion of the research. In contrast, AR seeks both to change and improve the status quo of a problematic situation as well as contributing to extending scientific knowledge about that situation. Much has been written in the literature about a supposed dichotomy between positivist and interpretivist research approaches in the social sciences. The literature generally places AR firmly in the interpretivist camp. However the researcher, will reflect on the pragmatic nature of AR, suggesting that elements of both can very happily cohabit within an empirical AR study.

In terms of results, field work examples are shown, which demonstrate that supply chain stakeholders have a very sophisticated understanding of the nature and causes of defects and have much to

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contribute to their avoidance. However, they are seldom asked to make any contribution in this area, or indeed contribute to the continuous improvement potential, portrayed as a key element of project ISO9001 organisational QA planning. AR is often criticised for being case based, thus difficult to generalise. The researcher argues strongly here; that, (1) knowledge from the example defect problems is readily generalizable; and, (2) the research process followed can also be generalised, once re-contextualised for other situations. The researcher concludes that AR has significant potential in future construction research, but also faces the possibility of substantial barriers to its practice.

Keywords: Action Research, Defects, Quality-Assurance, Rework, Supply-Chain

Enhancing Trust Through Performance Certainty

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Georgios Kapogiannis [*2]

In the construction industry, trust between parties is not always readily established. This research considers that the sharing of “accurate” performance data could enhance trust, collaboration and transparency between constructors and their clients. In particular the measurement of the production rate of concrete floor slabs in multi-storey construction could be investigated through the analysis of data transmitted over wireless networks. The data is generated from load and location sensors and once retrieved may be presented, interpreted and simulated in a BIM collaborative environment. This will permit a deeper understanding of construction production outputs, enhancing their contribution to the recording and forecasting of progress. Sharing of this information facilitates precision, transparency and accuracy in terms of progression monitoring, effectively building trust. This building of trust could be an efficient marketing tool, with potential economic ramifications. A literature review found that measurable performance data which can be recorded and analysed, interpreted and offered to stakeholders adds value. However, there is little published work on the use of sensors to harvest and transmit real-time data over wireless networks. In terms of research methods, they will be principally quantitative, with the primary research formed of data collection and analysis from field trials. Additional methods will include quantitative methods, including surveys and interviews to gain an insight into industry and academic opinion.

Key words: Trust, performance, transparency, accuracy, progress.

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Improvement Of Dimensional Tolerances In Construction: The Role Of Lean And BIM

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Mark Shelbourn [3]

All materials and elements in the construction industry have their own dimensions and their position on the drawings is specified. In reality, however, these elements and materials cannot be exactly dimensioned and positioned as they were designed. The accepted amount of this variation is the tolerance of the material or installed position of the material. Management of the tolerances aims to utilise various tools and methods in order to (1) attain the highest conceivable quality and performance to deliver the maximum value and to (2) avoid any interruption in flow due to tolerance-related problems with regard to actual process capability to minimise the waste. However, tolerances in construction are not neither adequately accommodated in design nor controlled during production. Designers often specify point solutions and it is presumed that operatives on site will adjust the tolerances based on common practices and design codes. Hence, tolerance management in construction is almost an unattended area and still relies on expert knowledge or rules of thumb.

Tolerance failures in construction during both manufacturing and positioning are considered as one of the root causes of defects. With regards to the concept of chains of waste, tolerance-related problems not only cause defects but also create a chain of wastes. They have costly impacts indirectly due to deterioration in quality of related activities and longer project lead time, and directly due to cost of rework. Moreover, poor management of tolerances results in incompatibility of tolerances in the end product with standards and contractual agreements. It also influences the customer satisfaction and is often at the centre of disputes between the consumer, contractor, supply chain, and client.

Defects and following chains of waste caused by tolerance failures have remained in the industry and are repeated continually even after the development of new technologies. This view implies that their occurrence are seldom due to absence of contemporary technology or the state of the art. However, it is surprising that most of the literature in this field continues to concentrate on technological solutions without considering the need for an effective management system. Continuous improvement and learning from experience are the core of this management system to reduce tolerance problems and remove their causes.

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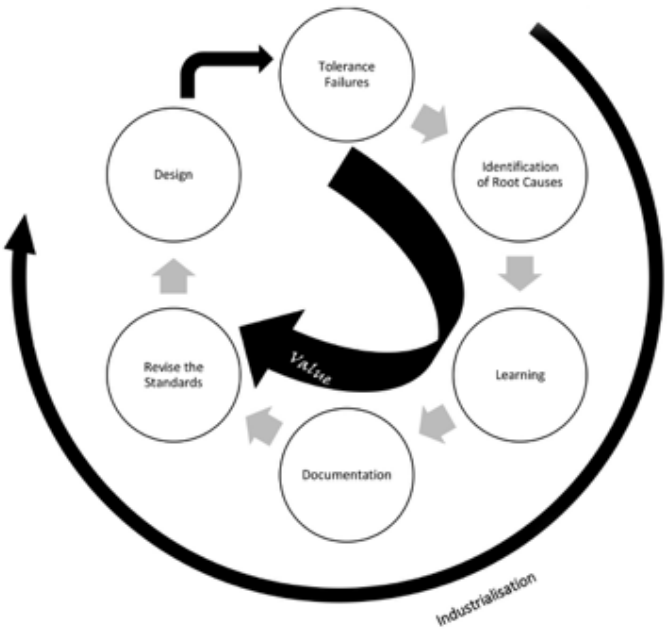
The need for buildings with higher quality and reaching the construction perfection by minimising the waste and maximising the value through applying Lean principles and techniques is growing. For example, Poka Yoke (mistake proofing) mechanism is a Lean tool that can play an important role in improving the construction tolerances during the manufacturing and positioning. Moreover, recent developed technologies, particularly Building Information Modelling (BIM) along with 3D imaging technologies such as laser scanner, have provided the potential to improve the dimensional quality control of construction projects through advanced tolerance analysis and management capabilities. These all urges more researches on better tolerance management in construction.

Lean Tolerance Management Cycle is suggested in this stage of the research based on the configuration of existing research elements identified from literature review and two factory visits. This cycle is envisaged to enable the industry to deploy all the required aforementioned key parameter for an effective management of tolerances. In other words, this cycle enables the industry to have better compliance with dimensional tolerances from managerial viewpoint which means: 1) higher quality, 2) lower cost, and 3) shorter lead time.

Keywords: Tolerance Management, Lean, BIM



Implementing Lean Practices In Engineer-To-Order Prefabricated Building Systems

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The industrialization of production processes is one of the ways it is possible to achieve better quality, safety and productivity. In the construction industry, the use of industrialized components has evolved into the use of industrialized building systems, in which engineered-to-order (ETO) products became an important competitive advantage. In this kind of production system the customer order is located at the design stage. Different production technologies affect production planning and control systems, and will often require a change in the management assumptions. Most of ETO companies disregard the fact that the participation of the client since the conception of the project will bring a higher level of uncertainty to the product development.

From a lean perspective, the management-as-organizing approach is seen as a way to avoid traditional and ineffective project management approaches. In an ETO production system, the management approach needs to rely on the need to learn from what happens during daily production processes, and on plans that are able to absorb changes on project demands or clients' needs. The aim of this research was to develop an integrated planning and control model for ETO prefabricated building systems, integrating design, manufacturing and site assembly. The research was part of a partnership with a steel fabricator company that was interested in improving its production planning system. The implementation adopted some strategies from the action-research, so that the solutions needed to be collectively constructed between the researcher and the practitioners, in order to have an effective use in the organization.

The discussion will focus on the implementation process, and the learning cycles it generated. This included a series of tools and management practices developed in order to understand and better control the work-in-progress, and to use up-to-date information about the construction sites. In this investigation, BIM was not addressed. However, some further studies, in the same company, highlighted the use of this technology for decreasing the complexity of logistics operations on the plant and on the construction sites. More recently, a study focused on how it could be incorporated to benefit the whole project life cycle.

Keywords: Engineer-to-order; management-as-organizing; action-research

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