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ORGANIZING IT IN CONSTRUCTION: PRESENT STATE AND FUTURE CHALLENGES IN SWEDEN

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SUMMARY: *The expectations on IT-tools for improved business benefits are still high in Sweden. At the same time there is limited research on IT-tools in the organizational context and thus limited knowledge on the present state of IT in the Swedish construction sector. This article presents recent findings from a combined quantitative and qualitative study on IT, organization and communication in the Swedish construction sector. The purpose is to develop knowledge and understanding of the current situation in Sweden and to elaborate on future challenges. The findings show that the use of IT-tools is widely spread but that the knowledge and understanding of how to benefit from using IT-tools is less developed. The findings also indicate that the use of IT-tools in the production phase needs to be more interactive and proactive. This knowledge is of importance in order to allow informed decision-making in how to integrate IT-tools in the organizing and communication processes in construction projects, as well as how to do investments and develop practices, education and regulations. The conclusion is that project practitioners still search for the benefits of using IT-tools within construction projects.*

KEYWORDS: *Project communication, Project management, IT, BIM, Construction projects*

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1. INTRODUCTION

The construction industry is characterised by highly interdisciplinary, fragmented and temporary project organizations, process discontinuities and unique projects. These characteristics make construction project performance highly dependent on efficient communication, collaboration and successful integration of a multitude of competences (Dainty et al, 2006, Emmitt, 2010, Emmitt and Gorse 2003, 2007, Slaughter, 1998, Van Fenema and Räisänen, 2005, Winch, 2010). Despite this, communication, collaboration and competence integration are areas not getting enough strategic attention from practice or theory (Dainty et al, 2006, Wikforss and Löfgren, 2007). In fact, in many of the efforts in the construction industry today, communication, collaboration and competence integration have been reduced to a secondary issue in favour of rationalizing the physical design and production processes, as if effective communication practices and technologies are taken for granted (Wikforss and Löfgren, 2007).

One area in which the construction industry has paid attention and invested major resources during the last decades is IT-tools, in particular Building Information Model (BIM) tools, to support the work of construction management organizations (Amor et al, 2002, Becerik-Gerber and Rice, 2010, Hartmann et al, 2012, Jacobsson and Linderoth, 2010, 2012, Linderoth and Jacobsson, 2008, Samuelson, 2002, 2008, Wikforss and Löfgren, 2007). Building Information Modeling (BIM) can be understood as a digital representation of the building process to facilitate exchange and interoperability of information in digital format (Eastman et al, 2008) which promises to improve the communication and collaboration between construction project actors through high interoperability of data (Hardin, 2009). However, the introduction and implementation of IT-tools in the construction industry to support the work of construction management teams is still a problematic issue (Hartmann et al, 2012) and this development is still showing limited effects on business benefits even if it is claimed to have a recognized potential (Wikforss and Löfgren, 2007). There has also been a rapid development of hardware, software and concepts that has as opened up for new and innovative solutions, for example in the area of sustainable construction (Hallberg and Tarandi, 2011).

When communication, collaboration and integration is discussed and managed in construction, it usually comprises of technical aspects of information handling, such as modeling, classification and standardisation and there is a lack of studies on IT-tools in construction projects from an organizational perspective, i.e. that study IT-tools in the organizational context (Jacobson and Linderoth, 2012, Wikforss and Löfgren, 2007). There are also only a few studies examining user's general perceptions of the impact of the IT-tools they are using and the implications for construction project management practice (Jacobsson and Linderoth, 2012).

1.1. Study approach and purpose

A widely acknowledged attempt to evaluate the use of IT-tools in construction is the "IT-Barometer" instrument (Samuelson, 2002, 2008, 2010), a survey that has been used (more or less modified) in at least 11 countries in the last decade and hence provides both longitudinal and international comparisons (Davies, 2010). This paper, which presents findings from a recent combined qualitative and quantitative study in the Swedish construction sector, is based on selected results from the fourth IT Barometer" performed in Sweden during 2011 and selected results from a qualitative case study of a contemporary collaborative construction project in Sweden.

The purpose of this paper is to situate the use of IT-tools in contemporary Swedish construction project practice and analyse the use of IT-tools in the organizational context. The aim is to develop knowledge and understanding of the current situation in Sweden and elaborate on future challenges. Up to date information and empirically based knowledge is of importance in order to allow informed decision-making in how to integrate IT-tools in the organizing and communication processes in construction projects, as well as how to do investments and develop practices, education and regulations. This knowledge is needed by industry, industry related networks, regulatory bodies and by academia pursuing research and university education for example in Construction Project Management. This knowledge is also of use for future international comparative research.

This paper is structured as follows: It starts with a background into previous research and findings within communication and IT-tools in construction. After this review, the paper then describes the research methodology used. The paper then continues with a section of selected results from the survey including longitudinal and international comparisons and after that follows a presentation of the case study. We then triangulate the quantitative and qualitative findings to gain situated insights on IT-tools in the organizational context. The paper ends with a concluding discussion where present state and future challenges in the Swedish construction sector are presented.

2. COMMUNICATION AND IT IN CONSTRUCTION

Communication in construction is a broad area that includes for example oral, written, formal, informal and digital communication and it considers the improvement of organizational processes and work procedures, as well as the sharing of information and knowledge between different professionals in projects and industries (Dainty et al, 2006, Emmitt and Gorse, 2003, 2007, Wikforss and Löfgren, 2007). Both the design phase and the production phase of construction projects share a need for rapid access to information and communication in real time and IT-tools are introduced and implemented with the purpose of improving communication, control and coordination processes, and to break down barriers between professionals (Wikforss and Löfgren, 2007). This implementation requires not only technical solutions but also changes in work tasks and project participants skills (Froese, 2010). It also requires knowledge and understanding of how to benefit from using IT-tools (Jacobsson and Linderoth, 2012). After all, construction project practitioners have to understand how to work with IT-tools to support specific work processes (Hartmann and Levitt, 2010).

Communication in construction projects is based on both the formal and controlled exchange of documents and the informal and interactive problem solving (Wikforss and Löfgren, 2007). Thus, IT-tools play an important role for communication in construction. However, the temporary, multidisciplinary, creative and reactive project environment, constantly handling problem situations, results in communication action patterns that are dynamic, spontaneous and informal, why communication cannot be viewed as a whole and it is impossible to control through formal IT-tools (Dainty et al, 2006). Although IT provides tools to enable us to keep track of the entire stock of information, it can also give rise to the information anarchy prevailing in certain projects.

The expectations on improved project performance and increased business benefits by introducing and implementing IT-tools are still high. However, the high expectations have not yet been met (Andresen, 2001, Hartmann et al, 2012, Wikforss and Löfgren, 2007). The reasons are many: for example a strong need for "breaking down traditional boundaries and overcoming process discontinuities" and to make room for project practices where actors and processes are more integrated (Dainty et al, 2006, p. 223). Although communication is known to be of vital importance for the collaboration and integration of competences and processes, and for the development, planning, design and production phases of construction projects, research show that there is an ineffective use of IT-tools, for example concerning intra- and inter- organizational coordination (Adriaanse and Voordijk, 2005, Becerik-Gerber and Rice, 2010, Jorgenson et al, 2003, Linderoth and Jacobsson, 2008, Jacobsson and Linderoth 2010, 2012, Molnár et al, 2007, Wikforss and Löfgren, 2007).

Research on web based project networks (Löfgren, 2008, Wikforss and Löfgren, 2007) shows that visions and intended purposes do not comply with how such systems are perceived and used in project practice. Users tend to use the networks as little as possible, and if they used them, it was primarily as a pool for storing documents that had already been approved. In other words, project networks were not used as active, dynamic communication and interaction networks but as passive, static archives and did not support the intensive communication and interaction needed for the actual problem-solving and decision-making processes. Instead, this vital communication and interaction was conducted through other channels, and information was more likely to be distributed in real time (ibid.).

Research on IT-tools in construction (Linderoth and Jacobsson, 2008, Jacobsson and Linderoth, 2010, 2012, Molnár et al, 2007) confirms that large building and construction companies use IT-tools to a major extent in order to co-ordinate and manage their internal information flows. However, one crucial dimension of IT-tools is the top management´s ability to monitor and control projects. Accordingly, IT-tools such as planning, estimating costs and constructing project budgets, following up costs and consumption of resources can be seen as means for the permanent organization to monitor and control the projects (Linderoth and Jacobsson, 2008). At the same time, IT-tools supporting the production process are rare. This could partly be explained by a lack of project cost follow up, and consequently there is limited input of relevant data for evaluation of executed projects and for calculating new projects. Hence there is a lack of sharing knowledge and experience. In practice, construction costs are often expensed as 'various' costs, making thorough follow up and correct evaluations difficult. This is also a background for the lack of IT-tools in this area.

Evaluating the benefits of the use of IT-tool in the construction industry in relation to project performance, and in particular productivity, is not easy (Sulankivi, 2004). There is an apparent contradiction, known as the "productivity paradox", between the remarkable advances in computer power and the slow growth of productivity (Brynjolfsson, 1993). According to Brynjolfsson (1993) and Brynjolfsson and Yang (1996) who have studied the productivity paradox, there are four potential factors why research have not been able to show increase in productivity based on increased IT use; mismeasurement, redistribution, time lags and mismanagement.

There is also research that shows positive effects on implementing and using IT-tools in construction. Several case studies (Khanzode et al, 2008, Eastman et al, 2008, Khemlani, 2004, Kymmell, 2008, Gerber, 2007, Kam et al, 2003) shows examples of BIM contributing to improved project performance by making the building process more efficient and effective (Becerik-Gerber and Rice, 2010). According to these case studies BIM provides the following benefits: accurate and consistent drawing sets, early collaboration, synchronized design and construction planning, clash detection, model-driven fabrication and greater use of prefabricated components, support of lean construction techniques, and streamlined supply chain management (ibid). However, as Becerik-Gerber and Rice (2010) add, these cases do not provide a complete and comprehensive list of benefits and associated efforts. A majority of what has been written about BIM aims at convincing others on the possible benefits of using IT-tools, rather than being in-depth reflective discussions on the organizational prerequisites needed for these benefits to actually be fulfilled. In other words, the earnings are presented, but not the associated efforts.

3. METHOD

This study has been performed in cooperation with the Swedish Construction Federation and the method used is triangulation (Denzin, 2006), including both quantitative and qualitative approaches. Triangulation refers to the application and combination of several research methodologies in the study of the same phenomenon and it is a useful technique that facilitates validation of empirical material through cross verification from more than two sources.

3.1. Quantitative study

"IT-Barometer" surveys in the Swedish construction sector has been performed in 1998, 2002 and 2007 and are presented in Samuelson (2002, 2008) and critically reflected upon in Samuelson (2010). The IT-Barometer project originally started in 1997 as an initiative of the Swedish R&D- program 'IT Bygg och Fastighet 2002'. The aim of the project was to create a measuring tool for the use of IT in the construction and facility management sector, and to perform measurements at intervals of some years. Three criteria were set up for the survey tool. It should:

- Be repeatable and comparable over time.
- Be comparable between countries.
- Cover all categories of companies in the construction industry, which was defined as architects, technical consultants, contractors, facility managers and the materials industry.

During the years since the first survey, there has been a major development of the use of IT in the construction industry in particular by increased access to the Internet and different web services which have changed the ways of communicating project specific information. There has also been a rapid software development regarding BIM and an increased knowledge and awareness of BIM during this last decade.

This IT-Barometer survey was performed in 2011 in accordance with the three criteria (above) except for minor modifications in order to meet industry, technological and practical changes; for example the use of portable devices. The trends and developments of the use of computers, hard- and software as well as plans and strategies for the use of IT, is still observable and serves as foundation for the triangulation with the qualitative results. A statistically chosen selection of 1507 workplaces from the construction industry in Sweden, divided into architects, engineers, contractors, facility managers and the material industry, has been asked to answer a web-based questionnaire concerning their use of IT. The selection was based on Statistics Sweden (source: www.scb.se) national register on companies and workplaces.

A workplace is defined as each address where a company carries out activities. This approach makes the answers more balanced, since larger companies with different activities may have difficulties in providing answers for the whole company. The workplaces are also divided into four groups of sizes with respect to number of employees: 1-9, 10-49, 50-199 and 200-. The selection was made as a stratified free random selection, where stratified stands for the division into the categories and sizes above. A free random selection was then made for each stratum. The IT-Barometer aims to describe the situation in the construction industry as a whole, why it is important to consider the size of the companies. The answers received have been weighted with respect to number of employees in each workplace, to make sure that every answer represents its part of the industry. This method is well described in (Samuelson, 2002).

The inquiries were sent by postal to the IT-responsible at each selected workplace. A postal reminder, and reminders by phone to major workplaces was also used as the major workplaces affect the total use of IT in a more extensive way. A total of 294 workplaces answered the questionnaire, which is equal to a response rate of 20 %. The response rate is similar to other studies of this type (for example Davies, 2010) and does not provide sufficient data to provide statistically significant results. Still, the survey presents observable development trends and the survey, in combination with the qualitative case-study results, provides an important knowledge and awareness of the present use of IT, strategies, effects and future challenges. The analysis of the survey was done in accordance with the number of employed at each workplace and thus makes it possible to evaluate the total use of IT in the construction sector.

3.2. Qualitative study

The case study follows a longitudinal case study approach (Yin, 2009) to situate project communication and in particular IT in contemporary construction project practice and contribute to project theory and construction project management practice (Eisenhardt, 1989). Interpretative case studies are a recommended method when the aim is to try to understand an emerging process of organizational transformation through the use of IT (compare with Linderoth and Jacobsson, 2008). The case project is a contemporary collaborative construction project executed in Sweden. When finished, after a duration of 4,5 years, and a project budget of approximately 450 Million SEK, the building will be more than 13 000 square meters. The case project aims at the following collaborative characteristics: a mutual goal, an open economy and relations built on mutual trust (compare with Nyström 2005, 2007, Kadefors, 2004). Included in this paper are tentative findings since the production phase is currently still going on.

A qualitative and interpretative approach is practiced (Silverman, 2001, 2010) including interviews with main stakeholders, participant observations, informal meetings, regular dialogs along the project process, internal and external documents such as project time plans, organizational chart and collaborative project goal statements. The 19 interviews with project actors covers both the design and production phase and were based on a semi structured interview guide with open-ended questions. All interviews were transcribed and analysed. The analysis followed an interpretative process was in order to gain a comprehensive – holistic – understanding of the organizational setting: the building project practice including the use of IT in the design and production phase. The interpretation was focusing on patterns of actions (Czarniawska, 2004) and representative extracts were selected to construct the narratives.

4. SELECTED RESULTS FROM THE 2011-YEAR SWEDISH IT-BAROMETER

The following section presents the results of the survey on a general level for the Swedish construction sector and on the use of IT-tools. Then follows the major changes in the use of IT-tools and the effects and strategies in relation to IT-tools. The results of the IT Barometer for 2011 have been presented in a report in Swedish (Samuelson, 2012).

4.1. General IT-level

The amount of workplaces that have computers and access to the Internet is more than 99 % (which was the case already in 2007). Thus, the technical infrastructure opportunities for effective communication and information exchange in the construction sector are good. The development of wireless solutions and mobile Internet has been positive for the construction sector because of its high level of temporary and remote workplaces and it has provided the sector with increased flexibility and accessibility. Project stakeholders and participants are able to get access to project specific shared information, independent of their geographical position. In an international comparison (for example Davies, 2010), the Swedish construction sector has higher level of mobile Internet access and mobile phones among employees, a situation that could be explained by a general high level of mobile Internet and mobile phone in Swedish society.

4.2. General use of IT-tools

The survey includes questions on which special activities, linked to the core business, that are performed using IT and to what extent information is exchanged by using IT-tools. There are also questions on Building Information Modeling (BIM), Electronic Document Management (EDM) and Electronic Data Interchange (EDI), which are three major areas of importance for collaboration and communication between actors and stakeholders that can support both single users and interconnected processes.

The survey results show that IT-tools are used in slightly different ways depending on the user, whether it is an architect, engineer, contractor, facility manager or from the material industry, however it is primarily used for the design process and for administrative functions, rather than as a support for the production process. However, users use IT-tools differently: for example, contractors use EDM and BIM less than both consultants and architects. The fact that actors use BIM at different levels has consequences on the possibility of achieving effective project communication and make use of IT-investments.

The previous studies from 2007 (Samuelson, 2008) showed similar results and they are in line with the results in international comparisons (Davies, 2010). There is also IT-support available for construction process core activities and processes, however IT-tools have not yet replaced all traditional manual work procedures that could have been improved by IT-support, and when IT-tools are used it take place in the same processes, and in the same work procedures as before. IT-tools are thus primarily used to make ordinary work, routines and processes faster and more efficient.

4.3. Major changes in the use of IT-tools

A major change in the use of IT-tools can be observed among architects in relation to planning. The architects are currently at the highest level, compared to engineers and contractors. This can be the result of the strong increase of awareness and use of BIM among architects, which can be used as a base for planning in cooperation with the actors in the production phase. A bit surprising is the fact that there is still a relatively low use of IT-tools in relation to time- and resource planning among contractors (40 %), despite their major need for planning activities. One explanation of the lower use of IT-tools in general by the contractors could be their relatively high level of craftsmanship, which is not easy to support with IT-tools. But planning and cost control are business-critical issues for contractors and there are lot of applications on the market.

Another major change since 2007 is the increase in the contractor's use of IT-tools in relation to supply chain/purchasing, now 65 % (45 % in 2007). IT-tools for supply and purchasing are a good support in a process where major amounts of supply from different suppliers are to be controlled. Also, the contractor's use of IT-tools for digital information exchange have had a rapid increase since 2007, now 75 % (35 % in 2007) probably because of increased use of mobile Internet at the construction sites. Another explanation is that web-based project networks have been established as common work method and that these networks have been integrated into the organizations project management systems. This has contributed to reducing the 'gap' that existed between the actors in the construction process when design and production was handling information differently.

The use of BIM has had a rapid increased during the second part of the last decade, a development supported by organizations such as buildingSMART and OpenBIM. Hand made drawings are rapidly decreasing and even early sketching of spaces and volumes are more often done with the use of computers. However, the fact that BIM is used more often does not automatically mean that all of its functionally is used. The survey shows that there are today only a few designers who are only working in 2D and that the mainstream designers are working in both 2D and 3D (figure 1). The study also shows the importance of geometry and that most designers have not yet taken the step to use the models for other information than geometric data. The general observation is that there is an increase in the general awareness and use of BIM and that there is an increase of experts in BIM at the companies within the construction sector. However, in total, they still represent a minor part: only one out of ten of the respondents' claims that they work with other object-based information besides geometric data.

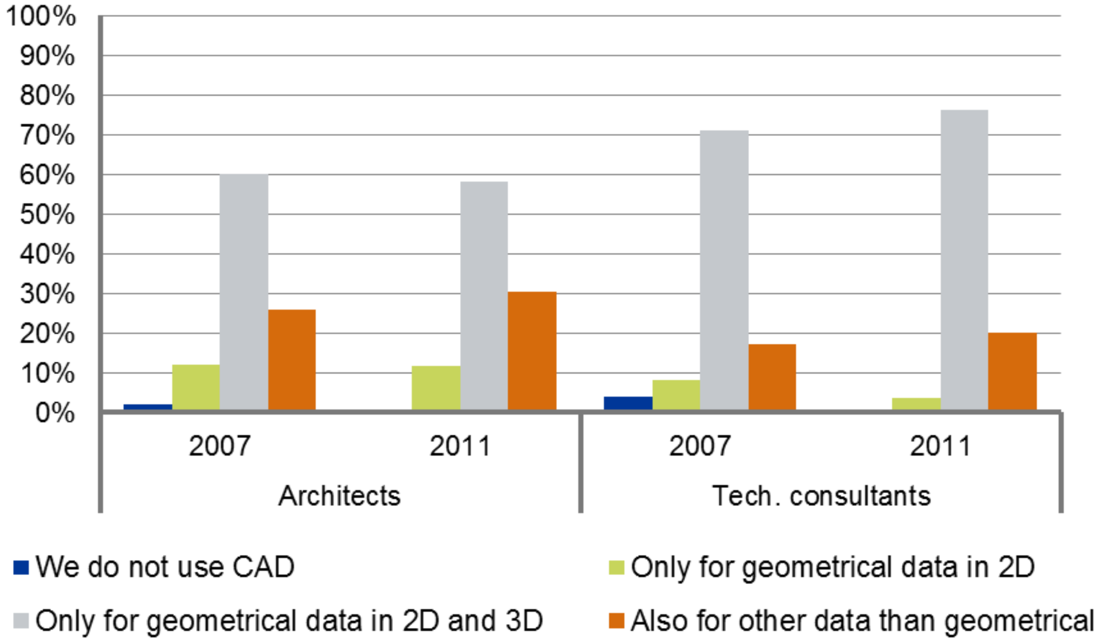

FIG. 1: Proportion of use of CAD for different kinds of data.

Whether an individual or a company is investing in IT-tools or not is a matter of recognizing the benefits and positive effects. However, what complicates this transition process is the fact that benefits are often not possible to recognize or evaluate until after some time, or later in process. It is also not unusually that an effort made by one actor regarding BIM, creates a benefit later in the process for another actor. This means that there is a risk of sub optimisation unless the actor that has to make the effort does not get other incentives.

EDM use is another use of IT-tools that has increased since 2007 (figure 2). Despite the increase in modeling tools, most of the information is still exchanged via documents. The amounts of documents and versions that are digitally exchanged have increased since 2007. Also the frequency has increased, probably because digital information exchange is more smooth and easy. This in turn demands safe, systemized and structured ways of managing and storing the documents, both from the creator and user perspective. The level of EDM use is 90 % among the architects and 50 % among the sector in total. Thus, there is a 'gap' between the different actors awareness and use with the risk of communication problems such as misunderstandings and that wrong information is used in the projects.

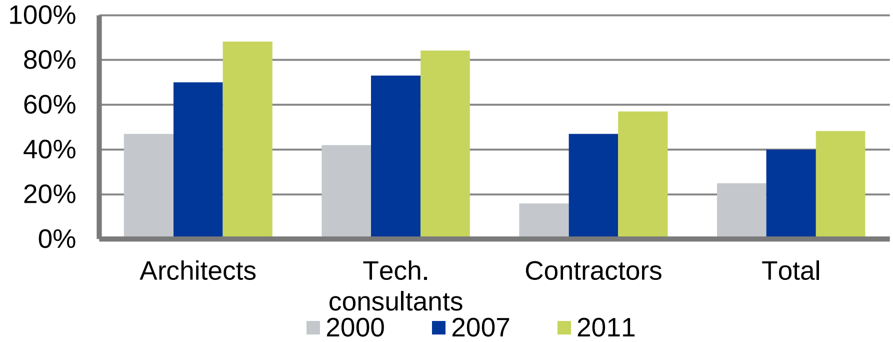

FIG. 2: Proportion of employees in workplaces where EDM is used in projects.

Most information exchange is still done by using documents and not by using digital models. This is a fact worth mentioning. The high expectations expressed concerning BIM over the years, for example when it comes to enable information exchange of entire information models or model data to handle risk, have thus not yet been met. One explanation is that the lack of complete and reliable standards for design and use of construction information models is a barrier for this development to take place. There are also still legal issues determining the use of the models left to be solved. In addition, there is also a lack of business models, which would make all the actors benefit from a shift to construction processes actually using the technology available to its full extent.

4.4. Effects and strategies in relation to IT-tools

The respondents have been asked to estimate how investments in IT-tools have changed during the last two years and how they expect IT-investments to change during the following two years. The results show that the previous investments that were on a relatively high level are expected to slightly decrease, i.e. the results show a stabilizing trend. The respondents were also asked to prioritize between different motives for IT-strategies. It was perceived that it was most important to make “the technical” and “the administrative” work more efficient. This response can be found also in previous surveys. The development of new products/business models was perceived to be of least importance. This response is also the same as in previous surveys.

Thus, there is a clear ambition to do present activities more efficient – to do what’s already done in a better and faster way – but no clear ambitions to use IT in order to develop the business or to do things in a new way. A change since 2007 is that “demands from new employees” have become a more important motive than before, something that could be explained by the fact that new (younger) employees that have met the new IT tools during their university studies and thus realized their possibilities.

4.5. Summary

IT-tools have primarily been used to support intra-organizational processes such as planning and follow up. However, with increasing globalisation and developed collaboration (strategic alliances, collaboration, partnering etc.) the use of IT-tools to increase inter-organizational communication and information exchange is developing, for example within BIM and EDM. This shift, from a narrow internal perspective on communication, to also include external and collaborative perspectives on communication contributes to changes in work, routines and processes.

One major challenge, and a paradox, is the use of IT-tools for innovation and for developing the business. Companies that have invested in IT-tools do not always reach the desired competitive advantages because they are still acting within the same process as before, a process that is primarily focusing on repetitiveness and standardisation, rather than innovation and business development. It is also a process that the companies share with all other project actors, which is not easily changed by one single actor. Consequently, to reach major effects of IT-investments, companies need to co-operate and develop in the same direction at the same time.

5. IT-TOOLS IN A CONTEMPORARY SWEDISH CONSTRUCTION PROJECT

The case project is a project starting off with strong collaborative ambitions and strong intentions of using IT-tools to support communication, collaboration and project performance. Also, the expectations on benefits from using IT-tools were high, for example on improved efficiency. The case project will first be presented on a general level and then with focus on the use of IT-tools from an organizational perspective. Additional findings from the case study, with focus on project communication and boundary actions are presented in Karrbom Gustavsson and Gohary (2012).

5.1. The case project

The case project is currently being executed in Sweden. The duration is estimated to 4.5 years and the project budget is approximately 450 million SEK. The procurement form is a so-called “General Construction in collaboration” where the operational responsibility is shared between the property owner/client (planning and design works) and the general contractor (production works) and where there is an extensive overlap in order to facilitate both inter- and intra-organizational collaboration and integration by increasing project communication and bringing in previous experience and knowledge into the process.

The collaborative project approach applied in this case, with mutual goals, open economy and relationship based on trust, is a relatively new organizational setup. Most but not all project actors have worked with a similar collaborative setup previously. The purpose of the collaboration project is, according to the interviews, “to jointly work for the projects best” and “always put the project first”. This project is also said to be “the most collaborative project” they have ever taken part in and it is the project “that has taken collaboration most serious”. However, from the overall and legal perspective following the general construction procurement form, the owner is still overall responsible for the whole construction project process, from initiation to handing over.

A mutual collaborative goal agreement was developed in the early stages and signed by all main stakeholders to establish commitment among the actors. To facilitate continuous commitment and improvements, the agreement has been followed up by surveys and regular discussions at regular collaboration workshop meetings. There was also a goal price developed in order for the main stakeholders to mutually gain economically from keeping up an effective and productive project process.

The case project specific characteristics are a complex and innovative architecture that demands innovative solutions concerning construction, communication, material, logistics and installation. The site is narrow, which put pressure on organizing for example site offices, site works, deliveries and logistics, and there are also several strong project stakeholders involved, all anxious about this being a successful project that meets their high spoken and unspoken expectations. There are also several different opinions on the best way to improve the construction process and several company specific management and quality systems interacting in the project.

5.2. Communication actions

There were several actions taken to support communication, on a formal and informal level during both design phase and production phase. There was a joint project office used by owner, general contractor and some of the consultants during design. Thus, there was a sharing of social space. This sharing of spaces was also accomplished during production, when two of the owner’s representatives were located in the site office together with the general contractor and some of the sub contractors. The sharing of spaces was perceived as positive and contributing to “creating a positive atmosphere”. There was also focus groups developed with a mix of professional specialists to work on specific challenging and innovative tasks, for example the façade, and there was an approach established during design to be open for changing operational responsibilities when needed in order to always put the project best first.

A commonly used web-based project network was used to integrate all project actors. It was mostly used for storing documents like meeting memos and drawings, and for storing the model. According to the project actors, the network was not used as a tool for active interaction at all, “we use it in case we have to go back to a document and check”. There were also various combinations of regular meetings in large and smaller groups on different levels and with different purposes. The meetings changed during the process depending on the needs, perceived usefulness and relevance and in accordance with traditional construction praxis.

It was required that all design works should be done in object-based 3D-modeling and all planners (architects, structural engineers, technical consultants etc.) were following this and created their respective model (i.e. the A, K, E, V etc., model) in their respective software. For some this was more challenging than for others. Some of the planners were using new software and they had to learn the software at the same time as they performed the actual work. Object-based 3D-modeling was familiar to most actors, however at different levels; there was a span from (almost) novels to those who were experts. The purpose of using object-based 3D-modeling varied among the actors:

“To communicate architecture is really difficult. Pictures and models is what we have got to use.” (Architect Project Manager)

“The information in 3D is for co-ordination with the others and for visualizing our installations for everyone.” (Design Engineer Project Manager)

”We need the 3D-model because we want to twist and turn the model to see how it really looks”. (Design Engineer Project Manager)

"We can get quantities from the 3D-model." *(Contractor Project Manager)*

"It is used for site work co-ordination" (Contractor Site Manager)

There was a need for additional necessary IT-skills and the specific software to integrate separate models during the design phase. Therefor, the owner contracted an external expert on BIM who had the necessary skills and software for integrating the separate models (A, K, E, V etc.) into one model. The expert also facilitated planning meetings and gave support to the planners if they needed assistance. The external expert was described as a "guide for support" and as someone the project team members could turn to when having questions or problems. The external expert was also described as "the expert who integrates the models and brings out the facts that are needed: the clashes". This role, as BIM-expert, is rather new and has not yet been established: the expert is neither a project manager nor a structural engineer and has not the answers to all technical and organizational questions raised during the process.

The owner's initial intentions were to implement and use object-based 3D-modeling to support project communication, visualisation and co-ordination. The aim was to gain a better overall understanding of the building and its unique design, structure, installations and layout. The intentions were to use the model for quantifying material and supply, to do energy and acoustics calculations and simulations, clash control and visualisation. The aim was also that the same model would be used in design and production. The actual use of the model during design was however mainly clash-detection and visualisation, "in order to try to understand this unique building".

When going from design to production, the responsibility for the model was handed over from the owner to the general contractor. The general contractor´s initial ideas of creating and using a specific "visual room" where all project specific information would be visually organized and where most project related meetings would take place, were however changed during the early stage of the production process when it turned out that the room chosen was not suitable. The major amount of meetings that were held in the site office occupied the room too much limiting the informal and on-demand driven access to the visual project specific information.

Consequently, all visual information (time plans, logistic plans, drawings, to-do-lists etc.) was moved to the corridor, renamed "the visual street". In addition, a smart projector was purchased and installed in the room for supporting co-ordination and visualisation during meetings. There was also a monitor installed in the "drawing room" occasionally used to display selected sections of the model while going trough the drawings.

In production, the model was used mainly for quantifying minor parts of the material and supply. There were additional manual quantifying performed to insure the quality of the work. The model was also used for co-ordinating the workforces on the narrow site, "to see who works where". A routine that was established during production included that a paper copy of each floor was extracted from the model and by using a smart projector during the meetings, the contractors could mark with their respective colour where they currently were working.

In retrospect – the project is currently in the production phase – the 3D-model created during the design phase did not come to serve as many functions as was initially planned, neither in the design phase nor in the production phase. Instead, it came to be mostly used for co-ordination, visualization, clash control, and in a minor scale also for quantifying materials and supply. The external expert on BIM was not used during the production phase, except for occasionally updating the model when there were changes made in one of the separate models. By using the external expert "we do not need to learn this or buy the software".

5.3. Summary

The case project represents a multi-functional, multi-organizational and multi-communicational challenge for all actors involved. The communication strategies used included implementation of IT-tools, physical co-location, regular meetings and collaboration workshops. Also, there was an external expert contracted to support the actors. Thus, necessary competences were contracted, rather than developed and there were no formal strategy for learning processes on how to benefit from using IT-tools.

6. ORGANIZING IT IN CONSTRUCTION: DISCUSSING PRESENT STATE AND FUTURE CHALLENGES IN SWEDEN

Based on the findings from the two studies, the survey and the case study, it is apparent that IT-tools are widely spread within the Swedish construction industry: most actors have computers and mobile access to the Internet. This is the case also in other countries (Davies, 2010). The use of IT-tools is however varying between design phase and production phase. In production IT-tools are mostly used for administrative purposes: for making sense of the planned building, and for co-ordinating the actual on-site works, i.e. to prevent things from going wrong. Thus, IT-tools in production create reactive communicative actions such as to save and/or to display what has already been decided upon, i.e. to confirm and control. The design phase, on the other hand, is highly IT-supported. In the early stages IT-tools are used for 3D-schetches, then for the design of system documents and building permits, and finally for specifications and detailed design. The IT-tools used during design work create proactive communicative actions where the design is gradually developed in the communication between the specialists in what could be understood as an explorative and iterative process where ideas are tested against each other.

Design is about predicting the future use of the idea and also to make it buildable. The actor’s competence represents a unique combination of theoretic knowledge, practical knowledge and tacit knowledge, a competence-mix that present IT-tools cannot match. One problem is that current IT-tools and current IT-use do not support proactive, interactive, exploratory and iterative collaborative work processes. Hence, in their communicative problem solving practice, the actors combine several manual and technical methods. This is one explanation why the high expectations on BIM, as a universal problem solving solution for improved performance are not – and cannot – be fulfilled. The actors choose to use IT-tools in some situations – when they see and make sense of the use of it – and choose not to in other situations.

One conclusion is that IT-tools still search for their use and their benefits within construction in Sweden. Consequently, it is of importance to raise the question if the planned use of IT-tools really matches the needs, or if the full potential of using IT-tools lies in the organizing of design and production and in the skill of the practitioners (compare with Froese, 2010, Hartmann et al, 2012). One answer to the question would be to align the IT-tool with the construction management methods (Hartmann et al, 2012). Hartmann et al (2012) argues for the possibility to implement BIM based tools in the construction organization in a “technology pull” manner. The argument is based on the need for in depth understanding of the underlying project methods that guide the operation of a project team and by aligning the existing functionality of BIM based tools with these methods (ibid.).

The use of IT-tools for proactive and innovative work in order to challenge existing practices and create new business opportunities is not common. One reason for this could be a lack of knowledge on how to actually make sense of how to benefit from using IT. There is also a lack of knowledge and focus on how to organize IT, i.e. where, when, why and how to use IT, for example in relation to construction project management methods and models (compare with Hartmann et al 2012). The findings from this study show that there is an increasing gap between those who are experts (i.e. who know both how to use IT-tools and benefit from using IT-tools) and others. The fact that an external BIM-expert is contracted shows that it is not common knowledge how to integrate IT-use in the day-to-day organizing activities and how this integration could be of use for the individual, the project or the company.

This study also confirms that there are major ambitions on the use of IT-tools but also that there are few well prepared plans and only limited previous experiences on how to actually make use of IT-tools to improve project performance. One empirical example is the “visual room” which, despite major ambitions, role models in other industries and support from central functions in the general contractor company, turned out not to work. One obvious reason was the layout and size of the chosen room, but other reasons were also contributing. There was, for example, a lack of clear ideas of goals or needs and no routines developed in beforehand on how to organize or manage the information, communication and meetings. Thus, there was technical and physical infrastructure available but no clear work processes or strategies on how to organize, manage or benefit from, visual communication. Since there was no clear idea on the expected benefits from visual communication there were no clear incentives to actually take it serious.

This study indicates that the use of IT-tools is widely spread in the Swedish construction industry but that the knowledge and understanding of how to benefit from using IT-tools is less developed. In order for the benefits to take place, more focus must be on finding ways of making IT-tool use – i.e. the work processes – more interactive and proactive, in particular in the production phase. History has provided construction management scholars with for example PC, CAD and BIM, all of which have changed the prerequisites for construction project managers and project participants. The next step for IT-use in construction, which is already here, but of which we know very little, is the use of social media such as Twitter, Facebook and blogs. Thus, there is a need for more studies on IT-tools in the organizational context to further develop the knowledge and understanding of communication and IT-use in construction.

7. REFERENCES

Adriaanse, A. and Voordijk, H. (2005). Interorganizational communication and ICT in construction projects: a review using metatriangulation. *Construction Innovation: Information, Process, Management*, Vol. 5, No. 3.

Amor, R., Betts, M., Coetzee, G. and Sexton, M. (2002). Information Technology for construction: Recent work and future directions. *Itcon*, Vol. 7

Andresen, J. L. (2001). A Framework for Selecting an It Evaluation Method – In the Context of Construction. Rapport. BYG-DTU R-012.

Becerik-Gerber, B. and Rice, S. (2010). The Perceived Value of Building Information Modelling in the US Building Industry. *ITcon*, Vol. 15.

Brynjolfsson, E. (1993). The Productivity Paradox of Information Technology: Review and Assessment, *Communications of the ACM,* Vol. 36, No. 12, pp. 66-77.

Brynjolfsson, E. and Yang, S. (1996). Information technology and Productivity: A Review of the Literature, *Advances in Computers,* Academic Press, Vol. 43, pp. 179-214.

Dainty, A., Moore, D. and Murray, M. (2006). *Communication in Construction. Theory and Practice*. London: Taylor & Francis.

Davies, K. (2010). IT Barometer New Zealand – A survey of computer use and attitudes in the New Zealand Construction Industry. Proceedings of the CIB W78 2010: 27th International Conference – Cairo, Egypt, 16-18 November.

Denzin, N. K. (2006). Sociological methods: a sourcebook. Aldine Transaction (5th ed).

Eastman, C., Teicholz, P., Sacks, R., and Liston, K. (2008). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*. John Wiley & Sons.

Eisenhardt, K. (1989). Building Theories from Case Study Research. *The Academy of Management Review,* Vol. 14, No. 4, pp. 532-50.

Emmitt, S. (2010). *Managing Interdisciplinary Projects*. London: Spon Press.

Emmitt, S. and Gorse, C. (2003). *Construction Communication*. Oxford: Blackwell Publishing.

Emmitt, S. and Gorse, C. (2007). *Communication in Construction Teams*. London: Taylor & Francis.

Froese, T. (2010). The impact of emerging information technology on project management for construction. *Automation in Construction*. Vol. 19, pp. 531-538.

Hallberg, D. and Tarandi, V. (2011). On the use of open BIM and 4D visualization in a predictive life cycle management system for construction works. *ITcon* Vol. 16, pp. 445-466.

Hardin, B. (2009). *BIM and Construction Management: Proven Tools, Methods, and Workflows*. Sybex.

Hartmann, T. and Levitt, R.E. (2010). Understanding and managing three-dimensional/four-dimensional model implementations at the project team level. *Journal of Construction Engineering and Management*, Vol. 136, pp. 757-767.

Hartmann, T., van Meervald, H., Vossebeld, N. and Adriaanse, A. (2012). Aligning building information model tools and construction management methods. *Automation in Construction*. Vol. 22, pp. 605-613.

Howard, R, Kiviniemi, A, and Samuelson O (1998). Surveys of IT in the construction industry and experience of the IT-Barometer in Scandinavia. *ITcon*, Vol.3.

Jacobsson, M. and Linderoth, H. (2012). User perceptions of ICT impacts in the Swedish construction companies: ' its fine, just as it is'. *Construction Management and Economics*, Vol. 30, No. 5, pp. 339-357.

Jacobsson, M. and Linderoth, H. (2010). The influence of contextual elements, actors's frames of reference, and technology on the adoption and use of ICT in construction projects: a Swedish case study. *Construction Management and Economics*, Vol. 28, No.1, pp. 13-23.

Jorgenson, D.W., Ho, M.S and Stiroh, K.J. (2003). Growth of US Industries and Investments in Information Technology and Higher Education, *Economic System Research*, Vol. 15, No. 3, pp. 279-325.

Kadefors, A. (2004). Trust in project relationships - inside the black box. *International Journal of Project Management*, Vol. 22, No. 3, pp. 175-182.

Kam, C., Fischer, M., Hänninen, R., Karjalainen, A. and Laitinen, J. (2003). The product model and Fourth Dimension project, *ITcon,Vol.* 8, Special Issue IFC - Product models for the AEC arena , pp. 137-166.

Karrbom Gustavsson, T. and Gohary, H. (2012). Boundary action in construction projects: new collaborative project practices. *International Journal of Managing Projects in Business*. Vol. 5, No. 3.

Khanzode, A., Fischer, M. and Reed, D. (2008). Benefits and lessons learned of implementing building virtural design and construction (VDC) technologies for coordination of mechanical, electrical and plumbing (MEP) systems of a large healthcare project, *ITcon*, Vol. 13.

Khemlani, L. (2004). The Eureka Tower: A case study of advanced BIM implementation, *AECBytes.*

Kymmell, W. (2008). *Building information modeling: planning and managing construction projects with 4D CAD and simulations.* New York: McGraw-Hill.

Linderoth, H.C.J. and Jacobsson, M. (2008). *Understanding adoption and use of ICT in construction projects through the lens of context, actors and technology*. CIB W78, International Conference on Information Technology in Construction, Santiago, Chile

Löfgren, A. (2008). *Making mobile meaning: expectations and experienced of mobile computing usefulness in construction site management practice*. PhD-thesis. Stockholm: KTH-Royal Institute of Technology.

Molnár, M., Anderson, R. and Ekholm, A. (2007). *Benefits of ICT in the construction industry – Characterization of the present situation the house building processes.* In Proceedings of CIB W78 conference 2007 in Maribor.

Nyström, J. (2005). The definition of partnering as a Wittgenstein family resemblance concept. *Construction*

Management & Economics, Vol. 23, No. 5, pp. 473-481.

Nyström, J. (2007). *Partnering: definition, theory and evaluation*. PhD-thesis. Stockholm: KTH-Royal Institute of Technology.

Rivard, H. (2000). A Survey on the Impact of Information Technology on the Canadian Architecture, Engineering and Construction Industry. *ITcon*, Vol. 5, pp. 37-56.

Samuelson, O. (1998a). IT-Barometern 1998 – Läget för IT-användningen inom byggande och förvaltning i Sverige. Stockholm: KTH

Samuelson, O. (1998b). *IT-Barometern– uppbyggnad av en undersökning av IT-användande i byggsektorn*. M.Sc thesis, Dept. of Construction management and economics, Stockholm: KTH-Royal Institute of Technology. (In English: IT-barometer – design of a survey on the use of IT in construction)

Samuelson, O. (2002). IT Barometer 2000 – The Use of IT in the Nordic Construction Industry. *ITcon* Vol. 7, pp. 1-26.

Samuelson, O. (2008). The IT-barometer – a decade's development of IT use in the Swedish construction sector. *ITcon*, Vol. 13, pp. 1-19.

Samuelson, O. (2010). *IT-innovationer i svenska bygg- och fastighetssektorn*. *En studie av förekomst och utveckling av IT under ett decennium*. PhD-thesis. Helsinki: Svenska Handelshögskolan.

Samuelson, O. (2012). *IT-Barometern. En mätning av bygg- och fastighetssektorns IT-användning*. TRITA-FOB-Rapport 2012:1. Stockholm: KTH-Royal Institute of Technology.

Schenck, D. and Wilson, P. (1994). *Information Modeling: The EXPRESS Way*. New York: Oxford University Press.

Silverman, D. (2001). *Interpreting Qualitative Data: Methods for Interpreting Talk, Text and Interaction*. 2nd ed. London: Sage.

Silverman, D. (2010). *Doing qualitative research*. *A practical handbook*. 3rd ed. London: Sage.

Sulankivi, K. (2004). Benefits of centralized digital information management in multi partner projects, *ITcon*, Vol. 9.

Slaughter, E.S. (1998). Models of Construction Innovation, *Journal of Construction Engineering and Management*, Vol. 124, No. 3, pp. 226-231.

Van Fenema, P. C. and Räisänen, C. (2005). Invisible Social Infrastructures to Facilitate Time-pressed Distributed Organizing. *Time & Society*, Vol. 14, No. 2-3, pp. 341-360.

Wikforss Ö. and Löfgren A. (2007). Rethinking Communication in Construction. *ITcon*, Vol. 12, pp. 337-345.

Winch, G. M. (2010). *Managing Construction Projects*. London: Wiley-Blackwell.

Yin, R.K. (2009). *Case study Research, Design and Methods,* 4th ed. London: Sage.