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Research paper

Benefits, Barriers and Applications of Information Communication Technology in Construction Industry: a Contemporary Study

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Abstract

In the construction industry there is a necessity for improving the construction efficiency through adopting innovative methods. Information and Communication Technologies (ICT) help in increasing the client satisfaction reduce coordination errors and provide a greater understanding among project participants in terms of better handling issues and requirements. Better efficiency can be achieved by making a building smarter. Construction projects are faced with many challenges that must not be ignored or underestimated. Some of the wicked problems and challenges such as understanding how one decision will impact decisions in other areas; problem of addressing the risk due to dynamic and uncertainty existing in the environment; resolving conflict where there are competing claims resulting both good and bad outcomes from the same value system are required to be well managed, if required using innovative methods such as using ICT and software packages. Therefore Objective of this research is to explore and describe the use and applications of information and communication technologies in construction industry. It involves examining the current trends of ICT based construction practices and also to assess the potential for its improvement by way of innovation. In this the journey started with describing what innovative methodologies are required to be considered to drive the discussion of adopting and using ICT to handle the wicked problems in construction industry. Two rationalities are considered as a basis for working on ICT applications in construction management viz.: (i) Six stages of Project Life cycle management and (ii) Nine project management knowledge areas as described by PMI.

Keywords: *Construction Industry, ICT Applications, Construction Project Management Solutions, Current trends in Construction Practices, Energy Efficiency in Building Construction, IoT in Construction Management.*

1. Introduction

In the construction industry there is a necessity for improving the construction efficiency through adopting innovative methods (Oad, 2016). Information and communication technologies and their usage will help in increasing the construction efficiency and solve the special challenges such as sustainable construction and its management. The construction industry is well-known for its highly fragmented and competitive environment (Kalinichuk, 2013). Nowadays majority of the building projects are hardly treated without communication facilities and information transfer (Bjork, 1999). The Architecture, engineering and construction industry is showing great interest in accepting new technologies in achieving visualization, data analysis, information sharing, communications and collaboration activities (Thomassen, 2011). These ICT technologies help in increasing the client satisfaction reduce coordination errors and provide a greater understanding among project participants in terms of better handling issues and requirements (Kalinichuk, undated). Better efficiency can be achieved by making a building smarter. A smart building is an intelligent space that optimizes efficiency, comfort, safety for people and asset performance within the building (Intel, 2015).

IoT can play a good role in managing smart building systems and in building automation (Intel, 2015).

IoT based solutions that are based on open platforms give property owners and building managers a higher level of command and fine control comparing to today's closed and proprietary building management systems. By 2020, it is expected that more than 50 billion devices will be connected to the cloud and each other in what is commonly called the IoT -Internet of things (Intel, 2015).

2. Problem Statement

Construction projects are faced with many challenges that must not be ignored or underestimated. These projects are increasingly becoming competitive, complex and difficult to manage. Using traditional approaches may not provide solutions to address such wicked problems. The challenge becomes greater when joint ventures, partnerships and sub-contracting agreements are involved. In such scenarios adopting ad hoc and traditional approaches to construction management often fail to perform and managers need to consider adopting alternative approaches to solve these wicked problems. Some of these wicked problems typically are as follows: understanding how one decision will impact decisions in other areas; problem of addressing the risk due to dynamic and uncertainty existing in the environment; resolving conflict where there are competing claims resulting both good and bad outcomes

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from the same value system (Maqsood, Finegan and Walker, 2003).

3. Research Objective

Objective of this research is to explore and describe the use and applications of information and communication technologies in construction industry. It involves examining the current trends of ICT based construction practices and also to assess the potential for its improvement by way of innovation.

4. Methodologies and Principles

Some of the earlier attempts of methodologies suggested are: Soft Systems Methodology (Checkland, 1999; Barry and McIntosh, 2001; and Maqsood, Finegan and Walker, 2003); TAMPA (Vasista, 2007); ASCP (AlSudairi and Vasista, 2013) and CRASP (Vasista and AlSudairi, 2014) and Innovative Process Quality Approach (Gryna, 2001; Vasista and AlSudairi, 2018).

A. The TAMPA Methodology

IoT consists of networks of sensors attached to identifiable things or objects and communications devices, providing data that can be analyzed and used to initiate automated actions (Lake, Rayes and Morrow, 2012). Whenever a business enterprise is established, it either explicitly or implicitly demands a particular business model that describes the design of a value creation in terms of both delivering value to customers and profit to business enterprise. The ultimate goal of any strategic decision is to create value (AlSudairi and Vasista, 2012). IoT are coordinated by a logic, which utilizes the data for value creation (Gromov, 2015). The primary value creation drivers such as strategic management theories related to markets and e-businesses are tightly coupled with the customer needs identified during the analysis of the data gathered from interviews at the case companies as well as to the interpreted problems organizations wishing to implement IoT are facing (Kreicbergs and Stiernspetz, 2017). The information value at the decision making stage involves balancing the relationship between project functionality and cost, information related to stage wise objectives and overall goal of the project. Building Information Modeling has an important role to play in terms of providing building information value chain in view of analyzing and rendering value and value-addition aspects (Zhao and Wishuang, 2017).

TAMPA, CRASP and ASCP methodologies as well as IoT based principles and practice enables organizations in identifying the potential value and its creation as well as in developing strategies to capture such value for utilizing it to obtain the operational benefits of construction industry (Kejriwal and Mahajan, 2016).

Transform-Analyze-Measure-Predict-Act (T-A-M-P-A) is an extended methodology to MPA methodology mentioned in Berson, Smith and Thearling (2000). TAMPA is a closed information value loop that passes through the loop stages called T-A-M-P-A (Vasista, 2007). The TAMPA methodology basically when takes the motivation from the underlying methodology called the CRASP (Customer-Resopnd-Adapt-Sense-Provider) methodology (AlSudairi and Vasista, 2014) and supported by the ASCP methodology (i.e. General ABSTRACTION-STANDARDIZATION-CUSTOMIZATION AND PERSONALIZATION levels of information abstraction) while dealing with the adaptability of the information abstraction (AlSudairi and Vasista, 2013) in view of dealing with the communications and standards (e.g. the reference module of CRASP methodology) aspects be they technical, legal and regulatory (The Economics Intelligence Unit, 2017) or social (Casaletto, 2017) and can be re-depicted in the following way for the construction industry context. While CRASP methodology deals capturing, validating and verifying as well as communicating and responding to the customer and provider at the environment level (external knowledge value), the TAMPA focuses on the process of eliciting and creating the knowledge based value towards supporting the strategic decisions both covering customer perspectives level and profit or revenue generation covering the provider perspective. The CRASP methodology for this context has been described as follows:

B. The CRASP methodology

1) Customer: When using resources and applying skills, customers create and co-create value (Zhang, 2016) for themselves in their everyday practices.

2) Respond: Ambient intelligent systems such as home and building automation systems are becoming more acceptable as they are capable of actuating automatically on behalf of users to fulfill their requests and enable activities (Camacho, Undated). Building automation systems aims at controlling electric devices such as luminaries, HVAC (heating, ventilation and air-condition) systems, window blinds etc. in order to reproduce the desired behavior in the building. Thus actuators define the behavior of the various elements of the building (Aguiam, undated).

3) Adapt: The decider receives the solutions and data generation by the resolver and advisor and reads actuators data in order to verify whether device actuations are needed to make the environment adapt to the current situation. This sort of state must be automatically detected in order for the system to dynamically adapt the environment's conditions through device actuations in order to comply with the preferences of both occupants and activity's conditions (Camacho, undated). Finally, the actuators are the ultimate goal of the system as they are the one that will effectively perform the desired behavior in the building. They transform the action received by the system into physical changes in the devices installed in the building (Aguiam, undated).

4) Sense: Sensors are the way by which the system captures the environment of the building and its properties (Aguiam, undated). It develops controls that allow a building to sense the power demand on the grid but remain intensive against power outrages. For example a modern lighting system can be controlled by sensing the occupancy with space detector or light sensor. The performance can degrade without automated monitoring and fault detection as well as the sensors and controls on which they rely; the number and range of sensor types installed in commercial buildings these days is inadequate to provide sufficient automated monitoring. Typical applications of sensors in buildings are meant to modulate the performance of HVAC system for thermal comfort (Zhang, Lam and Wang, 2014), adjusting lighting levels (Ler, 2006) and ensuring the safety of occupants. In addition to HVAC related sensors such as thermal, temperature, light, acoustic, photo, pressure and humidity sensors etc., and sensors for other aspects of buildings exist that may not appear to be directly related to energy use and thermal comfort but may find use in the future. Additionally, strain sensors are widely used to monitor structural safety. Sensors related to indoor air quality monitoring to maintain healthy and productive work environment can also be enabled. Wireless sensors are used in industrial processing and manufacturing industries to control buildings through building automation technology (Brambley, Hansen, Haves, Holmberg, McDonald, Roth and Torcellini, 2005).

5) Provider: The enterprise as provider cannot deliver value, but only offer value propositions. When creating interactive contacts with customers, the firm develops opportunities to co-create value with them and for them. As the value is co-created, the provider has a better chance to influence customer's value fulfilment during the process (Gromov, 2015).

The loop is competed by providing directions, suggestions and decisions to Act derived from the deep insights and advanced machine-to-machine (M2M) interfaces that can enable Building Automation and Management Systems (BAMS) due to its enhanced intelligence obtained from the Predictive insights for building operations; with the capability of Measuring the IoT business index for construction, real-estate and facilities management (see figure below); from the aggregated data that can be

Analysed through different analytical tools not only for predictive capabilities but also for descriptive and prescriptive capabilities using different analytical tools. Such data aggregation is possible by Transforming the structured and unstructured data from different internal and external systems (Kejriwal and Mahajan, 2016) using data warehousing (Brohman, Parent, Pearce and Wade, 2000) and data mining technologies (Silwattananusarn and Tuamsuk, 2012) in machine learning environment (Arciszewski, Usmen, 1993; Asadi, AlSubaey and Makatsoris, 2015). In the context of Service Quality management and control, however it is important to see not to get the affects of conflicting and degrading of the service quality as a whole within the Wireless sensor network environment. An indoor wireless sensor network that is designed with BIM data can provide a detailed description of the building environment. Such environment is required for accurate predictions of signal propagation and therefore link quality between sensor needs in the building (Zhang, Seet and Lie, 2015; Vasista and AlSudairi, 2018).

C. The IOT Principles

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D. Research Methodology

It is a qualitative research methodology focused literature based survey and review done to fulfil the objective working for the problem statement.

5. Literature Survey and Review

The Definition of Innovation

Innovation is the actual use of nontrivial change and improvement in a process product or system that is novel to the institution developing the change (Freeman, 1989; Dickinson, Cooper, Dermott and Eaton, 2005). While innovation adds value, it may also have a negative effect such as forces to reform old organizational forms and practices. They may also become threat to those organizations that do not innovate (Nufocus Group, undated). Innovation like many business functions is a management process that requires specific tools, rules and discipline (Davila et al, 2006). The goal of innovation process is to achieve enhanced performance (Barrett and Sexton, 2006).

Benefits of ICT in Construction Industry

ICT can play an important role to improve productivity and quality in the following aspects of development areas. The benefits of ICT in construction industry include the following: Reuse of experience, quantity take-off, fragmentary product definition, cooperation and ICT policies, interoperability, virtual reality and computer aided design (Molnar, Andersson and Ekholm, 2007). Inter-related factors associated with projects, team management, technology and organization, strategic benefits (Ahuja, Yang and Shankar, 2009). Employee satisfaction, adapting niche requirements, moving online and empowering semantics (Klinc, Dolenc and Turk, 2008). Reduced mistakes in documents, easing of complex tasks, time saving and increased productivity (Mutesi and Kyakula, 2011). Improved quality of work, makes complex tasks easier to perform, saves time, increases the speed of work, improves productivity, saves cost, facilitates decision making, enhances the public image, reduces the errors, reduces mistakes while documenting, increases the document preparation quality (Zachiang, 2017). Organization related benefits: Better information assessment and management within organization, increase in overall organizational efficiency, useful information compiled and disseminated to other projects; Projects related benefits: Projects completion as per the estimated time, client satisfaction, project completion as per specifications, project information obtained in real time, Effective change management, project managers can spend more time on managerial works (as compared to focusing more on operational works), life cycle management becomes competitive factor, effective contract management, effective concurrent construction management, reduced risk of errors and rework on projects, effective material procurement and management, reduced administrative costs of document handling and distribution to multiple parties, richer information made available to managers, less time spent in query and approval process, one-source documentation archive maintained for clients, all communications maintained for tracking purpose; Team management related benefits: Effective communication between project team members, greater management control, motivation of the work force, effective collaboration and co-ordination between project team members, effective joint decision making; Technology related benefits: Ease to retrieval of information, increased information portability in ICT environment, flow of accurate information, hardcopy storage of documents, improved capability of the system, multi location availability of data (Prasanna and Raja Ramanna, 2014). Transparency, better governance, quality assurance and enhanced capability of decision making (El-Sabini et al., 2009). Ensure accurate estimates, schedule labour and equipment with ease, Simplify document management, reduce the complexity of HR issues, increase profit with less risk (Kinuthia, 2014).

Benefits of ICT in Construction Industry

High cost of investment, system malfunction, virus attacks, high cost of professionals to employee (Mutesi and Kyakula, 2011). Computer literacy, financial barriers such as high investment and maintenance costs, organizational barriers such as lack of incentives, poor ICT strategies, lack of training, lack of appropriate ICT support; lack of training, cultural issues, reluctance to changes in business processes; Technological barriers such as difficulty in coping up with new technologies; lack of support from ICT providers, inefficient use of software, ill defined processes and infrastructure problems; Legal barriers such as risks for liability, lack of legal support for use of ICT, security of ICT transactions, issues in handling electronic information and documentation (Zachiang, 2017). Poor ICT infrastructure, Unfamiliarity of local personnel with ICT in remote construction sites, No financial justification for ICT training for personnel, complicated administrative process for ICT development (Alaghbandard, Asnaashari and Preece, 2011).

6. Applications of ICT in Construction Industry

The following are some of the ICT based software and equipment used in Uganda's construction industry: MS Word, MS Excel, MS Power Point, Auto CAD, Master Bill (Quantity surveying software), Microsoft Project, Book keeping software, Mobile phones, intranet and internet (Mutesi and Kyakula, 2011). Publication/dissemination of information, Feedback, access to database, handling registrations, sales of products and services, access to personal records, e-procurement, e-commerce, search engines, web directories, project management and online project collaboration, virtual reality technology, digital communication, digital multimedia; competitive advantages, reduced business costs, improved customer satisfaction, company and product promotions (Kajewski and Weippert, 2001).

Two rationalities are considered as basis for working on ICT applications in construction management: (i) Six stages of Project Life cycle management and (ii) Nine project management knowledge areas as described by PMI.

PMI considered broadly four project management life cycle stages viz. (i) Project starting, project planning, project execution and project closing (PMI,2008:16), when two phases viz., project feasibility and project evaluation proposed and suggested by Archibald, Filippo and Filippo (2012) are considered, it becomes six phase comprehensive construction project life cycle model. However in this research a little modified life cycle phases in to six of construction project management mentioned in Guo, Li, Skitmore (2010) are considered to discuss ICT applications in construction management. The six stages are: (i) Conceptual, (ii) feasibility study & evaluation, (iii) design, (iv) tendering and contract, (v) construction and (vi) utilization & maintenance stages (Vasista, 2017).

These two rationalities have been considered for bringing up the literature on ICT applications in civil engineering construction area.

The Nine knowledge areas that are mentioned in the PMBOK guide are: Integration management, scope management, time management, cost management, quality management, human resources management, communication management, risk management and procurement management. According to PMBOK guide (PMI, 2008), a project manager is expected to perform 42 processes including 20 planning processes (Zwikael, 2009)

E. ICT application software for Construction Project Life Cycle Management

AutoDesk BLM is project Life cycle management software based on Buzzsaw Server and provides online service to project management. REVIT is one of the software modules embedded in Buzzsaw and can supply a visual design environment and facilitates collaborative design in the design phase only but not in construction phase (Guo, Li and Skitmore, Undated)

1) Conceptual Stage: The conceptual phase is of strategic importance in the project environment (Abdul-Kadir and Price, 1995). In this phase, the need, opportunity or problem is confirmed (Vannin, 2012). Virtual reality and CAD software (Adwan & Al-Soufi, 2016) in construction management (Kano, 2006) such as Smart Plant Review – Intergraph Incorporated, FourDviz-Balfour technologies and Common Point 4D-Standford University (Heesom and Mahdjoubi, 2004).

2) Feasibility & Evaluation: In this phase the overall feasibility of the solution for the identified problem is evaluated. The overall goal of using a building information model is to provide reliable data to the decision maker in order to evaluate the cost and benefits of different waste management alternatives. The required data to conduct cost-benefit analysis of demolition waste management of the case study can be retrieved from the Revit model which has been evolved during design, construction and facility management phases (Hmadi, Bulbul, Pearce and Thabet, 2014).

3) Analysis and Design: The building design process typically involves the participation of architects, engineers and material suppliers, in some project delivery systems, contractors are also involved in the design process (Dogan, Kilic Calgici, Arditi and Gunaydin, 2015). The design phase is intended to demonstrate the clients' construction intentions, including the functional requirements and standards of the proposed project through an implementation model. It might involve the multi-disciplinary collaborative work too meet the owner's intentions (Xu, Ma and Ding, 2014). Structural Aided Analysis and Design software package for structural engineering called STAAD.Pro is an analysis & design software package for structural engineering used in performing the analysis and design of wide variety of types of structures. It was developed by Research Engineering International in Yorba Linda, CA later it was sold to Bentley systems in late 2005 (Sasidhar, Manadeep, Ikkurthi and Srujana, 2017). Furthermore, 3D and 4D CAD models enhance the ability to identify issues with a design's constructability (Hartmann and Fischer, 2007). Building Information Modeling software can be used for parameter design and collision detection in the design phase (Xu, Ma and Ding, 2014).

4) Tendering & Contract: Evaluating contractor ability can be done using tools such as Qualifier-I and Qualifier-II. However to evaluate the bidding price an attempt is made by developing a software tool using MS-Excel and Visual Basic (PongPeng, Undated).

5) Construction: BIM software can be used to monitor safety in the construction phase. The C-BIM contains information produced in construction activities. It involves the owner, design company, supervision company, general contractor, subcontractors, material suppliers, equipment suppliers and relevant government departments. The major activities in construction phase includes activities such as: obtaining construction permits, information on regulation and technical standards, choosing supervision unit and subcontractors, signing construction contracts, organizing and examining drawings, programming, operating and explaining design and technical aspects; site management, resources management, schedule management, cost management, quality management and safety management; acceptance of completion materials, project delivery and property handover (Xu, Ma and Ding, 2014).

6) Utilization & Maintenance: BIM software can be used analyse the building performance in the utilization (during the operational phase) and maintenance phase. The main activities in this phase includes: maintenance of buildings and facilities, daily maintenance and management of construction equipment (such as electricity, heating, ventilation, air conditioning, elevators, etc.); keeping the surroundings of the building as clean and green, personnel file management, formulation of rules and regulations, public safety and security management (Xu, Ma and Ding, 2014).

F. ICT application software for PMI's project management knowledge areas

1) Integration Management: Project management software packages generally facilitate the integration of project data, the interaction with enterprise systems and interoperability with new IT. Besides optimizing the productivity of the teams, the system allows to make better decisions (Pellerin, Perrier, Guillot and Leger, 2013). BIM is an effective tool to integrate information from different stages to promote information communication and reuse.

2) Scope Management: Project performance is often defined in terms of schedule, scope and cost. BIM as a scope management tool can become evident and can be understood from the frequency of articles appeared after research done on the PMI topics in the reviewed literature on BIM by Khaddaj and Srour (2016). An Integrated 5D BIM model immediately updates both the schedule and budget when any design change occurs. It helps in checking the project scope and becomes a trustworthy liaison between the designers and owners. For example, BIM is considered for scope management in the construction project of Shang-

hai Tower, Walt Disney Concert Hall Audubon Centre (Bryde, Broquetas and Volm, 2013).

3) Time Management: MS Project software works to compute project schedules, determining the critical path, over allocated resources, what more resources are required to complete a project on time, determines when finances will be needed to be committed (Kinuthia, 2014).

4) Cost Management: Easy build is an Oracle based suite of application software that addresses the operational requirements of the construction industry including features of compliance regulations, finance and project management; Easy build monitors profitability, does cash flow management and reporting, works to compute project costs, revenues, sub-contract liabilities, valuation adjustments and final account forecasts (Kinuthia, 2014).

5) Quality Management: Project Management software can also serve as a quality management system. It acts an enabler of the Project Management and Information System improvement to play as an integral part in management of the construction projects. Furthermore, today's Project Management standards, i.e. BS6079-1:2002, the guide to project management and BS6079-2:2000, The Project Management Vocabulary define and advocate the use of IS/IT in project management. For example, the GALA construction management software available in South Eastern Europe based countries supports quality assurance in project management through double loop learning (Vukomanovic, Radujkovic and Alduk, 2012).

6) Human Resources Management: HR management involves people centred aspects such as defining roles, interviewing, reviewing performance, providing feedback, coaching, identifying learning and development needs and conducting performance reviews all require special skills. The outcomes of HRM includes: employee engagement, commitment, motivation and skill so that they can contribute to the business outcomes of productivity, quality and customer satisfaction as well as contributing to financial performance outcomes such as increase in profit, sales, market share and market value (O'Riordan, 2017). Construction Management related project management information system can be categorized as (i) in-house developed (proprietary systems) Packaged software, Groupware and specialty software. The research conducted by Jung, Kim and Joo (2011) in South Korea indicated that about 7.7 percent software of the 39.7% of CM-PMIS software that are proprietary systems can contribute to Human Resources Management. All CM-PMIS software are less project and engineering oriented systems but has a capability of dealing with 52% structured data and 48% unstructured data (Jung, Kim and Joo, 2011).

7) Communication Management: Information and communication technology (ICT) enhanced communication strategy can help building project managers in the successful delivery of the projects (Yang, Ahuja and Shankar, 2007). Project Communication Management is the backbone to effective decision making during the lifespan of a project (MnKandla, 2013).

8) Risk Management in Dynamics and Uncertain Environment: ERP systems and project management software packages are desirable for projects where the environment is well structured, but he GCT (Group Collaboration Technologies) must be given special weight for projects where the environment is less structured, uncertainty and volatile (Pellerin, Perrier, Guillot and Leger, 2013). Project Portfolio Software systems such as Primavera Systems have been developing their Project Management Software package for construction and today it has become a leading provider of the Portfolio management solutions for the construction industry. This kind of Project management software strives to integrate project management processes with an on-site management and the common practice in the construction south Eastern Europe based countries (e.g. Crotia) and also in many developed countries (Vukomanovic, Radujkovic and Alduk, 2012). Risk management is handled in BIM as a part of life-cycle information management (Xu, Ma and Ding, 2014).

9) Risk Management in Dynamics and Uncertain Environment: Procurement management process related to the project involves purchasing, training, contract administration, logistics, procurement follow-up and inspection, material management on site (Pellerin, Perrier, Guillot and Leger, 2013). GALA is a construction management software stepped into the market in 2003 as a Project management software. It uses a large database of normative work, material, equipment that provides analysis of the cost. GALA supports on-site management and procedures prescribed by local conditions (Vukomanovic, Radujkovic and Alduk, 2012).

7. Managing Wicked Problems

Decision Making: Project Communication Management is the backbone to effective decision making during the lifespan of a project (MnKandla, 2013). ICT can monitor decisions and actions to ensure that interim conditions for meeting all of the project's performance goals and will prevail (Perkinson and Ahmad, 2006). Sage 200 construction (contract management) software provides real-time visibility of contract information allowing you to manage budgets and costs effectively while measuring performance against targets throughout the project lifecycle, minimizing risk and allowing informed decisions to be made with confidence (Kinuthia, 2014). ICT creates necessary conditions for the complete approach to project delivery. ICT ensures functioning over determination of design, construction and maintenance dimensions and helps to consolidate separated knowledge advancements made within time, cost, accessibility, crime, sustainability, acoustics, thermal and visual comfort, build ability and maintainability into decision-making tool (Kalinichuk, undated).

Managing Risks and Conflicts in Construction Projects: Risks and conflicts are unavoidable in almost every construction project whether it is building projects, civil works, or any other type of construction projects. Risk is inherent in all human endeavors including construction activities. Managing construction project risks is considered as compulsory for any successful project (Sharma and Swain, 2011). According Chapman and Ward (2002), effective risk management is doing the right things in a way to ensure that the project is risk efficient and project objectives are achieved (Osipova, 2008). The consortium behind RiMaCon identified a major gap between the available risk management methodologies and their practiced and efficient application by SMEs in the construction sector. It is found that there was no robust risk management system suitable for easy adoption or application by SMEs and that current risk management system is used only for ad-hoc assessment, rather than continuous assessment, monitoring and review (University of Woverhampton, 2017). The system used for risk management in projects has been mainly based on a qualitative analysis, but this technique does not allow to record risks, issues and actions taken to resolve them as well as lessons learned so that they can be used for development of new projects. The risk management factors can be classified into different maturity levels such as: Communication, Process, Integration, Knowledge and organization levels (Serpell, Ferrada, Rubio and Arauzo, 2015).

Operational and Energy Efficiency: Complete construction business management software solutions therefore provide one way to handle the complexities of the entire project life cycle. This software can help contractors minimize risks and hold all appropriate parties accountable. With more end-to-end control and seamless workflows, contractors can achieve operational efficiencies and cost reductions to guarantee profitability (Kinutha, 2010). Implementing mobile construction software can improve operational efficiency across all levels of project management. Use of Mobile software eliminates physical paper work. This means an elimination of time-consuming and tedious task of filling out forms and more time spent on other works. Time and communication management also ensures operational efficiency (Riddell, 2017).

The energy sector is closely interconnected with the building sector and integrated information and communication technologies

solutions for effective energy management supporting is a key element for making a city or building smart. An IoT based system can enhance the interactivity of the buildings' energy management systems. For example, Schneider Electric StruxureWare is a platform of open, interoperable, and scalable software applications that provides energy managers with enterprise, operations and control level responsibility to optimize energy usage. Similarly, Honeywell Attune Advisory Services is powered by cloud-based Software as a Service (SaaS) technologies that help to determine how to save energy, time and money. Siemens Synco manages energy plants and HVAC (heating, Ventilation, and Air Conditioning) equipment. Cylon Energy solution is a building energy monitoring system that provides real-time information on energy usage and consumption information for every 15mts (Marinakis and Doukas, 2018). With increasing adoption of smart building solutions, the built environment will achieve new efficiencies in energy use and improvements in occupant comfort. These solutions could use the IT approaches such as a cloud-based approach and automation and real-time analytics and integration with utilities and infrastructure. With smart building technology it is possible to reduce carbon emission in the US by 130-190 million tons of CO2. The related electricity cost savings amount to US$20-25 billion (Accenture, 2011).

8. Conclusions

Construction industry is one of the largest economic sectors, which is characterized as a traditional industry with a low innovation rate. The paradigm shift of Information Communications Technology (ICT) has created new opportunities and changed the way of working and has potential to change the processes of construction industry in the near future. The usage of ICT solutions indicate that all companies use tools which increase internal efficiency and internal effectiveness (Sulakatko, 2016), i.e. improves the performance of internal business process. Correspondingly the research conducted by Sulakatko (2016) concluded that the use of ICT as a part of digitalization is important to construction industry. The development of smart buildings is now taking the intensive demand for ICT with requirements such as intelligent building management, adaptive energy systems, assisting technologies, remote monitoring and so on. In addition to it, the emergence of Internet of Things (IoT), where unique identifiers are allocated to physical objects, can enable almost anything be connected to a network (Sharma and Singh, 2015). This kind of innovative technology-based adoption in construction industry will help in transferring the production information to workers, use of web applications will help to promote collaborative work to enter data and distribute the shared information and the use of electronic devices (e.g. IoT based sensors and actuators) will help in collecting and disseminating the data as well as information easier (Orihuela, Orihuela and Pacheco, 2016). ICT implementation when adopted by the company will affect it in terms of electronic communication system, documentation, accounting, quantity surveying, engineering design and drawing as well as project planning and tracking. For example, the implementation case studies in Malaysia showed the result that ICT can assist in achieving construction project success by meeting the criteria of considering i.e. time, cost, quality, scope and customer satisfaction. Therefore, ICT is one of the key determinants of project success (Chan, 2015)

9. Future Research

The future research is to explore and determine the constituent capabilities and effectiveness of Construction Project management Information and Communication System Software for professional construction management firms, through conducting survey and by making statistical data analysis on the data obtained. The composition of Project Management Information System is targeted to investigate the findings based on two perspectives or dimensions viz. system configuration (e.g. in-house developed (proprietary systems), Enterprise System Software, Group Ware and Professional Software) and construction business function (e.g. design, estimating, cost and time etc.). Two more dimensions that are also focused are to see what extent this software could provide the nine knowledge areas mentioned by PMI and the capability of supporting construction Life cycle phases (or their activities). The project management performance or success in terms of effectiveness and efficiency by taking a specific example domain such as energy efficiency may also be included.

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