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CITAX: A Collaborative ICT Standards Model for the Irish Construction Industry

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ABSTRACT

The Irish construction industry is facing a series of fundamental challenges that is affecting every player in the AEC lifecycle, from architects to engineers to quantity surveyors to owners to tenants. Despite technological advances in recent years, the Irish construction industry lags behind other industries in respect to ICT investments. Although there is a pressing need for innovation, existing procurement and tendering procedures in Ireland largely discourage new ideas and put further pressure on thin margins that characterise the competitiveness of the construction sector. The low level of inter-company ICT connectivity reflects the general fragmented and adversarial nature of the Irish construction industry, where the absence of dominant players has precluded the imposition of de facto inter-company ICT standards, as has been the case in the retail supermarket sector. This paper will present the results of a two-year research project which sought to demonstrate that, by the adoption of readily available ICT tools, particular business processes in construction could be dramatically improved. The paper goes on to describe the opportunities and challenges that have arisen as the project draws to a close. It will, in particular, focus on the introduction of ICT standards within the Irish construction industry. The ultimate goal is not only to have ICT standards in place, but also to provide the impetus to ensure that as many stakeholders as possible use them. How this might be achieved is also part of the project and its success will be judged by the extent of the adoption of the standard by the industry.

KEYWORDS

Construction, ICT standards, re-engineering.

1.0 INTRODUCTION

The Irish economy has come to rely heavily on the construction sector with the result that construction accounts for a sizeable proportion of economic activity. The direct contribution of the construction sector to the Irish economy was almost €35bn, or 24% of GNP, in 2007 (DKM, 2008). The buoyant construction industry in Ireland has resulted in many of the larger industry players operating internationally with the majority of work being done by local or national Small to Medium Enterprises (SMEs).

It has been extensively reported by many authorities that the exchange of data between project teams in the construction industry is not efficient (for example, Latham, 1994; Gunnigan et al., 2004; NIST, 2004, Hore and West 2005a and Hore

and West 2005b). There are many millions of documents (such as drawings, specifications, bills of quantities, correspondence, schedules, programmes) currently exchanged in paper form between Irish practitioners. It is commonplace that each of these documents are subsequently re-keyed, photocopied, scanned and filed, as they pass between different locations and computer applications (Hore and West, 2005c).

There is an array of collaborative initiatives globally seeking to introduce interoperable data exchange standards within the AEC/FM sector, through organisations such as the Construction Industry Institute (USA); VTT (Finland); Construct IT (UK), Construction Excellence in the Built Environment (UK). The International Alliance for Interoperability (IAI) is a global coalition of industry practitioners, software vendors and researchers who collectively promote the need for information to flow from one computer to the next throughout the life cycle of a construction project. The IAI have developed Industry Foundation Classes (IFCs) for both product and non-product data exchange standards to enable them to be adopted in the industry (Froese, 2003).

This paper will outline the progress of a particular project managed by the Construction IT Alliance (CITA) in Ireland, a group that is endeavouring to promote ICT standards in the Irish construction industry. The project, known as the CITAX (CITA eXchange) project, is a two-year collaborative project involving twenty five CITA member organisations who are seeking to demonstrate that significant measurable economic improvements can be achieved by using readily available ICT tools to radically improve business processes in the Irish construction industry. This paper will specifically focus on the progress being made by CITA in delivering these ICT standards. It will be seen that although good progress has been made, a formal implementation of ICT standards has not yet been achieved. The barriers to its introduction will also be examined.

2.0 DEVELOPING ICT ADOPTION IN THE IRISH CONSTRUCTION INDUSTRY

At present the extent of use of ICT in the Irish construction industry is relatively unsophisticated, mainly dependent on telephone, facsimile machines and networked personal computers (Thomas, 1999). At the simplest level, the electronic transmission of business documents offers savings in paper and postage (Hore and West 2005a). By going a step further, businesses can make strides in communicating with their partners, at relatively low cost, through direct links (internet or intranet) between their computers (Hore and West, 2005b).

The opportunity to enhance efficiency in a fragmented industry by working together has been recognised by the government and industry leaders. Consequently, CITA was formed to focus on the promotion of ICT in the Irish construction sector. Having its origins in the Dublin Institute of Technology, CITA is now an independent company whose membership currently comprises in excess of 140 corporations drawn from a broad cross-section of the Irish construction industry, including architects, engineers, contractors, suppliers, clients, ICT companies, government departments, state agencies and third level institutions. The main source of funding originates from membership subscriptions with other income sourced from training courses and sponsorship of events. The main activities involve organising bi-annual member meetings, training courses, information dissemination through the organisations website and online newsletters and promoting the work of its Special Interest Group (SIG) network. The Alliance aims to encourage participants in the Irish construction

industry to take full advantage of current and emerging ICT (Thomas and Hore, 2003).

3.0 ICT INTEGRATION AND THE NEED FOR COMMUNICATION STANDARDS IN CONSTRUCTION

Competition from international firms, as a result of increased globalisation, has prompted a renewed focus on improving general performances within the construction industry, both in Ireland and in the United Kingdom. For over 10 years the question that is often asked is why, when other industries have successfully made use of ICT, construction has been so slow to do the same (see, for example, Latham 1994, Egan 1998 and Building Centre Trust, 1999)

There is broad agreement that the nature of the construction industry is different to other industries, such as the manufacturing or retail sector, where processes and the working environment are well defined and controlled (Gann, 1996). The temporary nature and uniqueness of construction projects is reflected in one-off locations, designs solutions and project teams, which leads to a very fragmented communication platform (see Figure 1). This has lead to poor communication and inefficient information practices that have contributed to the emergence of dysfunctional supply chains (Love et al., 1999).

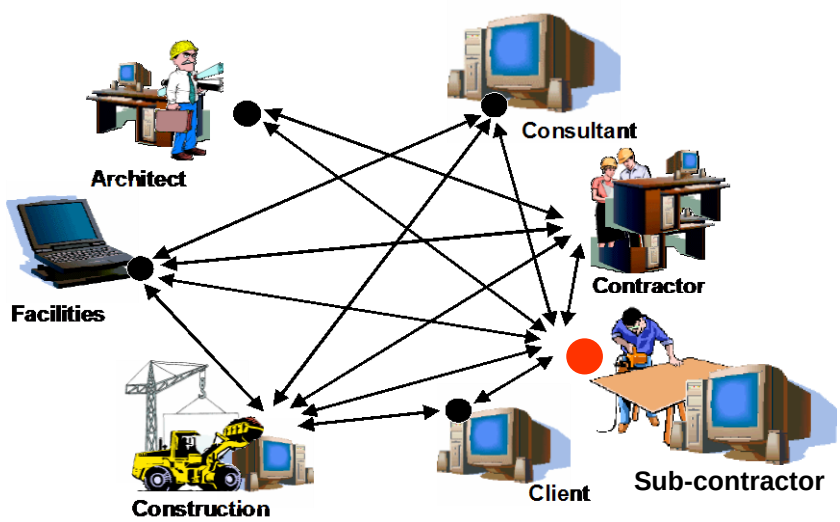

Figure 1. Fragmented nature of the construction industry (Sarshar et al., 2000)

A study by the US National Institute for Standards and Technology (NIST, 2004) has estimated that the cost of not having interoperability in the US Capital Facilities industry is about $15.8 billion per year. This has stimulated many major construction clients in the US to develop a national Building Information Modelling (BIM) standard. In both Finland and Denmark, for example, there has been a major commitment by the public sector and large construction process stakeholders to the adoption of Industry Foundation Classes (IFC) (Howard and Bjork, 2008). This, in turn, has created challenges for the application of ICT in the Irish construction industry.

It is now becoming accepted that the preferred communication model for managing information on a construction project should be based on a central project model, through which all the information is disseminated (Figure 2).

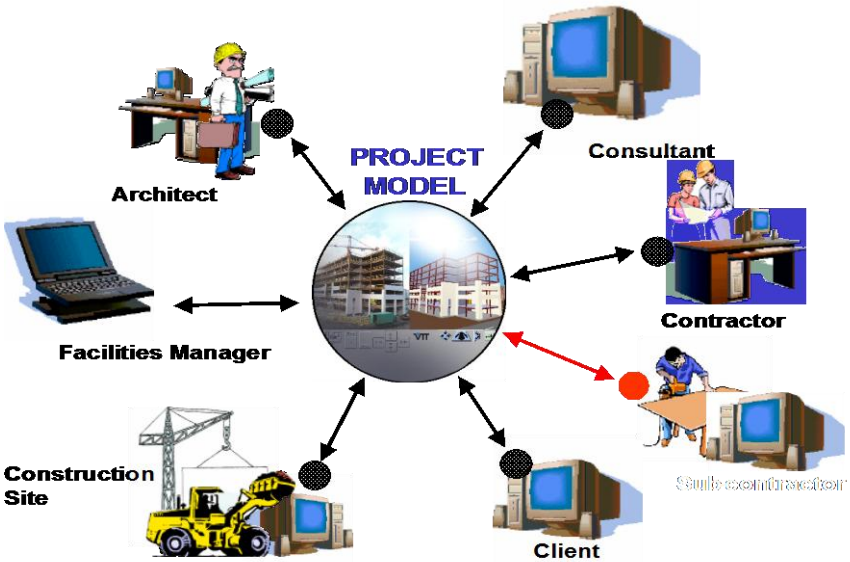

Figure 2. Preferred communication model for construction (Sarshar et al., 2000)

Construction sectors in many countries around the world are increasingly recognising the importance of ICT. ICT is improving the capability and efficiency of specific aspects within the construction process. It also has the potential to vastly improve communication throughout the construction process through electronic dissemination of information (West and Hore, 2007). ICT should support the entire construction process from inception through to the operational maintenance of the building asset. Figure 3 illustrates the integrated nature of the project model across the construction project life-cycle.

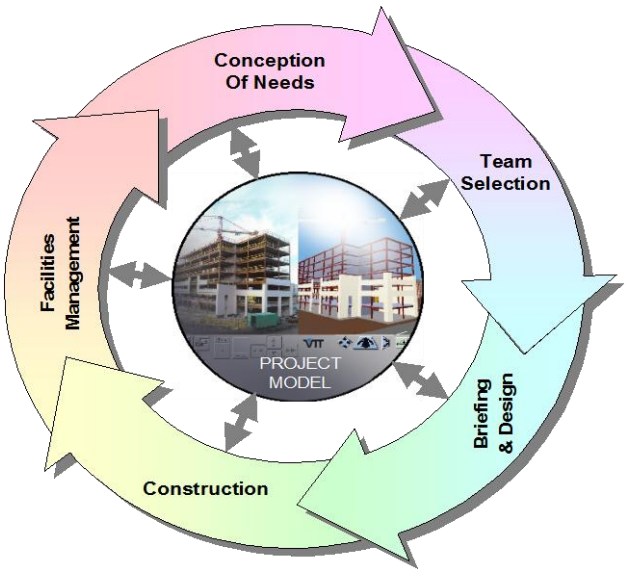

Figure 3. Project model for construction (Sarshar et al., 2000)

Representation of all the information needed to describe buildings throughout the design, construction and facilities management of a construction project has long been an objective of those applying ICT in building (Eastman, 1999). With the establishment of project information standards, the information becomes more compatible with the receiving party's systems. Consequently, the amount of information contained within the documents that can be re-used becomes greater (Building Centre Trust, 2001).

The core driver to IT integration is the establishment of common standards for the exchange of information. It is the lack of information exchange standards that prevent systems from communicating with each other and from information being exchanged effectively within the industry. Developing standards in a fragmented industry such as construction is extremely difficult and is hampered by commercial interests, which often naturally oppose standardisation for very sound reasons, such as the need to recoup investments in software developments.

The goal of the single building information model has existed for over thirty years and various standards have been published leading up to a ten-year development of the IAI and the IFCs (Howard and Bjork, 2007). The IAI and IFCs have been the most ambitious programmes for standardising object models in buildings, but neither the standard nor product modelling is widely used in industry. There is also highly differing views among researchers as to the optimal structure of BIM-models (Amor and Faraj, 2000). The IFC standard has been adopted by the majority of the large CAD vendors and in several countries there are strong government-level policies in place to ensure the adoption of the standard (Amor et al., 2007).

4.0 THE SEARCH FOR ICT STANDARDS IN THE IRISH CONSTRUCTION INDUSTRY

From the early years of CITA, the organisation has promoted the need for universal protocols and standards. One of the earliest achievements of the Alliance was the development and promotion of its own CAD Layering Convention. Based on a standard used by a Dublin-based architectural firm, CITA expanded the convention to include layers that are also relevant to structural/civil and building service engineers. The standard quickly became adopted by a number of key architectural practices and local authorities in Ireland. It was also adopted by The Royal Institute of Architects in Ireland in their best practice guidelines in 2003.

Beheshti et al. (2003) defined the word "standard" as "either widely recognised or employed as a model of authority or excellence". However, the development of ICT standards in construction has been slow and lacks general agreement. This is mainly due to the lack of dominant players resulting from the fragmentation of the industry.

In 2006 CITA carried out a survey among architectural and engineering practices as to the extent of use of the CITA CAD layering convention (Kenny, 2006). In excess of 40 responses were received from a total sample of 86 practices. At the time of the survey the uptake of the convention was relatively low with only 20% confirming their adoption of the standard. When asked about the barriers which undermined the adoption of the standard in the respondent's organisation, the following reasons were given.

- Lack of time to implement such a standard (30%).
- Uncertainty about how to measure the costs and benefits of such investments in time (18%).

- A general lack of awareness of the benefits that a CAD layering convention can bring to the Irish AEC industry (18%).
- Lack of promotion of the layering standard by professional bodies, clients, the government and state bodies (18%).
- Conventions are currently not yet reliable in design (15%).
- Employees are likely to resist the introduction of a CAD layering convention (12%).

Despite the clear presence of such barriers, 76% of construction professionals responding to this survey testified to being aware of the CITA CAD Layering standard. In order to further build upon this awareness, respondents were asked to rate a selection of strategies that CITA might adopt in order to gain a more widespread adoption of a CAD layering convention. The following strategies were identified, in order of preference:

- Work with professional bodies in promoting the convention.
- Promote the adoption of the convention by government and state bodies.
- Carry out a pilot study on a live project in order to review its performance and measure the business benefits of its application.
- A panel of experts should be appointed to review the CITA convention and report on its strengths and weaknesses.
- Instigate a CITA public relations programme to promote the convention.

This example of implementation of communication standards by CITA within the Irish construction industry is a useful lesson to further plans to implement other standards in the sector, such as e-procurement, e-tendering and Building Information Modelling (BIM).

5.0 CITAX PROJECT

An additional example involving the CITA eXchange (CITAX) project sought to verify that significant measurable economic benefits can be achieved by collaborating trading network members by the use of existing ICT standards in their business processes (DETE, 2006, West and Hore, 2007 and EC, 2007). The CITAX project focused on five module areas:

- Module 1 - Production and exchange of CAD drawings.
- Module 2 - Production and exchange of trading documentation, such as purchase orders, goods received notes and invoices.
- Module 3 - The pricing of tender documentation electronically and recommendation of a preferred tender for selection.
- Module 4 - The storage, retrieval and general dissemination of project information on construction projects.
- Module 5 - The use of CAD software in the production of bills of quantities.

Each module involved a Project Leader drawn from industry together with a cross section of companies from different disciplines, including the support of an academic institution. Figure 4 illustrates, at a high level, the methodology adopted in the

project. CITAX has a clearly structured plan, describing tasks, schedules and responsibilities for each of the module teams.

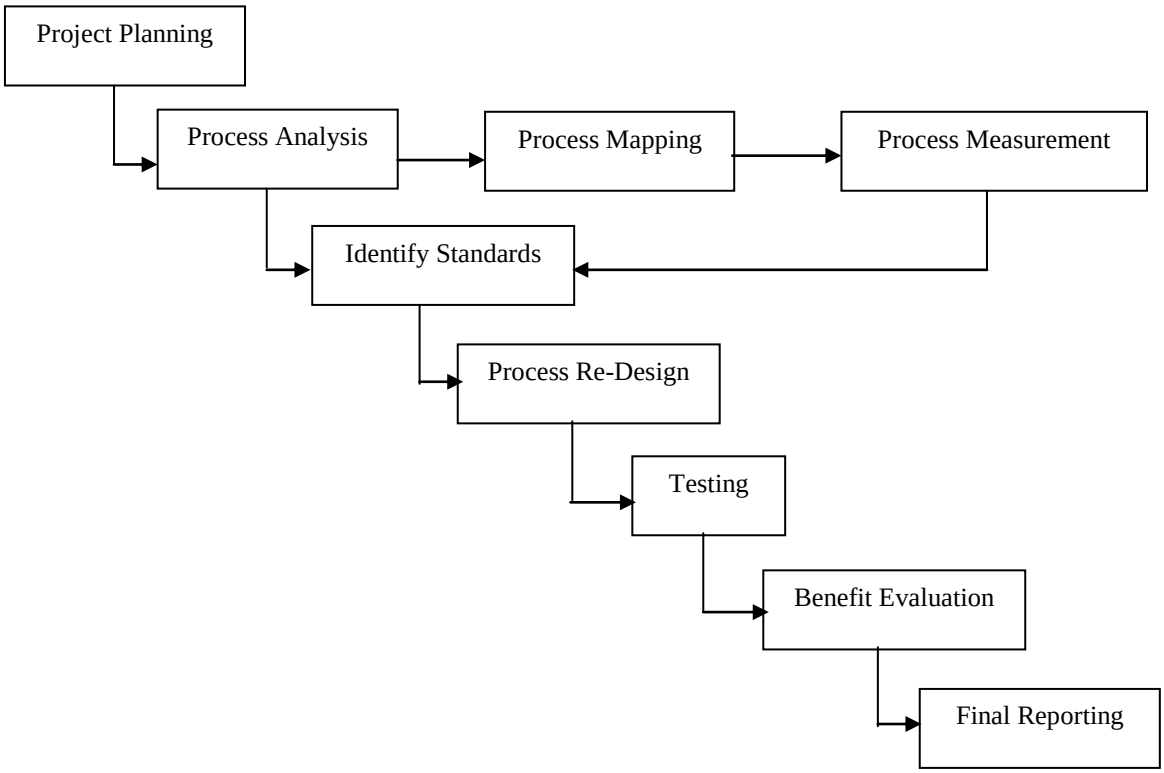

Figure 4 CITAX Methodology

An example of work on ICT standard implementation was carried out by the module 2 team investigating implementation of e-procurement, which focused on the following objectives:

1. Develop a universally acceptable XML standard for electronic exchange of purchase orders, delivery notes and supplier invoices.
2. Demonstrate, by participation in a live pilot project, that purchasing data transactions can be more efficiently exchanged between trading network members by the adoption of the XML standard.

One of the most significant challenges for the CITAX module 2 team was how to tailor-make a suitable XML standard that would be acceptable to the vast majority of players in the Irish construction sector, especially as many traders are small enterprises. For the adoption of a common XML standard to be widespread, it was important that the companies participating in the project would define and agree sets of message sets for each of the stages of the trading process.

The module team identified a number of messaging formats that needed to be agreed among the participating companies, with the intention of developing a CITAX XML Trading standard (see Table 1).

Message Type	Message Content
Order	Order messages are created by the contractor and sent to the supplier.
Order Confirmation	On receipt of an order from a contractor, it is created/saved on the supplier's system. Confirmation of the details recorded/received is transmitted back to the supplier. This can include out of stock notifications. This message can also be used to create an order on the contractor's system if it has not been recorded there previously.
Order Cancellation	Used to cancel an order that had previously been sent through from the contractor.
Shipping Notice	An Electronic Shipping Notice (eSN) is an advice from the supplier to the contractor listing the items that are to be delivered. It is effectively the supplier's dispatch note and is transmitted in advance of the delivery as soon as the dispatch details have been verified by the supplier.
POD	A POD (Proof of Delivery) is a document that lists items delivered together with the contractor's signature, captured electronically. It is the basis on which contractors can be invoiced for items delivered.
GRN	A GRN (Goods Received Note) is the contractor's equivalent of the POD, i.e. it shows from a contractor's perspective what was delivered to site.
Invoice	Document that charges the contractor for items delivered.
Credit Note	Document that credits the contractor account for items such as pricing corrections; credit for items not received; or credit for damaged items.

Table 1. CITAX Module 2 XML Message Formats

XML standards have been developed in several industries, such as business, retail and also the building and construction industry. For example, the Building and Construction XML (bcXML) (Toleman et al., 2001), Electronic Business XML (ebXML) (Lima et al., 2003) and Industry Foundation Classes XML (ifcXML) (Froese, 2003). These standards are essentially shared vocabularies and rules for defining the structure, content and meaning of similar XML documents. XML is extensible because each element of data is separately identified, all of the elements do not have to be present in the message, only the elements that are required by the message definition, the XML schema.

Having reviewed the standards available, the team chose to use as a base the BASDA eBuild XML standard. A variety of other standards were reviewed such as EDI and GS1 XML, but the eBuild XML standard is currently used widely in the UK construction industry, although there are a number of new messages that will have to be developed by CITA, particularly for PODs and GRNs. It has also become apparent that the proliferation of standards means that each organisation that trades electronically has to have a flexible system that caters for all of the other standards in the marketplace. The possibility of universal buy-in to one common XML schema, though difficult to achieve, has obvious advantages and is vital to successful industry-wide implementation.

To achieve this buy-in there needs to be a business impact of adopting XML technologies. For any company that shares information with its customers as a critical part of the value chain it delivers, the creation of a single source of information from which you can deliver all current and future messages will provide demonstrable benefits which can both increase revenue and decrease costs.

CITA have through a new eCommerce group which has facilitated dialogue between the Irish construction supply chain, which otherwise would not have been possible. The independence of CITA is important in allowing member confidence in the impartiality of advice and in facilitating this dialogue. The methodology currently adopted by the CITA eCommerce group to ensure buy-in includes:

1. Secure contractor and supplier commitment within the Irish construction supply chain.
2. Establish a steering group to manage the direction of eCommerce implementation.
3. Agree infrastructure for messaging formats and exchange mechanisms.
4. Initiate implementation programme with steering group members.
5. Prove business case in eCommerce among a wider supply chain.
6. Elicit support from industry bodies and lead construction businesses.
7. Rollout implementation across the industry.

The module team are currently organising the pilot or testing phase, engaging with software users and vendors. Presently there are two pilot projects underway that will adopt the eBuild XML standard. The unwillingness of some software vendors to interoperate with other software companies is a very significant hurdle that has to be overcome by the industry. Current clients of the software company see that they cannot achieve a comprehensive rollout of e-procurement with their suppliers because of this issue.

Preliminary findings from the project demonstrate that there are significant opportunities for increased efficiency and effectiveness in the industry. A strong business case has been made for ICT adoption, through:

1. Accelerating the industry adoption of CAD standards, electronic commerce, electronic tendering, electronic collaboration and computer aided measurement within the Irish construction industry.
2. Accelerating the industry adoption of product data standards sets that will support electronic commerce activity within the Irish construction industry.
3. Accelerating the adoption of interoperable building information model-based software through testing and demonstration.
4. Establishing methods that facilitate the harmonisation of existing building information modelling and bring consistency to the construction industry's efforts to integrate the supply chain with common information models.
5. Assisting the Irish construction industries in developing and implementing interoperability standards and work process improvements that reduce the life cycle time, costs and risks.

All modules have completed phases 1-5 and most are completing their benefit evaluation and are in the process of preparing their final report. There is one module team that is currently waiting for software availability to undertake its pilot, but it will complete its work in June. The project teams went beyond their original project scope to incorporate cost and time estimates for both existing processes and for the revised

processes that have been developed as part of the work of the project teams. These cost estimates strengthen the business case for adopting the output from the project teams, because they clearly demonstrate the savings and operational benefits that accrue from the revised processes. The teams are now working on their final reports that will document the work that they have undertaken which will include:

1. An introduction to each project.
2. Analysis of existing industry practice.
3. Estimated cost of current practice.
4. A revised process that eliminates the inefficiencies identified in current practice.
5. Estimated cost for the revised process and identification of the savings that are possible.
6. Details of the pilots that were undertaken to prove that the revised process works.
7. Recommendations from the teams.

6.0 STRATEGY FOR IMPLEMENTATION OF ICT COMMUNICATION STANDARDS IN IRELAND

Having demonstrated the business case for both contractors and suppliers to adopt ICT in their conversion to e-commerce practices, the key to success in implementing any ICT standards involves reaching cross-community agreement on a willingness to participate through:

1. A strong commitment from leading construction industry companies to collectively rather than individually take a lead and actively participate in the implementation.
2. Demonstration of the potential impact of ICT standards in
    - Creating a step-change in communication efficiency for all parties to the supply chain
    - Developing new or adoption of existing international standards
3. A willingness of suppliers to adopt the new XML standards for document exchange in their purchasing software and to invest in developing a supplier-specific product code database for ordering.
4. An openness of all major software vendors associated with participating contractors and suppliers to alter their software to accommodate the new XML standard. The work undertaken by the software vendors must be financed by the demonstrable efficiency gains of the contractors and suppliers on implementation of the new e-purchasing practices.

An example includes creating generic codes for products to which both suppliers and buyers would map their product codes. This would mean that buyers and suppliers would only have to map their codes once. Through CITA a wide platform has been created which has facilitated dialogue between these three parties, which otherwise would not have been possible. Therefore, the challenges facing the Irish construction include:

- develop tools, protocols and standards which are non-proprietary and which facilitate interaction between participants in the industry.

- define and promote standards in data communications.
- through piloting, measurement and demonstration, promote building information modelling across the industry.
- identify and design services and products which will enable the participants in the industry to work collaboratively through the supply chain in Ireland and internationally.

Despite these challenges, it is likely that the industry will begin adopting ICT standards in the short term, although it is recognised that it will take time to filter through the entire industry. The adoption of e-procurement by a sufficient threshold of parties is likely to catalyse others in the market because the use of e-procurement will be seen as a providing competitive edge, much as quality assurance schemes did in the 1990s.

7.0 CONCLUSION

There are some serious challenges facing the construction industry that are motivating new approaches to how one designs, builds, operates, and maintains buildings and infrastructure. While new ICT solutions are designed to address challenges in the construction industry, there is not an integrated approach to its implementation.

The aim of the CITAX project is to prove that the benefits of widespread ICT deployment within the construction sector will benefit all companies participating in electronic exchange and cooperation. The strength lies in involving both ICT providers and companies from both sides of the construction sector. The active involvement of companies from throughout the sector facilitate the dissemination of project results not only to those firms, but also among their suppliers, customers and partners, generating impact beyond the direct participants.

The advancement of data and information standards facilitates the knowledge development process which requires a group effort. The fragmented nature of the construction industry is a major impediment in this process. However, developing universal standards is essential for the construction industry. Any ICT standards must ensure collaboration and continuing commitment among the participants. The involvement of numerous stakeholders causes organisational problems, and imposes the need for consistent highlighting of the “win-win” outcome for the participants over and above any individual and conflicting interests. Effective management and administration of the ICT standard roll-out is also necessary for marketing and for spreading information, so that the standards becomes widely known and accepted in the industry.

The experience of working on the CITAX project identified a number of ingredients that must be present for successful diffusion of ICT standards in the construction industry. Developing an e-business policy initiative requires sectoral understanding and commitment that only industry can provide. A sectoral focus helps to create a critical mass as single firms are very limited in their ability to innovate without the cooperation and alignment of the wider construction community. The longer term objective of CITA is to develop a platform for the design, development and implementation of open standards that would be fully utilised within the Irish construction supply chain. This project has demonstrated what actions might be required to achieve this prize.

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