IT in transportation construction: opportunities and barriers to implementation

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Abstract

Information technology (IT) in construction has been one of the rather popular research topics in recent literature. IT innovations and possible applications in construction industry, as well as implementation strategies and barriers to successful implementation have been analyzed in detail. These studies, however, have generally focused on building construction environment, which limits the applicability of their findings to transportation construction. Transportation construction, the largest non-residential sector within the US construction industry, is fundamentally different than building construction in many aspects. Some of these major differences were analyzed with regards to the applicability of the current IT implementation study findings to transportation construction industry. In addition, possible IT benefits and barriers specific to transportation construction industry were also discussed.

Keywords: information technology, transportation construction, barriers to IT implementation

1 Introduction

We have witnessed the rapid technological improvements information technology (IT) in last two decades that has become an integral part of a number of industries and have led to redefinition of many business processes. The definition of the IT in the literature varies; yet, in this article it is referred to as innovative technological advancements that can influence existing business processes to improve organizational efficiency. IT has long been effectively used in service, retail, and manufacturing industries; however, the diffusion within the construction industry has been marginal. Researchers have shown great interest in the topic and identified more specific barriers to IT implementation (Bowden et al., 2006; Davis and Songer 2008; Ruikar et al., 2005; Peansupap and Walker, 2006); nature of the industry and the uniqueness of products (projects), lack of understanding the IT benefits and management support, substantial capital investment and recurring costs, and standardization issues associate with IT systems development.

Although researchers approached the implementation barriers from different perspectives; cultural resistance to technological change at the organizational level (Serafeidimis and Smithson, 2003; Gunasekaran et al., 2001; Ruikar et al., 2005), fragmentation of the industry (Boddy et al., 2007; Nitithamyong and Skibniewski, 2004; Bakis et al., 2007; Love et al., 2004; Andresen et al., 2000), and user resistance (Pean supap and Walker, 2006; Stewart and Mohamed, 2003; Davis and Songer, 2008) seem to be the more outstanding factors identified in recent literature.
2 What is missing?

In a recent article Hartman and Fischer (2009) directed some criticism to the approach taken to address user resistance, which is considered as one of the more significant factors preventing successful IT implementation. The authors argued, unlike the traditional view, that user resistance is not a hindrance to the successful IT implementation; but rather, a natural process associated with change, a framework proposed by change management researchers, and treating user resistance as a change process would be more beneficial than assessing it as an individual characteristics. The paper also delivers some synergies obtained from benchmarking the change management principles from other fields and/or industries to better handle the user resistance during IT implementation.

On a similar note, most of recent IT related research focused on the building construction domain which limits the implementation of their theoretical findings to diverse fields of practice. Few studies that have extended the research to other construction segments generally employed surveys to collect data rather than conducting objective business analyses whose reliability is susceptible as the accuracy of their results heavily depend on the participant demographics and attitude as well as the design of surveys and interpretation of researchers. Unfortunately, in construction research there are no clear benchmarks or guidelines to help the researchers in survey structuring and conducting to ensure objective and comprehensive data collection. Thus, we believe there is supporting information to conclude that the most of the IT related construction research used the building construction environment as the medium and characteristics of other segments were generally ignored.

Hence, this study will identify the fundamental differences between building construction and transportation construction in terms of their implications on IT adoption. These discussions will be followed by elaborating on possible IT benefits and transportation construction specific barriers to implementation based on current business characteristics of State Highway Agencies (SHAs) within the US.

3 Transportation construction basics

It should be noted that a healthy transportation infrastructure is crucial for the welfare of the roadway users. This puts substantial social responsibility on the research community to ensure the success of infrastructure maintenance and project completion. In addition, the sheer size of the industry along with continuous investment requirement for maintenance and operation also make the transportation industry a viable candidate for research efforts to improve the efficiency of the business practices. Transportation construction is the largest non-residential construction segment (Table 1) in the US.

<table>
<thead>
<tr>
<th>Type of construction</th>
<th>Value ($M)</th>
<th>Change from 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall total</td>
<td>910,767</td>
<td>-14.4</td>
</tr>
<tr>
<td>Total private</td>
<td>588,951</td>
<td>-21.9</td>
</tr>
<tr>
<td>Total public</td>
<td>321,816</td>
<td>3.8</td>
</tr>
<tr>
<td>Total residential</td>
<td>258,546</td>
<td>-22.9</td>
</tr>
<tr>
<td>Total non-residential</td>
<td>652,221</td>
<td>-10.5</td>
</tr>
<tr>
<td>Transportation</td>
<td>124,601</td>
<td>2.90</td>
</tr>
</tbody>
</table>

Transportation construction industry activities are composed of constructing and maintaining the transportation infrastructure, which is mainly composed of roads and bridges. The work is characterized as heavy equipment and material dependent, and unlike building construction, manual labor is not very critical. Because the performance of transportation structures is primarily dependent on the material properties, there is significant emphasis on material testing. Subsequently, quality control and assurance are upmost importance. Prequalification of suppliers, subcontractors as well as
contractors is a common practice. Transportation construction tasks are relative simple (except for high rise bridges and major interchanges), linear, and repetitive. Unit price based competitive bidding is the most common project delivery method (Jofre-Bonet and Pesendorfer, 2000). The design is generally completed by design firms; thus, design and construction activities are segregated; however due to repetitive and rather simple tasks, design-construction integration is not very significant. Compliance with the strict regulations set by highway agencies is mandatory to qualify to bid for transportation construction projects.

4 Differences between the transportation and building construction industries

4.1 Lack of Leadership and management support in IT implementation

One of the most significant differences between transportation construction and building construction is the ownership of the constructed facilities. In building construction, most of which is commercial and residential construction, developers who generally act as the owners throughout the construction later passes the ownership of the constructed structures to other third parties. On the other hand, the transportation construction is constructed for and owned by State Highway Agencies (SHAs) that act as the sole owner of the infrastructure. This might seem an insignificant and not relevant to IT implementation; however, due to lose owner/contractor relation dynamics, the IT adoption is generally approached from the contractor point of view who has limited interested in the project after completion, or even during construction provided their benefits are not diminished, mostly due to the current contractual agreements (London and Kenley, 2001). Moreover, the tight cash flow cycles coupled with relatively low profit margins reduce the opportunities for contractors to invest in IT investment to improve their competitiveness. On the other hand, SHAs have substantial interest in improving the efficiency of their supply chain, and financial and administrative flexibility to implement IT solutions among their business partners.

4.2 Fragmentation of the construction industry

A fragmented industry is defined as an industry in which no firm has significant market share and can strongly affect the industry trends and outcomes (Porter, 1980). A number of researchers identified the construction industry as a fragmented industry (Boddy et al., 2007; Nitithamyong and Skibniewski, 2004; Bakis et al., 2007; Love et al., 2004; Andresen et al., 2000), considering the size composition of the construction companies and the parties involved. Fragmentation is deemed to be a fundamental factor preventing successful IT implementation. However, it seems like there is confusion here as to what a fragmented industry actually is; as, fragmentation is generally referred to as scattered and segmented construction supply chain. Thus, IT implementation barriers are associated to technical difficulties caused by the company size composition of the industry. However, the term fragmented industry is very well defined in manufacturing industries in competitive strategy framework and is not necessarily attributable to the physical size of the companies. Within this fragmentation framework; transportation construction cannot be classified as fragmented because most of the construction is completed by SHAs and they have enough influence on the industry to affect the trends and outcomes. One of the more visible examples of such an instance is Electronic Data Interchange (EDI) systems implementation of Wal-Mart (Blanchard et al., 2008). The company had enough leverage over its suppliers, a concept introduced by Porter (1979), to mandate adaption of a rather innovative and expensive operate regardless of their IT maturity.

4.3 Uniqueness of the projects and adversarial contractual agreements

Construction projects are considered unique because project compositions, parties involved as well as their ever changing locations and environmental conditions; although project activities and supply
chain mechanics hardly differ from project to project. The ever changing project partners and activity locations create substantial technical issues in creating IT applications as well as cause problems in justifying the investment. Moreover the adversarial project based agreements are made to improve the profits of parties involved rather than improving the supply chain efficiency (Azambuja and O’Brien, 2009). The uniqueness of the projects is less emphasized in transportation construction. SHAs function within a state and the construction activities are generally completed by smaller units (i.e. district construction offices) within even smaller geographic regions (i.e. districts, counties). The work to be performed is relatively simple, repetitive and shows little variation in techniques or productivity rates. Moreover, due to heavy equipment and material requirements as well as the associated transportation costs, most of the work is completed by local firms. The qualification requirements as well as the rating systems used, each party involved in transportation construction activities is rated based on performance, help SHAs develop longer term partnerships with their sub(contractors) and suppliers when compared to their building construction counterparts.

4.4 Standardization issues

One of the major technical challenges in implementing IT results from lack of standards that will bring multiple parties to a common medium when addressing the business practices. Two of the more outstanding studies in building construction area are ISO10303 Industrial Automation Systems - Product Data Representation and Exchange (STEP) standards (www.steptools.com) developed by International Standards Organisation (ISO) and Industry Foundation Classes (IFC) standards developed (www.iai-tech.org) by International Alliance for Interoperability (IAI). The applicability of these standards to improve the current interoperability among project participants and issues faced in development are beyond the scope of this paper; yet, one of the problems to be addressed is to gain international acceptance from professionals in addition to creating valid standards (Drogemuller, 2009). In case of transportation construction, though, the business practices are quite similar across different SHAs because of the information diffusion and collaboration among them. Moreover, there are multiple national guidelines and standards set by national agencies to be used by SHAs. American Association of State Highway and Transportation Officials (AASHTO) standards and references for design and construction, and Manual on Uniform Traffic Control Devices (MUTCD) manual published by United States Department of Transportation (USDOT) Federal Highway Administration (FHWA) in Traffic Control Plan (TCP) design are two of the many national standards used in transportation construction. These national agencies take input from SHAs and other transportation agencies when developing their guidelines; increasing the acceptance rate of their standards. Furthermore, there have been a number of standards development projects undertaken recently; two of the most visible ones being; TransXML (www.transxml.org) and Data Interchange for Geotechnical and GeoEnvironmental Specialists (DIGGS) (www.diggsml.com). Each of these two projects have participants from industry as well as the highway agencies at the state and federal level; thus, the standards development reflect their input and ease the applications development process and improve the acceptance ratios by the industry.

5 Possible IT benefits in transportation construction industry

Perhaps one of the factors that generally is overlooked in terms of measuring the IT benefits is the lack of alignment between IT applications and conventional business practices. The rate of change in construction business practices with technology is substantially lower than what manufacturing industries enjoyed in recent years. Thus, most of the proposed IT benefits are generally limited to the improvement of data exchange and management methods (Gunesekaran et al., 2001; Dehlin and Olofsson, 2008; Pena-Mora et al., 1999). Some of the benefits associated with improved administrative data processing are; improved efficiency and increased cost saving by reducing the
administrative efforts for document processing, improved delivery time by shortening the processing cycle, minimized user interference and improved data accuracy, reduced waste by streamlining business cycle and reduced/eliminated data rekeying, and improved collaboration and supply chain integrity through integrated data management. These immediate benefits might not seem very important; however, there is substantial documentation in transportation construction due to separated design and construction phases and social and judicial responsibilities of the highway agencies. Moreover, some of the other IT benefits, design-construction integration, improved productivity through accelerated contract delivery, are either not as substantial or feasible because of transportation construction relations. The more specific benefits will be realized in areas of quality and cost control, and improved organizational and supply chain integrity. Quality control and assurance and cost control are crucial for success of a transportation construction program. Data integration from field to databases using data interchange methods (EDI, XML, e-commerce tools) have the potential to improve the traditional practices which are slow and inefficient. More importantly the IT tools can be used to improve the intra-organizational and inter-organizational interoperability. The SHAs function as multi party conglomerates, whose lower branches conduct actual construction while the central offices perform administrative duties. The integrity among these units as well as with third parties involved in construction activities is crucial in managing construction programs.

6 Implementation issues in transportation construction

Most of the contractors working with SHAs have little flexibility in their cash flows and little incentive to invest in IT systems due to their traditional approach to the business. As mentioned earlier the SHAs have leverage to require that IT systems be implemented. i.e. electronic bidding is more common in transportation construction industry because it is the only form of submitting a bid. However, IT awareness must be created among contractors in order to ease the transition to using IT and eliminate possible user resistance. Moreover, SHAs must provide additional resources, either in terms of financial flexibility or managerial support for training during earlier phases of IT implementation. Another important barrier to be overcome, substantial amount of data to be exchanged, is what makes IT necessity for an efficient and integral supply chain. In addition to certain technical issues associated with the volume of data to be exchanged, the data is generally exchanged in certain formats, which are hardly the most efficient methods and are not easily changed due to the heavy bureaucracy involved in decision making. Perhaps the most difficult challenge is to overcome possible operational cultural resistance within SHAs. Managerial acceptance and support within the organization is crucial as, SHAs are positioned to be the initiators of the IT implementation.

7 Conclusion

Transportation construction is substantially different from building construction segment in terms of the work characteristics as well as the supply chain relations. These fundamental differences were generally ignored in recent IT research, which limited applicability of their findings to transportation construction. Some of the major differences between the US transportation construction segment and building construction, from which most of the IT related research was devised, were discussed and their implications in IT implementation were underlined. The analysis indicated that most of the IT implementation problems valid for vertical construction are either not relevant or less emphasized for transportation segment. Moreover, some of the highly praised benefits of IT implementation in building construction, such as design-construction integration, may not be as crucial due to difference in transportation construction business practices.
8 Recommendations

Perhaps a more in depth study of transportation construction industry built around a case study may shed some more light on the best practices to create IT awareness and to provide implementation guidelines. Benchmarking successful IT applications in different industries while keeping the construction specific characteristics in perspective may also be useful in addressing IT implementation issues. Note that the differences within construction industry should be within strategic management of IT perspective; fragmentation, competitor analysis and industry life cycle analysis are some of the important areas to be considered. Although it is necessary to have guidelines in IT implementation, generic frameworks developed within a specific area of construction with no consideration to strategic implications of the business characteristics have little meaning in actual implementation due to the diversity that exists in construction.

References


