State of the Construction Information Technology Development Industry in Canada

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ABSTRACT: This paper studies the state of companies that develop information technology (IT) for the construction industry in Canada. The study collects survey results and other data about these companies. It explores the number and nature of companies, their products and markets, and their opinions about IT trends, opportunities and barriers, and collaboration with government and university resources. The study concludes that a small construction IT industry exists in Canada with some established, successful companies and a number of younger ventures.

1 INTRODUCTION

Various survey and research projects in the field of information technology (IT) for the architecture, engineering and construction and facilities management (AEC/FM) industry have been done worldwide in the past few years. Such surveys were conducted in New Zealand (Doherty 1997; Joo Ting 2000); United Kingdom (Amor 1998; Ingirige et al. 2001); Denmark, Finland and Sweden (Howard et al. 1998; Samuelson 2002); Hong Kong (Futcher 2001; Futcher and Rowlinson 1999); Saudi Arabia (O'Brien and AL-Biqami 1999); South Africa (Arif and Karam 2001); Malaysia (Mui et al. 2002); and recently in China (Xiang et al. 2004) and Turkey (Sarshar and Isikdag 2004).

In the United States, a survey of E-business implementation in the construction industry was conducted in 2003 (Issa et al. 2003); moreover, the American Construction Financial Management Association conducts a regular IT survey for the construction industry every two years (CFMA 2004). Most of the above studies focus on computer usage or impact of IT on the AEC/FM industry or related trades. These studies significantly benefit both users and suppliers of IT products and service; however, surveys that focus on the developers of IT (rather than the users) in this area are rare.

In Canada, many parties have an interest in the field of information technology for the AEC/FM industry. Rivard (Rivard 2000) carried out a survey on the impact of information technology in the Canadian AEC industry in 1998-1999. Another survey of innovation, advanced technologies and practices, including IT application, in the construction and re-

lated industries was conducted by Statistics Canada and National Research Council of Canada in 1999 (Anderson and Schaan 2001). A recent survey result of IT applications in construction was presented by the University of Alberta (El-Ghandour and Al-Hussein 2004). A significant amount of research was carried out in this field in the Department of Civil Engineering at the University of British Columbia (UBC). Froese (Froese 2001; Waugh et al. 1996) analyzed the future trends in information technologies for project management. Similar to the international construction IT surveys, those in Canada have focused on IT usage or on IT research and trends. There is very little data upon which to assess the actual current state of the IT development segment of the Canadian construction industry.

This paper is the result of a collaborative research project, "A Study of Information Technology Development for the Canadian Construction Industry", which was sponsored by the Industry Research Assistance Program (IRAP) of National Research Council of Canada (NRCC) and carried out by the Civil Engineering Department of UBC in 2004. Both of these groups pursue a mandate of supporting the Canadian construction industry with a particular focus on technology development in general and IT in particular. Both have been involved in many close collaborations with Canadian construction IT development firms in the past. Yet neither group had any objective information about this industry segment as a whole.

The objective of this project, then, was to survey the state of the IT development sector within the Canadian construction industry. The following questions illustrate the type of information being sought:

- What are the primary categories of construction IT development in Canada?
- What are the approximate number and size of construction IT development companies in Canada?
- What is the general level of technology for Canadian construction IT developers?
- How does this level of technology compare with the level of technology currently in use within Canadian construction companies?
- What is the relative market share for Canadian companies nationally and internationally?
- How does the level of technology of Canadian developers compare with international leaders in the respective fields?

The project was launched in August of 2003. Pre-research and other preparation for the project was completed at the end of 2003 and the project was officially launched in the early part of the year 2004. The project involved an examination of Canadian companies involved in the development of IT products for the construction industry, including the identification of such companies, investigation through web sites and other public information sources, and an on-line survey of the executives and managers of these companies.

2 STUDY METHODOLOGY

2.1 *Overall Project*

The research project consists of four phases:
- *Phase one:* Identify, catalogue, and categorize as many Canadian organizations as possible involved in the development of IT products, IT research and development, offering of IT-based services, development or promotion of IT standards, etc., relating to the AEC/FM industries and identify key trend setting IT-related organizations or initiatives internationally.
- *Phase two:* Develop a questionnaire for data collection from targeted organizations. This task defined the information that needed to be gathered from a selected set of the identified organizations and constructed an appropriate survey tool, such as a project website, for collecting this information.
- *Phase three:* Carry out data collection. The survey designed in Phase two was carried out in this stage.
- *Phase four:* Data analysis and reporting.

2.2 *Sample Population*

The task of sample collecting was to identify, catalogue, and categorize Canadian organizations that are involved in the development of IT products related to the AEC/FM industries. The sample selection criteria were as follows:
- Companies that are located in Canada,
- Companies that develop IT products as part or all of their business activity,
- Companies whose IT products are marketed within the AEC/FM industry, either as stand-alone products or as an integral part of a service offering.

The initial survey sample information was acquired through the Strategis online database of Canadian companies from Industry Canada (Industry Canada 2004), supplemented by additional sources such as information provided by IRAP staff. The initial search identified 362 potential candidate companies that identified their focus as both IT and construction (a database was established to track information about the target companies). Among these selected companies, 258 companies were IT-based firms and organizations, while 104 companies belonged to construction-related businesses. The figures represent 4.8% of the 5402 IT-based companies, and 5.2% of the 1988 construction firms that were listed in the Strategis database. Next, the web site of each of the companies was investigated to further evaluate their fit within the target scope, leaving 178 samples. Later, a further review by the IRAP and UBC team further refined the list to excluded companies that did not appear to be within the specific target scope of this study, leaving 86 companies. This figure suggests that 1.1% of IT-based and 1.4% of construction-related companies are involved in the development and selling of IT products to the construction industry in Canada.

3 SURVEY FINDINGS

3.1 *Respondents Profiles and Company Information*

3.1.1 *Response Rate*

Survey return rates vary around the world. Most mail surveys in the construction industry hover around 10%. The rate was 7% for the general survey in New Zealand (Doherty 1997); 10% in Denmark and 16% in Sweden (Howard et al. 1998); 10% in Saudi Arabia (O'Brien and AL-Biqami 1999); and recently, 10.5% in China (Xiang et al. 2004). The number of responses for this survey was 38, of which 33 were complete and valid responses, corresponding to total and valid response rates of 44% and 38% respectively. With a relatively low population sample, this survey will have a high margin of error. In general, survey research cannot be considered statistically significant with anything less than a 50% return rate. However, even though a low response rate was obtained, when combined with the Internet research and several follow-up conversa-

tions with some of the companies (email exchanges, personal interviews and telephone conversations), the findings of the survey are still thought to present useful information about the respondents and show tendencies in the development of IT for the Canadian construction industry.

Of the responses, 34% were from Ontario, 27% from BC, 24%% from Alberta, 9% from Quebec, and 3% each from Saskatchewan and New Brunswick.

3.1.2 Company Type Regarding Head Office and Branch Office

Among the respondents, over 90% were from head offices of Canadian companies, while 7% were branch offices of Canada-based firms and only 3% were branch offices of non-Canadian companies. Also, about 90% of respondents held senior management positions (e.g., owner, president, or CEO), while the balance included IT managers, marketing managers and/or chief representatives.

3.1.3 Company Size

Table 1 lists the size of the respondent companies. The companies were generally small to medium-sized (the only large companies were large engineering companies that included IT as a minor part of their product and service offerings). Table 2 shows what portion of their business activities are related to construction IT.

Table 1. Number of Employees

Response	Percentage
0 to 4	21%
5 to 9	12%
10 to 24	34%
24 to 50	12%
51 to 100	3%
Greater than 100	12%
No response	6%

Table 2. Percentage of business relating to construction IT products

Response	Percentage
100% of business	37%
51-99% of business	18%
10-50% of business	24%
0-9% of business	15%
No response	6%

3.1.4 External Resources Used

The last question of Section 1 asked about the external resources employed by the companies in the development of IT solutions. Government technology assistance programs and research and development tax credit programs were each used by about one third of the companies. 18% of the companies used venture capital, while 12% reported that they have not used any significant external resources.

3.1.5 Companies with WebPages

In conducting the study, it was found that 100% of the respondents were found to have their own e-mail addresses and as well as a home page on the World Wide Web. The proportion of companies with their own web site was 38% for the Canadian construction industry in 1999 (Rivard 2000) and 81% across the overall United States construction industry in the year 2004 (CFMA 2004).

3.2 Product and Market Information

In this section of the questionnaire, up to three major products could be detailed in the response form. Only one fourth of the firms reported more than one major product. Some firms indicated that additional products were being developed.

3.2.1 Product Category

Question 2.2 evaluated the types of products developed in the surveyed companies. As shown in Table 3, planning and scheduling, project team communication and collaboration, and project estimating top the product category list. Of the companies that responded with "Other", most described their systems as a combination and/or variation of the described the other categories (particularly those relating to collaboration).

Table 3. Product category

Response	Percentage
Planning scheduling	35%
CAD, 3D models, visualization, and GIS to support construction	16%
Project estimating	26%
Project team communication and collaboration	28%
Project procurement and bidding	14%
Project performance monitoring and control	16%
General business application areas	14%
Economic and risk analysis	2%
Planning and design of construction operations	2%
Coordinating construction operations	12%
Cost/schedule/productivity analysis	14%
Planning, controlling, and advising, for quality, safety, and environmental	9%
Field automation and robotics	2%
Advisor systems for construction methods	2%
Other	16%

3.2.2 Implementation Technology

Question 2.3 asked about the implementation technologies used to implement the products. About half (49%) of the respondents used web-based systems as their implementation technology, followed closely (47%) by "stand-alone" desktop PC applications. "Add-on" tools for CAD, Spreadsheets, databases, etc., and embedded IT (i.e., software embedded into other devices such as tools, buildings products, etc.) each represented a small proportion of the responses.

3.2.3 Product Overall Technology Level

Question 2.4 asked respondents to assess their products' overall level of technology relative to a technology evolution life-cycle. 16% described their products as emerging technology (pre-commercial or limited early-adopter users). The largest group (59%) reported that their products are at the level of early-adopter technology, which we defined as technology that is currently in use by industry leaders and is comparable to the "best-of-breed" products available in its class available anywhere in the world. About one fifth described their products as mainstream technology level. While this self-assessment can be expected to reflect bias towards an over-assessment of respondents' own level of technology, it shows a strong emphasis on new and innovative solutions rather than well-established, mature (legacy) product lines.

3.2.4 Primary Competitive Advantages

Question 2.5 asked about the primary competitive advantages of the products. The comment-based responses were summarized into the categories shown in Table 4.

Table 4. Types of Competitive Advantages

Response	Percentage
Features/Technology	42%
Ease of Use	24%
Price/Value	24%
Strategic relationships/tie ins with other products and services	21%
Integration/compatibility issues	18%
Specialized knowledge/expertise	18%
First to market	12%
Ability to customize	9%
Established reputation	9%

3.2.5 Critical Strategic Partnerships

Companies reported on strategic partnerships that were critical to their products. Of these, customized links with other products or services were the most frequently cited (35%). Companies also identified reliance on platform software (19%), Outsourced software development (9%), and research collaboration (7%). Others (16%) include cooperation with international developers, marketing partnership with third parties, and marketing alliance with Construction Specification Canada.

3.2.6 Primary Intended Product Users

Many of the respondents reported that their products were aimed at more than one target user group. The highest number of responses related to the three primary parties to construction projects: contractors (head office) (51%), engineers (47%), owners (42%), and architects (42%). All of the other user groups, however, were also frequently identified. In terms industry segment, commercial and institu-

tional building construction was the most highly targets segment (54%), but again, all of the segments were frequently identifies as targets with the exception of the renovation/do-it-yourself segment, which was identified by only 19% of respondents.

These results suggest that no single user group represents a dominant market target for the developers. Rather, they are pursuing users from across the range of project professionals. This is consistent with the emphasis placed on collaboration and integration issues by many of the products, which implies that the products are useful for users from across the project teams.

Developers are strongly focused on international (56%) or, to a lesser extent, North American (28%) markets. It seems that developers believe this Construction IT is truly a global industry; that their products have the potential to compete internationally; and that this international market is necessary for their commercial success.

3.2.7 Estimated Product User Number and Targeted Market

Table 5 shows how respondents reported the number of users for their products. While there were several products in each category (including several with more than 10,000 claimed users), most reported less than 100 users. Respondents' estimate of their current market share is shown in Table 6. Of the figures provided (40% did not provide an estimate), most again indicated a small market share (37% estimate their market share at less than 10%).

Table 5. Estimated Product User Number

Response	Percentage
Less than 100	42%
100 to 1,000	14%
1,000 to 10,000	23%
More than 10,000	19%
No answer	2%

Table 6. Current share of target market

Response	Percentage
Less than 10% market share	37%
10% to49% market share	14%
50% to 99%	7%
100%	2%
No answer	40%

The consequences of these two results, particularly combined with the previous results indicating the small size of the development companies and the focus on international markets, suggest that a large percentage of the products are in very early commercialization stages. In an industry with a traditionally high failure rate, it must be assumed that a significant portion of these products will ultimately fail to reach long-term commercial success. Still, the results also show that successes are possible.

3.3 Opinions on Construction Information Technology

3.3.1 The Level of Technology of Canadian Construction IT Developers

Respondents were asked to assess the level of technology within Canadian Construction IT developers compared with the rest of the world. The results show some differences in opinion. Forty percent of the respondents believe that Canadian construction IT developers' technology level is as good as or better than the world-wide industry leaders, 27% rates the Canadian developers as similar to other advanced countries, and 33% thought that the Canadian developers were somewhat behind many other advanced countries.

Overall, then, there is support for both the proposition that Canadians believe they can compete with the best in the world in construction IT, and the proposition that Canadian's feel somewhat behind the world leaders in this area. It may be that Canadian's believe the capabilities of individual people and companies are as good as any, but that Canadians may lag behind in construction IT as an overall industry, or in terms of the level of technology of the Canadian marketplace relative to other leading countries.

3.3.2 Important Trends for the Construction IT

Respondents were asked to describe the IT trends that they think will be important for the construction industry over the next 10 years (Table 7). The strongest response (67%) was for Web-based collaboration and project management systems. The categories of software integration and knowledge management, which could be related to web-based collaboration) also received strong support. The other category that also received a significant number of responses was 3D CAD and visualization. These responses indicate a strong belief in the importance of the various collaboration technologies that are still emerging.

Table 7. Important trends for the construction IT

Response	Percentage
3D CAD and visualization	33%
Web-based collaboration an project management systems	67%
Integration of software tools across the project lifecycle	43%
Artificial intelligence, expert systems, etc.	17%
Knowledge management	40%
Other	7%
No answer	3%

3.3.3 Opportunities for Improvement

In the first of four open-end questions, respondents were asked what they thought were the biggest issues in the Canadian construction industry that could be improved through IT solutions. The responses were grouped into categories and subcategories as listed in Table 8 (responses may have identified more

than one category or subcategory). Again, the most frequently identified issues related to collaboration (including communications, document management, and interoperability). There were also several responses that identified issues relating to efficiency and productivity, as well as comments about project management systems (project control, estimating, etc.). Other topics were raised but were only mentioned once (3% corresponds to a single response).

Table 8. Opportunities for Improvement to Canadian Construction Industry

Opportunities for Improvement Categories and - Subcategories	Percentage Category	Subcategory
Collaboration	33%	
- Collaboration/communication		27%
- Document management		15%
- Interoperability		3%
Efficiency/Productivity	18%	
Project Management Systems	12%	
- Project control/management systems		9%
- Estimating		3%
Embedding new construction expertise in design	3%	
Simplified systems for small contractors	3%	
Training	3%	

3.3.4 Barriers for Development

The second open-ended question asks about the biggest issues and barriers that cause difficulties for Canadian companies developing IT solutions for the construction industry. Most of the respondents believe that the biggest barriers relate to the acceptance of new technologies by the industry. The second largest category related to the financial issues for IT development (some responses related to both of these categories). Table 9 summaries the responses.

Table 9. Barriers for Construction IT Developers

Barriers for IT Developers Categories and - Subcategories	Percentage Category	Subcategory
Industry acceptance	58%	
- Resistance to change		27%
- Awareness/understanding of technologies/opportunities		18%
- Reluctance to invest in IT systems		9%
- Reluctance to invest in R&D		9%
- Lack of "trail blazers"		3%
- Limited computer use in field		3%
Financial barriers	30%	
- Reluctance to invest in IT systems		9%
- Reluctance to invest in R&D		9%
- Cost of accessing markets		6%
- Cost of development		3%
- Cost of senior resources		3%
- Availability of investment capital		3%
Market barriers	9%	
- Small Canadian Market		6%
- Marketing Support		3%
Resources barriers	6%	
- Cost of senior resources		3%
- Loss of programmers to US		3%
Technical barriers	3%	
- Wireless access		3%

3.3.5 Government Support

The third open-ended question asked how government support programs could better support businesses (summarized in Table 10). The most common topic related to providing some form of leadership in developing the market for new construction IT, followed by responses calling for various forms of financial assistance (tax related, R&D support, etc.). A number of the responses made a point of stating that the companies had no need of government support programs.

Table 10. Government Support

Opportunities for gov. support Categories and - Subcategories	Percentage *Category* *Subcategory*
Leadership in Market Development	33%
- Leading by example	*9%*
- Industry Education/providing information	*15%*
- Encouraging change	*6%*
- Trade missions	*3%*
Financial (Taxation, R&D support programs, etc.)	21%
None	12%

3.3.6 University Collaboration

The final open-ended question inquired about opportunities the respondents perceive for potential collaboration with University researchers and students. A wide range of responses were given (summarized in Table 11). The largest category related to various ways of utilizing university-based expertise (relating to both technology and marketing). Other responses commented on the role of universities in training students and industry practitioners. Several responses also discussed what IT developers have to offer to University programs, e.g., bringing industry experience to students.

Table 11. Opportunities for University Collaboration

Opportunities for Univ. Collaboration Categories and - Subcategories	Percentage *Category* *Subcategory*
Expertise	36%
- Development of/collaboration on technical components or standards	*18%*
- Assessment of developers' products	*9%*
- "Pure" research	*6%*
- Analysis of trends and markets	*6%*
- Marketing support	*6%*
Training	12%
- Use solutions in training students	*9%*
- Training	*3%*
Providing Co-op programmers	3%
Developers providing experience/expertise to students	9%

4 ANALYSIS

This section presents subjective interpretation of the survey results. It first considers the status of the Canadian construction IT industry, as suggested by the results. Next, it outlines the main issues raised by the survey responses. Finally it suggests the potential role of government that might be implied by the findings.

4.1 Status of the Construction IT Industry

Based on our analysis, the following conclusions can be drawn regarding the state of the construction IT industry in Canada:

– The number of Canadian companies competing in the relatively mature areas of construction IT (e.g., Stand-alone analysis applications) is very small. These companies should be considered on an individual basis, but as a group they do not appear to have the potential to make a significant impact on the field of construction IT.

– A larger number of Canadian companies are competing in newer areas of construction IT, most notably Internet-related systems. Although the number of companies is still small, this could justifiably be described as an industry "cluster". The characteristics of this cluster are typical of an emerging industry; they are mostly small, entrepreneurial ventures. Some have already achieved a degree of success and market leadership, but most are in the early phases of the corporate lifecycle (and a high attrition rate may be expected over the long term). As a group, this cluster could not be described as having made a significant impact on the overall construction IT landscape and it is behind similar clusters in other countries (an international comparison is discussed later in this section). However, the potential for impact and success exists as this cluster seems to be well positioned in terms of both market and technology. As a whole, the technology for this category of systems is well-proven and is in everyday use in industry, yet the technology and its applications are still evolving and have yet to be adopted by the majority of industry.

– There is no significant group of companies pursuing construction IT relating to emerging technologies such as integration and interoperability. A commercial market for this technology may not exist at this time, but this may well be an emerging technology segment in the future.

4.2 Issues for the Canadian Construction IT Industry

This section summarizes key issues facing the Canadian construction IT industry.

4.2.1 Technology

The survey results gave no indication that Canadian construction IT industry faces any particular tech-

nology-related challenges. Within the young but proven IT areas such as internet-based applications, there appears to be no reason that Canadian companies cannot compete technically with any international competitors. However, there was also no information to suggest that Canadian companies are leaders in IT (see international comparisons).

4.2.2 *Financial Resources*

While it did not appear to be an overwhelming issue, financial issues where mentioned by almost a third of the respondents as a barrier to IT development. These related to both the willingness of the industry to invest in IT (addressed further in the market issues section following), investment in R&D, and the cost of development. These issues may be reflective mainly of the early venture phase of many of the respondent companies.

4.2.3 *Market Issues*

The most significant issues identified by respondents as facing the construction IT industry related to their market—in particular, over half of the respondents described weak industry acceptance and resistance to change as key barriers. Respondents described this issue in a number of ways: resistance to change; awareness/understanding of technologies/ opportunities; reluctance to invest in IT systems or in R&D; and lack of "trail blazers". One possible explanation for industry reluctance, of course, is simply that the offerings are not sufficiently of value to the construction industry. However, the degree of adoption to date suggests that the overall uptake of these technologies is probably following similar trends to previous IT such as CAD, scheduling software, etc., as the technology slowly matures and establishes itself as an essential tool. While it may be typical for such technology, the challenge of market development (establishing a clear understanding and desire for the technology within the industry) is clearly a major issue for many of the companies in the construction IT cluster.

4.2.4 *International Comparisons*

Approximately two-thirds of respondents felt that Canadian expertise was at least as good as other advanced countries. No data was collected during this study to objectively compare Canada's construction IT industry with other countries. However, this section provides a brief comparison of our understanding of the state of construction IT in Canada, as suggested by this study and other information, with our knowledge of construction IT in certain other countries. We share the respondents perception that, within their target areas of activity, the Canadian construction IT companies appear to be generally on par with activities in other countries. The level of adoption by industry of this IT appears to be somewhat lower than might be expected in several other countries.

In more advanced areas of construction IT (e.g., the technology such as the use of building information models) Canadian companies and researchers are contributing but are under-represented relative to several other countries. In particular, a number of other countries have embarked on significant initiatives specifically targeted at improving construction IT (or at improving the effectiveness of construction as a whole with IT as a significant component). Common characteristics of these initiatives include the following:

- The initiatives involve participation from most or all of: individual construction and IT companies, industry organizations, research organizations and universities, government bodies, and public R&D funding agencies. The initiatives are being lead by government, research organizations, or industry organizations.

- Knowledge of the initiatives is widespread in industry.

- Some commercial development based on the technology, pilot projects, and some innovative uptake of the technology by industry is underway. Mainstream use of the technology is not yet occurring.

Countries that are known to have such initiatives include Australia, Finland, Japan, Norway, Singapore, Sweden, the UK, and the USA. No similar initiatives are known to be underway within Canada.

4.2.5 *Community of Practice*

The most significant issue facing the Canadian construction IT cluster may be market development, but it is very difficult for the individual small construction IT companies to foster widespread change throughout the industry. Perhaps the most notable difference between Canada and the leading construction IT countries is the existence of definable communities of practice for construction IT, which do not appear to exist within Canada. Some of the typical characteristics of these communities of practice in other countries are as follows:

- Organizations and individuals with a particular interest in advancing construction IT exist in construction and IT companies, industry organizations, research organizations and universities, and government bodies (both as construction clients and R&D agencies).

- These members are generally aware of each other as having common interests.

- One or more organizations play a centralized, leadership role in providing some form of organization for this group.

- There is a degree of clarity of vision regarding future goals and objectives.
- There are effective forms of communication and regular interaction among the groups members (e.g., regular technology seminars).
- There are various collaborative activities that cross segmental boundaries (e.g., pilot projects involving research organizations, industry, and government).
- There are some degree of common resources (e.g., targeted government industrial R&D funding programs).

4.3 *Possible Roles for Government*

The results from this study suggest that existing governmental programs such as the Industrial Research Assistance Program (IRAP) are well-received by the construction IT companies. Based on the previous analysis, government could provide leadership and support in two key areas: market development activities and the development of communities of practice in construction IT. Both of these activities should be considered from the perspective of improving the overall Canadian construction industry in addition to the Canadian construction IT sector in particular.

5 CONCLUSIONS

The overall conclusion is that a Canadian construction IT cluster exists. It has some good and successful companies, but is very small. Under present conditions, it might be expected that a small number of companies will continue to emerge and develop to a level of some success. However, these will develop as isolated individual companies rather than as an industry segment as a whole (i.e., there will be minimal synergy among the technical and market development efforts). Furthermore, their overall impact on the Canadian construction industry will be low. At this rate, Canadian construction IT is likely to be in a class below the leading countries in this field.

There appears to be enough activity in the newer areas of construction IT, with no major structural barriers, that the potential exists for a more significant construction IT sector on par with world leading countries. This would likely require the types of communities of practice for construction IT that exist in some other countries.

6 ACKNOWLEDGEMENTS

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