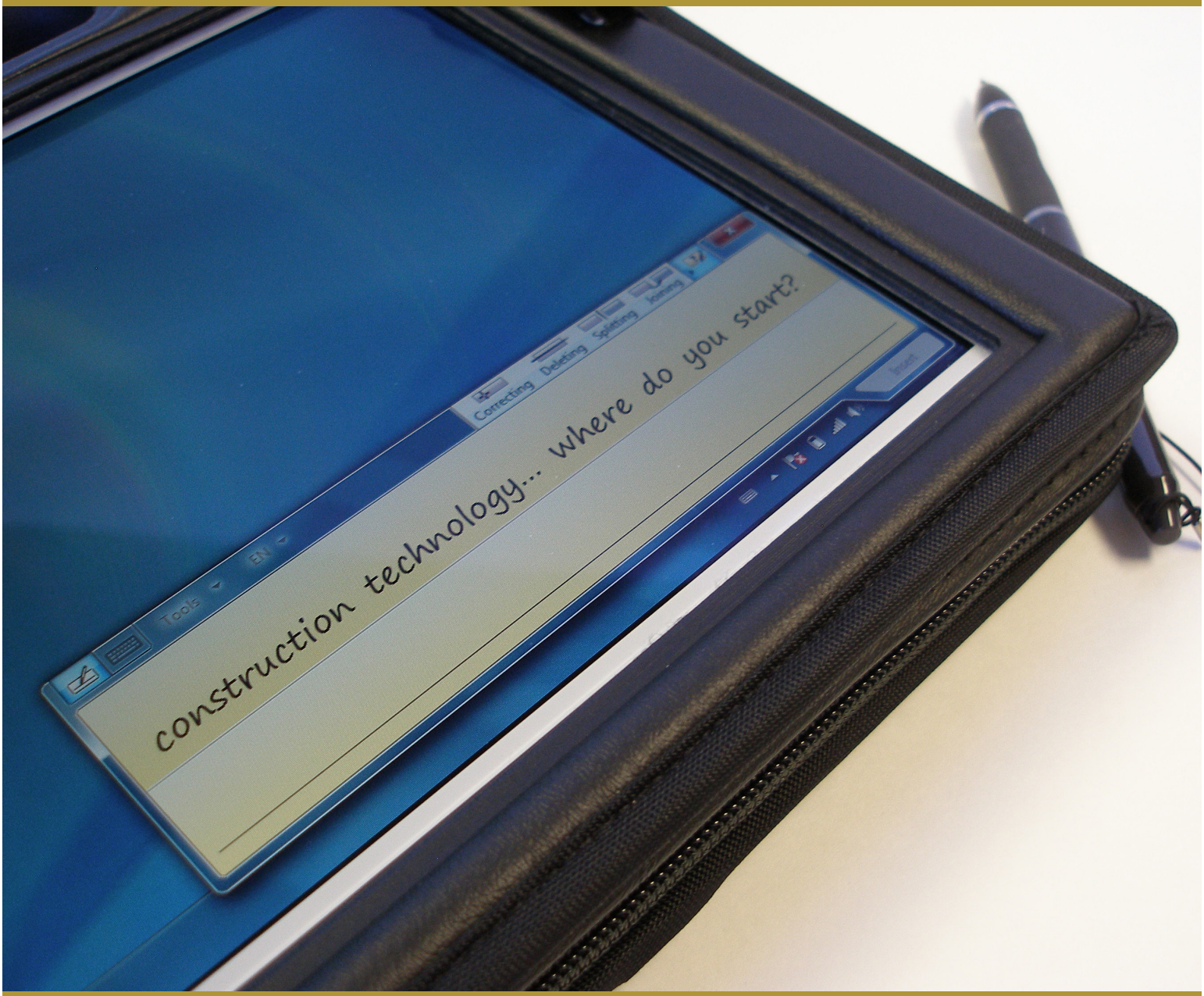
Functional Information

# TECHNOLOGY Phase 1

## Overview Report




Nova Scotia Construction Sector Council
Industrial-Commercial-Institutional

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Industrial-Commercial-Institutional

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Nova Scotia Construction Sector Council
Industrial - Commercial - Institutional

# Executive Summary

This report contains the results of a study for the Nova Scotia Construction Sector Council – Industrial-Commercial-Institutional (NSCSC-ICI) under the project entitled "Functional Information Technology (FIT) Project." **The study is separated into two parts: Part I is intended as an overview of the study; Part II contains all details of the analyses undertaken.**

The University of New Brunswick Construction Engineering and Management Group completed this first phase of the FIT Project over the period of September 2009 – February 2010. The general purpose of the study was to examine the information and communication technology needs of on-site managers in the construction industry, develop an implementation guide and suggest technologies that should be pursued for piloting. The study was completed by:

1. Conducting a review of the current state of information and communication technologies in the construction industry.

2. Completing a process analysis of on-site management tasks.

3. Assessing the capacity of the industry in terms of adoption and implementation of new technologies.

The first step was to establish a scope of technologies to be examined. A review of current activity in the adoption and implementation of information and communication technologies (ICT) was completed. The most prominent international efforts are summarized, and a general technology framework established. The highlight of this step recognizes that the primary issue is one of adoption and implementation versus the availability of technologies. The next step was to identify a representative group of organizations with which to conduct a detailed process analysis and complete an assessment of capacity. The process analysis was completed with face-to-face data collection interviews with representatives from the organizations. Senior representatives from the organizations were surveyed to complete the assessment of capacity.

To accelerate the adoption and implementation of appropriate information and communication technology in the construction industry, the NSCSC-ICI should consider the following recommendations:

1. Address the need to overcome the perceived ICT implementation barriers of cost and technical expertise by providing opportunities for organizations to participate in **pilot technology adoption and implementation projects**, and facilitate the **capture of best practices**.

2. Identify participants and pursue piloting activities with a structured approach for technologies that support **safety management processes**, with consideration given to **change management processes**.

3. Address the need to bring a better understanding of the overall importance of the information management function to an organization, by developing support in the form of **training** on the topic of **information management in construction**.

4. Address the identified lack of formal processes by **re-examining training** that supports **performance management** (for productivity) and **worksite management** (for materials and equipments).

# 1 Introduction

The Nova Scotia Construction Sector Council – Industrial-Commercial-Institutional (NSCSC-ICI) initiated a project entitled Functional Information Technology (FIT) Project to "examine the information technology needs of the foreman/supervisor and develop an Information Technology implementation planning model that individual firms can adopt within the Nova Scotia ICI construction industry. Additionally, this project examines the construction sector's exposure to new technologies and innovative construction solutions and identifies specific applications that can be piloted or immediately deployed."

The NSCSC-ICI engaged the University of New Brunswick's Construction Engineering and Management Group (UNB CEM) to carry out the first phase of the multi-phase FIT project. UNB CEM structured the project in two parts:

i. defining the information and communication technology (ICT) needs of the foreman/supervisor position and identifying potential solutions; and
ii. developing a customized ICT assessment model to support adoption and implementation processes.

The FIT project was carried out through completion of the following tasks, with reference to the NSCSC-ICI FIT Project *scope of work*.

**A. Define the Technology Baseline**

1. *Collect "best/current practice" research regarding technology usage in the construction sector*
2. *Examine the construction sector's exposure to new technologies and innovative construction solutions*

This task was accomplished by assembling existing knowledge on the topic of ICT in the construction industry and examining, in more detail, activities in technologies associated with on-site construction management. A framework was established to collect best practices and examine the penetration of technology. The industry's exposure to new technologies was examined from the review of existing technology and through the engagement of industry members in the interview steps noted in the next task.

**B. Define Position-Specific ICT Needs**

3. *Develop interview and research guides to investigate functional technology needs of foremen/site supervisors, along with the company and worksite needs*
4. *Identify target industry stakeholders for interviews and sources for research*
5. *Conduct industry and stakeholder interviews*
6. *Identify the present mode (current state) of operation and use of technology at the foreman/supervisory level*
7. *Detail the role technology can have characterized by the job and/or the individual*

The information and communication technology needs of the *on-site manager*'s role were defined through a structured approach that captured the:

- processes completed by this position;
- information requirements;
- current contextual aspects (e.g., working environment); and
- current level of technology use.

The approach consisted of first identifying a representative group of organizations with the assistance of the FIT Project Steering Committee. The skill profile from the "Better SuperVision" program (BSV 2006) was used to structure the management processes for data collection. Research protocols were established to protect the anonymity of participants and ensure the confidentiality and integrity of the data collected during a face-to-face interview process.

**C. Identify Requirements and Capacity**

8. *Identify the present mode of operation (current state) for each firm/company interviewed*
9. *Detail what information is exchanged and where opportunities for improvement exist (Business Process Reengineering)*
10. *Define the information needs related to the job site, immediate company and other construction partners based on the occupation and size of the job (large vs. small)*
11. *Separate information management practices based on the characteristics of the information that is exchanged*

The results of the interviews identified each organization's current processes with respect to information management. The combined data collected for all organizations was analyzed to identify the opportunities for improvement with respect to current processes. The assessment of the capacity of organizations to adopt and implement new technologies was completed through a survey at a senior management level. The results of the survey validated the representative group of organizations and served as a trial application of a self-assessment tool.

**D. Identify Common Opportunities**

12. *Define the technological service that would address the information needs*
13. *Contrast current modes of operation with IT enabled options*
14. *Identify specific technology-based process applications that can be piloted or immediately deployed*

The areas of opportunity identified are compared with the current state of potential ICT solutions. The current state of technologies was generated by the research team's familiarity with current technologies and best practice research. The NSCSC-ICI also provided an opportunity for a member of the research team to attend the most recent Consumer Electronics Show (CES 2010) to examine the latest trends in technology. The recommendation of potential solutions considers incremental opportunities rather than those that require a radical change to current practices. A guide to piloting potential technologies is provided based on known best practices for ICT in the construction industry (Appendix A).

## 1.1 Structure of Report

The FIT study information is separated into two parts:

- Part I is an overview of the study; and
- Part II contains details of the analyses undertaken (Part II is available for download at www.nscsc.ca).

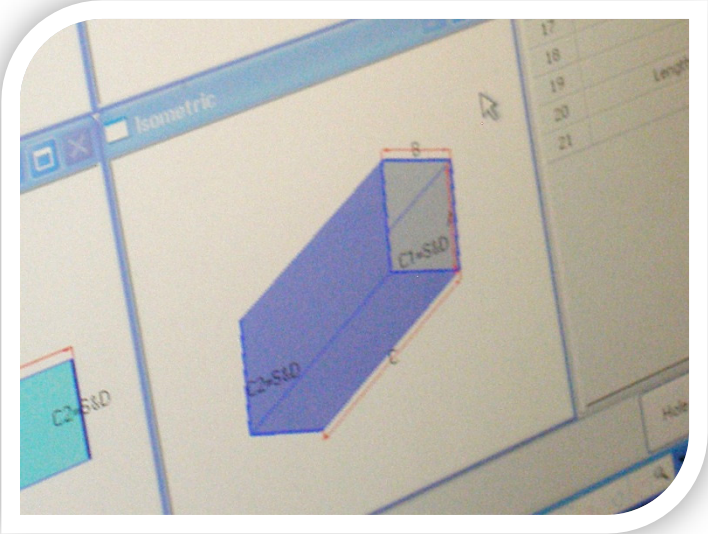
Part I of the report begins with a review of the current state of information and communication technologies in the construction industry and presents a general framework to examine the topic. It also includes a summary of known best practices for the adoption and implementation of on-site management solutions. Next, the results of two analyses are presented:

1. an examination of current management process; and

2. assessment of the capacity of organizations to adopt and implement technologies.

The report then identifies potential technologies to consider for adoption at the industry level. An approach for individual organizations to use is then presented based on the steps followed in this study and best practices. The report concludes with recommendations to consider as the NSCSC-ICI moves forward with this initiative.

# 2 The Construction Industry and ICT




Many researchers are engaged in examining the issues surrounding the topic of information and communication technology and the construction industry. What follows, is not intended to be a comprehensive examination of the topic, but rather to establish a context for the technologies being considered.

***Note:*** *Additional information on some of the currently active efforts on the topic of the construction industry and ICT is included in Part II of the report.*

## 2.1 Current Efforts

In the United States, the Fully Integrated and Automated Technologies consortium (FIATECH) recently developed an "Emerging Construction Technologies Catalogue" (FIATECH 2010). This catalogue acknowledged a lag in the adoption and implementation of technology in the industry that is contributing to a trend of decreasing productivity. The listing of technologies in Table 2.1 is generated from the emerging technologies catalogue.

The construction industry in the United Kingdom has been at the forefront of international movements making comprehensive changes to the construction industry to improve its performance. The Constructing Excellence initiative has united many of these efforts and includes a focus on information technology in construction (CE 2010). One of the efforts that was initiated in the UK, and which is more focused on technologies in support of onsite management, is the

Construction Opportunities for Mobile IT (COMIT 2010). This initiative seeks to advance the adoption and implementation of technologies for the benefits of the construction industry through sharing of information, and the capture and dissemination of best practices.

In Canada, there are no initiatives on the scale as those noted above; however, Canadian researchers do participate in global efforts. Nonetheless, there is significant activity within Canada on the topic of information and communication technologies in the construction industry. The bulk of the research performed on the topic of construction process technologies is by researchers at universities in the fields of construction engineering and construction management. The most recent inventory of this research activity is reported in "Strategic Roadmaps for Construction Innovation: Assessing the State of Research" by Froese and Rankin (2009). Additionally, the newly formed National Research Council Canada (NRC) Centre for Computer Assisted Construction Technologies (NRC-CCCT) is also building a significant amount of activity in this area (NRC-CCCT 2010).

Table 2.1: Emerging construction technologies.

| Technology | Description |
|---|---|
| Construction Simulation Technologies | 3D and 4D technologies in support of planning and design. |
| RFID for Construction Materials Management | Radio frequency identification to provide a wireless means of communication between objects and the systems used to manage them. |
| Wireless Networks for Construction Sites | In support of a paperless jobsite that facilitates all data transfer among project participants. |
| Mobile User Interfaces | Mobile computing devices such as wearable and handheld computers, PDAs, Smart phones and their extensions through GPS, RFID and other technologies. |
| Technology Training Tools | Computer assisted learning, virtual reality and augmented reality applications. |
| Automated Tool and Supply Management | Another RFID application area for tool issue and receipt, inventory and accounting. |
| Sensing Technologies for Facility Performance | Providing feedback on environmental conditions through wireless sensors and predicting incidents of poor performance or failure. |
| Materials Logistics Management | Using RFID and GPS technologies to provide real time status of critical materials. |
| Subsurface Mapping Technologies | Ground penetrating radar and electromagnetic sensing to locate items of interest (e.g., existing pipes) underground or in other materials (e.g., concrete). |

## 2.2 A Basic Framework

The domain of information and communication technology in the construction industry is quite large with respect to the scope of processes that are addressed. Figure 2.1 presents a conceptual figure of information management in the construction industry. The figure indicates the dimensions of:

1) phases over the life cycle of a project (design, construction, operation);
2) levels of management processes (corporate, project, site); and
3) the depth of information management (data, information, knowledge).

As noted previously, the focus of this study is on ICT during the *construction* phase, at the *site* level, and primarily addresses the management of *data*.

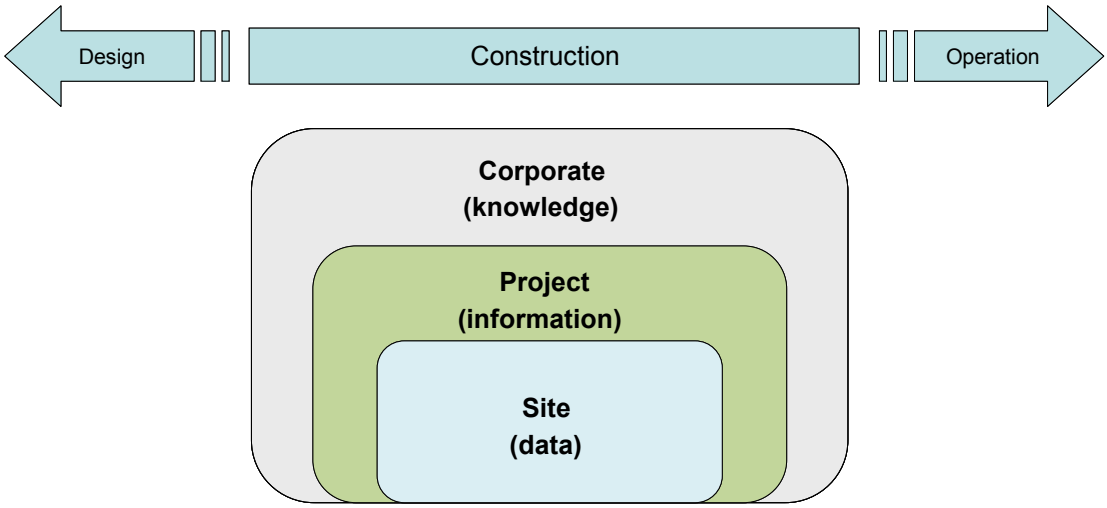



Figure 2.1: A conceptual framework for information management in the construction industry.

## 2.3 Technology Overview

Based on the framework presented in Figure 2.1, Table 2.2 summarizes the dominant *issues* and areas where *solutions* are being developed for ICT in the construction industry. For example, at the *corporate* level the general *requirements* are for systems to support *knowledge and information management*. The types of *applications* available at this level include *business information systems*. The dominant *issues* are the ability to facilitate migration with existing (so called 'legacy') systems and integration between systems that have evolved to support single business units. The emerging *solutions* at this level are systems that provide more functionality or the ability to expand on capabilities, and better methods for exchanging data between systems.

Solutions tend to be suitable for a wider range of types of organizations (i.e., not specific to construction).

At the *project* level, the applications support planning and control of the various project objectives (e.g., time, cost, scope). Ongoing *issues* at this level are: the ability to seamlessly integrate systems that have evolved for specific functions (e.g., scheduling applications, cost control applications); and the ability to communicate information to an audience of many perspectives (e.g., owners, designers, builders, users). *Solutions* that are emerging in this area include: better ways to access and control information (e.g., automation data flow through web based systems); and more intuitive means to communicate the information (e.g., interactive models).

At the *site* management level, *applications* support information management steps (e.g., capture, communicate, retrieve) between various locations on project sites and an organization's corporate activities. Due to the conditions under which these technologies are used, the dominant *issues* are mobility and usability. Emerging *solutions* focus on improving aspects of portability and ruggedness, as well as the manner of inputting and accessing information (e.g., interface).

Table 2.2: Summary of current ICT developments in the construction industry.

| Level | Requirements | Applications | Issues | Solutions |
|---|---|---|---|---|
| corporate | • knowledge management<br>• information management | • business/management information systems (e.g., accounting, payroll, corporate performance, client relations) | • migration from legacy systems<br>• integration between systems | • expanded capabilities (e.g., enterprise resource planning)<br>• data exchange standards |
| project | • planning<br>• control | • project objective management (e.g., estimating and costing, scheduling, Computer-Aided Design (CAD), quality and safety databases) | • interoperability of systems<br>• communication<br>• sharing of information (integrity of data) | • project information systems (e.g., web based)<br>• automated workflow<br>• enhanced CAD (e.g., 3D, 4D, Building Information Modeling (BIM))<br>• interactive displays |
| site | • retrieval<br>• capture<br>• transmit | • information capture and tracking (e.g., structured forms, checklists, work status) | • mobility of technology<br>• usability of technology | • mobile computing (e.g., connectivity, ruggedness)<br>• multimodal interfaces (e.g., data, voice, spatial, conditions) |

## 2.4 Results of Technology Overview

The review of current research indicates an industry that is lagging behind in its effective use of information and communication technologies. While there are many areas in which technologies are still emerging, and areas where improvements are required (e.g., interoperability of systems will remain a challenge in the foreseeable future), there are many more areas where solutions are currently available as "off the shelf." The largest barrier for the construction industry in integrating technology is overcoming the issues associated with the technology adoption and implementation process.

Each of the international initiatives noted previously make a considerable effort to assist practitioners in the adoption and implementation of ICT. One approach is to provide information on technologies, and in particular documentation of successful and unsuccessful uses, in the form of **best practices**. The following is a prime example of general guidelines that have been developed for adoption and implementation for on-site management applications (from COMIT 2009):

"Think process, then software, then hardware…"

"Beware of 'shiny shoes'…"

- Think process, then software, then hardware; don't think "we need to give them a PDA".
- Involve your end user at all stages, but remember that they may not have the wider business perspective.
- Beware of "shiny shoes"; ICT salesmen might be good at selling solutions, but may not be so good at understanding the real needs of the industry.
- Be open-minded in all respects; let the best solution emerge from your analysis.
- The dominant trend of success for on-site solutions is a one year return on investment.

# 3 Identification of Opportunities in Processes

The process analysis was undertaken to define current processes for on-site management, to capture the current level of support, and to identify potential opportunities for improvement from an industry level. The analysis of results provides a summary of opportunities for improvement.

***Note:*** *Part II of the report contains: 1) the details of the selection of a representative group of organizations studied, 2) the data collection protocols, 3) details of the process definitions, and 4) a summary of observations.*

## 3.1 Approach

A representative group of organizations was defined for data collection. Table 3.1 is a matrix of organizations who participated in the process analysis. The matrix is based on the parameters of organization type, organization size, and perceived level of innovation management maturity (i.e., how likely an organization is to adopt new technologies). The greater number of larger organizations and specialty contractors reflects the fact that there are greater differences in the processes of these organizations.

Table 3.1: Organizations used in face-to-face data collection.

| Organization Type and Size | | Participating Organizations (perceived innovation maturity) | | | |
|---|---|---|---|---|---|
| | | proactive | | | ad hoc |
| **General Contractors** | Small | Company A | | | |
| | Large | Company B | | Company C | |
| **Specialty Contractors** | Small | Company D | | Company E | |
| | Large | Company F | Company G | Company H | Company K[1] |

[1] The designations "I and J" were not used.

Each organization identified was requested to participate in the project in two stages:

- to assist in data collection of on-site management processes through face-to-face interviews; and
- to pilot a portion of the organizational assessment model by completing an on-line survey (see Section 4: Innovation Capacity Assessment).

The data collection interviews generally lasted between 1.5 and 3 hours. The primary objective of the exercise was to define the management processes for on-site managers. Therefore, depending on the structure of the organization, and the current position and experience of those interviewed, it was sometimes

necessary to interview multiple people from a single organization. Interview participants included those in roles identified as project manager, site superintendent, and foreman.

## 3.2 Results of Process Definition

The data collected from the interviews was used to define the processes of on-site management. The process definitions include specific aspects about how data flows. Table 3.2 lists the on-site management processes identified.

Table 3.2: On-site management processes.

| Management area | Process |
|---|---|
| time | • scheduling |
| | • coordination |
| cost | • work-hours |
| | • purchasing |
| scope | • changes |
| safety | • hazards |
| | • training |
| | • inspections |
| | • incidents |
| performance (quality) | • inspection |
| | • testing |
| performance (productivity) | • *(no formal process)* |
| performance (human resources) | • *(no formal process)* |
| worksite (equipment) | • storage |
| | • maintenance |
| worksite (materials) | • handling |

The following aspects of the dataflow within each of these processes were defined:

- number and type of steps in a process (e.g., access, input)
- process participants (e.g., project manager, supplier)
- context of the process (e.g., the environment)
- direction and initiator of the data (e.g., received or generated by on-site manager)

- frequency of the dataflow (e.g., as required, daily)
- type of data (e.g., textual, numeric, graphical)
- standard documents that might be produced (e.g., schedule, timesheet)
- current method of data flow (e.g., paper or electronic)

## 3.3 Analysis of Processes (Opportunities Identified)

From the data collected, potential opportunities for improvement are identified at an industry level (versus any individual organization) from two perspectives:

1. process improvement perspective; and
2. information management.

Areas with the most consistency in process were found to be:

- scheduling
- coordination
- work hours
- all processes in the safety management area

Less consistent are the processes of:

- changes
- inspection
- testing
- purchasing

The analysis of the results indicates that the opportunities for improvement include *worksite (equipment)* and *worksite (materials)* processes as well as *performance (productivity)* processes although they are not currently commonly practiced (see Table 3.3).

The processes of *purchasing* and *performance (human resources)* also demonstrated variances, but these were attributed to organizations limiting the on-site managers' role in these processes.

Table 3.3: Summary of process improvement opportunities.

| Process | Rationale |
|---|---|
| worksite (equipment and materials) management | in general, not well structured processes |
| performance (productivity) management | in general, not common practice |

The opportunities for improvements in information management were identified through an examination in the flow of data for the processes noted previously (see Table 3.4). The process of *coordination* is identified because it is well-structured (less variance across organizations) and it has the greatest number of steps. Therefore, it presents an opportunity to support a more complete information management cycle. The process of *change* is also identified because of the number of steps but it does exhibit more variance across organizations. The most common process structure has two steps: *access* and *input*. Therefore, support in the form of an ICT solution for two-step processes would have the broadest impact. The *work-hours* and all *safety management* processes are well-structured two-step processes.

The type of information required in support of a process step will influence the combination of hardware and software solutions that are applicable to meeting the functional requirements.

Several other aspects of information management are also important to note because they will ultimately help identify which combinations of hardware and software solutions can meet functional requirements:

- the majority of communication is within an organization
- the most frequent steps are daily
- time and cost management processes require only textual and numeric support
- the *changes* process and safety management processes require graphical support
- the majority of processes are completed in a site office environment
- a few processes require information of a graphical and environmental natural to be captured in the field (e.g., safety incidents that capture pictures of site conditions).

Table 3.4: Summary of information management opportunities.

| Process | Rationale | Other Considerations |
|---|---|---|
| coordination | well structured;<br>number of steps in the process | |
| changes | number of steps in the process | graphical data;<br>field context |
| work-hours | well structured;<br>input and access cycle | |
| safety management | well structured;<br>input and access cycle | graphical and environmental data; field context |

# 4 Innovation Capacity Assessment

The assessment of an organization's innovation management practices indicates its capacity to adopt and implement new technologies. A summary of the approach to assess capacity is included. The opportunities identified are based on the assessment of the representative organizations.

***Note:*** *Additional information on the development of the assessment method (e.g., research background and survey details) is provided in Part II of the report, along with a more detailed analysis of the assessment results.*

## 4.1 Approach

The capacity for the adoption and implementation of technology was measured through an assessment of innovation management practices. Based on the concept of management maturity and a review of previous studies, five (5) key process areas (KPAs) were identified for evaluation. Each KPA consists of a set of factors. A questionnaire was developed based on the KPAs identified and additional questions were added in order to complete the picture with respect to information management approaches for each participating organization. Table 4.1 summarizes the topics covered in the survey questionnaire. The final version of the survey was delivered to the representative organizations for completion via the web-based survey application Zoomerang (2010). Questions related to innovation management practices employed a three point scale of: *agree*, *partially agree*, and *disagree*. Questions in *The use of ICT* section were single or multiple selection type questions.

Table 4.1: Summary of survey questionnaire.

| **Section 1: Networking and communication** | **Section 2: Organizational resources** |
|---|---|
| • Market positioning<br>• Interacting with clients<br>• Interacting with suppliers and subcontractors<br>• Accessing technical support | • Evaluating resources<br>• Innovation champion<br>• Team structuring<br>• Employee retention |
| **Section 3: Knowledge management**[1] | **Section 4: Strategic commitment** |
| • Identifying, capturing, and storing knowledge<br>• Assessing and developing knowledge | • Strategic decisions<br>• Commitment to innovation<br>• Innovation evaluation program |

| Section 5: Organizational culture | Section 6: The use of ICT |
|---|---|
| • Communication<br>• Motivation<br>• Empowerment | • Current resources<br>• Investment in ICT<br>• Benefits of ICT<br>• Barriers of ICT |

[1] Knowledge management is defined as the management of information (e.g., manuals) and people (e.g., skills, know-how) to identify, capture, store, and enable access to organizational knowledge.

The aggregate scores for the innovation management maturity of each organization are provided in Figure 4.1, where organizations with higher scores were deemed to be more proactive in their approach to technology. In this assessment, all topics are treated equally, where the maximum maturity level that can be achieved is 3.0 (i.e., each of the five KPAs can contribute a maximum of 0.6). Figure 4.1 shows the relative contribution of each KPA to the aggregate maturity for each organization.

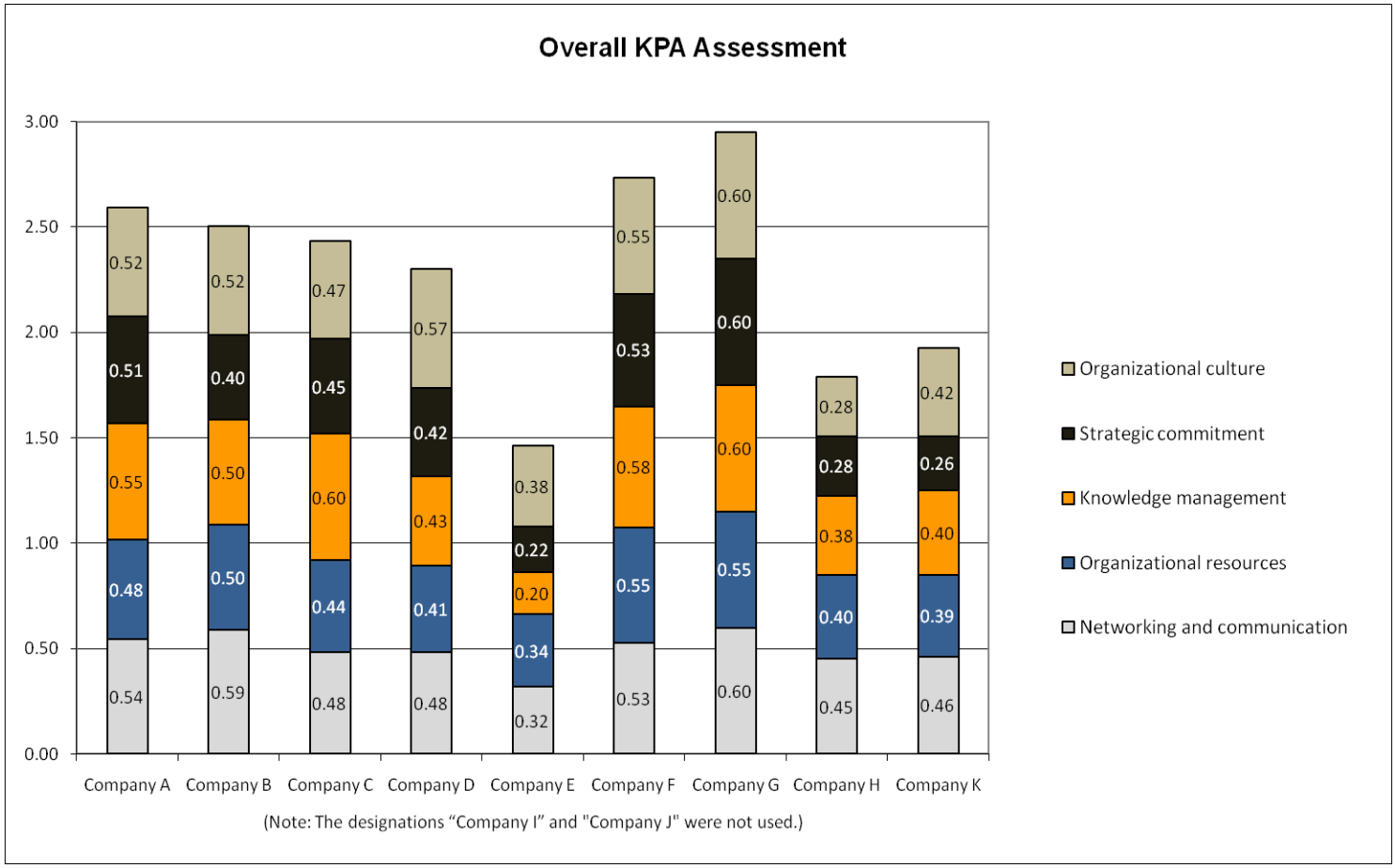



Figure 4.1: Aggregate maturity scores of representative organizations.

## 4.2 Analysis of Capacity Results (Opportunities Identified)

The results of the capacity assessment and current trends in ICT are presented in Table 4.2 and Table 4.3. The areas of *networking and communication*, *strategic commitment*, and *organizational culture* are all reflective of the overall maturity scores. These are indicators that point to opportunities for improvement in the area of organizational resources (identifying an *innovation champion*) and *knowledge management* in general.

Table 4.2: Summary of measured capacity.

| KPA | Comments |
|---|---|
| 1. Networking and communication | Trend is higher ranking than maturity. |
| 2. Organizational resources | Indicates the lack of an innovation champion. |
| 3. Knowledge management | An indicator of low maturity. |
| 4. Strategy commitment | Trend is lower ranking than maturity. |
| 5. Organizational culture | Is reflective of overall maturity. |

The results of the trends in ICT indicate that the resources required to support new technologies are in place with respect to employee capabilities and financial commitment. The results also point to a desire to pursue mobile technologies and those related to cost control. The *primary barriers* are *costs of ICT* and a *lack of knowledge* or *lack of technical expertise* of specific ICT solutions. In summary, organizations have allocated financial resources and feel their employees are capable in learning to use ICT solutions, but are concerned about justifying the investment and having adequate access to the right type of technical information.

Table 4.3: Results of the current trends with respect to ICT.

| ICT Perspectives | Comments |
|---|---|
| 1. Perceived capacity | 85% have the required capacity. |
| 2. Intent to invest | Over half are prepared to increase investment. |
| 3. Motivation | The most frequent motive is increasing efficiency and competitiveness. |
| 4. Technology focus | The most frequent focus is on cost control and mobile computing. |
| 5. Perceived barriers | The primary barriers are costs of ICT and lack of knowledge about ICT. |

# 5 Potential Technologies


In addition to a literature review of emerging technologies, the most recent Consumer Electronics Show (CES 2010) was attended to identify trends. In general, the technology trends applicable to the construction industry include:

1. streamlining communication between project participants to enhance collaboration; and
2. emerging technologies that support data sharing (e.g., the use of lightweight portable scanners, projectors, and laptops).

***Note:*** *A detailed and broader review of technology trends that are relevant to the construction industry is provided in Part II of the report.*

IT solutions need to be:
- Useable in the field
- Able to capture and transmit textual, numerical, graphical, and environmental data.

The process improvements noted in Section 3 suggest solutions that require:

1. use in a field context; and
2. capture data types that go beyond textual and numerical to include graphical and environmental.

Developments in technology that are *particularly relevant* to the opportunities identified include:

- **Ergonometric designs** – Although not a prominent topic among the various exhibitors, many of the technologies on display provided greater comfort for users through improved ergonometric design. Ease of use is an important aspect for tools and equipment within the construction industry. Thus any

attempt to minimize discomfort for workers may potentially result in greater productivity and fewer workplace health and safety related incidents.

- **Enhanced human-computer interface** – A significant theme among many of the products exhibited at CES was improved human-computer interaction. A variety of methods focus on data entry and manipulation, such as touch-screens which enable multi-point interaction with the computer. Other examples included: touch sensitive gloves that direct computer actions (currently used within the gaming industry); a multitude of touch-sensitive monitors; voice command options; and durable keyboard/mouse products. This theme suggests that members of the construction industry may be better able to interact with and manipulate project information, as well as utilize data-entry methods appropriate to the work environment (e.g. hands-free for increased safety on the job site).

- **Durability** – Construction tools and equipment must be capable of withstanding the many environmental and contextual aspects that can result in unwanted damage. Trends include improved durability of various items such as: waterproof televisions; sun-readable monitors; water and dust-proof keyboards; scratch resistant screens, and shock proof computers. Greater durability will enable a broader array of devices to be used in a work site environment, as they are more able to resist adverse conditions.

- **Improved information capture and display** – Information can be captured in various formats to improve its management and comprehensiveness. Mechanisms that enable users to store and manage extensive amounts of data in diverse formats (e.g., as digital video and images, text, and numerical) are now available. For instance, devices to capture video have been incorporated into sunglasses, highlighting their mobility. Methods of display are also evolving continuously, allowing superior detail in images, as well as greater accessibility and interaction. In terms of the construction industry, sophisticated display mechanisms may result in superior collaboration among participants, and a better understanding of project components and progress. An example of this evolution are newly emerging three-dimensional monitors, which permit the user to view items from all three dimensions, offering a more realistic viewpoint.

Additional trends identified at the CES that are relevant to the construction industry but not necessarily as relevant to the process opportunities identified include:

- Increased portability – The ability to transport equipment and tools (e.g., printers and computers) to and from the work site was a highlight among many vendors.
- Greater information storage capacity – Data storage devices are gaining in their information capacity, as well as decreasing in size at significantly lower costs.
- Enhanced audio communication – Many of the leading product developers in cellular technology were present at the convention, demonstrating the advancements made in size, software development, and ergonomics.
- Wireless data transfer – One of the most significant trends among current and new technology is the ability to send and receive information wirelessly.
- Sustainable products – A section of vendor stalls was dedicated to sustainable technologies such as extended battery life, recycled materials in new products, and environmentally-friendly manufacturing processes.

# 6 Implementation Tools

Although the analyses completed in this study were performed at the organizational level, the results can be interpreted and applied for the purpose of making broader industry level recommendations. The results provide justification for the types of technologies that might be pursued for the purposes of gaining additional knowledge in the form of best practices. However, the challenge to accelerate the impact of information and communication technologies in the industry remains at the organizational level in the act of adoption and implementation. Figure 6.1 provides an overview of the recommended steps from an organization's perspective. It indicates the steps to be taken, the methods (tools applied), and the people that must participate.

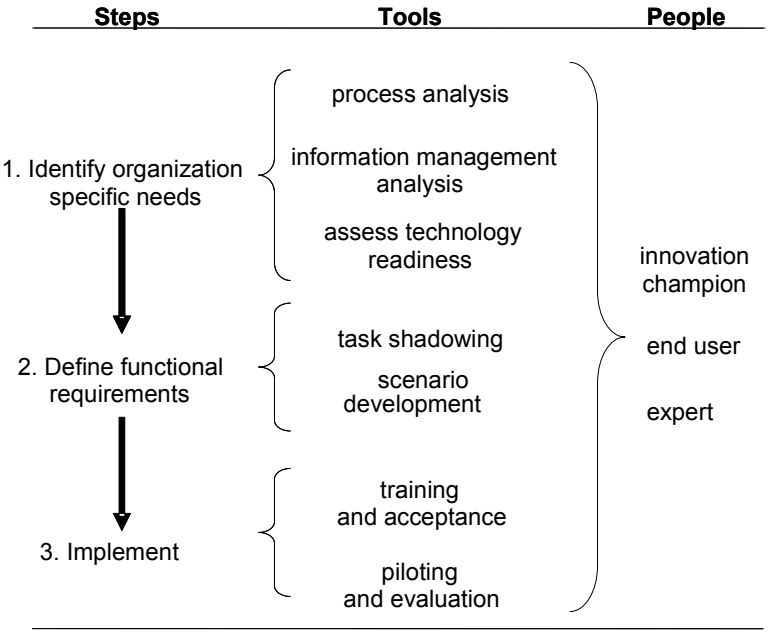



Figure 6.1: Flow chart for a successful adoption and implementation.

Before implementing ICT, organizations must assess their processes and capacity.

The steps that were followed in this study mirror the steps that must be performed with more rigour at an organizational level to ensure a successful implementation:

- assessment of processes, and
- assessment of capacity.

In addition to these two steps, and with reference to the best practices noted earlier, the active involvement of those that will be using the technology is necessary for success.

# 7 Conclusions and Recommendations

In summary, the activities completed in this study resulted in:

- a process definition for the purpose of identifying opportunities for improvement;
- a capacity assessment to identify gaps in the adoption and implementation process; and
- the identification of trends in technology to identify relevant development in this area.

The activities were performed at a more detailed level but have been aggregated to make recommendations at the industry level.

The recommendations for the NSCSC-ICI to consider are sorted according to:

1. the support that the NSCSC-ICI can provide to the industry to accelerate the adoption and implementation of information and communication technologies in the construction industry; and
2. the processes to address and technologies that should be pursued in a piloting and capturing of best practices approach.

## 7.1 The Support to Provide

The NSCSC-ICI can support the industry through the following activities:

- **Provide an opportunity for participation in piloting of technology adoption and implementation projects.** This activity addresses a need to overcome the perceived barriers of cost. It also provides for an external champion, and by extension, will address the gap in the identification of an internal champion to participate.

- **Develop support in the form of training which explicitly addresses the topic of information management.** This addresses the need to bring a better understanding of the overall importance of this function to an organization. It will better prepare for the involvement in any adoption and implementation initiatives.

- **Develop training which explicitly supports the processes of performance (productivity) and worksite processes (materials and**

**equipment) management.** This addresses the identified lack of formal processes in these areas.

- **Provide expertise and knowledge through the capture of best practices (in a way that demonstrates impact, including cost).** This addresses the need to overcome the barrier of technical expertise through a piloting exercise. If done properly through an industry organization, i.e., NSCSC-ICI, it can be effectively captured in a format that can be shared with others.

## 7.2 The Technologies to Pursue

Technology related to safety management processes should be the primary target for adoption using an incremental approach.

The process analysis results present several options (i.e., coordination, changes, work hours, safety management). Considering an incremental approach and taking advantage of recent trends in technology development; the processes under **safety management** should be the primary target, with consideration given to the **changes** process.

The advantages of pursuing safety management processes is that they are well structured and they involve a less complicated two-step "access and input" cycle, while also introducing the advantages of facilitating the capture of rich data in a field context. Pursuing support for the processes surrounding *changes* would also take advantage of current trends in technology. However, this would also involve a more complex process (i.e., more steps) and would also require a more robust system to complete the information management cycle. Therefore, the recommendation is to pursue each process with a suitable organization (or organizations) using the implementation tools.

To ensure usability and acceptance of technology, the proposed users must participate.

The general functional requirements defined can serve as a means to shortlist potential solutions. However, in order to support aspects of usability and technology acceptance, the specific technology selection step must involve the participation of the proposed technology users from each organization.

Appendix A is a **self–assessment** form to help organizations to start thinking about potential areas of improvement and their existing capacity to adopt and implement information and communication technologies.

***Note:*** *Part II of the report includes background on the technology acceptance aspects of the adoption and implementation process.*

# References


- BSV (2006). Better SuperVision – Construction Foreman/Supervisor - Skill Profile, developed by BSV, accessible at http://www.bettersupervision.org/docs/courses/curriculum.asp/
- COMIT (2009) Construction Opportunities for Mobile IT, Current status of Mobile IT: A Review of Case Studies, Sponsored by the UK Department of Trade and Industry, 32 pp.
- CES (2010). International Consumer Electronics Show, Las Vegas, http://www.cesweb.org/
- FIATECH (2010). Fully Integrated and Automated Technologies, http://fiatech.org/
- Froese, T. and Rankin, J. (2009). Strategic Roadmaps for Construction Innovation: Assessing the State of Research, Journal of Information Technology in Construction (ITCon), 24(26), 400-411.
- NRC CCCT (2010). National Research Council of Canada – Centre for Computer Assisted Construction Technologies, http://www.nrc-cnrc.gc.ca/eng/ibp/irc/ccct/index.html
- Zoomerang (2010). Create On-line Surveys, http://www.zoomerang.com/

# Appendix A: Self Assessment Form
# ICT Support of On-site Management Processes

This self-assessment form is a general guide for an organization to identify potential areas of improvement for on-site management processes. It provides a check of capacity to adopt and implement information and communication technologies (ICT) to help improve the management processes identified. **The form contains two steps that are only intended as a basic starting point for discussion within an organization**. The next step would be a detailed documentation of current processes and resources available to pursue improvements. **It is strongly recommended that the next step be conducted with the assistance of someone familiar with these tasks.**

## Step 1: Process Opportunity:

### A) Potential on-site management processes to improve

Best practices in the application of information and communication technologies indicate that the first step is to take a broad look at management processes and short list those in need of improvement.

The short list is then prioritized based on:

- the estimated effort required to make a change; and
- the impact that an improvement can make.

Basic questions to address when assessing each process:

1. Is the information exchanged in a timely manner?
2. Can the information generated in the process be accessed easily?
3. Does poor information exchange have an adverse impact on the project (e.g., cost quality, time)?

*Complete Assessment Table A1.*

**Table A1: Identifying opportunities to improve on-site management processes.**

| Processes | Opportunity | | | Effort Required to Change | Impact of Change | Importance Ranking |
|---|---|---|---|---|---|---|
| | no | maybe | yes | from 1 (high effort) to 5 (low effort) | from 1 (low impact) to 5 (high impact) | (sum of effort and impact) |
| **Time management** | | | | | | |
| • overall project scheduling | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • short term scheduling | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • work coordination | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| **Cost management** | | | | | | |
| • managing worker hours | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • on-site purchasing | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| **Scope management** | | | | | | |
| • change orders | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| **Safety management** | | | | | | |
| • hazard assessments | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • safety training | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • safety inspections | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • incident reporting | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| **Performance management** | | | | | | |
| • quality inspection | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • quality testing | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • productivity | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • human resources | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| **Worksite management** | | | | | | |
| • equipment storage | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • equipment maintenance | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| • materials handling | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| **Other processes (specify)** | | | | | | |
| | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| | | | | 1 2 3 4 5 | 1 2 3 4 5 | |
| | | | | 1 2 3 4 5 | 1 2 3 4 5 | |

## B) Potential approaches for improvement

Best practices in the application of information and communication technology indicate that incremental (versus radical) changes to an organization's processes have a greater chance of success. *Based on the processes from table A1, rank the top 5 highest for combined effort and impact (insert in table A2).*

**Table A2: Identifying top 5 processes.**

| Top Five Processes | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |

For each process consider the following questions:

1. Is the process clearly defined within the organization?

   **If no**, then consideration should be given first to sorting out the process itself before the introduction of technology is considered.

   (Figure A1 provides a sample of process mapping for documenting processes.)

2. Are there many information management steps in the process?

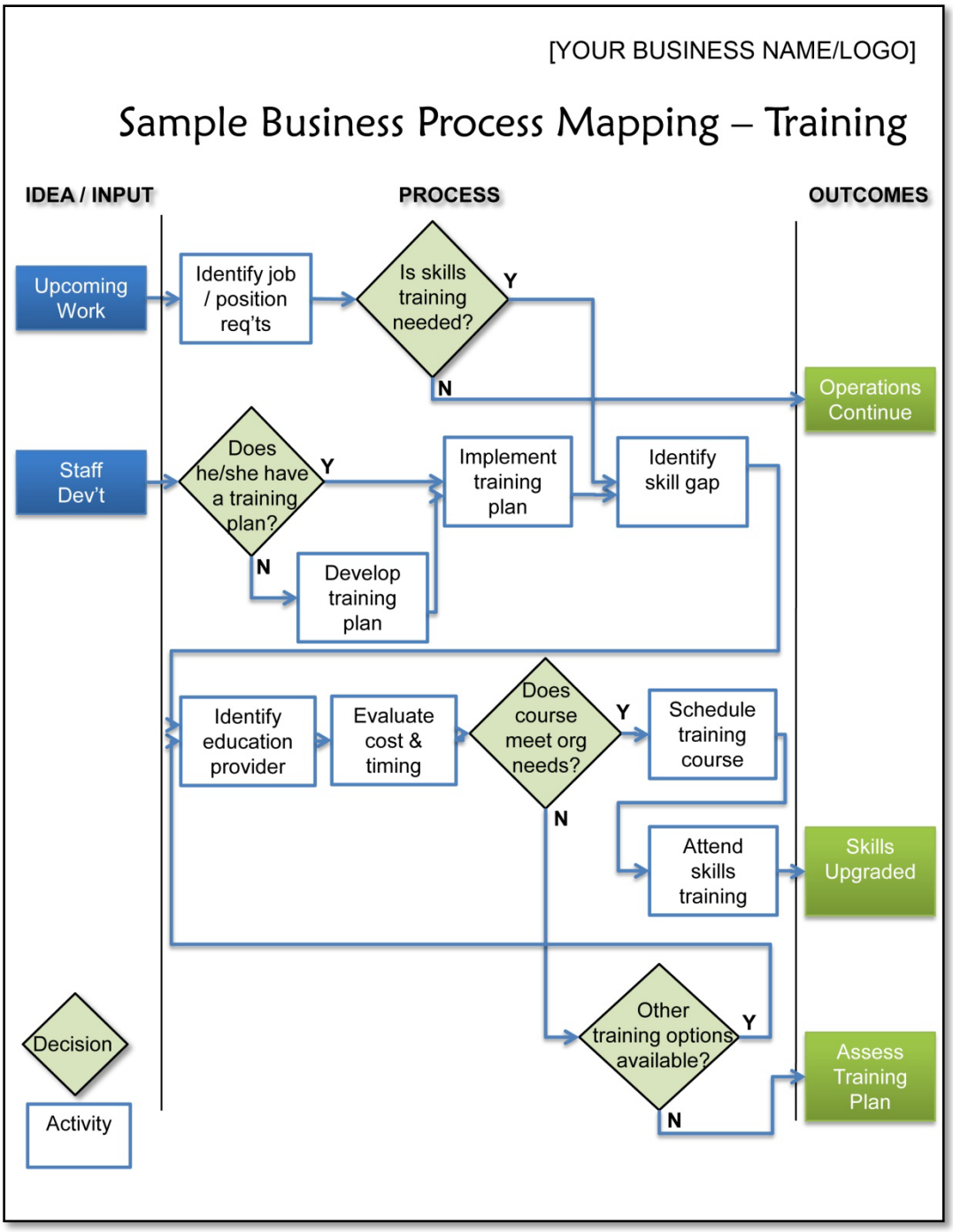
   **If yes**, then consideration should be given to how complex this process is and whether it must be integrated with existing information and communication technologies.

3. Are there many different individuals (both inside and outside the organization) directly involved in the information management steps?

   **If yes**, then consideration should be given to a process that is less complicated with respect to the participants that are involved.

*Document current processes and resources available to pursue improvement.*

**Figure A.1**




Phase 2 of the Functional Information Technology project is intended to help organizations address the next steps in the adoption and implementation of ICT.

## Step 2: Organizational Capacity

**Assess the capacity of an organization to pursue technology adoption and implementation.**

Best practices in the application of information and communication technologies indicate that a successful experience depends on several key aspects of organizational capacity (management, process, and resources). Before starting on the improvement of processes identified in Step 1, an organization should be aware of its readiness from several perspectives to explore potential ICT solutions.

**Management commitment** – The organization recognizes the necessity of allocating resources (e.g., capital, labour, plant, expertise and knowledge) for the success of innovation and adjusts resource allocation for each innovation project based on an assessment.

Agree ☐
Partially Agree ☐
Disagree ☐

**Empowerment of employees** – The organization promotes the participation of employees in change initiatives and provides the appropriate authority to make decisions autonomously.

Agree ☐
Partially Agree ☐
Disagree ☐

**Assessing and developing the organization** – The organization has a process in place to evaluate overall organizational strengths and weaknesses (e.g., review meetings) and changes are introduced based on evaluations (e.g., training programs).

Agree ☐
Partially Agree ☐
Disagree ☐

**Innovation evaluation program** – The organization has a program in place to evaluate and assess innovations that involve participation from all levels of the organization and acts on recommendations developed.

Agree ☐
Partially Agree ☐
Disagree ☐

**Designated change leader** – The organization has a person appointed to initiate and sponsor process changes with the authority (within limits) to apply changes without going through upper management.

Agree ☐
Partially Agree ☐
Disagree ☐

**Accessing technical support** – The organization is knowledgeable of the existing technical support infrastructure (e.g., industry associations, educational institutions, governmental agencies) and actively participates and follows-up on technical support programs.

Agree ☐
Partially Agree ☐
Disagree ☐

If the answer to **any** of the questions is either disagree or partially agree then this aspect should be addressed (with an accompanying strategy) as it introduces a **risk** to a successful adoption and implementation process. **Again, it is strongly recommended that the next step be conducted with the assistance of someone familiar with these tasks.**

# Appendix B: Glossary of Abbreviations

| Acronym | Description |
|---|---|
| **3D** | 3 dimensional |
| **4D** | 4 dimensional |
| **BIM** | Building Information Modeling |
| **CAD** | Computer-aided design |
| **CE** | Constructing Excellence Initiative (from the United Kingdom) |
| **CES** | Consumer Electronics Show |
| **COMIT** | Construction Opportunities for Mobile IT |
| **FIATECH** | Fully Integrated and Automated Technologies Consortium |
| **GPS** | Global positioning system |
| **ICT** | Information and communication technology |
| **IT** | Information technology |
| **KPA** | Key process area |
| **NRC** | National Research Council Canada |
| **NRC-CCCT** | National Research Council Canada Centre for Computer Assisted Construction Technologies |
| **PDA** | Personal digital assistant |
| **RFID** | Radio frequency identification |

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