Digital Technology Roadmap Search and Assessment for the Construction Sector

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Executive Summary

The Digital Technology Adoption Pilot Program (DTAPP) is an initiative of the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP) to assist small and medium-sized enterprises (SMEs) increase their productivity through the accelerated adoption of digital technologies and building of digital skills. NRC IRAP has signed a DTAPP contribution agreement with Red River College (RRC) to develop and implement digital technology awareness, assessment and learning, and advisory services for Manitoba SMEs. Although these activities will be available to SMEs in all sectors of Manitoba's economy, the agreement is focused on the construction and manufacturing sectors.

This study searched for and assessed information to assist RRC to develop a Digital Technology Strategy to improve the productivity of SMEs in Manitoba's construction sector. To provide context for this study, information was gathered about the nature, size, workforce trends and training needs of Manitoba's construction sector, especially its SMEs. To obtain insight about how active Manitoba's construction industry is in promoting the awareness and adoption of digital technology to improve the productivity of its members, an online search was conducted of 14 provincial industry and professional associations.

This study's next step was a search for organizations elsewhere in Canada and internationally that promote digital technologies to enhance the productivity of their constructions sectors. The study's final step reviewed the digital technology roadmaps and framework documents from other jurisdictions to determine their key findings or 'lessons learned' and relevance to Manitoba's construction industry SMEs.

It was found that Manitoba's construction sector is overwhelmingly dominated by SMEs, especially micro (1 to 4 employees) and small ones (5 to 99 employees). For RRC's DTAPP activities, the primary audience is likely small SMEs since most micro SMEs would have limited resources or need to adopt new digital technologies. Although the five medium-sized construction SMEs (100 to 499 employees) in Manitoba may benefit from an increased awareness of digital technologies through RRC's efforts, they are also more likely to have the resources to independently identify, assess and adopt technologies that would improve their productivity.

The online search of provincial industry and professional associations revealed that except for some introductory courses about building information modeling (BIM), Manitoba's construction industry does not appear to very active in promoting the awareness and adoption of digital technology to improve the productivity of its members. This confirms that there is a significant gap in the market RRC's DTAPP activities can address.

Although there is considerable information available about productivity concerns in the construction sector and how to address these concerns, very little of this information specifically targets SMEs and how they can increase their productivity though the increased adoption of digital technologies.

A small set of documents from other jurisdictions were identified that can inform RRC's development of a Digital Technology Strategy for Manitoba's construction industry SMEs. Based on trends evident in these jurisdictions, the digital technologies that appear to have the most potential to boost the productivity in the construction sector that will be relevant to SMEs in Manitoba include:

1. Building Information Modeling (BIM)
2. Online document control
3. Innovative use of mobile computing device
4. Automatic identification and information capture (i.e. RFID tags, barcodes, QR codes)
5. Greater use of automated equipment

It is recommended that this report be shared with key stakeholder groups in Manitoba's construction industry for their feedback and to identify any gaps or missed opportunities as part of RRC's process to develop a Digital Technology Strategy for Manitoba SMEs.

Since there is a possibility that DTAPP projects similar to RRC's may emerge in other jurisdictions in Canada, especially with respect to the adoption of BIM, RRC should collaborate with these other projects to minimize any duplication of effort.

Finally, the University of Manitoba's Faculty of Engineering is researching the use of information and communication technology to improve collaboration in the construction industry. RRC should explore to what extent the U of M may want to become involved in RRC's DTAPP activities.

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1.0 Introduction

1.1 Digital Technology Adoption Pilot Program

The Government of Canada, as part of its Digital Technology Strategy, has launched the Digital Technology Adoption Pilot Program (DTAPP). Delivered through the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP) DTAPP's goal is to assist small and medium-sized enterprises (SMEs) across Canada increase their productivity through the accelerated adoption of digital technologies and building of digital skills. DTAPP will run from October 2011 to March 31, 2014.

DTAPP utilizes new and existing networks and relationships with colleges and other organizations across Canada. NRC IRAP has signed a DTAPP contribution agreement with Red River College (RRC) in Winnipeg to develop and implement digital technology awareness, assessment and learning, and advisory services for Manitoba SMEs. Although these planned activities will be available to SMEs in all sectors of Manitoba's economy, the focus of the agreement is on the construction and manufacturing sectors.

Under its DTAPP agreement, RRC is undertaking activities in four areas:

1. **Digital Technology Strategy Development** – RRC will develop a 'Digital Technology Strategy' for both of Manitoba's construction and manufacturing sectors.
2. **Digital Technology Events** – RRC will organize and host a series of workshops, speakers and other events Manitoba SMEs to increase their awareness and motivation to adopt digital technologies improve their productivity.
3. **Digital Technology Advisory Support Service** – RRC will provide an advisory service to Manitoba SMEs to help them assess their preparedness to implement new digital technologies, select appropriate technologies based on this assessment, and assist with implementation.
4. **Digital Technology Industry Outreach and Linkage Facilitation –** RRC will link SMEs to digital technology related expertise, capabilities, and facilities at the College and other technology centres. This will include building and formalizing construction and manufacturing networks into separate databases to prepare for future outreach.

1.2 Objectives of this Study

The overall objective of this study was to search for and assess information that will assist RRC to develop a Digital Technology Strategy to improve the productivity of SMEs in Manitoba's construction sector. To achieve this objective, specific goals for the study were to:

- identify any existing digital technology roadmaps (TRMs) or similar documents for the construction sector that have been developed elsewhere in Canada or internationally;
- review these TRMs and determine what digital technologies are being used in other jurisdictions and their relevance to Manitoba's construction sector; and

- report on how these TRMs, and their recommendations, can be adapted and applied by RRC to develop its Digital Technology Roadmap for construction SMEs in Manitoba.

1.3 Study Approach and Methodology

To provide context for this study, information was gathered about the nature, size, workforce trends and training needs of Manitoba's construction sector, especially its SMEs. This information was derived from these sources: Industry Canada's *Key Small Business Statistics and SME Benchmarking Tool*; Statistics Canada's *Canadian Business Patterns Database* and *Small Business Profiles*, Construction Sector Council of Canada's *Construction Forecasts* website and the Manitoba Construction Sector Council's *Manitoba Construction Sector Training Needs Analysis*.

To obtain insight about how active Manitoba's construction industry is in promoting the awareness and adoption of digital technology to improve the productivity of its members, an online search was conducted of 14 provincial industry and professional associations (see list in Appendix A). For each association, their websites, newsletters, course calendars and press releases were surveyed to identify what, if any, services, events, seminars or training related to digital technology and productivity they offer to their members.

The next step in the study was a search for organizations elsewhere in Canada and internationally (primarily the U.S. and European Union) that are promoting digital technologies to enhance the productivity of their constructions sectors. Upon identification of an appropriate organization, a further search was conducted to determine whether they have produced a 'Digital Technology Roadmap' or other similar document that:

- identifies current or emerging digital technologies that can improve the productivity of their construction industry; and
- provide a framework or recommendations to increase awareness and accelerate adoption of these construction-related digital technologies.

To provide a more complete sense of construction-related digital technology trends in other jurisdictions, an online search and review of scholarly articles and papers, conference presentations, blogs and other information sources was also conducted.

The study's final step consisted of a review of the digital technology roadmaps and framework documents from other jurisdictions to determine their relevance to Manitoba. This review focused on identifying the key findings or 'lessons learned' from these roadmaps and other documents that can inform RRC's development of a Digital Technology Strategy for Manitoba's construction industry SMEs.

2.0 Profile of Manitoba's Construction SMEs

2.1 Definitions and Statistics

The emphasis of RRC's DTAPP agreement with NRC-IRAP is on SMEs (the term for small and medium-sized enterprises) in Manitoba's construction and manufacturing sectors. It is therefore important to define what types of firms and individuals will be targeted by the activities under this agreement by clarifying who is deemed to be part of the 'construction sector' and what is meant by a 'SME':

Construction Sector – For the purposes of RRC's DTAPP efforts, it is recommended that the College define its primary target audience using the North America Industry Classification System's (NAICS's) definition of the construction sector and its subsectors.

Since 2007, industries in Canada, Mexico and the United States have been classified according to NAICS. This system provides common definitions of the industrial structure of the three countries and a common statistical framework to facilitate the analysis of the three economies.

Under NAICS, the construction sector "comprises establishments primarily engaged in constructing, repairing and renovating buildings and engineering works, and in subdividing and developing land. These establishments may operate on their own account or under contract to other establishments or property owners. They may produce complete projects or just parts of projects. Establishments often subcontract some or all of the work involved in a project, or work together in joint ventures."

Because there are substantial differences in the types of equipment, work force skills, and other inputs required by establishments in this sector, the construction sector is divided into three subsectors. The first two subsectors are 'Construction of Buildings' and 'Heavy and Civil Engineering Construction', depending upon whether the firms are primarily engaged in the construction of buildings or in heavy construction and civil engineering projects. Establishments in these two subsectors are known by a variety of designations such as general contractor, builder, construction manager, etc. The third subsector is 'Specialty Trade Contractors' that specialize in one particular construction activity or trade.

In planning RRC's DTAPP activities, it is important that they reflect that firms within the Construction of Buildings subsector tend to specialize in either residential (single-family homes and multiple-family dwellings) or non-residential buildings (commercial, institutional and industrial) – see Table 1 for a breakdown of 2011 permit values for Manitoba.

Table 1 – 2011 Unadjusted Permit Values for Manitoba

Non-Residential			Residential	
Commercial	Industrial	Institutional	Multiple	Single
$367,796,000	$183,716,000	$100,565,000	$322,160,000	$1,211,326,000
$652,077,000			$1,863,403,000	
$1,863,403,000				

Source: Statistics Canada

Small and Medium-Sized Enterprise (SMEs) –The size of a business can be defined by

- the value of its annual sales;
- its annual gross or net revenue;
- the value of its assets; or
- the number of people it employs.

For activities under RRC's DTAPP agreement, it is recommended that the definition of a SME be based on the number of employees since this is consistent with the method used by Statistics Canada and Industry Canada to categorize construction firms.

In Canada, Statistics Canada reports that for the Construction of Buildings subsector, 43.0% of establishments have one or more employees while 57.0% are 'non-employers' or 'indeterminate'. In Manitoba, the split is 47.7% vs. 52.9% for employers vs. non-employers or indeterminate.

Table 2 on page 5 shows the breakdown of employer vs. non-employer or indeterminate establishments for Manitoba, as well as the other provinces and territories. (*Note: Non-employers are in effect owner-operated and the owners do not pay wages or salaries to themselves as an employee of the company. Some establishments do not employ any individuals, and in some cases the employment type of an establishment cannot be determined and has been classified by Statistics Canada as indeterminate.)*

Table 2 – Number of Construction Establishments by Employment Type and Region

Province	Employers	Non-Employers/ Indeterminate	Total	% of Canada
Alberta	5,016	7,146	12,162	14.1%
British Columbia	6,170	9,695	15,865	18.3%
Manitoba	**1,114**	**1,222**	**2,336**	**2.7%**
New Brunswick	988	578	1,566	1.8%
Nfld. & Labrador	781	293	1,074	1.2%
Northwest Territories	68	44	112	0.1%
Nova Scotia	1,088	706	1,794	2.1%
Nunavut	27	12	39	0.0%
Ontario	11,328	20,546	31,874	36.9%
Prince Edward Island	221	99	320	0.4%
Quebec	9,212	7,682	16,894	19.5%
Saskatchewan	1,063	1,228	2,291	2.6%
Yukon	73	78	151	0.2%

Source: Statistics Canada Canadian Business Patterns Database, December 2010

Under Industry Canada's *Key Small Business Statistics*, business establishments are considered *micro* if they employ fewer than 5 people. Above this threshold, a goods-producing firm is considered *small* if it has fewer than 100 employees while for service-producing firms the cut-off point is set at 50 employees. Above that size, and up to 499 employees, a firm is considered *medium-sized*. The term *SME* is used to refer to all establishments under the *large* cut-off of 500 employees. Table 3 on page 6 provides a count of the number of employer establishments in the Construction of Buildings subsector by employment size category for Manitoba and the rest of Canada.

Based on Table 2 and 3, it is clear that Manitoba's construction sector is overwhelmingly dominated by SMEs, especially micro and small ones. For RRC's DTAPP activities, it would be reasonable to assume that the primary audience is likely small SMEs (i.e. 5 to 99 employees).

Most micro SMEs (1 to 4 employees) would have limited resources or need to adopt new digital technologies. Although the five medium-sized construction SMEs in Manitoba may benefit from an increased awareness of digital technologies through RRC's efforts, they are also more likely to have the resources to independently identify, assess and adopt technologies that would improve their productivity. The validity of these assumptions needs to be tested when RRC consults with industry stakeholders for the development of a Digital Technology Strategy for SMEs in Manitoba's construction sector.

Table 3 – Number of Construction Establishments by Employees and Region

Province	Employment Size Category (Number of Employees)			
	Micro (1 to 4)	**Small** (5 to 99)	**Medium** (100 to 499)	**Large** (500+)
Alberta	3,443	1,515	50	8
British Columbia	4,056	2,081	30	3
Manitoba	643 (57.7%)	466 (41.8%)	5 (0.5%)	0
New Brunswick	576	409	3	0
Nfld. & Labrador	417	363	1	0
Northwest Territories	26	38	4	0
Nova Scotia	639	443	6	0
Nunavut	4	21	2	0
Ontario	7,264	3,987	66	11
Prince Edward Island	131	90	0	0
Quebec	5,695	3,477	37	3
Saskatchewan	670	383	9	1
Yukon	44	29	0	0
CANADA	23,608 (63.6%)	13,302 (35.8%)	213 (0.6%)	26 (0.1%)

Source: Statistics Canada Canadian Business Patterns Database, December 2010

2.2 Digital Technology Awareness and Training

On online search of 14 provincial industry and professional associations revealed that except for some introductory courses about building information modeling (BIM), Manitoba's construction industry does not appear to very active in promoting the awareness and adoption of digital technology to improve the productivity of its members.

A similar search was conducted of a database of construction industry training that has been complied by the Manitoba Construction Council. Of the more than 400 training opportunities that are listed, the only ones related to digital technology were about BIM.

3.0 Digital Technology Roadmap Search and Assessment

3.1 Current and Emerging Digital Technologies for Construction

Based on trends evident in other jurisdictions, these are the current and emerging digital technologies that have been the most frequently cited as having the potential to boost the productivity in the construction sector that will also be relevant to SMEs in Manitoba:

1. Building Information Modeling (BIM) – This technology is defined by the Institute for BIM in Canada as "both the creation of a set of digital models of a planned or built environment, as well as the process of working collaboratively with these models during the lifecycle of that facility."

   Of all the digital technologies for the construction sector listed in this section, BIM by far has the most momentum. Although various studies have shown that BIM is most widely used during the design phase of a project, other disciplines including contractors and building operators are increasingly using BIM. Applications of BIM include site modeling, spatial programming, design authouring, design reviews, engineering analysis, code compliance, cost estimation, and sequential planning of construction activities.

   BIM enhances productivity by facilitating communication and collaboration between disciplines through data interoperability throughout the construction life cycle. It allows professionals of all backgrounds to re-use the same data to make informed decisions and contribute the results of their tasks into the collective model.

   Because of the strong growth in the use of BIM, this technology has been ranked high in its relevance to Manitoba construction SMEs.

2. Online document control – This technology refers to the use of specialized software for the electronic distribution and management of construction documents for the design, bidding and building phases of a project. It represents an easier to use, secure and more flexible alternative to using basic File Transfer Protocol (FTP) based solutions to upload and share documents among project teams.

   The relevance of this technology to Manitoba SMEs is high. With the inevitable growth of BIM, SMEs will come under increasing pressure to shift from paper-based plans, specifications, addendums, meeting minutes, shop drawings and other documents to electronic ones. Online document control software offers the potential to boost productivity by reducing the time that SMEs currently spend ordering, printing and distributing traditional documents.

   Increasing the awareness and adoption of online document control by Manitoba SMEs will also compliment Manitoba's Online Planroom service offered by the Winnipeg Construction Association that provides project notifications, new bid opportunity notices, bid calendar, take-off tools, and online plan booking.

3. Innovative use of mobile computing devices – This technology refers to the use of wireless mobile computing devices for the management of on-site construction information and communications.

   The emergence of new mobile computing devices (e.g., the iPad and other tablet and handheld computers) and ever increasing capability of existing devices (e.g. the iPhone and other smart phones and personal digital assistants) offer new opportunities to boost construction productivity by enhancing the timely and effective exchange of information. This is especially true when these devices are combined with other digital technologies such as GPS (Global Positioning System), RFID (radio frequency identification) and augmented reality visualization.

   The relevance of this technology for SMEs in Manitoba's construction sector is high. Many SMEs already have smart phones and are increasingly acquiring tablet computers but seldom exploit the power of these devices beyond the basics (i.e., wireless phone calls, sending and receiving e-mails, internet browsing).

4. Automatic identification and data capture (AIDC) – This refers to a collection of technologies that provide a unique identification system that can provide a wide range of information about the materials, products, tools, equipment and other objects they are either attached to or embedded in.

   From a construction perspective, examples of AIDC that are attracting attention include RFID (radio frequency identification) tags and bar codes. Key differences between RFID and barcode technology is that RFID eliminates the line-of-sight reading that barcodes depend on and that RFID scanning can be done at greater distance than barcode scanning. QR code (Quick Response Code) is a new type of two-dimensional barcode that is becoming popular due to its fast readability and large storage capacity of information compared to a standard barcode.

   AIDC technologies such as RFID tags, barcodes and QR codes have the potential to increase productivity by improving the management of construction sites by making it easier to identify and track materials, supplies and equipment.

   The relevance of this technology for Manitoba SMEs in the construction sector is medium to high. The cost of AIDC technologies is low and can be integrated with smart phones, tablets and other mobile computing devices that many SMEs already own. The greatest appeal of this technology is likely to be SMEs who tend to operate more complicated job sites and have a high number of projects occurring at the same time.

5. Greater use of automated equipment – This refers to equipment that uses digital technology to reduce, or in some cases even eliminate the need for labour to continuously operate it. Some examples are automated equipment for excavation

and earthmoving operations, the placement and finishing of concrete, and trenchless technologies for the installation of underground infrastructure.

Although this technology has the potential for significant labour productivity gains, in most cases it requires a large capital investment. Because of this, plus that fact that automated equipment tends to be available for niche applications, the relevance of this technology for Manitoba SMEs was rated low to moderate but may be high for a few individual firms.

3.2 Digital Technology Roadmaps and Other Framework Documents

The search for examples from other jurisdictions of digital technology roadmaps for improving the productivity of construction SMEs that could serve as a template for Manitoba proved frustrating.

Although documents that discuss the concern about lagging construction productivity in Canada and internationally are easy to find, few specifically address how digital technologies can be used to address these concerns. Where digital technologies in the construction sector are discussed, these discussions and recommendations are frequently limited to information and communication technology (ICT), which is just one subsector of digital technology. For example, in July 2011 the University of Cambridge's Centre for Technology Management released a comprehensive listing of more than 2,000 public domain roadmaps for wide range of sectors including 45 construction industry roadmaps. The four roadmaps related to digital technology, are all limited to ICT issues.

Due to a lack of examples of digital technology roadmaps, it was necessary to expand the search to provide a more complete sense of construction-related digital technology trends in other jurisdictions by reviewing scholarly articles and papers, conference presentations, blogs and other information sources.

From the large number of information sources consulted, a small set of documents emerged that can inform RRC's development of a Digital Technology Roadmap for Manitoba's construction industry SMEs. A summary of these documents and some of their key findings are presented in Appendix B.

4.0 Conclusions and Recommendations

4.1 Conclusions

Information gathered about the nature and size of Manitoba's construction sector confirms that it is overwhelmingly dominated by SMEs, especially by firms with less than 100 employees.

Most micro SMEs (i.e., those with less than five employees) probably have limited resources or need to adopt new digital technologies. There are only five medium-sized

(100 to 499 employees) construction SMEs in Manitoba and no large firms (500 or more employees). Small SMEs (5 to 99 employees) represent the main audience that RRC should target for its DTAPP efforts.

On online search of 14 provincial industry and professional associations and a database of more than 400 construction-related training opportunities revealed that except for some introductory BIM courses, Manitoba's construction industry is not promoting the awareness and adoption of digital technology to improve the productivity of its members. This confirms that there is a significant gap in the market RRC's DTAPP activities can address.

There is considerable information available, both in Canada and internationally, about concerns of the construction sector's productivity, and how it can be improved. However, very little of this information is specifically targeted to SMEs and how they can increase their productivity though the increased adoption of specific digital technologies. A small set of documents were identified that can inform RRC's development of a Digital Technology Strategy for Manitoba's construction industry SMEs (see Appendix B).

Based on trends evident in other jurisdictions, there are five digital technologies that appear to have the most potential to boost the productivity in the construction sector that will also be relevant to SMEs in Manitoba. They include:

1. Building Information Modeling (BIM)
2. Online document control
3. Innovative use of mobile computing device
4. Automatic identification and information capture (i.e. RFID tags, barcodes, QR codes)
5. Greater use of automated equipment

4.2 Recommendations

Recommendation #1 – This report should be shared with key stakeholder groups in Manitoba's construction industry for their feedback and to identify any gaps or missed opportunities as part of RRC's process to develop a Digital Technology Strategy for Manitoba SMEs (see Appendix C for suggested letter).

Recommendation #2 – There is a possibility that DTAPP projects similar to RRC's may emerge in other jurisdictions, especially with respect to the adoption of BIM. With the assistance of NRC-IRAP, RRC should collaborate with these other projects to minimize any duplication of effort.

Recommendation #3 – The University of Manitoba's Faculty of Engineering is researching the use of information and communication technology to improve collaboration in the construction industry. RRC should explore to what extent the U of M (Dr. Mohamed Issa) may want to become involved in RRC's DTAPP activities.

Appendix A – Manitoba Construction Industry and Professional Associations

Architectural & Building Technologists Association of Manitoba Inc. (ABTAM)

Association of Consulting Engineering Companies Manitoba (ACEC-MB)

Association of Professional Engineers and Geoscientists of Manitoba (APEGM)

Certified Technicians and Technologists Association of Manitoba (CTAM)

Construction Association of Rural Manitoba Inc. (CARM)

Manitoba Association of Architects (MAA)

Manitoba Association of Sheet Metal and Air Handling Contractors Inc. (MCAC)

Manitoba Building Officials Association (MBOA)

Manitoba Construction Sector Council (MCSC)

Manitoba Electrical League Inc. (MEL)

Manitoba Heavy Construction Association Inc. (MHCA)

Manitoba Home Builders Association (MHBA)

Mechanical Contractors Association of Manitoba (MCA-MB)

Winnipeg Construction Association (WCA)

Appendix B – Document Review Summary Sheets

Document: *Advancing the Competitiveness and Efficiency of the U.S. Construction Industry (2009)*
https://download.nap.edu/catalog.php?record_id=12717

Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry

Summary: This report is the result of a request by the U.S. National Institute of Standards and Technology (NIST) that the National Research Council appoint an ad hoc committee of experts to provide advice for advancing the competitiveness and productivity of the U.S. construction industry.

The construction sector was defined in this report as commercial (including high-rise and multi-family residential), industrial and heavy construction (infrastructure) projects. The report did not address single-family and low-rise residential projects, primarily because this industry segment is predominantly composed of firms with fewer than 10 workers.

To gather data for this task, the Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry Workshop commissioned three white papers by industry analysts and held a 2-day workshop in November 2008 to which 50 additional experts were invited. A range of activities that could improve construction productivity were identified in the papers, at the workshop, and by the committee itself. From among these, the committee identified five interrelated activities that could lead to breakthrough improvements in construction efficiency and productivity in 2 to 10 years.

Key Points: The following are the five "opportunities for breakthrough improvements" that were identified:

1. Widespread deployment and use of interoperable technology applications, also called Building Information Modeling (BIM);
2. Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information;
3. Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes;
4. Innovative, widespread use of demonstration installations; and
5. Effective performance measurement to drive efficiency and support innovation.

The report provides specific examples of digital technologies for the first two opportunities listed above:

- For the widespread deployment and use of interoperability

technology, the report recommends the increased use of a range of information technology tools and applications including computer-aided design and drafting (CADD), three- and four-dimensional visualization and modeling programs, laser scanning, cost-estimating and scheduling tools, and materials tracking.

- For improved job site efficiency, the report recommends greater use of automated equipment (e.g., for excavation and earthmoving, concrete placement, pipe installation) and information technologies (e.g., radio frequency identification tags for tracking materials, personal digital assistants for capturing field data), process improvements, and the provision of real-time information for improved management at the job site.

The report also notes although industry analysts differ on whether construction industry productivity is improving or declining, there is agreement that there is significant room for improvement.

To expedite the five "opportunities for breakthrough improvements" noted above, the committee that produced the report made these three recommendations:

Recommendation #1 – NIST should work with industry leaders to bring together a critical mass of construction industry stakeholders to develop a collaborative strategy for advancing the competitiveness and efficiency of the capital facilities sector of the U.S. construction industry. The collaborative strategy should identify actions needed to fully implement and deploy interoperable technology applications, job-site efficiencies, off-site fabrication processes, demonstration installations, and effective performance measures.

Recommendation #2 – NIST should take the lead in developing a "technology readiness index" similar to indexes developed by the National Aeronautics and Space Administration and the Department of Defense, for high-risk, high-cost, high-impact construction-related innovations. Such an index could help mitigate the risks of using new technologies, products, and processes by verifying their readiness to be deployed on a widespread basis.

Recommendation #3 – NIST should work with the Bureau of Labor Statistics, the U.S. Census Bureau, and construction industry groups to develop effective industry-level measures for tracking the productivity of the construction industry and to enable improved efficiency and competitiveness

Document: *Catalogue of Emerging Construction Technologies (2005)*
http://www.nscsc.ca/Documents/FIT_Final_Report_Part_II__v4_web.pdf

Fully Integrated and Automated Technologies (FIATECH)

Summary: FIATECH has been established through a partnership between the Construction Industry Institute (CII) and the U.S. National Institute of Science and Technology (NIST). It is an industry consortium that "*provides global leadership in identifying and accelerating the development, demonstration and deployment of fully integrated and automated technologies to deliver the highest business value throughout the life cycle of all types of capital projects*."

The purpose of FIATECH's *Catalogue of Emerging Construction Technologies* is to make information about emerging construction technologies with near-term potential for widespread use in construction available in an organized way to assist in accelerating their adoption.

Key Points: The motivation behind FIATECH's catalogue is that a lag in the construction industry's adoption and implementation of technology has contributed to decreased productivity in the construction industry over the last three decades.

The catalogue identifies a total of nine emerging construction technologies (see Table 4 on page 17). There is some overlap between the various technologies, especially with respect to RFID (Radio Frequency Identification). FIATECH is significantly influenced by the industrial construction sector, as indicated by their emphasis on materials management.

Table 4 – FIATECH Catalog of 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	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).

Document: *Functional Information Technology (FIT) Project: Part II Detailed Analysis (March 2010)*
http://www.nscsc.ca/Documents/FIT_Final_Report_Part_II__v4_web.pdf

Nova Scotia Construction Sector Council Industrial-Commercial-Institutional (NSCSC-ICI)

Summary: This report was completed for the NSCSC-ICI by the New Brunswick Construction Engineering and Management Group at the Department of Civil Engineering, University of New Brunswick. The purpose of the study was to:

1. Examine the information and communication technology needs of on-site managers in the construction industry.
2. Develop an implementation guide.
3. Suggest technologies that should be pursued for piloting.

The study involved conducting a review of the current state of information and communication technologies in the construction industry; completing a process analysis of on-site management tasks; and assessing the capacity of the industry in terms of adoption and implementation of new technologies.

Key Points: The report provides these recommendations for the NSCSC-ICI to accelerate the adoption and implementation of information and communication technologies in the construction sector:

- Provide an opportunity for participation in piloting of technology adoption and implementation projects. This addresses a need to overcome the perceived barriers 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 association, i.e., NSCSC-ICI, it can be effectively captured in a format that can be shared with others.

Appendix C – Industry Stakeholder Consultation Draft Letter

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Applied Research and Commercialization
C506-2055 Notre Dame Avenue
Winnipeg, Manitoba R3H 0J9

(insert date)

(insert industry stakeholder contact info)

Dear (insert name):

RE: Digital Technology Strategy Consultation

I am writing to invite your organization and the other associations that guide the activities of the Manitoba Construction Sector Council to a meeting to learn about and discuss the development and implementation of a digital technology strategy for small and medium-sized enterprises (SMEs) in Manitoba's construction sector. The meeting will be held on (insert date and time) at (insert location).

The Government of Canada has launched the Digital Technology Adoption Pilot Program (DTAPP) to assist SMEs across Canada increase their productivity through the accelerated adoption of digital technologies and building of digital skills. More information about DTAPP can be found at this link: htttp://www.nrc-cnrc.gc.ca/eng/ibp/irap/digital-technology-adoption/dtapp-index.html

Red River College has signed a DTAPP contribution agreement with NRC-IRAP to undertake several initiatives to promote awareness and increase the use of digital technologies for SMEs in Manitoba. The construction industry is one of two sectors where these efforts will be focused. The College needs your input and advice to help guide the development and delivery of these initiatives to ensure they are relevant to your membership.

To confirm your organization's participation in this consultation meeting, please contact me at bwennekes@rrc.mb.ca or 631-3323.

Thank you for considering this request.

Sincerely,

Brent Wennekes
Technology Transfer and Communications Manager