A CONSTRUCTION INFORMATION MANAGEMENT ASSESSMENT MODEL

by

Ferzon Aziz

Master of Science (Distinction), University of the West Indies, 2008
Bachelor of Engineering, University of Guyana, 2003
Diploma in Technology, University of Guyana, 2001

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

in the Graduate Academic Unit of Civil Engineering

Co-Supervisors: Jeff H. Rankin, PhD, PEng, Civil Engineering
Lloyd M. Waugh, PhD, PEng, Civil Engineering

Examining Board: Yuri Yevdokimov, PhD, PEng, Civil Engineering
Trevor Hanson, PhD, PEng, Civil Engineering
Dhirendra Shukla, PhD, PEng, Electrical and Computer Engineering

External Examiner: Kasun N. Hewage, PhD, PEng, Civil Engineering, Construction Management, The University of British Columbia

This dissertation is accepted by the Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

June 2014

©Ferzon Aziz, 2014
ABSTRACT

Organizational-level information management (IM) has the potential to improve performance in construction-owner organizations. The lack of a model to comprehensively assess the organizational-level IM performance has inspired the need for this research. The goal of this research is to develop an organizational-level IM performance assessment model to measure and improve the organizational-level IM performance in construction-owner organizations. The model consists of three interconnected perspectives: (i) the organizational-level IM framework, which identifies and defines the eight organizational-level IM components, the six IM activities, and the 40 lagging and leading key performance indicators (KPIs) needed for comprehensive IM performance measurement; (ii) the IM performance measurement method to measure the organizational-level IM performance; and (iii) the IM performance improvement method to improve the IM performance for the IM components. A systems approach was used to validate the capability of the model for use in IM performance assessment through seven construction IM researchers across Canada and 11 strategic managers in eight construction-owner organizations in three Canadian Maritime provinces. The testing of the model consisted of measuring the IM performance at the KPI-level and measuring the lagging metric-level performance for a specific management process (change order process). The results validated the capability of the model to assess the organizational-level IM performance in the organizations. The key contribution of this study to IM researchers and strategic managers is the developed model, which provides insight into the measurement and improvement of organizational-level IM performance in construction-owner organizations.
ACKNOWLEDGEMENTS

I would like to acknowledge and express my sincere appreciation to the people to whom I am most grateful. To my co-supervisors Professor Jeff H. Rankin and Professor Lloyd M. Waugh, I express my deepest gratitude for your continuous involvement and unwavering support. Your funding, expertise, patience, guidance, and positive support are truly appreciated and valued. There is no doubt that both of you provided excellent guidance and advise that kept me focused and continuously heading in the right direction. To my friends, I would like to thank you for the valuable discussions and the fun memories. To my family, I would like to thank you for your support. To the examiners, I would like to thank you for your valuable time and feedback. To Joyce Moore, Melody Pollock, and Nancy McEwan from the Department of Civil Engineering, I would like to thank you for being so helpful throughout my degree. Finally, I would like to thank the construction researchers, managers, and organizations for participating in this research.
# Table of Contents

ABSTRACT ........................................................................................................................................... ii  
ACKNOWLEDGEMENTS ......................................................................................................................... iii  
Table of Contents .................................................................................................................................... iv  
List of Tables ........................................................................................................................................... vii  
List of Figures ......................................................................................................................................... viii  
List of Acronyms .................................................................................................................................... ix  
1 Introduction .......................................................................................................................................... 1  
  1.1 Background ...................................................................................................................................... 1  
  1.2 Problem .......................................................................................................................................... 3  
  1.3 Hypothesis ....................................................................................................................................... 4  
  1.4 Goal ................................................................................................................................................. 4  
  1.5 Objectives ...................................................................................................................................... 4  
  1.6 Scope and limitations ......................................................................................................................... 4  
  1.7 Methodology ................................................................................................................................... 6  
  1.8 Readers’ guide ................................................................................................................................. 7  
References ................................................................................................................................................. 10  
2 Identify and Define the IM components, IM activities, and KPIs ......................................................... 12  
  Abstract ............................................................................................................................................. 12  
  2.1 Introduction ..................................................................................................................................... 13  
  2.2 Literature review .............................................................................................................................. 14  
    2.2.1 IM frameworks ............................................................................................................................ 15  
    2.2.2 Indicators of performance .......................................................................................................... 16  
  2.3 IM components ............................................................................................................................... 18  
    2.3.1 Identifying the IM components .................................................................................................. 18  
    2.3.2 Defining the IM components .................................................................................................... 21  
  2.4 Relationships between the IM components ....................................................................................... 21  
    2.4.1 Identifying the relationships ..................................................................................................... 21  
    2.4.2 Defining the relationships ........................................................................................................ 22  
  2.5 IM activities and KPIs ..................................................................................................................... 23  
    2.5.1 Identifying the IM activities and KPIs ..................................................................................... 23  
    2.5.2 Defining the IM activities and KPIs .......................................................................................... 25
2.6 Summary of the organizational-level IM framework ........................................ 30
2.7 Researchers’ validation of the IM activities and KPIs ........................................ 31
  2.7.1 Researchers’ validation method ................................................................. 32
  2.7.2 Researchers’ validation results ................................................................. 35
2.8 Discussion ........................................................................................................ 39
2.9 Conclusions ....................................................................................................... 41
References ............................................................................................................... 43

3 Validate the IM activities and KPIs ................................................................. 45
Abstract .................................................................................................................. 45
3.1 Introduction ........................................................................................................ 46
3.2 Literature review .............................................................................................. 47
3.3 Practitioners’ validation method ................................................................. 50
  3.3.1 Select the organizations and strategic managers ........................................ 51
  3.3.2 Develop the interview questions and survey ............................................. 52
  3.3.3 Conduct the face-to-face interview survey ............................................... 55
  3.3.4 Analyze the data to verify and evaluate the IM activities and KPIs .......... 56
3.4 Practitioners’ validation results ........................................................................ 57
  3.4.1 Appropriateness and comprehensiveness of the IM activities and KPIs .... 57
  3.4.2 Accuracy of the IM activities and KPIs ..................................................... 58
  3.4.3 Relevance of the IM activities and KPIs .................................................. 64
3.5 Discussion ........................................................................................................ 64
3.6 Conclusions ....................................................................................................... 66
References ............................................................................................................... 68

4 Measure organizational-level IM performance ............................................... 69
Abstract .................................................................................................................. 69
4.1 Introduction ........................................................................................................ 70
4.2 Literature review .............................................................................................. 71
4.3 Method .............................................................................................................. 73
  4.3.1 Measure the KPI-level performance for the IM components ................. 74
  4.3.2 Select the IM components for metric-level measurement ..................... 77
  4.3.3 Select a management process for metric-level measurement ............... 77
  4.3.4 Measure the metric-level performance for the selected IM components in the selected management process ................................................................. 79
4.4 Results .............................................................................................................. 81
List of Tables

Table 1-1: Summary of the methodology ................................................................. 6
Table 2-1: IM activities for the IM processes component ........................................ 25
Table 2-2: KPIs for the ICT resources component ................................................... 26
Table 2-3: KPIs for the practice resources component .............................................. 27
Table 2-4: KPIs for the people resources component .............................................. 27
Table 2-5: KPIs for the IM inputs component .......................................................... 28
Table 2-6: KPIs for the IM outputs component ........................................................ 28
Table 2-7: KPIs for the IM constraints component .................................................. 29
Table 2-8: KPIs for the IM objectives component .................................................... 29
Table 4-1: Selected management process scope for IM measurement ....................... 78
Table 4-2: Performance measures, metrics, and questions for the change order process. 80
List of Figures

Figure 2-1: The IDEF0 representation (adapted from Presley and Liles 1995) .............. 20
Figure 2-2: Details of the proposed organizational-level IM framework ...................... 30
Figure 2-3: The IM researchers’ appropriateness rating by IM component .................... 37
Figure 3-1: The previously developed organizational-level IM framework ................... 47
Figure 3-2: Practitioners’ appropriateness responses by organization ......................... 58
Figure 3-3: Assessment actions performed in organization X .................................... 59
Figure 3-4: Assessment actions performed in organization A ..................................... 61
Figure 3-5: Assessment actions performed in organization B .................................... 64
Figure 4-1: The IM components, IM activities, and KPIs ........................................ 71
Figure 4-2: Details of the IM performance measurement method ................................ 73
Figure 4-3: KPI-level performance score by IM component ..................................... 82
Figure 4-4: KPI-level performance score by IM activity and KPI ............................... 83
Figure 4-5: Metric-level performance score by lagging KPI ..................................... 83
Figure 5-1: The organizational-level IM components, IM activities, and KPIs ............. 96
Figure 5-2: The organizational-level IM performance measurement method .............. 99
Figure 5-3: The organizational-level IM performance improvement method ............ 101
Figure 5-4: The organizational-level IM performance assessment model .................. 102
Figure 5-5: KPI-level performance score by organization ....................................... 105
Figure 5-6: KPI-level performance score by organization and IM component .......... 106
Figure 5-7: KPI-level performance score by KPI and organization ......................... 107
Figure 5-8: Metric-level performance score by organization .................................. 108
Figure 5-9: Metric-level performance score by lagging KPI ................................... 108
List of Acronyms

CI: Construction Industry
CIS: Computer Information System
ICT: Information and Communication Technology
IDEF: Integration Definition
IM: Information Management
IT: Information Technology
KPIs: Key Performance Indicators
PMBOK: Project Management Body Of Knowledge
PMI: Project Management Institute
1 Introduction

This chapter presents the background to the dissertation by highlighting the need for organizational-level information management (IM) performance assessment in construction-owner organizations. The research problem, hypothesis, goal, objectives, scope and limitations, methodology, and the readers’ guide are also presented.

1.1 Background

Information is an essential functional requirement for construction organizations (Titus and Brochner 2005). Sheriff et al. (2012) defines information as “The product of the contextual understanding and interpretation of data.” Assessing the value of information enables organizations to efficiently and effectively identify, create, analyze, access, and use information to improve performance (Hicks 2007). Tang et al. (2008) noted that surveys have indicated that 80% of information filed in organizations has never been used, 60% of knowledge workers time is spent looking for information, 50% of errors in construction projects are related to poor information, managers spent approximately two hours per day looking for information, and 50% of the information found is of no value.

The management of information is recognized as a key area to improve performance in construction organizations and new methods to assess IM is being investigated as a result of the following: (i) delays due to information overload, (ii) errors due to incorrect information, (iii) inefficiencies due to poorly organized information, and (iv) inability to evaluate the value of stored information (Tang et al. 2008). Detlor (2010) defines IM and the IM goal as follows:
Information management is the management of the processes and systems that create, acquire, organize, store, distribute, and use information. The goal of information management is to help people and organizations access, process and use information efficiently and effectively.

Measuring and improving IM performance can: (i) reduce uncertainty in planning and decision-making, (ii) improve the planned performance level to better control operations, (iii) provide historic performance information from past actions and decisions, (iv) simplify problems to make them manageable, (v) enhance understanding, and (vi) improve communication (Lucey 2005).

A review of construction IM literature indicates that IM researchers are focusing on various components of IM (e.g., people, processes, information and communication technology, practice, constraints, and information) primarily at the project-level in organizations, while there is limited emphasis on IM at the organizational-level. There is also research concentrating on project life cycle IM and information evaluation. Emphasis is placed on improving the effectiveness and efficiency of information flow and communication between project participants to enhance the project decision-making process. There is also research concentrating on information and communication technology (ICT) implementation and evaluation to improve project-level IM. Emphasis is placed on enhancing collaboration, coordination, and information exchanges between project participants to improve project management performance.

The majority of approaches reviewed focused on providing a better understanding of specific IM components and improving the characteristics within each IM component to enhance the IM performance of an organization or a project. Despite the limited emphasis
on IM at the organizational-level, researchers such as Hicks (2007) and Sheriff et al. (2012) have recognized that a comprehensive organizational-level IM approach has greater potential to improve IM performance and provide greater benefits to organizations relative to those approaches that focus on individual IM components. In a study of information managers in the construction industry, Sheriff et al. (2012) concluded that a holistic (comprehensive) IM approach is required to optimize the capability of people with ICT to control and use information to improve performance in organizations. A holistic IM approach refers to the skills, strategies, processes, and tools that are used to manage the life cycle of information within an organization (Sheriff et al. 2012). However, a review of construction IM literature for the period 2000 to 2013, indicate a lack of an organizational-level assessment model or framework that encompasses the key IM components (e.g., IM processes, information and communication technology resources (ICT) resources, practice resources, people resources, IM inputs and outputs, IM constraints, and IM objectives) required for comprehensive organizational-level IM performance assessment. Moreover, there is a lack of research on the comprehensive organizational-level IM assessment in construction organizations, which indicate that comprehensive organizational-level IM performance assessment is rarely studied and therefore not well understood.

1.2 Problem

The problem to be addressed by this research is that there is no model to comprehensively assess the organizational-level information management performance in construction organizations.
1.3 Hypothesis

The organizational-level information management performance in construction-owner organizations can be comprehensively assessed within a single model, using data collected from strategic managers of information.

1.4 Goal

The goal of this research is to develop a model to comprehensively assess the organizational-level information management performance in construction-owner organizations.

1.5 Objectives

The objectives of this research are:

i. To identify and define the IM components, IM activities, and key performance indicators required for comprehensive IM performance measurement.

ii. To validate the IM activities and key performance indicators.

iii. To measure organizational-level IM performance.

iv. To define the components of the IM assessment model.

1.6 Scope and limitations

The scope of this dissertation is limited to the initial phase of this research that identifies, defines, and validates the IM components, IM activities, KPIs within the IM framework required for comprehensive organizational-level IM performance assessment. It also develops the methods to measure and improve the IM performance, as well as integrate the IM framework with the measurement and improvement methods to develop the
organizational-level IM assessment model required for comprehensive assessment. In this model, “comprehensive assessment” refers to the use of the KPIs within the IM framework to comprehensively assess the organizational-level IM performance through the measurement and improvement methods. The validation and testing of the model are limited to the use of IM activities and KPIs to assess the organizational-level IM performance in eight case study construction-owner organizations in three Canadian Maritime provinces. The KPIs validation uses a systems approach and is limited to construction IM researchers and industry practitioners (strategic managers of information) identified using non-probability sampling approach. The IM performance measurement is limited to the KPI-level performance for all IM components and the metric-level (detailed-level) performance for the lagging KPIs for a selected management process (change order process) in order to limit the time required for this phase of the research. There is no discrimination between paper and electronic information artifacts in this research. The next phase of the research that is outside the scope of this dissertation will focus on developing the performance measures and metrics for each KPI from the KPIs’ definitions, validating the developed measures and metrics, validating the improvement method within the model, implementing the model in multiple types of construction organizations, and identifying the organizational requirements for implementing the model. Once both phases of this research are completed, the deliverable will be a comprehensive assessment model to measure and improve the organizational-level IM performance in construction organizations.
1.7 Methodology

The research methodology is a systems approach incorporating attributes of both qualitative and quantitative research design perspectives given the nature of the topic being studied. The combination of these research design perspectives is reflected in the application of social science research methods to construction (Abowitz and Toole 2010).

The attributes of the qualitative research design perspective are utilized in purposive sampling of the experts and in the iterative literature review process to identify the IM components, IM activities, and KPIs. The attributes of the quantitative research design perspective are utilized in designing the data collection instrument and collecting the validation and testing data. A summary of the methodology is presented in Table 1-1, highlighting the research activities, the resources required by the activities, and the chapter where the activities are located within this dissertation. The organizations in Chapters three and four are different from those in Chapter five, resulting in a total of eight organizations.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Resource</th>
<th>Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify and define the IM components, the IM activities, and the</td>
<td>Construction IM literature</td>
<td>2</td>
</tr>
<tr>
<td>KPIs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Validate the IM activities and KPIs</td>
<td>Construction IM researchers</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Strategic managers in organizations X, A, and B</td>
<td>3</td>
</tr>
<tr>
<td>3. Measure the organizational-level IM performance</td>
<td>Strategic managers in organizations A and B</td>
<td>4</td>
</tr>
<tr>
<td>4. Identify and define the perspectives of the IM assessment model, and</td>
<td>Strategic managers in organizations A, B, C,</td>
<td>5</td>
</tr>
<tr>
<td>test the model in organizations</td>
<td>D, and E</td>
<td></td>
</tr>
</tbody>
</table>
1.8 Readers’ guide

This dissertation is presented in six chapters. This introductory chapter highlights the need for the research and presents the research hypothesis, goal, objectives, scope, methodology, and the structure of the dissertation. Chapters 2, 3, 4, and 5 are presented as stand-alone papers addressing specific research objectives. Each paper consists of an abstract, introduction, methodology, results, discussion, conclusions, and references. Chapter 6 presents the overall conclusions based on each research objective, as well as the limitations and recommendations, the implications of the research, and suggestions for future work in this area of research. Inherent in this form of dissertation is repetition between the chapters, specifically the information in the introduction of each chapter. The content of Chapters 2, 3, 4, and 5 are described below:

Chapter 2: Identify and define the IM components, IM activities, and KPIs. This chapter addresses objective one of this dissertation. It provides the structured process used to identify and define the IM components, IM activities, and KPIs in the developed IM framework. The completed framework consists of eight organizational-level IM components based on the IDEF0 modeling method and the construction conceptual assessment model, identified through a review of 55 documents in IM literature from 1990 to 2010. The IM components were used as the basis to identify the six IM activities and the 40 KPIs required for comprehensive IM performance measurement, based on a review of 381 articles in construction IM literature from 2000 to 2011. The initial validation through seven Canadian construction IM researchers revealed that the IM activities and KPIs are appropriate and comprehensive for use in performance
measurement. In addition to the following two conference papers, two manuscripts of this chapter are pending submission to the journal of *Automation in Construction* and the *Journal of Construction Engineering and Management* as extended papers. The candidate is the principal author, and the candidate’s co-supervisors are the co-authors.


**Chapter 3: Validate the IM activities and KPIs.** This chapter addresses objective two of this dissertation. It presents the industry practitioners’ validation method used to further validate the IM activities and KPIs identified and initially validated in Chapter 2. The validation method consists of a structured approach to evaluate the appropriateness, comprehensiveness, accuracy, and relevance of the IM activities and KPIs using six strategic managers in the Canadian Maritime provinces. The validation results from the construction organizations capture feedback from the managers to confirm the validity of the IM activities and KPIs. The following conference paper is based on this chapter. The candidate is the principal author, and the candidate’s co-supervisors are the co-authors.


**Chapter 4: Measure organizational-level IM performance.** This chapter addresses objective three of this dissertation. It presents the method used to measure the organizational-level IM performance, which consists of four steps. The first step
identifies the IM components assessed within the organizational-level performance management cycle based on the assessment actions performed by strategic managers on the IM activities and KPIs. The second step selects a specific IM component for metric-level measurement based on the IM needs. The third step selects a specific organizational-level management process for metric-level measurement based on the IM needs. The fourth step uses developed performance measures, metrics (formulae) and questions for each KPI within the selected IM component to measure the metric-level (detailed-level) IM performance for the selected organizational-level management process. This performance is measured using the results from four engineering strategic managers in two organizations in the Canadian Maritime provinces. The results demonstrate the capability of the method to measure performance and identify opportunities for improvement within each organizational-level IM component for the selected management process (change order process) in each organization. The following conference paper is based on this chapter. The candidate is the principal author, and the candidate’s co-supervisors are the co-authors.


Chapter 5: Define the components of the IM assessment model. This chapter addresses objective four of this dissertation. It presents the developed IM assessment model to measure and improve the organizational-level IM performance in construction-owner organizations. The model consists of three perspectives: the first perspective is the organizational-level IM framework (Chapter 2), which identifies the IM components, IM
activities, and KPIs for comprehensive IM measurement; the second perspective is the IM measurement method (Chapter 4), which measures the organizational-level IM performance using the developed KPIs; and the third perspective is the IM improvement method (Chapter 5), which analyzes and interprets the measured performance to identify the changes needed to improve the organizational-level IM performance. The model is tested through five strategic engineering managers in five construction-owner organizations in three Canadian Maritime provinces. The testing consists of measuring the IM performance at the KPI-level for each IM component and measuring the lagging performance for a selected management process (change order process) at the metric-level. The results identify opportunities for improvement within each IM component and within the change order process in each organization. A manuscript of this chapter is pending submission to the ASCE Journal of Construction Engineering and Management. The candidate is the principal author, and the candidate’s co-supervisors are the co-authors.

References

2 Identify and Define the IM components, IM activities, and KPIs

Abstract

Comprehensive organizational-level information management (IM) measurement has the potential to improve IM performance in construction organizations. However, the organizational-level IM components and key performance indicators (KPIs) to measure each component are not adequately defined in construction IM research. This chapter proposes an organizational-level IM framework, which identifies the IM components, IM activities, and KPIs required for comprehensive organizational-level IM performance measurement in construction-owner organizations. The eight IM components (IM processes, ICT resources, practice resources, people resources, IM inputs, IM outputs, IM constraints, and IM objectives) are identified and defined based on the analysis of 55 documents related to IM frameworks published from 1990 to 2010. In addition, a total of six IM activities, as well as 40 lagging and leading KPIs are identified and defined based on the analysis of 381 IM journal articles published from 2000 to 2011 inclusive. Initial validation of the IM activities and KPIs through an online survey of seven construction IM researchers across Canada shows a 92% agreement with regards to the appropriateness of the IM activities and KPIs for use in comprehensive organizational-level IM performance measurement. The proposed IM framework provides a better understanding of organizational-level IM and the KPIs needed to comprehensively measure the IM performance in construction-owner organizations.

Keywords: Information management, IM framework, key performance indicator, construction organization.


2.1 Introduction

Information management (IM) is recognized as a key area to improve performance in construction organizations (Hicks 2006). Construction IM studies have developed different approaches (e.g., models and frameworks) to improve the effectiveness and efficiency of specific IM components, such as information and communication technology (ICT), to meet the information needs of decision-makers. However, most studies focus on project-level IM, and there is limited emphasis on holistic (comprehensive) and organizational-level IM approaches in construction organizations (Hicks 2007, Sheriff et al. 2012). A holistic IM approach is described by Sheriff et al. (2012) as consisting of skills, strategies, processes, and tools that are used to manage the life cycle of information within an organization. However, the IM components and key performance indicators (KPIs) required for comprehensive organizational-level IM measurement in construction organizations are not defined in IM literature, suggesting that organizational-level IM components and KPIs are not fully investigated and therefore not well understood.

The objective of this chapter is to define the IM components, the IM activities, and the KPIs within an organizational-level IM framework required to comprehensively measure
organizational-level IM performance in construction-owner organizations. This chapter presents the refined researchers’ validated framework including the structured literature review processes used to identify the IM components, as well as the IM activities and KPIs. An earlier version of the IM framework was presented in Aziz et al. (2012), and the steps used to validate the IM activities and KPIs within the framework are similar to those presented in Aziz et al. (2013).

The remaining sections of this chapter are as follows: Section 2.2 presents the literature review highlighting the contribution of existing IM frameworks, Section 2.3 presents the method to identify and define the IM components, Section 2.4 presents the method to identify and define the relationships between the IM components, Section 2.5 presents the method to identify and define the IM activities and KPIs within each IM component, Section 2.6 presents a summary of the proposed organizational-level IM framework, Section 2.7 presents the initial researchers’ validation method and results used to evaluate the appropriateness and comprehensiveness of the IM activities and KPIs for use in organizational-level IM measurement, Section 2.8 presents the discussion of the IM framework and the researchers’ validation results, and Section 2.9 presents the conclusions of this chapter.

2.2 Literature review

The IM frameworks and performance indicators in construction IM literature are examined in this section.
2.2.1 IM frameworks

A comprehensive review of construction IM literature was conducted for the period 2000 to 2013 inclusive, expanding on a previous review (Aziz et al. 2011). This review identified several IM frameworks (e.g., Stewart and Mohamed 2004, Lee and Yu 2012) with emphasis on evaluating specific IM component such as ICT resources (e.g., hardware, software, and telecommunication). However, there is no model or framework in the literature that focuses on the comprehensive assessment of organizational-level IM performance in construction organizations. Moreover, there is no model or framework that takes into consideration the key IM components (e.g., IM processes, ICT resources, practice resources, people resources, IM inputs and outputs, IM constraints, and IM objectives) required for comprehensive organizational-level IM performance assessment.

Nonetheless, there are studies that acknowledged the need for a comprehensive approach to IM in construction organizations. A study by Hicks (2007) recognized that the majority of IM assessment frameworks focus on specific IM components and highlighted the need for a comprehensive IM approach to improve IM performance in construction organizations. Similarly, Sheriff et al. (2012) concludes that a holistic (comprehensive) organizational-level IM approach is needed to improve performance in engineering organizations. This lack of a comprehensive organizational-level IM framework in construction IM literature that identifies and defines the IM components, IM process activities, and KPIs required to measure the organizational-level IM
performance in construction organizations indicates that organizational-level IM performance is not fully investigated and therefore not well understood.

2.2.2 Indicators of performance

There are three key limitations of existing performance indicators identified in the literature reviewed. The first limitation is the difficulty of performance indicators to precisely capture and quantify activities conducted in an organization, which is due to the lack of consensus on the definition of the term ‘performance’ because it is not absolute; it is related to the activities conducted (Samsonowa 2012) (For a comprehensive review on the terms performance, performance measurement, KPIs, measures, and metrics see Samsonowa 2012).

The second limitation is the divergent goals and objectives between construction researchers and managers performing measurement in organizations. Researchers often focus on defining, validating, and generalizing indicators of performance to address specific research questions, while managers, often under time pressure, require indicators that will provide quick and meaningful performance results (Melnyk et al. 2004).

The third limitation is that managers encounter challenges to identify and apply the appropriate performance indicators to organizational processes (Samsonowa 2012). For example, to identify the organizational-level performance, managers first have to identify the appropriate performance indicators and then accurately group the relevant indicators in order to understand and identify the overall performance. However, the
accurate classification of relevant indicators for performance measurement is challenging (Hwang et al. 2010). Several approaches to develop classification for performance indicators are: the balanced scorecard, the strategic profit impact model, and the theory of constraints (Melnyk et al. 2004). This suggests that properly developed and grouped KPIs are capable of providing meaningful and valuable performance information to managers. Parmenter (2010) define a KPI as:

“a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization.”

KPIs can influence an organization’s decisions and actions through three basic functions: (i) control (allow for evaluation and control of resources), (ii) communication (provide understanding of the intricacies of related processes while communicating performance), and (iii) improvement (allow for intervention by identifying gaps between performance and expectations) (Melnyk et al. 2004). The key criticisms of KPIs are the lack of comprehensiveness to measure performance (Kagioglou et al. 2001), and poorly defined KPIs results in the failure to measure performance (Bourne et al 2002). Moreover, measurement frameworks that utilize KPIs are criticized because of inadequate selection and grouping of KPIs to provide meaningful results (Kagioglou et al. 2001), as well as the lack of adequate components to measure performance (Bassioni et al. 2004).

Another consideration is the criteria used to evaluate and select KPIs. Carlucci (2010) reviewed the various evaluation criteria in literature and concluded that there are numerous and frequently interchangeable criteria with a combination of meanings
(definitions) used to evaluate and select the right performance indicators. Moreover, Carlucci’s analysis of the literature revealed four general criteria that can be used to select performance indicators. The four criteria are summarized as follows: (i) *Relevance*: relates to measuring as close as possible the result that is intended be to measured; (ii) *Reliability*: relates to errors and biases, and that the measure represents what it claims to represent; (iii) *Comparability and consistency*: relates to performance indicators used for the comparison of different organizations and their application of over time; and (iv) *Understandability and representational quality*: relates to interpretability, understanding, ease of use, meaning, and format of indicators. Although KPIs continue to be a focus in construction IM literature, there is a lack of research on the identification and application of KPIs to comprehensively measure the organizational-level IM performance in construction organizations.

### 2.3 IM components

The method used to identify and define the IM components in the proposed framework are presented below.

#### 2.3.1 Identifying the IM components

The IM components in the framework were identified through a review of IM literature published in electronic English-language journals, conference proceedings, technical reports, and books for the period 1990 to 2010 inclusive. This period was selected because the electronic documents were available via an online library at the University of New Brunswick. The review provides insight into both IM and construction
assessment frameworks in literature. The three-step process to identify the IM components is as follows:

(i) Select the documents for review: The online research databases *Compendex, Inspec,* and *Scopus* were searched and 78 documents were identified using the search terms: “information management model,” “information management measurement,” “construction assessment,” “measurement framework,” “measurement model,” “assessment model,” “performance measurement,” “performance assessment,” and “performance evaluation.” A review of each document’s abstract, introduction, and conclusion identified 55 relevant documents. The documents consist of 38 journals articles, seven conference papers, three technical reports, and seven books.

(ii) Review the documents: The 55 selected documents were reviewed to identify the IM components that exist in the literature. The IDEF0 model (Presley and Liles 1995) and the construction conceptual assessment model (Fayek et al. 2008) provided the basis to identify the key generic IM components within the developed organizational-level IM framework and the relationships between the components. The two models are briefly described below to demonstrate their usefulness in identifying the IM components.

The IDEF0 model is described by Noran (2004) as a process or activity oriented modelling tool that represents the functional framework of a system (i.e., ‘what to do’) and consists of five components: (i) process or activity (that can be linked to other processes or activities), (ii) input (resources consumed or transformed by the process), (iii) output (things created by the process using the input), (iv) constraints or control on processes or activities (things guiding the process such as policies, guidelines, standards,
and laws), and (v) mechanisms or resources (agents that accomplish the action or activities in the process). Details on the characteristics and use of the IDEF0 model are provided in FIPS PUBS (1993).

Figure 2-1: The IDEF0 representation (adapted from Presley and Liles 1995)

The construction conceptual assessment model developed by Fayek et al. (2008) is based on the IDEF0 model and assesses construction processes. This model shows the application of the IDEF0 model to construction processes. The model expands the constraints component of the IDEF0 model into two sub-components (objectives and conditions), and focuses on a specific sub-component (practices) within the mechanism component. Moreover, it suggests ways to measure the objectives, conditions, and practices components within the model. A similar expansion of the IDEF0 model components was used to identify the IM components in the developed IM framework.

(iii) Identify the IM components: A total of eight components (IM processes, information and communication technology resources (ICT), practice resources, people resources, inputs, outputs, constraints, and IM objectives) were identified for the IM framework.
2.3.2 Defining the IM components

The function of each component was used as the basis to define each component as follows: (i) IM processes: the IM activities performed by people within each organizational-level management activity, (ii) ICT resources: the characteristics of the computer information system (CIS) (software, hardware, and telecommunication) used by people to perform the IM activities, (iii) Practice resources: the characteristics of IM practices used by information managers to guide the functioning of the IM processes), (iv) People resources: the IM characteristics of information managers and users required for effective and efficient operation and management of the IM processes, (v) IM inputs: the characteristics of information required for the effective functioning of the IM processes, (vi) IM outputs: the characteristics of information produced by the IM processes that are of value to decision makers, (vii) IM constraints: the organizational characteristics that may limit the effective and efficient functioning of the IM processes, and (viii) IM objectives: the planned outcome characteristics that measure the IM processes capability to achieve the IM goal.

2.4 Relationships between the IM components

The relationships between the IM components in the framework were identified from the literature review method used to identify the IM components in Section 2.3.1 and presented below.

2.4.1 Identifying the relationships

The relationships between the components evolved from the analysis and synthesis of the following: The description of the five components in the IDEF0 model by Noran
(2004) (presented in Section 2.3.1); the description of the relationships between the six components of the construction conceptual assessment model (Fayek et al. 2008); the adoption of a process view of IM in this research; the adoption of Choo (2008) IM process view of a continuous cycle of six closely related activities within the IM process; and the identification of the means to measure the IM components.

2.4.2 Defining the relationships

The relationships between the eight IM components are defined as follows: The *IM Inputs* contribute information required to perform the *IM processes*; The *IM processes* transform the *IM Inputs* information to produce the *IM Outputs* information that is of value to decision makers; The *people resources* are used to perform and manage the activities within the *IM processes*; The *ICT resources* are used by the *people resources* to perform the IM activities within the *IM processes*; The *practice resources* are used by the *people resources* to guide the functioning of the IM activities within the *IM processes*; The *IM constraints* identify the organizational IM characteristics that limits the effective and efficient execution of the IM activities within the *IM processes*; and the *IM objectives* measure the capability of the IM activities performed in the *IM processes* to achieve the IM goal for an organizational-level management process. The relationships between the IM components were assumed to be representative of the interactions between IM organizational-level IM components and were not validated in this dissertation. This assumption is based on the fact that the relationships were developed based on those identified in the IDEF0 model, and the IDEF0 model is an
established method designed to model the processes and actions within organizational systems.

2.5 IM activities and KPIs

In this section, the IM components are used as the basis to classify the construction IM literature, which is subsequently used to identify the IM activities and KPIs. The method used to identify and define each IM activity and KPI (different from the one used to identify the IM components in Section 2.3.1) is presented below.

2.5.1 Identifying the IM activities and KPIs

The IM activities and KPIs within the IM components were identified through a structured literature review of construction IM research for a 12-year period (2000 - 2011 inclusive) based on 381 articles (different from the 55 documents stated in Section 2.3.1). This review provides an extensive view of construction IM research found in English-language academic journals for the review period. The review is limited to research articles, technical articles, and literature reviews, and does not include case studies, conceptual articles, general reviews, and viewpoints, nor does it capture pertinent research published in other languages.

The three-step process to identify the IM activities and KPIs is as follows:

(i) Select the databases, journals, and articles: The seven online research databases Compendex; Inspec; Scopus; Business Source Premier; Academic Source Premier; Web of Science; and the Library, Information Science and Technology Abstracts were searched using the search terms “Information Management” and “Construction Industry.” The most frequent seven “Information Management” and “Construction
Industry” journals were selected from each database (98 journals in total), because initial analysis showed that selecting additional journals did not provide additional relevant articles. The journals with no access to the content (seven journals) and duplicated journals (45 journals) appearing in multiple databases were removed. Searching each “Information Management” journal for “Construction Industry” and each “Construction Industry” journal for “Information Management” identified the IM articles that focused on the construction industry (570 articles in total), also this search eliminated an additional 18 journals for not providing any new articles. The relevant articles with a primary focus on IM were selected through a review of the abstract, keywords, and conclusions. The keywords were adopted from the Inspec database thesaurus and were used to verify that the articles have a primary focus on IM. The keywords include: “Information,” “Information Management,” “Construction Information Management,” “Information Technology,” “Information and Communication Technology,” “Information System,” “Records,” “Data,” “BIM,” “Communication,” “Document,” and “Text.” This resulted in the elimination of 189 articles that did focus primarily on IM.

(ii) Review the articles: A total of 381 articles from 28 journals were reviewed to identify the IM characteristics within each article (e.g., information accessibility, information frequency, and interoperability). An iterative review, analysis, and synthesis process was used to identify and convert the IM characteristics from the articles into IM activities and KPIs. This process was also used to categorize each activity and KPI into the eight IM components, based on the definition developed for each component (Section 2.3.2).
(iii) **Identify the IM activities and KPIs:** A total of six IM activities and 40 KPIs were identified for the eight components.

### 2.5.2 Defining the IM activities and KPIs

The definitions for the finalized IM activities and KPIs identified for the IM components are presented Tables 2-1 to 2-8. The initially developed IM activities and KPIs definitions are presented in the questionnaire in Appendix A. These initial definitions were subsequently revised after an initial validation to improve clarity in the terminology and phrasing of the definitions and are included in Appendix B. Subsequently refinements were made to the definitions to further improve clarity and neutrality. These refined and finalized IM activities and KPIs definitions are presented as follows:

**IM processes:** The six IM activities in Table 2-1 represent the steps within the IM processes. These activities were selected based on the IM activities identified by Choo (2008) and Detlor (2010) as continuous, cyclic activities in the IM process.

#### Table 2-1: IM activities for the IM processes component

<table>
<thead>
<tr>
<th>IM activity</th>
<th>Activities within the organizational-level IM process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information needs identification</td>
<td>Standardized steps to determine the information required in each management activity</td>
</tr>
<tr>
<td>Information acquisition and creation</td>
<td>Standardized steps to obtain or create information in each management activity</td>
</tr>
<tr>
<td>Information analysis and interpretation</td>
<td>Standardized steps to determine the value of information in each management activity</td>
</tr>
<tr>
<td>Information organization and storage</td>
<td>Standardized steps to group information for storage and retrieval in each management activity</td>
</tr>
<tr>
<td>Information access and dissemination</td>
<td>Standardized steps to retrieve and share information in each management activity</td>
</tr>
<tr>
<td>Information use</td>
<td>Standardized steps to utilize information in each management activity</td>
</tr>
</tbody>
</table>
**ICT resources:** The six KPIs in Table 2-2 measure the capability of software, hardware, and telecommunication within the computer information system (CIS) to achieve the organizational IM goal. These KPIs were developed based on the CIS characteristics identified through the analysis of construction IM literature from 2000-2011 inclusive.

**Table 2-2: KPIs for the ICT resources component**

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information classification</td>
<td>Standardized classification system to group information in the CIS for retention, retrieval, disposal, and update</td>
</tr>
<tr>
<td>Information navigation</td>
<td>Standardized list of keywords (controlled vocabulary terms) to index information in the CIS</td>
</tr>
<tr>
<td>Information traceability</td>
<td>Standardized process to track the changes of information artifact versions in the CIS</td>
</tr>
<tr>
<td>ICT connectivity</td>
<td>Standardized interconnected networks to transfer information in the CIS</td>
</tr>
<tr>
<td>ICT interoperability</td>
<td>Common standard to exchange and use information between interconnected applications in the CIS</td>
</tr>
<tr>
<td>ICT scalability</td>
<td>Capability of the CIS (software, hardware, and telecommunication) to meet current and future information needs</td>
</tr>
</tbody>
</table>

**Practice resources:** The seven KPIs in Table 2-3 measure the capability of IM techniques to guide the IM processes. These KPIs were developed based on the IM practice characteristics identified through the analysis of construction IM literature from 2000-2011 inclusive.
Table 2-3: KPIs for the practice resources component

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information governance</td>
<td>Standardized accountability framework to provide business needs prioritization, information system governance, IM leadership, and IM roles and IM responsibilities</td>
</tr>
<tr>
<td>Information quality management</td>
<td>Standardized IM risk mitigation framework to audit information quality and flow, human resource strategy, IM needs assessment, system and infrastructure reassessment, and process techniques re-engineering</td>
</tr>
<tr>
<td>Information service delivery</td>
<td>Standardized process to communicate and share information to meet the needs of each management activity</td>
</tr>
<tr>
<td>ICT adoption</td>
<td>Standardized process for user participation in CIS development, implementation, and modification</td>
</tr>
<tr>
<td>ICT quality assurance</td>
<td>Standardized process to mitigate errors from information storage, access, security, modification, and deletion in the CIS</td>
</tr>
<tr>
<td>IM benefits</td>
<td>Standardized process to identify tangible and visible IM changes in collaboration and user experience of the CIS</td>
</tr>
<tr>
<td>IM roadmap</td>
<td>Standardized process to link short and long term IM goals with business goal via change management, manage information as a strategic resource, and convert paper to electronic artifacts</td>
</tr>
</tbody>
</table>

People resources: The three KPIs in Table 2-4 measure the capability of information managers and users to effectively and efficiently manage and perform the IM activities to meet the organizational-level IM needs. These KPIs were developed based on the IM characteristics of people identified through the analysis of construction IM literature from 2000-2011 inclusive.

Table 2-4: KPIs for the people resources component

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM behaviour</td>
<td>Actions that influence changes to IM and the CIS</td>
</tr>
<tr>
<td>IM qualification</td>
<td>Knowledge of the IM processes and CIS use</td>
</tr>
<tr>
<td>IM skill</td>
<td>Experience and training required to use the CIS</td>
</tr>
</tbody>
</table>

IM inputs: The six KPIs in Table 2-5 measure the capability of information to accomplish the IM activities. These KPIs were selected based on the characteristics of
information identified by Chaffey (2003) and the classification of information by Lucey (2005).

**Table 2-5: KPIs for the IM inputs component**

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information certainty</td>
<td>Validity of information for each management activity</td>
</tr>
<tr>
<td>Information date</td>
<td>Period when information is created or modified for each management activity</td>
</tr>
<tr>
<td>Information detail</td>
<td>Features of information content for each management activity</td>
</tr>
<tr>
<td>Information frequency</td>
<td>Timing of information for each management activity</td>
</tr>
<tr>
<td>Information scope</td>
<td>Intended purpose of information for each management activity</td>
</tr>
<tr>
<td>Information source</td>
<td>Physical location of information for each management activity</td>
</tr>
</tbody>
</table>

**IM outputs:** The three KPIs in Table 2-6 measure the value of information produced in the IM processes. These KPIs were selected based on the characteristics of high quality information identified by O’Brien (2002) and Chaffey (2003). Value refers to information that possesses characteristics of high quality to decision makers.

**Table 2-6: KPIs for the IM outputs component**

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information content</td>
<td>Completeness of information for each management activity</td>
</tr>
<tr>
<td>Information form</td>
<td>Presentation of information for each management activity</td>
</tr>
<tr>
<td>Information time</td>
<td>Timeliness of information for each management activity</td>
</tr>
</tbody>
</table>

**IM constraints:** The eight KPIs in Table 2-7 measure the organizational-level factors that limit the functioning of the IM activities. These KPIs were developed based on the organizational-level IM characteristics identified through the analysis of construction IM literature from 2000-2011 inclusive.
Table 2-7: KPIs for the IM constraints component

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information overload</td>
<td>Standardized process to identify the amount of excess and unwanted information encountered for each management activity</td>
</tr>
<tr>
<td>ICT flexibility</td>
<td>Capacity of the CIS to meet users’ expectations and needs for each management activity without excessive costs, time, disruptions, performance losses, or reliance on legacy systems</td>
</tr>
<tr>
<td>IM complexity</td>
<td>Standardized process to identify complication in the CIS and in the management of information for each management activity</td>
</tr>
<tr>
<td>IM cost</td>
<td>Standardized cost strategy to manage and store information</td>
</tr>
<tr>
<td>IM culture</td>
<td>Standardized process to identify adversarial attitudes, divergent goals and objectives, functional fragmentation, and self-protective pressures in the IM processes</td>
</tr>
<tr>
<td>IM interdependency</td>
<td>Standardized process to integrate people with the CIS</td>
</tr>
<tr>
<td>IM legal requirement</td>
<td>Standardized process to comply with organization and government information regulations</td>
</tr>
<tr>
<td>IM organization structure</td>
<td>Standardized hierarchical arrangement that influence information accountability</td>
</tr>
</tbody>
</table>

**IM objectives:** The seven KPIs in Table 2-8 measure the capability of the IM processes to achieve the IM goal. These KPIs were selected based on the key characteristics of information identified by Zhao et al. (2008).

Table 2-8: KPIs for the IM objectives component

<table>
<thead>
<tr>
<th>KPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information accessibility</td>
<td>Retrieval of information from the CIS for each management activity</td>
</tr>
<tr>
<td>Information accuracy</td>
<td>Preciseness of information for each management activity</td>
</tr>
<tr>
<td>Information availability</td>
<td>Readiness of information for use when needed for each management activity</td>
</tr>
<tr>
<td>Information context</td>
<td>Understanding of information for each management activity</td>
</tr>
<tr>
<td>Information currency</td>
<td>Up-to-date information for each management activity</td>
</tr>
<tr>
<td>Information relevance</td>
<td>Application of information for each management activity</td>
</tr>
<tr>
<td>Information usability</td>
<td>Completeness of information for each management activity</td>
</tr>
</tbody>
</table>
2.6 Summary of the organizational-level IM framework

The developed IM framework (Figure 2-2) provides a generic and static representation of organizational-level IM in construction-owner organizations. The eight IM components (i.e., IM processes, ICT resources, practice resources, people resources, IM inputs, IM outputs, IM constraints, and IM objectives) represent the key organizational-level IM areas that should be measured to improve the IM performance within an organization. The six IM activities and 40 KPIs are used to comprehensively measure the organizational-level IM performance. The connections between the components highlight the relationship between the components.

![Diagram of IM framework]

Figure 2-2: Details of the proposed organizational-level IM framework
2.7 Researchers’ validation of the IM activities and KPIs

Using the four criteria identified by Carlucci (2010), described in Section 2.2.2, and an analysis of the common criteria used by construction-owner organizations (municipalities) to evaluate performance indicators for management process assessment, the following four criteria were developed to validate the KPIs in this study. The criteria development was necessary to ensure that the IM researchers could relate to the IM activities and KPIs. The evaluation criteria are: (i) appropriateness: relates to the agreement with the IM activities and KPIs for use in organizational-level IM measurement; (ii) comprehensiveness: relates to the completeness of the IM activities or KPIs for organizational-level IM measurement; (iii) accuracy: relates to the interpretation of the IM activities and KPIs in organizational-level IM measurement; and (iv) relevance: relates to the application of the IM activities and KPIs to organizational-level IM measurement. The first two criteria (i and ii above) were used to check the construct and content validity of the KPIs to ensure that the KPIs measured the performance that they were developed to measure and that each KPI definition fully encapsulates the requirement of each KPI. The last two criteria (iii and iv above) were used to check the reliability of the KPIs by checking the consistency of the KPIs to capture IM performance across managers and organizations.

The researchers’ validation method presented in this chapter uses the first and second criteria (appropriateness and comprehensiveness) to evaluate the IM activities and the KPIs for use in comprehensive organizational-level IM performance assessment. The appropriateness of the IM activities and KPIs was evaluated through the researchers’
agreement with the IM activities and KPIs for use in comprehensive IM measurement. The data for the evaluation were collected using agreement scale questions. The comprehensiveness was evaluated through each researcher’s ability to identify new IM activities or KPIs that were not included in the questionnaire survey (Appendix A). The data required for evaluation and recommended changes were collected using open-ended questions. The four criteria are also used in Chapter 3 (a subsequent validation study of industry practitioners to evaluate the IM activities and KPIs for use in comprehensive IM assessment).

2.7.1 Researchers’ validation method

The three steps used to evaluate the appropriateness and comprehensiveness of the IM activities and KPIs are presented below.

(i) Identify the construction IM researchers: The researchers were identified by my co-supervisors based on their knowledge of Canadian construction IM experts. The researchers were selected based on non-probability sampling similar to the expert sampling method described by Trochim (2006). Expert sampling involves the use of a sample of persons with demonstrated expertise and experience in a specific field, which is useful to elicit the view of the experts to gain insight into a specific field or topic (Trochim 2006). The selected researchers were contacted by email to participate in an online questionnaire survey. Canadian construction IM researchers were selected because this research is based on the construction industry in Canada. The selected researchers have worked in various areas within construction IM, including areas such as: information and communication technologies, information systems, and IM
practices. A total of 13 IM researchers were contacted via E-mail; ten agreed to participate in this study and seven (54%) completed the survey. The survey was available to the researchers for a period of 30 days (February-March 2012) to limit the time for this research. The majority of the questionnaires were completed within the last day of the survey. The time required to complete the survey is approximately 45 minutes.

**(ii) Develop the questions and questionnaire:** The steps used to design the questionnaire are similar to those suggested by Pickard (2007). A summary of the eight-step questionnaire design is as follows: review question requirements, develop list of potential questions, prioritize questions, evaluate potential questions, determine form of questions, construct specific wording of questions, structure questionnaire, evaluate and pilot test questionnaire, and revise and distribute (Pickard 2007). These steps ensure that the questionnaire is stand-alone, clear, and easy to understand by the respondents (Pickard 2007).

The questionnaire in Appendix A was based on the eight components of the IM framework (Figure 2-2) and consisted of 54 questions (a single Likert-scale question for each IM activity and KPI and one open-ended question for each IM component). A five-point scale Likert-scale (i.e., strongly disagree, disagree, neutral, agree, and strongly agree) was used and each point coded as 1, 2, 3, 4, and 5 to rate the appropriateness of the IM activities and KPIs for organizational-level IM performance measurement. The open-ended questions were used to collect any additional IM activities, KPIs, comments, and recommendations to improve the IM activities and KPIs. The Likert-scale was
selected and used based on the advantages described by Kothari (2004). A summary of the key advantages includes: easy to construct scale, easy to use, requires less time than other methods, and it is reliable. An example of the Likert-scale question is as follows: “Please state your level of agreement with the appropriateness of the KPI **Information accessibility** (i.e., the ease of retrieving information from the CIS for each management activity) for comprehensive organizational-level IM performance measurement.” An example of the open-ended question is as follows: “Please identify any KPI(s) not included in the questions and/or any specific comments/recommendations to improve the KPIs.”

To reduce biases from the collected data, the developed questions were specific, unaided, and neutrally structured to avoid leading biased questions, minimize question order biases, and reduce the candidate’s influence on the researchers’ responses. The IM activities and KPIs were described to be simple, clear, and concise to reduce misunderstanding. A scripted summary was also provided to the researchers to describe the research goal and the purpose of the survey, and to ensure that each researcher received the same information.

(iii) **Conduct the survey and analyze the data:** The IM researchers’ ratings for each IM activity and KPI were collected through an online questionnaire survey because of the convenience and ease to reach the IM researchers across Canada. The agreement ratings (i.e., strongly agree and agree ratings) indicate the appropriateness of the IM activities and KPIs for organizational-level IM performance measurement and were calculated by dividing the strongly agree and agree ratings by the maximum number of
ratings for a selected component. A similar calculation was used to identify the *neutral* and *disagree* ratings. The comments from the open-ended questions for the *neutral* and *disagree* responses were used to refine the IM activities and KPIs (no *strongly disagree* responses were received).

### 2.7.2 Researchers’ validation results

The researchers’ ratings in agreement with the appropriateness of the six IM activities and 40 KPIs for organizational-level IM performance measurement showed a 92% agreement rating (57% strongly agree and 35% agree) as shown in Figure 2-3, a 7% *neutral* rating, a single *disagree* rating, and no *strongly disagree* rating.

The comments for the *neutral* and *disagree* ratings were related to the definitions developed for the IM activities and KPIs. The comments for the *neutral* and *disagree* ratings revealed that 20 definitions (44%) did not fully encapsulate the requirements of the IM activities and KPIs for use in organizational-level IM measurement. Subsequently, the definitions were refined to ensure that the definitions better encapsulate the essential features and requirements of the IM activities and of the KPIs. The refinements included changes to phrasing and terminology in the definitions. For example, the phrasing in the definition for the KPI *Information Date* was changed from *historical, present, or future period* to the *period when information is created or modified for each management activity*. Likewise, the terminology in the definition for the KPI *IM Behaviour* was changed from *beliefs and values* to the *actions that influence changes to IM and the computer information system*. The refined definitions are presented in Appendix B and in Section 2.4.2.
The refinements made to the IM activities and KPIs based on the researchers’ recommendations in the open-ended questions for the *neutral* and *disagree* ratings were assumed to be adequate for further validation through strategic managers (Chapter 3) and were not subsequently confirmed by the researchers. This was assumed because the researchers’ recommendations were specific and confirmation of the changes made to the IM activities and KPIs definitions would not reveal any additional information to improve the appropriateness and comprehensiveness of the IM activities and KPIs. The refinements to the definitions were made only after analysis and agreement with the recommendations by the candidate and the candidate’s co-supervisors. Also, further validation of the definitions in Chapter 3 will provide opportunities for refinement. However, if the researchers’ recommendations were related directly to the appropriateness of the IM activities or KPIs for IM measurement (instead of terminology and phrasing of the definitions) then changes to the IM activities and KPIs would require verification by the researchers.
Figure 2-3: The IM researchers’ appropriateness rating by IM component

The details for the researchers’ appropriateness ratings are shown in Figure 2-3, and the recommendations to improve the comprehensiveness of the IM activities and KPIs definitions are described below.

**IM processes**: There are six activities within this IM component. The ratings show a 93% agreement (62% strongly agree and 31% agree), 7% neutral, and no disagreement. One researcher provided a neutral rating and recommendations for the IM activities information needs identification, information access and dissemination, and information use.

**ICT resources**: There are six KPIs within this IM component. The ratings show an 86% agreement (59% strongly agree and 27% agree), 14% neutral, and no disagreement. Three researchers provided neutral ratings and recommendations for all the KPIs except...
for *ICT interoperability*. The recommendations suggested the inclusion of *portability and remote field accessibility* within the definition of the KPI *ICT connectivity*.

**Practice resources:** There are seven KPIs within this IM component. The ratings show a 94% agreement (59% strongly agree and 35% agree), 6% neutral, and no disagreement. Two researchers provided neutral ratings and recommendations for the KPIs *information service delivery* and *IM roadmap*.

**People resources:** There are three KPIs within this IM component. The ratings show an 85% agreement (52% strongly agree and 33% agree), 10% neutral, and 5% disagreement. One researcher provided a neutral rating and a recommendation for the KPI *IM skill*, while another researcher provided a disagree rating and a recommendation for the KPI *IM behaviour*. The disagree rating recommended changes to the terminology in the definition as IM beliefs and values are difficult to measure and may not provide useful and meaningful indications of performance to managers.

**IM inputs:** There are six KPIs within this IM component. The ratings show an 86% agreement (41% strongly agree and 45% agree), 14% neutral, and no disagreement. Two researchers provided neutral ratings and recommendations for all the KPIs except for *information detail*.

**IM outputs:** There are three KPIs within this IM component. The ratings show a 100% agreement (57% strongly agree and 43% agree) with no neutral or disagree rating, and no recommendation.
**IM constraints:** There are eight KPIs within this IM component. The ratings show 96% agreement (50% strongly agree and 46% agree), 4% neutral, and no disagreement. One researcher provided a *neutral* rating and recommendations for the KPIs *ICT flexibility* and *IM legal requirement*.

**IM objectives:** There are seven KPIs within this IM component. The ratings show a 98% agreement (74% strongly agree and 24% agree), 2% neutral, and no disagreement. One researcher provided a *neutral* rating and a recommendation for the KPI *information relevance*.

Additionally, the IM researchers did not identify any new IM activities or KPIs, which indicates the comprehensiveness of the IM activities and KPIs for organizational-level IM performance measurement.

### 2.8 Discussion

The proposed IM framework provides eight IM components, six IM activities, and 40 KPIs to comprehensively measure the organizational-level IM performance within construction-owner organizations. The comprehensiveness of the IM framework (components and relationships) was checked during the literature review conducted to identify the KPIs, but no revision was necessary. The IM activities and KPIs developed for the *IM processes, IM inputs, IM outputs,* and *IM objectives* components can be linked to the work of several previous IM researchers. The KPIs in the *ICT resources, practice resources, people resources,* and *IM constraints* components are the aggregated results from analysis of construction IM literature and are proposed for organizational-
level IM assessment. The IM objectives component contains the lagging KPIs, and the ICT resources, practice resources, people resources, IM input, IM output, and IM constraints components contain the leading KPIs. The lagging KPIs identify the success of previous actions, initiative, and modifications made to organizational-level IM processes, and the leading KPIs identify the actions, initiative, and modifications required to improve the organizational-level IM processes.

The researchers’ validation results revealed that the construction IM researchers agreed with the appropriateness of the IM activities and KPIs for comprehensive organizational-level IM measurement (92% agreement). However, several researchers explained that the initial definitions did not fully encapsulate the functional requirements for three IM activities and 17 KPIs, and provided specific recommendations to improve the definitions. The researchers did not identify any additional IM activity or KPI, which indicates the comprehensiveness of the developed IM activities or KPIs for IM assessment.

The strength of the proposed IM framework is in its wide-ranging scope to provide a comprehensive view of organizational-level IM by identifying the IM components needed to measure IM performance. The IM components group the KPIs to provide understanding and meaningful insight into IM measurement. The specific definitions developed for each KPI identified the characteristics to measure for each KPI. The lagging and leading KPIs allow for the comprehensive organizational-level IM performance to be measured through strategic managers, which could save time and effort. Moreover, the KPIs will identify the managers’ success in optimizing the IM
resources and the effort required to adequately manage the IM resources and reduce the IM constraints to achieve the organizational-level IM goal. The KPIs can be used to measure and benchmark the organizational-level IM performance by comparing the plan to actual performance levels over time, thereby eliminating the need for frequently developing new KPIs and metrics. The KPIs can also allow organizations to benchmark IM performance internally, which can potentially be used to compare the IM performance between organizations (external benchmarking) providing the strategic managers in the organizations use the same KPIs.

2.9 Conclusions

The proposed IM framework aims to provide an understanding of organizational-level IM, and the IM activities and KPIs required to comprehensively measure the organizational-level IM performance in construction-owner organizations. This was accomplished using a structured literature review, analysis, and synthesis process, which identify the key IM components, IM activities, and KPIs required for the organization-level IM performance measurement. The initial researchers’ validation shows that the IM activities and KPIs are appropriate and comprehensive for organization-level IM performance measurement.

The key contributions of the developed framework to IM researchers studying organizational-level IM, and those industry practitioners (strategic managers) seeking to assess the organizational-level IM performance in construction-owner organizations are:
• The generic representation and static view of organizational-level IM in a construction-owner organization, which provides a comprehensive view of organizational-level IM to strategic managers.

• The key organizational-level IM components, which provide the core IM characteristics influencing organizational-level IM performance.

• The relationships between the IM components, which provides an understanding of the organizational-level IM structure to guide continuous performance measurement and improvement.

• The seven lagging KPIs to comprehensively measure the organizational-level IM success achieved from completed IM actions, initiative, and modifications, as well as the 33 leading KPIs to identify the organizational-level IM actions, initiative, and modifications needed to prevent degradation to IM performance and improve the IM performance (i.e., the capability to comprehensively measure the organizational-level IM performance using the framework).

This study is limited to construction-owner organizations, and the structure of the IM framework (i.e., components and relationships) is based on the author’s view of IM in a construction organization and has not been formally validated in this study. The researchers’ validated IM activities and KPIs should be further validated through industry practitioners in construction organizations before use in organizational-level IM performance measurement. Moreover, the IM activities and KPIs should not be generalized to other stakeholder organizations such as contractor, designer, and architect without proper testing in those organizations.
References


3 Validate the IM activities and KPIs

Abstract

The lack of key performance indicators (KPIs) to comprehensively measure the organizational-level information management (IM) performance in construction-owner organizations has prevented organizations from optimizing IM resources and reducing IM constraints. In Chapter 2 six IM activities and 40 KPIs needed to comprehensively measure organizational-level information management (IM) performance in construction organizations were identified, and initially validated through construction IM researchers. The objective of this chapter is to further validate the IM activities and KPIs with practitioners (strategic managers) in three large construction-owner organizations. A structured validation approach is used to evaluate the appropriateness, comprehensiveness, accuracy, and relevance of the IM activities and KPIs for IM measurement. This approach includes a structured interview survey of six strategic managers. The results verified the refinements made to the IM activities and KPIs based on the IM researchers’ recommendations obtained from the initial validation. The lack of inconsistencies in the managers’ responses and evidence provided by the managers confirms that the IM activities and KPIs are capable of measuring the organizational-level IM performance in construction-owner organizations.

Keywords: Information management, validation, key performance indicators.
3.1 Introduction

Information is an essential functional requirement for organizations in the construction industry (Titus and Brochner 2005). Information management (IM) measurement allows organizations to efficiently and effectively identify, create, analyze, access, and use information to improve performance (Hicks et al. 2006). Studies have recognized that a comprehensive approach to IM provides greater benefits to organizations, by optimizing the capability of people with information communication technology (ICT) to control and use information to improve performance (Hicks 2007, Sheriff et al. 2012). A key issue with a comprehensive IM approach for construction organizations is the lack of validated KPIs to measure the organizational-level IM performance.

The organizational-level IM framework developed in Chapter 2 and shown in Figure 3-1, identified the IM components, IM activities, and KPIs required for comprehensive organizational-level IM performance measurement in construction-owner organizations. The IM activities and KPIs were initially validated through seven construction IM researchers in Canada, using an online questionnaire survey. This researchers’ validation consisted of evaluating the appropriateness and comprehensiveness of the IM activities and KPIs for comprehensive organizational-level IM measurement.

The objective of this chapter is to further validate of the IM activities and KPIs through IM practitioners (six strategic managers) in three construction-owner organizations in the Canadian Maritime provinces. This practitioners’ validation uses a structured approach to verify the appropriateness and comprehensiveness of the IM activities from the researchers’ validation study, as well as evaluate the accuracy and relevance of the
IM activities and KPIs for use in organizational-level IM measurement. The accuracy of the IM activities and KPIs was evaluated in an earlier study (Aziz et al. 2013).

The remaining sections of this chapter are as follows: Section 3.2 presents the literature review highlighting the validation approaches used in construction management research, Section 3.3 presents the practitioners’ validation method used to evaluate the IM activities and KPIs, Section 3.4 presents the practitioners’ validation results, Section 3.5 presents the discussion of the practitioners’ validation results, and Section 3.6 presents the conclusions of this chapter.

![Image](image_url)

**Figure 3-1: The previously developed organizational-level IM framework**

### 3.2 Literature review

A key issue identified in construction IM literature is the variety of validation challenges
encountered by construction researchers due to the inherent difficulty of conducting research in real-life settings coupled with the interdisciplinary nature of construction management (Lucko and Rojas 2010).

The validation challenges encountered in construction research are overcome through the appropriate application of social science research methods such as surveys or case studies. However, the inherent limitations within a single research method can inhibit the validity, reliability, and generalization of the research findings. Consequently, a mix-method approach, which incorporates two or more complementary research methods to counteract the limitations of a single research method, is used to improve the validity, reliability, and generalizability of the research findings. (Abowitz and Toole 2010)

Moreover, probability-based sampling methods are effective in reducing bias within collected data, but are rarely feasible in construction research because of low response rate, which may not be practical for the generalization of research findings. This has resulted in the common use of non-probability-based sampling such as convenience sampling in construction research, although non-probability-based sampling prevent the calculation of sampling errors or confidence intervals. (Abowitz and Toole 2010)

The proper use of mix-method approaches can overcome inherent weaknesses of non-probability sampling methods (Abowitz and Toole 2010). Similarly, there are techniques that can be used to reduce biases in the different types of validation and sampling methods (Lucko and Rojas 2010). Because concepts such as ‘performance’ are not consistently defined, they are usually not easily measured (Samsonowa 2012), adding further to the validation challenges especially with the lack of existing test cases (i.e.,
data sets) to verify the validation results. A study by East et al. (2007) has identified that construction management research has limited test cases that can be used to verify or validate new research findings. Studies by Abowitz and Toole (2010) and Lucko and Rojas (2010) have identified the different types of validation used in construction research, which can overcome the lack of verification test cases.

In addition, the evaluation of KPIs is critical to ensure that the right indicators are used in performance measurement. There are numerous and frequently interchangeable criteria with a combination of meanings (definitions) proposed in literature to evaluate and select the right performance indicators for measurement (Carlucci 2010). Carlucci (2010) reviews previous evaluation criteria in literature and identifies four criteria that can be used to select performance indicators. The four criteria are summarized as follows: (i) Relevance: relates to measuring as close as possible the result that is intended be to measure; (ii) Reliability: relates to errors and biases, and how well it represents what it claims to represent; (iii) Comparability and consistency: relates an indicator use for the comparison of organizations and its application of over time; and (iv) Understandability and representational quality: relates to interpretable, understanding, ease of use, meaning, and format. These four criteria are presented from financial and economic perspectives and will require revisions to be applicable to information management KPIs evaluation. Based on these findings a non-probability sampling and case study approach has been adopted to evaluate the validity and reliability of the IM activities and KPIs for use in IM performance measurement.
3.3 Practitioners’ validation method

A total of four criteria (appropriateness, comprehensiveness, accuracy, and relevance) have been developed to evaluate the IM activities and KPIs in this chapter. The four criteria are described in Section 2.7. The development of these criteria was necessary to ensure the managers would relate to the IM activities and KPIs. The practitioners’ validation method presented below shows the structured approach used to evaluate the appropriateness, comprehensiveness, accuracy, and relevance of the IM activities and KPIs for use in organizational-level IM assessment. This approach verifies the initial researchers’ validated IM activities and KPIs.

The appropriateness was checked through the ability of the managers to relate the KPIs to organizational-level IM assessment, (i.e., the application of the KPIs to the organization). The comprehensiveness was checked through each manager’s ability to identify any new IM activities or KPIs that were not included in the interview survey in Appendix A. The accuracy was evaluated through the inconsistencies in the managers’ responses, which identified possible misinterpretations of the IM activities or KPIs by the managers (identified through inconsistencies across the managers’ responses and across assessment actions performed by the managers). Finally, the relevance was evaluated through the evidence provided by the managers, which showed how the IM activities and KPIs were applied to IM assessment in each organization (identified through actual assessment data and demonstration that showed how the assessment actions were performed on the IM activities and KPIs).
3.3.1 Select the organizations and strategic managers

Three large similar-sized organizations were selected based on their agreement to participate in this study and their proximity to the researcher (the organizations must be located in the Canadian Maritime provinces). Owner organizations were selected because they are more likely to have an established organizational-level information management system relative to the other stakeholders in the construction industry that was considered to participate in this study. The organizations are referred to as organizations X, A, and B to protect their identity. Each organization’s hierarchy structure was used to select the strategic information manager from the information technology (IT) and engineering departments within the organizations (six managers in total). These six strategic managers were selected because they are responsible for the strategic management of organizational-level IM within the organizations. The IT strategic manager controls the quality, effectiveness, and efficiency of the organization’s computer information system (CIS), which includes hardware, software, telecommunications, and stored information. The engineering strategic manager administers the quality, effectiveness, and efficiency of infrastructure designs, construction, and maintenance information within the organization.

The managers were selected based on a non-probability sampling method similar to the expert sampling method described in Section 2.7.1. The managers were experienced in managing infrastructure design, construction, and maintenance information strategically within each organization for more than two management cycle, which approximately 1.5 years per cycle in the participating organizations. The managers were contacted by email
to participate in the interview survey. In the first organization (organization X), the IT and Engineering operation managers were also selected to participate in the study. However, after analyzing the results it was found that the operations managers’ roles are participatory in the organizational-level IM assessment. Although the operations managers’ responses were free of inconsistencies and in agreement with the applicable strategic managers’ responses, the responses add limited insight into the assessment actions performed by the strategic managers and the operations managers’ responses were removed from this validation study.

### 3.3.2 Develop the interview questions and survey

The process used to develop the structured interview questions is similar to the questionnaire design steps presented by Pickard (2007), which included the following nine steps: review question requirements, develop list of potential questions, prioritize questions, evaluate potential questions, determine form of questions, construct specific wording of questions, structure questionnaire, evaluate and pilot test questionnaire, and revise and distribute (Pickard 2007). These steps ensure that the questions are clear and easily understood by the respondents. In addition, the structured interview process used in this research is similar to the following eight-stage interview processes presented by Pickard (2007), which is summarized as: themating, designing, interviewing, recording, transcribing, analyzing, verifying, and reporting.

The interview consisted of 49 questions; one “Yes/No” type question for each of the six IM activities and each of the 40 KPIs, and four open-ended questions (Appendix B). The 46 “Yes/No” type questions were used to evaluate the appropriateness and accuracy of
the IM activities and KPIs for organizational-level IM assessment. The open-ended questions were used to evaluate the comprehensiveness and relevance of the IM activities and KPIs, as well as collect any additional information that the managers deemed useful to improve the IM activities and KPIs. The questions focused on infrastructure design, construction, and maintenance information assessed in the organizational-level performance management cycle.

The assessment actions consistently performed by the strategic managers in the performance management cycle were used to evaluate the accuracy of the IM activities and KPIs for IM measurement in the organizations. The questions were coded with one for “Yes” and zero for “No” to indicate whether the managers performed the assessment actions on each IM activity and KPI in the performance management cycle. The four assessment actions performed within the management cycle are defined as follows: (i) Plan/identify (i.e., developing ways to achieve the desired level of performance), (ii) Measure/document (i.e., capturing and analyzing the performance), (iii) Control/assess (i.e., comparing the plan and actual performance for quality achievement), and (iv) Improve (i.e., taking corrective actions to refine the performance). The actions plan, measure, control, and improve were applied to the IM processes, ICT resources, and practice resources components. Similarly, the actions identify, document, assess, and improve were applied to the people resources, IM inputs, IM outputs, and IM constraints components. These two sets of assessment actions were necessary to depict the IM activities and KPIs that strategic managers can and cannot control within organizational-level IM. The actions plan, measure, control, and improve were applied to the IM
activities and KPIs that can be controlled by strategic managers, while the actions *identify, document, assess, and improve* were applied to the KPIs that cannot be controlled by strategic managers.

In addition, the reason for not assessing an IM activity or KPI was collected from each manager to identify the reasons for potential inconsistencies between the managers’ responses and inconsistencies across the assessment actions performed on an activity or KPI. The interview questions used in the face-to-face survey are included in Appendix B. An example of a “Yes/No” type interview question is as follows: *For the infrastructure design, construction, and maintenance information that you or your team manages. Do you identify, document, assess, and improve Information accessibility (i.e., ease of retrieving information from the CIS for each management activity)?* An example of the open-ended question for evaluating comprehensiveness is: *“Can you identify any additional IM activities and KPIs that are not included in any of the eight IM components?”*

To evaluate the relevance of the IM activities and KPIs for IM measurement, four discussion-type questions were developed to ensure the assessment actions were performed on each IM activity and KPI. The first discussion-type question checked “what information was managed and assessed” as well as, “what performance metrics were used in the assessment.” The second discussion-type question checked “who managed the information” and “who performed the assessment actions.” The third discussion-type question checked “how the information was managed (i.e., the processes and procedures),” and “how the assessment actions were performed.” The fourth
discussion-type question checked “when the managers performed the IM assessment activities (i.e., as specified in policies and schedules),” and “when the assessment actions were performed.”

To minimize biases, the developed questions were specific, unaided, and neutrally structured to avoid leading biased questions, minimize question order biases, and reduce the interviewer’s influence on the managers’ responses. The IM activities and KPIs were described to be simple, clear, and concise to reduce misunderstanding. A scripted summary was used to describe the research goal and survey purpose to the managers in order to provide a clear understanding for the interviews. A structured approach and scripted summary was used to conduct the interviews to ensure that each manager received the same information and was asked the same questions to minimize both interviewer and responder biases. The managers were also asked to provide an evidence for each “Yes” response, which was used to verify the responses collected during the interview. Finally protecting the identities and collected data through anonymity for each participating organization and manager (via UNB’s Ethics Board) further ensured that the managers provided accurate responses that are representative of each organization.

3.3.3 Conduct the face-to-face interview survey

A structured face-to-face interview survey was conducted to collect the managers’ responses for each IM activity and KPI in a pilot test using the three organizations. This type of survey was selected because of the convenience to meet with the managers to
clarify the questions and collect feedback and evidence on the evaluated IM activities and KPIs.

In organization A, the data to evaluate the relevance of the IM activities and KPIs for IM measurement were collected in a subsequent face-to-face interview with each manager. However, in organizations B and C the data to evaluate the four criteria (appropriateness, comprehensiveness, accuracy, and relevance) were collected in single interview with each manager.

3.3.4 Analyze the data to verify and evaluate the IM activities and KPIs

The data analysis calculated the appropriateness, comprehensiveness, accuracy, and relevance of the IM activities and KPIs for use in organizational-level IM assessment. The appropriateness was calculated by dividing the number of IM activities and KPIs applicable to each organization by the total number of IM activities and KPIs (46 total) and multiple by the number of managers (2 per organization). The comprehensiveness was calculated by dividing the number of new IM activities and KPIs (identified by the managers) by the total number of IM activities and KPIs. The accuracy was calculated by dividing the number of consistent assessment actions performed by the total number of assessment action for each IM component. The responses were checked across managers for inter-respondent (IR) inconsistencies, and across the assessment actions for assessment actions (AA) inconsistencies. The IR inconsistencies were said to occur if there were mismatch in either strategic manager response or explanation for not assessing an IM activity or KPI. The AA inconsistencies were said to occur if there were subsequent increase across the assessment actions performed on an IM activity or KPI in
the performance management cycle (e.g., the responses for \textit{plan} to improve, or \textit{identify} to improve, have a “No” response followed by a “Yes” response). The accuracy was verified through the managers’ explanation for not performing an assessment action. The relevance was calculated by dividing the number of IM activities and KPIs that were proven by the managers to be formally assessed by the total number of IM activities and KPIs. The assessment of the IM activities and KPIs was proved through evidence from previous organizational-level assessment performed by the managers.

3.4 Practitioners’ validation results

The results for the four criteria (appropriateness, comprehensiveness, accuracy, and relevance) used to validate the use of the IM activities and KPIs for organizational-level IM assessment in the three construction-owner organization are presented below.

3.4.1 Appropriateness and comprehensiveness of the IM activities and KPIs

The appropriateness of the IM activities and KPIs for organizational-level IM assessment in the three organizations is shown in Figure 3-2. The figure shows the percentage of IM activities and KPIs that are applicable to each organization. Although several IM activities and KPIs were not applicable to each organization, they are collectively applicable to the three organizations. There was no instant where a specific IM activity or KPI was not applicable to all six managers in the three organizations. Additionally, the managers did not identify any new IM activities or KPIs, which shows that the developed IM activities and KPIs are comprehensive for organizational-level IM assessment.
3.4.2 Accuracy of the IM activities and KPIs

The accuracy of the IM activities and KPIs for organizational-level IM assessment in each organization is presented below by organization, based on the assessment actions performed on the IM activities and KPIs. There are no inter-respondent (IR) inconsistencies between the managers, and there are no assessment actions (AA) inconsistencies across the assessment actions performed by managers. However, each manager did not assess all the IM activities and KPIs. As a result, the explanation for not assessing an IM activity or KPI in the organization is provided for each manager.

Organization X

The results in Figure 3-3 show the assessment actions performed on the IM activities and KPIs within the organization. Although there were no inconsistencies in the managers’ responses, each assessment action was not performed on each IM activity and KPI.
The explanations provided by each manager for not performing the assessment actions (plan, measure, control, and improve) are presented below:

- **IM processes:** The IT manager did not evaluate the IM activities *information creation and acquisition* and *information use*. The IT manager’s explanation indicated that the engineering manager evaluated these activities because the engineering department identifies, creates, and uses the information, while the IT department supports the storage and access of information within the computer information system (CIS). The engineering manager’s responses showed that the IM activities were evaluated in the engineering department, and the explanation confirmed the IT manager’s justification.

- **ICT resources:** The engineering manager only plans for the KPI *ICT scalability*, and explained that the IT department evaluates this KPI, while the engineering department is only required to provide any ICT needs to the IT department. The IT manager’s responses and explanation confirmed the engineering manager’s justification.
• **Practice resources**: The engineering manager only plans for the KPI *ICT adoption* and does not evaluate the KPI *ICT quality assurance*. The manager’s explanation indicated that the engineering department is only required to provide ICT needs to the IT department, and *ICT quality assurance* is evaluated in the IT department. The IT manager’s responses and explanation confirmed the engineering manager’s justification.

Similarly, the explanations provided by each strategic manager for not performing the assessment actions (*identify, document, assess, and improve*) are presented below:

• **People resources**: The engineering manager responses showed that the KPI *IM behaviour* is not improved within the department, and explained that the IT department improves *IM behaviour* through computer information system (CIS) training. The IT manager’s responses showed that *IM behaviour* was evaluated, and the explanation confirms the engineering manager’s justification.

• **IM inputs**: Both managers evaluated the six KPIs within this component.

• **IM outputs**: The IT manager did not evaluate the KPIs *information content* and *information form*, and explained that these KPIs are relevant to the engineering department and are evaluated by the engineering manager. The engineering manager’s responses showed that the KPIs are indeed evaluated in the engineering department, and the explanation confirmed the IT manager’s justification.

• **IM constraints**: The engineering manager did not evaluate the KPIs *information overload, ICT flexibility*, and did not perform the actions *assess and improve* on
the KPI IM interdependency. The engineering manager’s explanation indicated that the IT department evaluated the KPIs. The issues relating to IM interdependency were identified, documented, and reported to the IT department for assessment. The IT manager’s responses showed that these three KPIs are evaluated in the IT department, and the explanation confirmed the engineering manager’s justification.

- **IM objectives:** The IT manager did not evaluate the KPI information accuracy and explained that the accuracy of information is relevant to the engineering department. The engineering manager’s responses showed that the KPI is evaluated in the engineering department, and the explanation confirmed the IT manager’s justification.

**Organization A**

The results in Figure 3-4 shows that both IT and engineering managers in organization B did not perform each assessment action on each IM activity and KPI.

<table>
<thead>
<tr>
<th>IM component</th>
<th>Percentage of &quot;YES&quot; responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM processes</td>
<td>83 100</td>
</tr>
<tr>
<td>ICT resources</td>
<td>100 83</td>
</tr>
<tr>
<td>Practice resources</td>
<td>100 71</td>
</tr>
<tr>
<td>People resources</td>
<td>75 67</td>
</tr>
<tr>
<td>IM inputs</td>
<td>100 83</td>
</tr>
<tr>
<td>IM outputs</td>
<td>100 100</td>
</tr>
<tr>
<td>IM constraints</td>
<td>87 37</td>
</tr>
<tr>
<td>IM objectives</td>
<td>100 57</td>
</tr>
</tbody>
</table>

**Figure 3-4:** Assessment actions performed in organization A.
The explanations provided by each strategic manager for not performing the assessment actions (plan, measure, control, and improve) are as follows:

- **IM processes**: The IT manager does not evaluate the IM activity information use and explain that the engineering department evaluates the KPI. The engineering manager’s response and explanation confirmed the IT manager’s justification.

- **ICT resources**: The engineering manager does not evaluate the KPI information navigation and explain that the IT department evaluates the KPI. The IT manager responses and explanation confirmed the engineering manager’s justification.

- **Practice resources**: The engineering manager does not evaluate the KPIs information quality management and ICT quality assurance, and the engineering manager’s explanation confirmed that these KPIs are not evaluated within the engineering department resulting in a lack of performance data on these two KPIs. The IT manager’s responses showed that the two KPIs are evaluated in the IT department, and the IT manager’s explanation confirmed the engineering manager’s justification.

Similarly, the explanations provided by each strategic manager for not performing the assessment actions (identify, document, assess, and improve) are as follows:

- **People resources**: The IT manager only performs the assessment action identify on the KPI IM behaviour and the engineering manager does not evaluate this KPI. Both managers’ explanations indicated that this KPI is not evaluated formally within the organization.
• **IM inputs:** The engineering manager does not evaluate the KPI *information frequency* and explain that it is not formally evaluated within the department. The IT manager’s responses showed that *information frequency* is evaluated, and the explanation confirmed the engineering manager’s justification.

• **IM outputs:** Both managers evaluated the three KPIs within this component.

• **IM constraints:** Both managers do not evaluate the KPI *information overload*, and the managers’ explanations indicated that the organization does not have a proper method to evaluate this KPI. Moreover, the engineering manager does not evaluate the KPIs *ICT flexibility, IM cost, IM culture*, and *IM interdependency*. The engineering manager’s explanation indicated that the IT department evaluated these KPIs, and stated that the engineering department need to focus on these four KPIs to reduce IM expenditure. The IT manager’s responses and explanation confirmed the engineering manager’s justification.

• **IM objectives:** The engineering manager does not evaluate the KPIs *information context, information relevance*, and *information usability*. The engineering manager’s explanation indicated that the IT department evaluated these KPIs. The IT manager’s responses and explanation confirmed the engineering manager’s justification.

**Organization B**

The results in Figure 3-5 show that both managers fully evaluated the activities within the *IM processes* component and the KPIs in the *ICT resources, practices resources, people resources, IM inputs, IM outputs, and IM constraints* components. However, for
the *IM objectives* component, the IT manager does not evaluate the KPIs *information accuracy, information context*, and *information relevance* and explain that these three KPIs are of importance to engineers and are evaluated in the engineering department. The engineering manager’s responses and explanation confirmed the IT manager’s justification.

![Figure 3-5: Assessment actions performed in organization B.](image)

### 3.4.3 Relevance of the IM activities and KPIs

In the interviews, the managers successfully provided evidence to show how they assess each applicable IM activity and KPI within their organization. The evidence consists of actual IM activities and KPIs that were evaluated in previous organizational-level IM assessment.

### 3.5 Discussion

The structured practitioners’ validation approach was used to evaluate the appropriateness, comprehensiveness, accuracy, and relevance of the initially researchers’ validated IM activities and KPIs for use in comprehensive organizational-level IM assessment in a pilot test. The results show that the IM activities and KPIs are
appropriate for IM assessment in construction owner-organizations. The reason all the IM activities and KPIs were not evaluated in each organization is due to the organizational structure, which produces IM customization to suite the business needs. This produced varying IM roles for the IT and engineering strategic managers, resulting in each manager assessing different IM components within each organization, as indicated in the managers’ explanations for not assessing a particular IM activity or KPI (Section 3.4.2).

The comparison of the six managers’ responses shows that the KPI *ICT flexibility* is not assessed by the engineering managers in organizations X and A. Similarly, the KPI *information accuracy* is not assessed by the engineering managers in organizations X and B. There exist no other cases in this validation study where two or more managers in the same organization or in different organizations failed to evaluate a specific IM activity or KPI. The collective application of the IM activities and KPIs in the three organizations indicates that the changes made to the IM activities and KPIs (based on recommendations from construction IM researchers in the initial validation study) did improve the appropriateness of the IM activities and KPIs from the 92% agreement among the IM researchers. The failure of the strategic managers to identify any additional IM activities and KPIs indicate the comprehensiveness of the IM activities and KPIs for organizational-level IM assessment.

The lack of inconsistencies across the managers’ responses in each of the three organizations confirms that the IM activities, KPIs, and questions are clear and easily understood by each strategic manager. This lack of inconsistencies confirms the
accuracy of the IM activities and KPIs to consistently provide similar results from strategic managers in organizational-level IM assessment. The feedback from the managers for not performing an assessment action on an IM activity or KPI identifies opportunities for IM improvement within the organizations, and is not related to the capability of the IM activities and KPIs to capture pertinent performance data from managers.

The comments from the managers also indicate that organizations X and A have similar IM structure; i.e., the IT and engineering departments mutually depend on each other for effective and efficient management of information. However, in organization B there is greater IM independence between the IT and engineering departments, resulting in a higher assessment rate in both departments. Moreover, the results confirmed that in each organization, either the IT or engineering strategic managers evaluated the six IM activities and the 40 KPIs in organizational-level IM assessment, thereby confirming the relevance of the IM activities and the KPIs to construction-owner organizations. The key benefit of the validated IM activities and KPIs to strategic managers is the capability of the validated IM activities and KPIs to provide a comprehensive view of organizational-level IM performance.

3.6 Conclusions

The aim of this study was to conduct a practitioners’ validation on initially researchers’ validated IM activities and KPIs to evaluate their usefulness for comprehensive organizational-level IM assessment in construction-owner organizations. The practitioners’ validation was accomplished using a structured method. The findings
indicated that the IM activities and KPIs are capable of measuring the organizational-level IM performance through strategic managers in construction-owner organizations. The key contribution of this study is the validated IM activities and KPIs, which will be beneficial to strategic information managers seeking to assess the organizational-level IM performance in construction-owner organizations.

Despite the capability of method to adequately serve the validation purpose, there are limitations and biases in the approach. To limit the research time, the practitioners’ validation was restricted to three large similar-sized construction-owner organizations, which may not be representative of all construction-owner organizations in the Canadian Maritime provinces. Similarly, the IM activities and KPIs were not tested in other construction organizations such as architects, designers, and contractors. Therefore, it should not be assumed that the IM activities and KPIs are applicable to other construction organizations without further evaluation in those organizations.

In addition, there are inherent biases in the use of non-probability sampling, which do not allow for the calculation of sampling error or confidence intervals. Although biases cannot be completely eliminated, the following steps were taken to reduce biases from the validation method and results. The use of neutrally structured and scripted questions prevented leading biased questions and reduces the interviewer’s influence on the managers’ responses. The IM activities and KPIs definitions were simple, clear, and concise to reduce misunderstanding. The interview questions were specific, unaided, and positive to minimize question order biases. A scripted summary was used to describe the research goal and interview purpose to the managers, and conduct the interviews to
ensure that each manager received the same information. Finally, protecting the identities of the organizations and managers, and collecting evidence to confirm that each applicable IM activity and KPI was actually assessed within the organizations further minimizes biases and improves the accuracy of the responses.

References


4 Measure organizational-level IM performance

Abstract

The lack of key performance indicators (KPIs) to comprehensively measure the organizational-level information management (IM) has prevented construction organizations from optimizing IM to improve performance. The objective of this study is to measure the organizational-level IM performance in construction-owner organizations. A structured measurement method is developed, and pilot tested in two organizations using previously validated key performance indicators (KPIs) to collect performance data from strategic IT and engineering managers. The IM performance is measured for eight-key IM components at the KPI-level, and for the IM objectives component at the metric-level for a specific management process (i.e., change order process). The KPI-level results identify opportunities for improvement within the organizations for seven of the eight measured IM components, specifically in practice resources, people resources, IM constraints, and IM objectives components. The metric-level results also identify opportunities for IM improvement in information availability, accuracy, context, and relevance within the change order process. The pilot testing of the measurement method demonstrates the level of detail that can be accomplished in organizational-level IM performance measurement.

Keywords: Information management, organizational-level performance measurement, KPI, construction-owner organization.
4.1 Introduction

An organizational-level information management (IM) approach is recognized to provide greater benefits to construction organizations when compared to methods that only focus on specific components of IM such as information and communication technology (ICT) or IM constraints (Hicks 2007, Sheriff et al. 2012). To realize the benefits of an organizational-level IM approach construction organizations must measure the key IM components to effectively and efficiently improve performance within the organization. A key challenge identified in the review of construction IM literature from 2000 to 2011 inclusive (expanding on a previous review Aziz et al. 2011, as described in Chapter 2) is the lack of a suitable method with comprehensive key performance indicators (KPIs) to measure the organizational-level IM performance and provide meaningful results to managers in construction organizations.

The objective of this chapter is to measure the organizational-level IM performance in construction-owner organizations. A structured method is developed to measure the IM performance using the IM activities and KPIs developed in Chapter 2 (Figure 4-1) and validated in Chapter 3. The remaining sections of this chapter are as follows: Section 4.2 presents the literature review highlighting the state of IM measurement in construction, Section 4.3 presents the method developed to measure the organizational-level IM performance in two construction-owner organizations, Section 4.4 presents the measured results, Section 4.5 presents the discussion of the results, and Section 4.6 presents the conclusions of this chapter.
4.2 Literature review

The term ‘performance measurement’ is widely used, but the definition is incomplete (Samsonowa 2012). Based on the analysis of performance measurement definitions in literature, Samsonowa (2012) defined ‘performance measurement’ as “a process in which relevant data for performance indicators (as-is data) is collected; and the collected data is evaluated, analyzed and interpreted (comparison of as-is with to-be).” There are several internationally recognized measurement frameworks and methods that exist in performance measurement literature (e.g., Balance Scorecard, European Foundation for Quality Management, Just-in-time, Benchmarking, and Maturity modeling) (Bassioni et al. 2004). These frameworks and methods focus on specific aspects of performance.
measurement resulting in limitations, and making them unsuitable for use in organizational-level IM performance measurement.

The key limitations of these frameworks and methods are as follows: limited assessment criteria/perspectives, limited relations between criteria/perspectives, limited process to develop measures, and limited implementation and maintenance guidelines. Furthermore, there are gaps that these frameworks and methods do not address. These gaps include, providing managers with an easy solution that fits into existing measurement systems with minimum alteration, providing a procedure for target and standard setting of measures, providing a procedure to aggregate the different units of measurement, reducing the overload of measures in measurement systems, and providing a feedback loop to link measurement and management systems. (Bassioni et al. 2004)

The existing construction IM measurement methods focus primarily on evaluating specific IM components such as information technology and management information systems at the project level (e.g., Stewart 2007, Lee and Yu 2012). The few organizational-level studies in the literature have limited IM assessment criteria, and the project-level studies ignore IM across projects. The limited number of studies on organizational-level IM in construction (e.g., Hicks 2007, Sheriff et al. 2012) and the lack of research on comprehensive organizational-level IM performance measurement in construction organizations suggest that organizational-level IM performance measurement is not fully investigated and therefore not well understood.
4.3 Method

The developed performance measurement method consists of four steps (Figure 4-2). The first step measures the performance at the KPI-level for each IM component through the assessment actions performed by strategic managers on the IM activities and KPIs in the performance management cycle. The second step selects the IM component(s) for metric-level measurement. The third step selects a specific organizational-level management process for metric-level measurement. The fourth step measures the metric-level performance for the selected management process using developed performance metrics and questions for the KPIs within the selected IM component(s). Each step in the method is described below.

**Figure 4-2: Details of the IM performance measurement method**
4.3.1 Measure the KPI-level performance for the IM components

Data were collected from the strategic IT and engineering managers in two similar-size case study construction-owner organizations (referred to as organizations A and B to protect their identity) in the Canadian Maritime provinces. The managers were identified from each organization’s hierarchy structure and were contacted by telephone and email to participate in this study. The strategic managers are responsible for the continuous assessment of the organizational-level IM performance. The IT strategic manager controls the quality, effectiveness, and efficiency of the organization’s computer information system (CIS), which includes hardware, software, telecommunications, and stored information. The engineering strategic manager administers the quality, effectiveness, and efficiency of infrastructure designs, construction, and maintenance information within the organization.

A total of 46 “Yes/No” type questions were used for data collection to identify whether the six IM activity and 40 KPIs were evaluated within the organizational-level performance management cycle. A “Yes” response was coded as one to indicate that an assessment action was performed and a “No” response was coded as zero to indicate that an action was not performed on the IM activities and KPIs. The questions are the same as those used in Chapter 3 (Appendix B).

The four assessment actions performed within the management cycle are defined as follows: (i) Plan/Identify (i.e., developing ways to achieve the desired level of performance), (ii) Measure/Document (i.e., capturing and analyzing the performance), (iii) Control/Assess (i.e., comparing the plan and actual performance for quality
achievement), and (iv) *Improve* (i.e., taking corrective actions to refine the performance). The actions *plan*, *measure*, *control*, and *improve* were applied to the *IM processes*, *ICT resources*, and *practice resources* components. Similarly, the actions *identify*, *document*, *assess*, and *improve* were applied to the *people resources*, *IM inputs*, *IM outputs*, and *IM constraints components*. These two sets of assessment actions were necessary to depict the IM activities and KPIs that strategic managers can and cannot control in organizational-level IM. The actions *plan*, *measure*, *control*, and *improve* were applied to the IM activities and KPIs that can be controlled by strategic managers, while the actions *identify*, *document*, *assess*, and *improve* were applied to the KPIs that cannot be controlled by strategic managers.

The questions were applied to the managers through a face-to-face interview survey. The analysis of the “Yes” responses identified the IM activities and KPIs that were consistently assessed within the organization and provided the KPI-level performance score. The analysis of the “No” responses identified the IM activities and KPIs that were not formally evaluated or partially evaluated within the performance management cycle, and reveal the opportunities for improvement within each IM component. Moreover, the “No” responses were used to trigger questions regarding the managers’ reasons for not evaluating an IM activity or KPI within the organization.

The responses for each assessment action were counted once to determine the performance score for each organization. For example, if the IT manager responded with “Yes” and the engineering manager responded with a “No” to an assessment action, then the action was only accepted as being performed in the organization (i.e., “Yes”
response) if the reason given for the “No” response indicated that the action was outside the engineering manager’s scope, but within the IT manager’s scope.

The data were analyzed and presented by organization, IM component, and IM activity and KPI to identify opportunities for IM improvement within each organization. The percentage performance score for each organization was calculated using the actual performance score divided by the maximum score (i.e., 4 assessment actions x 46 IM activities and KPIs = 184). For example, the actual performance score for organization A is 116 (i.e., the number of “Yes” responses), the maximum score is 184, then the percentage score is (116/184) x100 = 63%.

Similarly, the performance score by IM component was calculated using the actual performance score and the maximum score. For example, the IM processes component’s actual performance score for organization A is 21 (number of “Yes” responses), and the maximum score for the IM processes is 6 IM activities x 4 assessment actions = 24, then the performance score is (21/24) x 100 = 88%. The maximum score for the remaining IM components will vary depending on the number of KPIs within that component.

Finally, the performance score by IM activities and KPIs was calculated using the actual performance score and the maximum score. For example, only the assessment action plan was performed on the IM activity information use in organization A. The actual performance score is one (i.e., a “Yes” response for assessment action plan). The maximum performance score for each IM activity and KPI is four (i.e., a “Yes” response for each of the four assessment action performed in the performance management cycle), then the performance score is 1 or (1/4) x 100 = 25%.
4.3.2 **Select the IM components for metric-level measurement**

To limit the time required to demonstrate the measurement method in this pilot test, the *IM objectives* component (i.e., the lagging KPIs) was selected for metric-level measurement. However, in an organization, the strategic manager will select an IM component using the results obtained from Section 4.3.1, and taking into consideration the organizational-level IM needs and goal.

4.3.3 **Select a management process for metric-level measurement**

A specific organizational-level management process was selected for metric-level measurement to allow time for a detailed analysis. In this case, the management process was selected by: (i) selecting a PMBOK knowledge area (project scope management) and the management process (scope change control) (PMI 2003), (ii) selecting a PMBOK process group (controlling), and (iii) selecting an organizational-level management process with standardized process activities common to all participating organizations to ensure information is readily available from the strategic engineering managers. The metric-level performance was demonstrated using only the strategic engineering manager because the change order process is managed within the engineering department and IT manager is not involved in this process.

The scope for the selected organizational-level management process is shown in Table 4-1, which is a summary of PMI’s mapping of project management and construction management processes (PMI 2003). The selected organizational-level management process is the change order process. The standardized change order process activities performed by the managers are seen to consist of five management activities, which
include: (i) review change request, (ii) issue contemplated change order, (iii) review quotes, (iv) review changes to contract, and (v) issue change order. In an organization, the strategic manager will select a management process for IM measurement based on the knowledge of management processes performance obtained from cyclic management processes assessment within the organization (e.g., a low performing management process identified from the annual performance assessment) and the organizational-level IM needs and goal.

Table 4-1: Selected management process scope for IM measurement

<table>
<thead>
<tr>
<th>PMBOK knowledge areas</th>
<th>PMBOK process groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project Integration Management</td>
<td>1 1 1</td>
</tr>
<tr>
<td>2. Project Scope Management</td>
<td>1 2 2 (One process selected)</td>
</tr>
<tr>
<td>3. Project Time Management</td>
<td>4 1 3</td>
</tr>
<tr>
<td>4. Project Cost Management</td>
<td>3 1</td>
</tr>
<tr>
<td>5. Project Quality Management</td>
<td>1 1 1</td>
</tr>
<tr>
<td>6. Project Human Resource Management</td>
<td>2 1 1</td>
</tr>
<tr>
<td>7. Project Communications Management</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>8. Project Risk Management</td>
<td>5 1</td>
</tr>
<tr>
<td>9. Project Procurement Management</td>
<td>2 3 1</td>
</tr>
<tr>
<td>10. Project Safety Management</td>
<td>1 1 1</td>
</tr>
<tr>
<td>11. Project Environmental Management</td>
<td>1 1 1</td>
</tr>
<tr>
<td>12. Project Financial Management</td>
<td>1 1 1</td>
</tr>
<tr>
<td>13. Project Claim Management</td>
<td>2 1 1</td>
</tr>
</tbody>
</table>

Total = 56 processes 1 26 10 13 6
4.3.4 Measure the metric-level performance for the selected IM components in the selected management process

The metric-level performance was measured for the change order process, using developed performance measure, performance metric (formulae), and questions for each lagging KPI within the IM objectives component. A performance measure was developed for each KPI using the KPI’s definition as a guide to quantify the KPI. A performance metric (formula) was developed for each performance measure using the description of the measure as a guide, which produces a formula to quantify the results. A question was developed for the numerator and denominator of each performance metric (formula) using the description of the numerator and denominator as a guide. The developed measures, metrics, and questions are shown in Table 4-2. The questions were used to collect data from the strategic managers to calculate the metric-level performance score for each lagging KPI. The data were collected during the same interview used to collect data for the KPI-level performance of the IM components. The analysis and interpretation of the calculated performance score for the lagging KPIs identify the opportunities for IM improvement within the change order process. The metrics and questions in Table 4-2 are not collectively exhaustive because a detailed analysis into the scope of the change order process is required to identify all possible metrics and questions. The metrics are not mutually exclusive because a single document can impact the performance of each KPI.

A similar process can be used to develop performance measures, metrics, and questions for any lagging and leading KPIs. The analysis and interpretation of the calculated
performance score for the leading KPIs can identify the specific IM components with the potential to improve the current IM performance. The performance assessment can be conducted monthly, biannually, annually, or as needed.

Table 4-2: Performance measures, metrics, and questions for the change order process

<table>
<thead>
<tr>
<th>Lagging KPI</th>
<th>Performance measure</th>
<th>Metric (Formula)</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information accessibility</td>
<td>Time to retrieve a stored document</td>
<td>Time to retrieve a document / Time in a work week</td>
<td>How long does it take to retrieve a stored document?</td>
</tr>
<tr>
<td>Information accuracy</td>
<td>Number of document containing errors</td>
<td>Number of documents with errors / Total number of documents reviewed per week</td>
<td>How many documents contain errors?</td>
</tr>
<tr>
<td>Information availability</td>
<td>Number of documents ready for use when needed</td>
<td>Number of documents ready for use / Total number of documents reviewed per week</td>
<td>How many documents are not ready for use when needed?</td>
</tr>
<tr>
<td>Information context</td>
<td>Number of documents easily understood</td>
<td>Number of documents easily understood / Total number of documents reviewed per week</td>
<td>How many documents are not easy to understand?</td>
</tr>
<tr>
<td>Information currency</td>
<td>Number of documents up-to-date</td>
<td>Number of documents up-to-date / Total number of documents reviewed per week</td>
<td>How many documents are not up-to-date?</td>
</tr>
<tr>
<td>Information relevance</td>
<td>Number of documents applicable</td>
<td>Number of documents applicable / Total number of documents reviewed per week</td>
<td>How many documents are not applicable for use?</td>
</tr>
<tr>
<td>Information usability</td>
<td>Number of document containing complete information</td>
<td>Number of documents containing complete information / Total number of document reviewed per week</td>
<td>How many documents contain incomplete information?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>How many documents are reviewed per week?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>How many hours are in your workweek?</td>
</tr>
</tbody>
</table>
The analysis of the collected data identified the lagging performance score for the change order process and opportunities for IM improvement within the process. The lagging IM performance score for the change order process by KPI was calculated using the actual performance score and the maximum score. For example, in organization A, the KPI information accuracy data showed that the total number of documents reviewed per week is 6. The number of documents with incorrect information is 2. The weekly average of reviewed change order documents that contained errors is \( \frac{2}{6} \times 100 = 33\% \). Therefore, the performance score for documents containing complete information (i.e., information usability) is \( 100\% - 33\% = 67\% \).

### 4.4 Results

The performance score for both construction-owner organizations (referred to as organizations A and B to protect their identity) is presented below.

#### 4.4.1 KPI-level results

The results show that organization A has a total performance score of 63\% and organization B has a score of 98\% (calculations are described in Section 4.3). The breakdown of the total performance score by IM components is shown in Figure 4-3. The results show greater opportunities for improvement in organization A.
The breakdown of the IM component performance score by IM activity and KPI is shown in Figure 4-4 for each organization. The results show the IM activities and KPIs that are evaluated within each IM component for both organizations. The percentages of assessment actions (plan/identify, measure/document, control/assess, and improve) performed on each IM activity and KPI are shown in the figure (described in Section 4.3).
4.4.2 Metric-level results

The metric-level performance score for the change order process (Figure 4-5) shows the opportunities for improvement in the lagging KPIs information accuracy, availability, and relevance within both organizations’ change order processes.
4.5 Discussion

A structured approach was used to measure the organizational-level IM performance in two construction-owner organizations. The results for the IM components provide an overview of the organizational-level IM performance within each organization. Moreover, measuring the IM activities and KPIs within each organization reveal the opportunities for improvement within each IM component. The assessment actions performed in the performance management cycle revealed opportunities for improvement in each IM activity and KPI. Further, details of the organizational-level IM performance were revealed through the change order process performance score, which identified specific IM opportunities for improvement within the selected management process.

In organization A, the opportunities for improvement are primarily in the ICT resources, practice resources, people resources, IM constraints, and IM objectives components. The managers’ explanations indicate that ICT resources are assessed for some critical systems only (e.g., financial system). The practice resources are partially assessed for critical processes in the financial system, and the engineering manager acknowledged that information quality control and ICT quality assurance are poorly assessed within the organization. The people resources are assessed informally and on a reactive basis when there is an issue. The IM constraints are assessed informally, and formal assessment of IM legal requirements is driven by public sector accountability. The engineering manager stated that the lack of assessment has resulted in excess information and information overload. The lack of an appropriate method to measure
information overload has resulted in approximately 300% more information being stored in the computer information system than is required for effective and efficient operation of the organization. As a result, new storage drives are added to the CIS to store new information without optimizing existing storage space. The IM objectives are assessed when there are issues relating to information accessibility, accuracy, availability, and currency. The KPIs information context, relevance, and usability are not assessed within the organization. Moreover, the measurement of the change order process shows 33% opportunities for improvement in information accuracy, information availability, and information relevance. The engineering manager’s explanation indicated that information overload has affected the accuracy, availability, and relevance of information in the change order process.

In organization B, the opportunities for improvement are in the IM processes and IM objectives components. The managers’ explanations indicated that information needs identification is not formally assessed, and information accessibility is improved on a reactive basis when there is an issue. The change order process results identified 20% opportunities for improvement in information availability, and 10% opportunities for improvement within information context and information relevance. The managers’ explanations indicated that more effort is required to transform paper information artifacts to electronic information artifacts, which in their view has affected the information availability, context, and relevance in the change order process.

In addition, the managers from both organizations indicated that although the KPIs were evaluated in the performance management cycle, they were not sure if the correct
metrics were evaluated for each KPI. During the interviews, the managers stated that the KPIs that are currently being used in their organizations are not adequately defined, which usually creates uncertainty in terms of the IM characteristic being measured within each KPI at the organizational-level. The implication is that poorly defined KPIs are used to measure and improve the organizational-level IM performance, which indicates that the improvements will not be capable of optimizing IM performance in construction-owner organizations. Moreover, the feedback from the strategic IT and engineering managers from both organizations indicated that the current performance management system within each organization is lacking adequate, comprehensive organizational-level IM assessment.

Additionally, feedback from the managers’ indicated that the key benefits of this study to their organization include the structured approach to measure the IM performance, which will be useful because of the ease of use. The managers in each organization also indicated that the measurement method used in this study could be implemented and maintained easily within their existing performance management system, because of the approach used to collect, analyze, and report the performance results. Furthermore, the managers stated that the results would be useful to benchmark their organizational-level IM performance internally and externally against other organizations (providing the organizations are using the same KPIs and measurement method).

4.6 Conclusions

The organizational-level IM performance in two construction-owner organizations is measured using a developed measurement method to identify opportunities for IM
improvement in a pilot test. The measurement identified opportunities by IM components, which revealed the specific IM activities and KPIs measured within each organization. The assessment actions performed in the management cycles identified further opportunities within each IM activity and KPI. The measurement of the change order process identified opportunities for improvement within the process and demonstrated the level of IM performance that can be accomplished from the measurement method.

The key contribution of this study is the structured method used to measure the organizational-level IM performance through the strategic managers in construction-owner organization. Despite the structured approach, there are limitations in the method. The metric-level (detailed-level) measurement was conducted for a single organizational-level management process (i.e., change order process) using only the lagging KPIs to limit the time require for the completion of the pilot testing. The measurement method provides only the results for the IM performance and does not provide any means of using the measured performance for IM improvement. Moreover, the IM activities, KPIs, and measurement method were not tested in other construction organizations such as architects, designers, and contractors. Therefore, the KPIs and measurement method must be tested before use for performance measurement in other types of organizations. Moreover, although biases cannot be completely eliminated, steps were taken to reduce the investigator and respondents biases from the results. This was accomplished using a scripted interview process to conduct the interviews, and by
using validated scripted questions that were neutrally structured and concise to ensure clarity for the managers.

References


5 Define the components of the IM assessment model

Abstract

A comprehensive approach to organizational-level information management (IM) assessment has the potential to improve IM performance in construction-owner organizations. The objective of this chapter is to define the three perspectives of the proposed organizational-level IM assessment model. The model can be used to measure and improve the organizational-level IM performance in construction-owner organizations. The first perspective identifies the IM components, IM activities, and key performance indicators (KPIs) required for comprehensive IM measurement; the second perspective identifies the steps to measure the IM performance using the KPIs; and the third perspective identifies the steps to improve the IM performance using the measured results to achieve the established organizational-level IM goal. The model has been tested through strategic engineering managers in five construction-owner organizations in three Canadian Maritime provinces. The test consisted of measuring the KPI-level performance for each IM component and the lagging metric-level performance for a selected organizational-level management process (i.e., change order process). The KPI-level results have identified opportunities for organizational-level IM improvement primarily in the people, ICT, and practice resources components. The metric-level results have identified opportunities for improvement primarily in information usability within the change order process. These opportunities for improvement reveal that detailed organizational-level IM performance could be consistently assessed within a single model.
Keywords: Information management, assessment model, KPIs, construction organization.


5.1 Introduction

Information management (IM) is recognized as a key opportunity to improve performance in construction organizations (Hicks et al. 2006). A comprehensive organizational-level approach to IM is recognized to provide greater benefits when compared to approaches that focus only on specific IM components (Hicks 2007, Sheriff et al. 2012). A comprehensive organizational-level IM assessment approach is beneficial because it can evaluate information within projects, information across projects, and other non-project related information stored in the computer information system (CIS) that is required to support the business needs and the management of an organization. A comprehensive organizational-level approach also allows for the optimization of IM resources (e.g., people, ICT, practices) and the reduction of IM constraints (e.g., information overload) to continuously improve IM performance. To continuously improve performance, strategic managers need to evaluate the organizational-level IM performance. The key challenge identified in construction IM literature is the lack of a model for comprehensive organizational-level IM performance assessment in construction organizations.
The objective of this chapter is to define the three perspectives of a proposed organizational-level IM assessment model, which can be used to measure and improve the IM performance in construction-owner organizations. The first perspective identifies and defines the IM components, the IM activities, and the lagging and leading key performance indicators (KPIs) required for comprehensive IM performance measurement (developed in Chapter 2); the second perspective identifies the method to measure the performance (developed in Chapter 4); and the third perspective identifies the method to improve the performance (developed in this chapter).

The remainder of this chapter is as follows: Section 5.2 presents the literature review highlighting the research on IM performance measurement and management, Section 5.3 defines each perspective of the model, Section 5.4 summarizes the developed model, Section 5.5 presents the test results for five construction-owner organizations, Section 5.6 discusses the results, and Section 5.7 presents the conclusion of this chapter.

5.2 Literature review

The current state of the three concepts (i.e., performance, performance measurement, and performance management) embedded in the organizational-level IM assessment model is examined below.

5.2.1 IM Performance

The term “performance” is widely discussed in construction IM performance literature but rarely is defined in construction research publications. However, in other fields of studies there are numerous definitions for “performance” because the term is not
absolute but relative to the context or field of study (Samsonowa 2012). A review by Samsonowa (2012) identifies that effectiveness and efficiency are common characteristics of “performance,” where “Effectiveness is the foundation of success – efficiency is the minimum condition for survival after success has been achieved. Efficiency is concerned with doing things right, effectiveness is doing the right things.” In this sense, performance depends on the level of goal attained (effectiveness) and the level of resources used to achieve the goal (efficiency) (Samsonowa 2012). In terms of IM performance the goal supports the effectiveness and efficiency of information access, process, and use (Detlor 2010). However, there is limited emphasis on effective and efficient organizational-level IM performance in construction IM literature.

5.2.2 Performance measurement

The need to improve the organizational-level IM performance measurement in construction is discussed in literature (e.g., Hicks 2007, Sheriff et al 2012). Similar to performance, Samsonowa (2012) notes that the term “performance measurement” is often used but not well-defined and existing definitions are incomplete. Samsonowa (2012) defined performance measurement as “A process in which relevant data for performance indicators (as-is data) is collected; and the collected data is evaluated, analyzed and interpreted (comparison of as-is with to-be).”

The existing performance measurement frameworks, such as the balanced scorecard, propose potential areas where performance measures can be useful, but fail to provide adequate guidelines to develop measures for each area, resulting in limited practical value to organizations (Neely et al. 2000). Bourne et al. (2003) provides a detailed
review of performance measurement evolution, performance measurement design process, and performance measurement implementation in organizations.

There are construction IM performance measurement frameworks and models focusing on specific IM components, such as information and communication technology (ICT) and management information systems at the project-level (e.g., Stewart 2007, Lee and Yu 2012). These frameworks and models are not suited for comprehensive organizational-level IM measurement because of several limitations. The limitations include the following: limited assessment criteria/perspectives, limited relations between criteria/perspectives, limited process to develop measures, and limited implementation and maintenance guidelines (Bassioni et al. 2004). Moreover, the limited number of studies on organizational-level IM performance measurement in construction IM literature indicates that comprehensive organizational-level IM performance measurement in construction organizations is not fully investigated and therefore not well understood.

5.2.3 Performance management

Similar to the previous two concepts above, the term “performance management” is seldom defined in construction IM performance literature, but widely defined in the general performance management literature. Samsonowa’s (2012) comprehensive review of the various definitions suggests that performance management contains all management activities (e.g., plan, organize, coordinate, lead, control, and motivate), and is composed of four elements (assessment actions) in the management cycle (i.e., plan, measure, analyze, and review). Attempts to effectively manage the assessment actions in
different disciplines (e.g., operational management and accounting) have produced several management systems. Some of the systems are developed based on the total quality management (TQM) movement (e.g., Baldridge, Six Sigma, ISO 9000, and European Quality Models), while others are based on the need for an alternative to traditional accounting performance measures (e.g., results and determinants framework, balanced scorecard, performance pyramid, and performance prism) (Atkinson 2006).

In construction IM literature, the performance management systems are primarily based on measurement systems such as the balanced scorecard and data envelope analysis, incorporating performance management techniques such as benchmarking. Current management systems focus either on the project or industry levels and possess limitations for organizational-level IM. The limitations include the following: inability to develop IM policy; ignored cultural issues; ignored business process techniques; inability to assess information, adopt new systems, and IT infrastructure; and no insight on the impact of certain technological and managerial factors on the overall organization’s performance (Gyampoh-Vidogah 2003, and El-Mashaleh, et al. 2007). Moreover, the lack of an organizational-level IM performance management system for construction organizations in IM literature indicates that comprehensive organizational-level IM performance improvement is not fully investigated and therefore not well understood.

5.3 Perspectives of the IM assessment model

The three perspectives of the developed IM assessment model are described below.
5.3.1 IM components, IM activities, and KPIs

The first perspective of the model is shown in Figure 5-1 and consists of the eight-key IM components containing the six IM activities and 40 KPIs required for comprehensive IM performance measurement at the organizational-level in construction-owner organizations. The eight organizational-level IM components are as follows:

- **IM processes**: identifies the IM activities embedded within each organizational-level management activity.
- **ICT resources**: identifies the KPIs to measure the characteristics of computer information systems (i.e., software, hardware, and telecommunication).
- **Practice resources**: identifies the KPIs to measure the characteristics of IM practices used to guide the IM processes.
- **People resources**: identifies the KPIs to measure the IM characteristics of information managers and users.
- **IM inputs**: identifies the KPIs to measure the characteristics of information required in the IM processes.
- **IM outputs**: identifies the KPIs to measure the characteristics of information produce from the IM processes.
- **IM constraints**: identifies the KPIs to measure the organization characteristics that may limit the functioning of the IM processes.
- **IM objectives**: identifies the KPIs to measure the characteristics of the IM processes to achieve the IM goal.
The KPIs in the IM objectives component are lagging indicators of performance, while the KPIs in the remaining components (except the IM processes component) are leading indicators of performance. A detailed description of the IM framework, including the definitions for each IM activities and KPI is presented in Chapter 2.

*Figure 5-1: The organizational-level IM components, IM activities, and KPIs*

### 5.3.2 Performance measurement method

The second perspective of the model provides the method that will be used by strategic managers to measure the organizational-level IM performance in construction-owner organizations. This measurement method is used in Section 5.5 and was described in Chapter 4 where the role of the strategic manager was replaced by the researcher. The measurement method shown in Figure 5-2 consists of the following four steps.
• **Step I:** *Measure the KPI-level performance for the IM components.* The performance for the IM components is measured through the assessment actions (i.e., plan/identify, measure/document, control/assess, and improve) performed on the IM activities and KPIs in the organizational-level performance management cycle, using the questions developed for each KPI. The assessment actions performed by the strategic managers on each IM activity or KPI in the performance management cycle are used to identify opportunities for organizational-level IM improvement within each IM component. The IM activities (Figure 5-1) are seen as sub-activities within each management activity and provided the link between the management activities and the KPIs. The IM activities should be considered in CIS development and improvement.

• **Step II:** *Select the IM components for metric-level measurement.* Using the opportunities for improvement within each IM component identified in Step I, the strategic information manager will select the specific IM components and their corresponding KPIs for measurement. The IM components selection also takes into consideration the organizational-level IM needs and goal. The KPIs within a selected IM component provide a detailed view of the IM performance for that component. To identify the impact of previous IM changes the *IM objectives* component must be selected for measurement (lagging performance). To identify all possible opportunities for IM improvement the *ICT resources, people resources, practice resources, IM inputs, IM outputs,* and *IM constraints* components must be selected for measurement (leading performance).
• **Step III:** *Select the management process for metric-level measurement.* The selection of an organizational-level management process for measurement is based on the strategic manager’s knowledge of organizational-level management processes (derived from performance issues identified from general performance measurement within the organization). To determine the IM performance comprehensively for a specific management process, the IM activities, as well as the leading and lagging KPIs within the seven IM components (Figure 5-1) should be selected for metric-level measurement.

• **Step IV:** *Measure the metric-level performance for the selected IM components within the selected management process.* The measurement of an organizational-level management process is accomplished using the KPIs within the selected IM components. To measure the performance for a specific management process the appropriate performance measures, metrics (formulae), and questions should be developed to quantify each KPI. The definition of each KPI is used to develop the performance measures for the corresponding KPI. The description for each developed performance measure is used to develop the performance metric (i.e., the formula) for that specific measure. The description for the numerator and denominator of the metric (formula) is used to develop the questions to collect data for the specific metric. The calculated value for the metrics provides the measured metric-level score for each KPI, as described in Chapter 4.
5.3.3 Performance improvement method

The third perspective of the model provides the method to improve the organizational-level IM performance. The IM improvement method is shown in Figure 5-3 and consists of the following three steps.

- **Step I:** Analyze and interpret the lagging IM performance score. The measured (actual) organizational-level lagging performance score can be compared to the planned (estimated) performance target, which is developed based on the previously measured IM performance score (if available for the same KPIs) taking into consideration the organizational-level IM needs and goal. The initial
measurement can be used to establish a baseline to compare future measurement if none exist. The comparison of the measured (actual) lagging performance to the planned performance should reveal the impact of previous changes (i.e., actions taken, initiatives implemented, and modifications made) to each IM component. The results can be used to improve the performance of the lagging IM component.

- **Step II:** *Analyze and interpret the leading IM performance score.* The leading measured (actual) performance scores are compared to the planned (estimated) performance target, which is developed based on the previously measured IM performance score (if available for the same KPIs) and the organizational-level IM needs and goal. The initial measurement can be used to establish a baseline to compare future measurement. The comparison of the measured (actual) leading performance to the planned performance should reveal the leading IM components with opportunities to improve the organizational-level IM performance (i.e., indicate where to make changes).

- **Step III:** *Identify the changes required to improve the IM components.* The IM performance for the selected organizational-level IM components is improved through corrective actions, initiatives, and modifications. The potential actions, initiatives, and modifications include the following: optimizing the *ICT resources*, refining the *practice resources* and *people resources*, refining the *IM inputs* and *IM outputs*, reducing the impact of the *IM constraints*, and refining the *IM objectives*. The outcome from the improvements to the IM components provides the basis to set a new organization-level IM target (goal).
5.4 Summary of the organizational-level IM assessment model

The organizational-level IM components, IM activities, and KPIs with the performance measurement and improvement methods (Figures 5-1 to 5-3), are combined to produce the three perspectives within the organizational-level IM assessment model shown in Figure 5-4. The IM assessment model provides strategic managers in construction-owner organizations with a system to comprehensively measure and continuously improve the organizational-level IM performance.
5.5 Testing the IM assessment model

The IM assessment model has been tested through the strategic engineering managers in five similar-size case study construction-owner organizations in three Canadian Maritime provinces, using the measurement method demonstrated in Chapter 4. The five organizations are labeled A, B, C, D, and E to protect their identity. The testing consisted of measuring the IM activities and KPIs performance at the KPI-level, as well as measuring the performance for a selected organizational-level process (i.e., the change order process) at the metric-level (detailed-level). The lagging KPIs in the IM objectives component was selected to measure the metric-level performance for the
change order process. The change order process was selected using the PMBOK knowledge areas and process groups (PMI 2003) to guide the selection process and to limit the time required to complete this test. First, the knowledge area (project scope management) and the project management process (scope change control) were selected, then a process group (controlling) was selected within that management process, and finally it was decided that the selected management process should have standardized management activities common to all participating organizations to ensure information is readily available from the engineering strategic managers. The scope for the selected management process is provided in Chapter 4. The management activities performed by managers within the change order process consist of the following: (i) review change requests, (ii) issue contemplated change orders, (iii) review quotes, (iv) review changes to contracts, and (v) issue change orders. The method used to collect data, and the results are presented below.

5.5.1 Data collection method

A face-to-face interview survey was used to collect data from the strategic engineering manager in five organizations. The interview questions used were validated and refined in Chapter 3, and described and used in Chapter 4. A total of 46 “Yes/No” type questions were used to identify the assessment actions performed on the KPIs in the performance management cycle (Appendix B). The questions were coded with one for “Yes” and zero for “No” to identify the actions performed in each organization. The four assessment actions performed within the management cycle are defined as follows: (i) Plan/Identify (i.e., developing ways to achieve the desired level of performance), (ii)
Measure/Document (i.e., capturing and analyzing the performance), (iii) Control/Assess (i.e., comparing the plan and actual performance for quality achievement), and (iv) Improve (i.e., taking corrective actions to refine the performance). The actions plan, measure, control, and improve were used on the IM processes, ICT resources, and practice resources components. Similarly, the actions identify, document, assess, and improve were used on the people resources, IM inputs, IM outputs, and IM constraints components. The two sets of assessment actions were needed to differentiate between those IM components that can be controlled by managers and those that cannot be controlled by managers, as described in Chapter 4.

The assessment of the change order process consisted of the following four questions (Appendix C): (i) What percentage of IM issues exist in the change order process? (ii) What are the possible IM issues? (using the questions developed for lagging KPIs in Table 4-2 in Chapter 4), (iii) What additional issues exist that is not included in the above questions? and (iv) Please rank the IM issues in question (ii) from most to least pertinent.

5.5.2 KPI-level results

The KPI-level results are presented by organization, by IM component, and by IM activities and KPIs to provide insight into the IM performance. The performance score by organization is shown in Figure 5-5 and is calculated using the actual performance score for each organization divided by the maximum score. For example, the actual performance score for organization B is 48 (i.e., the number of “Yes” responses), and
the maximum score is 184 (i.e., 4 assessment actions x 46 IM activities and KPIs). Therefore, the actual performance score is \((48/184) \times 100 = 26\%\).

![Figure 5-5: KPI-level performance score by organization](image)

The performance score by IM components for each organization is shown in Figure 5-6 and provides insight into each organization by identifying the IM components that are not evaluated within the management cycle. The performance score for each IM component is calculated using the actual performance score and the maximum score. For example, the IM processes actual performance score for organization B is seven (i.e., number of “Yes” responses), and the maximum score for the IM processes is 24 (i.e., 6 IM activities x 4 assessment actions). Therefore, the actual performance score is \((7/24) \times 100 = 29\%\). The maximum score for remaining IM components depends on the number of KPIs within that component.
Figure 5-6: KPI-level performance score by organization and IM component

The performance score by IM activities and KPIs is shown in Figure 5-7 and provides insight into each IM component by identifying the IM activities and KPIs that are not evaluated within the organizational-level management cycle. A set of KPIs (i.e., all KPIs within a component) must be selected for measurement to have a complete snapshot of the KPI-level performance for an IM component. The performance score by IM activities and KPIs is calculated using the actual performance score and the maximum score. For example, organization B only performed the assessment actions plan and measure on the IM activity information needs identification, resulting in an actual performance score of two (i.e., a “Yes” response for assessment actions plan and measure). The maximum performance score for each IM activity and KPI is four (i.e., a “Yes” response for each of the four assessment action performed in the performance management cycle). Therefore, the actual performance score is 2 or \( \frac{2}{4} \times 100 = 50\% \).
Figure 5-7: KPI-level performance score by KPI and organization.

5.5.3 Metric-level results

The lagging metric-level performance score for the change order process is presented by organization and by lagging KPI to identify the opportunities for IM improvement within the process. The performance score for the change order process by organization is presented in Figure 5-8. The managers did not suggest any additional questions to those in Table 4-2 (Chapter 4), and there was no consistency in the ranking of the IM issues captured by the metrics.
The metric-level change order performance score for each organization is presented in Figure 5-9 for the seven lagging KPIs identified in Table 4-2 (Chapter 4). The performance score for each lagging KPI is calculated using the performance metric (formula) developed for each performance measure and converting the score to a percentage. The lagging IM performance score for the change order process is calculated using the actual performance score and the maximum score. For example, in organization C the KPI information usability data show that the total number of documents reviewed per week is 10. The number of documents containing incomplete information is 6. The weekly average of reviewed change order documents that contain error is \((6/10) \times 100 = 60\%\). Therefore, the actual performance score for documents containing complete information (i.e., information usability) is \(100\% - 60\% = 40\%\).
5.5.4 Organizational-level IM goal

During the interviews, the managers in each organization identified the IM objectives that were important to achieve their organization’s IM needs and goal. The ranking of these objectives shows that the managers consistently identified the IM objectives *information accuracy, information relevance, and information accessibility* as key IM focus areas within the organizations. These three objectives are key focus areas in the five organizations at the KPI-level, except for *information accessibility*, which is not a KPI-level focus area in organization E.

5.6 Discussion

The IM assessment model incorporates eight IM components (containing six IM activities as well as 40 lagging and leading KPIs) with structured methods to measure and improve the organizational-level IM performance in construction-owner organizations. The IM components, IM activities, and KPIs provide the capability to measure the comprehensive organizational-level IM performance in construction-owner organizations, while the measurement and improvement methods provide the steps to measure and translate the performance results into solutions for IM improvement respectively.

The testing of the model in five organizations showed its strength in assessing organizational-level IM performance. The strategic managers confirmed that the measured IM score was an accurate indication of organizational-level IM performance in their organization by providing evidence from previous assessment to demonstrate the measurement of selected KPI. A comparison of the five organizations’ results shows that
the organizations are performing best in the *IM inputs* component and worst in the *practice resources* component. Additionally, the organizations are performing best for the KPI *information legal requirements* and worst for the KPIs *information traceability* and *information quality management*.

The results indicate that organization A is the most mature, and organization B is the least mature in terms of organizational-level IM performance. Organization A strategic manager’s explanation indicates that the organizational-level IM system, which includes a centralized computer information system (CIS), is quite developed and continuous effort is placed on maintaining an effective and efficient level of IM service. Organization B strategic manager’s explanation for not assessing the KPIs reveals a lack of a formal organizational-level IM system and ad-hoc IM within the organization. There is also lack of a CIS, and information is managed at the individual-level and stored on individual information users’ computers. Organizations C and D do have formal organizational-level IM systems and CIS. The managers’ explanations for not assessing all the KPIs indicate that the effort and investment in ICT have begun improving the CIS and IM within the organizations. Similar to organization B, organization E does not have an established organizational-level IM system or CIS, and individual user within the organization manages the information related to their own work. In both organizations B and E, when the strategic engineering managers need information from the operation managers, the information is stored in a spreadsheet format and transferred via portable data drives.
These findings indicate that the model will provide several benefits to organizations. For example, the model will provide mature organizations (e.g., organization A) with the opportunity to benchmark their performance against other organizations using the model for IM assessment. The model will provide those organizations that are in the process of formally improving their organizational-level IM performance (e.g., organizations C and D) with the right KPIs, metrics, and a method to assess IM performance. Moreover, the model will provide guidance and structure for IM performance assessment to those organizations with ad-hoc IM and limited people and ICT resources (e.g., organizations E). This implies that the model has a basic minimum requirement with respect to IM before the assessment can be useful. This suggests that organizations should have an established IM system with recognized organizational-level IM needs and goals, as well as information managers with the ability to evaluate the organization’s IM needs and set targets for the organizational-level IM goal.

Additional feedback from the strategic managers indicates that the key benefits of this model to their organization are the comprehensive view of IM (relating the first perspective) and the ease of use in applying the model (model is developed as a tool for strategic managers). The managers also indicated that the assessment approach could be implemented and maintained easily within their existing performance management system, because of the structured method used to collect, analyze, and report the performance results. Finally, the managers view the model as a tool to assess and benchmark their organizational-level IM performance internally and externally against
other organizations, which may lead to the identification of best practice across the organizations.

5.7 Conclusions

A structured approach is used to develop and test the proposed organizational-level IM assessment model. The model has been developed to provide a system to measure and improve the organizational-level IM performance. The test conducted in five construction-owner organizations, showed that the model is capable of measuring the organizational-level IM performance and identifying opportunities for IM improvement. The key contribution of this study is the organizational-level IM assessment model. This model will be useful to construction IM researchers and strategic managers in construction-owner organizations seeking to measure and improve organizational-level IM performance.

Despite the structured method used to test the model, there are several limitations to this study. The testing of the model is limited to measurement of the IM performance, and lagging metric-level (detailed-level) performance is measured only for the change order process. This testing approach was necessary to limit the time for this study, as well as to limit the extended time required to develop and validate the performance measure, metrics, and questions for each KPI (which would require at least one performance management cycle, approximately 1.5 years as indicated by the managers). Moreover, the performance improvement perspective of the model was verified by the authors, but was not formally validated through the strategic managers because at least one complete performance management cycle is required to identify the impact of previous actions on
IM performance in order to validate the improvement perspective. Finally, the model is tested in a limited number of owner organizations and the minimum applicability requirements of the model to an organization are not fully investigated for different construction stakeholders’ organizations.

References


6 General conclusion

This research presents an organizational-level IM performance assessment model, which provides construction organizations with the capability to measure and improve IM performance. The model contributes to organizational-level IM performance assessment through three interconnected perspectives. The three perspectives were developed from the existing body of knowledge (IM literature) and tested through seven construction IM researchers in Canada and 11 strategic IT and engineering managers in construction owner-organizations in three Canadian Maritime provinces. The three perspectives within the model are as follows:

1. **The organizational-level IM framework**, which identifies the IM components, IM activities, and KPIs required for comprehensive organizational-level IM measurement in construction-owner organizations.

2. **The organizational-level IM measurement method**, which identifies the steps to measure the organizational-level IM performance.

3. **The organizational-level IM improvement method**, which identifies the steps to improve the organizational-level IM performance.

The application of the model is based on the assumption that the KPIs in the *IM objectives* component in the organizational-level IM framework provides a lagging indication of the IM performance, whereas the KPIs in the *ICT resources, practice resources, people resources, IM inputs, IM outputs, and IM constraints* components provide a leading indication of the organizational-level IM performance. Critical to the success of this model is the link between measuring and improving the performance of...
the IM components (actual effectiveness and efficiency) and the degree of attaining the established organizational-level IM goal (planned effectiveness and efficiency).

The level of measurement and improvement of the IM components’ performance indicates the degree of achieving the established organizational-level IM goal. The over or under performance of the IM components depends on the performance score of the KPIs within each component and the setting of performance targets for the IM goal. The underlying theory for the proposed model is the continuous improvement of both lagging and leading IM performance at the organizational-level. The implementation of the model will allow strategic managers to easily measure and improve the organizational-level IM performance within construction-owner organizations.

The next section highlights the main conclusions for each of the four research objectives. This is followed by a discussion of the research limitations and possible recommendations, the overall implications of the research, and possible future work in this research area.

6.1 Conclusions based on research objectives

The first research objective (Chapter 2) was to identify the IM components, IM activities, and KPIs within the developed static and generic organizational-level IM framework. The framework was developed from construction IM literature and initially validated through seven construction IM researchers across Canada. The key deliverables from this objective are as follows: (i) the defined IM components, IM activities, and KPIs required for comprehensive organizational-level IM performance
measurement, (ii) the defined relationships between the IM components, (iii) the classified IM activities and KPIs within eight IM components to understand and measure IM performance, and (iv) the IM researchers’ validated IM activities and KPIs. The implication of this objective to construction-owner organizations is that strategic managers will have a comprehensive IM framework to understand organizational-level IM, and initially validated IM activities and KPIs to measure the organizational-level IM performance, thereby eliminating the need for organizations to develop KPIs.

The second research objective (Chapter 3) was to validate the six IM activities, as well as the 40 leading and lagging KPIs within the IM framework that was previously validated through IM researchers. The validation use a systems approach to evaluate the appropriateness, comprehensiveness, accuracy, and relevance of the IM activities and KPIs for use in IM measurement in three construction-owner organizations in three Canadian Maritime provinces. The validation was accomplished through industry practitioners (six IT and engineering managers) in a pilot test. The key deliverable from this objective is the validated (refined) IM activities and KPIs required for comprehensive organizational-level IM performance measurement. The implication of this objective to construction-owner organizations is that strategic managers will have a comprehensive set of validated IM activities and KPIs that can consistently measure the organizational-level IM performance.

The third research objective (Chapter 4) was to measure the organizational-level IM performance in two construction-owner organizations in a pilot test. The performance measurement was achieved through a case study based method and data collection from
the strategic IT and engineering managers within each organization. The key deliverable from this objective to construction-owner organizations is the method to measure the organizational-level IM performance using the validated IM activities and KPIs within the IM framework. The implication of this objective to construction-owner organizations is that strategic managers will have a simple and structured method to measure organizational-level IM performance. This method can provide meaningful IM performance score for each IM component using the developed KPIs and performance metrics to measure the performance of a specific organizational-level management process (e.g., change order process). The performance scores will help managers identify opportunities for organizational-level IM improvement within a selected management process.

The fourth research objective (Chapter 5) was to define the three perspectives of the organizational-level IM assessment model. The three interconnected perspectives of the model are as follows: the comprehensive organizational IM framework (i.e., IM components, IM activities, and KPIs), the organizational-level IM performance measurement method, and the organizational-level IM performance improvement method. The key deliverable from this objective is the integrated organizational-level IM assessment model to measure and improve the IM performance in construction-owner organizations. The IM framework and measurement perspectives provide detailed understanding of comprehensive organizational-level IM performance, and the improvement perspective provides the changes (i.e., actions, initiatives, and modifications) required to improve the organizational-level IM performance. The
implication of this objective to construction-owner organizations is that strategic managers will have a model to measure and improve the organizational-level IM performance in construction-owner organizations.

The key contributions of this research based on the four research objectives are as follows:

i. The organizational-level IM framework (i.e., IM components, IM activities, and KPIs) (Chapter 2).

ii. The six validated IM activities, the 33 validated leading KPIs, and the seven validated lagging KPIs (Chapter 3).

iii. The organizational-level IM assessment model (Chapters 2, 4 and 5).

6.2 Limitations and recommendations

The key limitations of this research and their resulting recommendations are as follows:

i. The validation of the framework is limited to seven IM researchers and 11 practitioners using a structured systems approach. The validation method provided a reliable indication of the appropriateness, comprehensiveness, accuracy, and relevance of the KPIs for use in IM assessment. However, it is recommended that the IM activities and KPIs be evaluated using a larger sample of IM researchers and strategic managers from different types of construction organizations to further verify the capability of the IM activities and KPIs for use in IM assessment, which will ensure that the definitions fully encapsulate the requirements of each KPI and any remaining subjectivity is removed from the definitions.
ii. The testing of IM measurement method in the model was limited to the identification of the assessment actions performed on the IM activities and KPIs within the organizational-level management cycle, and the detailed-level measurement was focused on the lagging performance for a specific organizational-level management process (change order process). Although this sufficiently demonstrated the measurement of organizational-level IM performance, it showed only the development of performance measures, metrics, and questions required to measure the lagging KPIs detailed-level performance for the change order process. Moreover, the managers indicated that IM changes are made at the beginning of each management cycle and evaluated at the end of each cycle, which is approximately 1.5 years for the participating organizations. This means that it will require at least one complete management cycle to develop, refine, and validate the measures, metrics, and questions in construction-owner organizations. Therefore, it is recommended that performance measures, metrics, and questions be developed and validated for each leading and lagging KPI, based on each KPI definition in order to measure a selected organizational-level management process at the metric-level (i.e., detailed-level) and to ensure the metrics and questions are collectively exhaustive and mutually exclusive. Equally, the metrics and questions used to assess the change order process should be revised to better reflect the characteristics of the KPIs. For example, the metric for the KPI information accessibility in Table 4-2 can be rephrased as “how much time is spent on
“accessing documents in a week” instead of “how long does it take to retrieve a stored document.”

In addition, detailed statistical analyses of the metric-level data collected for the 40 lagging and leading KPIs will provide insight into the relationships between the metrics and KPIs, and between the KPIs and IM activities. For example, a standard multiple regression analysis can be used to identify the relationship between the metrics (independent variable) developed for a specific KPI (dependent variable). It can also be used to identify the relationship between KPIs (independent variable) and each IM activity (dependent variable), and the relationship between the managers’ responses (independent variable) and the experience of each strategic manager (dependent variable). The identification of the relationship between each metric and KPI will be useful to validate the accuracy of the performance measures and metrics for IM measurement. The relationship between each KPIs and IM activity will be useful in developing computer information systems and in diagnosing specific issues relating to specific IM activities. Identifying the relationship between managers’ responses and experience will be useful in understanding the implementation of the model to organizations, and IM needs and goals.

iii. The IM improvement method within the model was not tested in the organizations because it requires the comparison of planned performance (before change) and actual performance (after change) in order to identify the impact of changes on each IM component. The performance comparisons require at least one complete management cycle (i.e., approximately 1.5 years) owing to a time
constraint in this research this was not possible. Moreover, the model was tested in eight organizations, which may not be representative of all construction organizations. The use of construction-owner organizations means that the findings may not be fully applicable to other construction organizations within the construction industry such as architects, designers, and contractors. Therefore, it is recommended that the model be tested in various construction organizations for an extended period to validate the improvements to each IM component and the applicability of the model to other types of construction organizations.

iv. There are limitations related to the value and comprehensiveness of the model to construction organizations. The lack of an existing construction organizational-level IM assessment model means that it was not possible to compare the developed model to other related assessment models to show the usefulness of the model. Moreover, it is difficult to draw comparisons to project-level models or models developed for other industries because of the different focus areas and context of use. Furthermore, the role of the strategic manager varied in each organization, and although precautions were taken to reduce both researcher and respondent biases in the responses, they cannot be eliminated entirely (a structured script was used to ensure all managers receive the same information and neutrally structured questions were used in the surveys). Therefore, it is recommended that the value and comprehensiveness of the model to the construction industry be further investigated to provide insight into the IM differences between construction organizations, identify the minimum
organizational-level requirements for the implementation of the model, and the level of performance measurement and improvement that can be achieved from the comprehensive model. To identify the value of the model, a cost-benefit analysis should be conducted to evaluate the impact, advantages, and disadvantages of implementing the model in organizations. The key steps within such a cost-benefit analysis should include the following: (i) identifying the tangible and intangible costs and benefits measures for the model, (ii) normalizing the costs and benefits measures, (iii) selecting the decision criteria, and (iv) comparing the normalized measures to the decision criteria to identify the value of the model to organizations.

6.3 Implications of the research and future work

Implications

The work in this dissertation has implications for both construction IM researchers and construction IM practitioners.

For construction IM researchers:

- The IM assessment model provides insight into organizational-level IM performance assessment in construction organizations by identifying the IM components, IM activities, and KPIs needed to comprehensively measure IM performance. The tested model consisted of three interconnected perspectives, which provide the means to measure and improve the organizational-level IM performance. The model also addresses the lack of a tested organizational-level IM assessment model in literature and addresses the limitations in existing
measurement frameworks, which include limited assessment criteria/perspectives, limited relations between criteria/perspectives, limited process to develop measures, and limited implementation and maintenance guidelines (identified in Chapter 5).

For construction IM practitioners:

- The IM assessment model provide strategic managers in construction-owner organizations with a tool to comprehensively measure and improve the organizational-level IM performance within a single model, thereby eliminating ad-hoc measurement and the need for organizations to continuously develop KPIs. The IM framework in the model provides strategic managers with a comprehensive set of organizational-level IM components, IM activities, and the lagging and leading KPIs required to measure organizational-level IM performance. The KPIs are grouped by IM components to provide managers with a structure to understand IM performance and to identify the IM components with opportunities for improvement. The IM performance measurement method provides strategic managers with the steps to measure the organizational-level IM performance and the guidance to develop performance measures, metrics, and questions for each KPI. The IM performance improvement method provides strategic managers with the steps, actions, initiatives, and modifications needed to improve performance in the IM components. The model also provides the opportunity for organizations to compare and benchmark organizational-level IM performance over time both internally and externally (with other organizations using the proposed IM model).
Future work

Future research work related to the IM model proposed in this research includes the following.

- The development of performance measures, metrics, and questions for each lagging and leading KPI, using the process demonstrated to measure the metric-level (detailed-level) performance for the change order process as a guideline. Strategic managers will be able to use the same KPIs, measures, metrics, and questions to continuously measure and improve the organizational-level IM performance over time, providing revision is made to the organizational-level IM performance target (goal).

- In addition, investigating the relationships between the metrics and KPIs will identify the capability of the metrics to predict the KPIs. Similarly, investigating the relationships between the KPIs and IM activities will identify the link between each KPI and IM activity, which will allow for investigation of issues relating to a specific IM activity. The link may be useful in diagnosing IM issues in computer information systems (IM activities should be a key consideration in computer information system design and improvement).

- The further development and implementation of the comprehensive IM model in multiple construction organizations over multiple management cycles to identify the level of performance improvement (i.e., effectiveness and efficiency) achieved, and to compare the results to existing approaches used in organizations. This will serve to highlight the importance and the benefits of a structured comprehensive organizational-level IM model to organizations, as
well as highlight the model’s level of integration into existing performance assessment systems within each organization. In addition, the applicability of the model to all organizations (e.g., owner, architect, designer, and contractor) in the construction industry will provide additional evidence to further validate the capability and comprehensiveness of the model for organizational-level IM assessment. This will identify potential benefits of the model to comprehensively optimize IM resources and reduce IM constraints within any construction organization.

- The application of the comprehensive model to benchmarking and maturity modelling of organizational-level IM performance. This will allow multiple organizations to compare their organizational-level IM performance providing the organizations are using the developed model, which could lead to the identification of IM best practices for organizations within the construction industry.

### 6.4 Concluding remarks

This research presents a structured model to assess the organizational-level IM performance in construction-owner organizations. The lack of such a model in literature means that the insights provided in this study can serve as the first step to further enhance the effectiveness and efficiency of organizational-level IM performance assessment in construction organizations. The comprehensiveness of the IM framework and ease of use are the key strengths of the model. The possibility to extend the model’s capability to organizational-level IM benchmarking is a potential added benefit to
construction organizations. The results from this research have demonstrated that the organizational-level IM performance can be comprehensively assessed through strategic managers within a single IM assessment model, thereby concluding this research.
Appendix A: (Chapter 2) Questionnaire survey

E-mail sent to researchers requesting their participation

Subject: UNB CEM Research Project

Dear Dr. ………………,

My name is Ferzon Aziz, a Construction Engineering and Management PhD. student being supervised by Dr. Jeff H. Rankin and Dr. Lloyd M. Waugh at the University of New Brunswick. I am seeking your participation in a survey of construction information management (IM) researchers as part of my research that should take approximately 45 minutes to complete. This is an online survey consisting of 54 questions grouped into 8 IM components.

The goal of my research is to holistically assess the organizational-level IM performance in construction organizations. To achieve this, I have developed key performance indicators (KPIs) for eight key IM components: IM processes, ICT resources, Practice resources, people resources, IM inputs, IM outputs, IM constraints, and IM objectives.

The purpose of this survey is to validate the KPIs prior to proceeding further with this research. The next research step will pilot test the KPIs in construction organizations. Your response and time are greatly appreciated. I will send you the link to the validation survey upon your agreement to participate. Thank you in advance.

Sincerely,

Ferzon Aziz
**Questionnaire**

**Research goal:** To holistically assess the organizational-level information management (IM) performance in construction-owner organizations (*holistic refers to all aspects of IM within a single organization in a single industry*). To achieve this, I planned to:

1. Develop an organizational-level IM framework (Figure 1) to identify the organizational-level IM components and key performance indicators (KPIs) for each component.
2. Validate the IM activities and KPIs through construction IM researchers and strategic managers in construction-owner organizations.

**Figure 1: Organizational-level IM Framework**

**Survey Purpose:** To accomplish item 2 in the list above. Prior to proceeding further, I would like your feedback on the appropriateness and comprehensiveness of the KPIs for use in holistic organizational-level IM performance measurement.

**Instruction:** Please state your level of agreement with the KPIs for use in comprehensive organizational-level IM performance measurement using the five-point likert scale labelled (strongly agree (SA), agree (A), neutral (N), disagree (D), and strongly disagree (SD)). This survey consists of 8 sections with 3 to 8 questions per section.

*Note: The blank space that was provided to answer the open-ended questions in this survey is reduced to decrease the length of this Appendix.*

<table>
<thead>
<tr>
<th>Information management (IM) process activities: the IM life cycle activities performed by people in each management activity</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information needs identification (i.e. listing of information to complete each activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Information creation and acquisition (i.e., determine the value of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Information analysis and interpretation (i.e., determine the value of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Information organization and storage (i.e., group information for easy storage and retrieval for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Information access and dissemination (i.e. internal and external location and distribution of information)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Information use (i.e. generation of decisions to complete each activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any IM activities not included above and/or any specific comments/recommendations to improve the activities.
### Information and communication technology (ICT) resources: the characteristics of the CIS used by people to perform the IM activities.

<table>
<thead>
<tr>
<th>Description</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Information classification</strong> (i.e. cataloguing based on a construction information classification system)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information navigation</strong> (i.e. mapping of information based on control vocabularies)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Information traceability</strong> (i.e. organization of information based on version control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>ICT connectivity</strong> (i.e. continuous and successful retrieval of information through interconnected systems)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>ICT interoperability</strong> (i.e., common standard to exchange and use information between interconnected applications in the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>ICT scalability</strong> (i.e. delivery of information to meet current and future demands through continuous incremental system upgrades)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.

### Practice resources: the characteristics used by managers to control the operation of the IM processes.

<table>
<thead>
<tr>
<th>Description</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Information governance</strong> (i.e., accountability framework for effective and efficient IM process, resources, and information use to achieve the organization's IM goal through business needs prioritization, information system governance, leadership, and roles and responsibilities)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information quality management</strong> (i.e., IM risk mitigation to optimize the quality of information and information flow in the CIS through audit, human resource strategy, needs assessment, system and infrastructure reassessment, and process techniques re-engineering)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>IM service delivery</strong> (i.e. standards and policies to guide information communication, exchange, and comprehensiveness)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>ICT adoption</strong> (i.e., user participation in CIS development to ensure acceptance of implemented changes to the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>ICT quality assurance</strong> (i.e., standardized process to mitigate errors from information storage, access, security, modification, and deletion in the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>IM benefits</strong> (i.e., tangible and visible IM changes to enhance collaboration and seamless user experience of the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. <strong>IM roadmap</strong> (i.e. link of short and long term goals through change management, the management of information as a strategic resource, and the conversion from paper to electronic artifacts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.

### People resources: the characteristics of information managers and users required for effective and efficient operation and management of the IM processes.

<table>
<thead>
<tr>
<th>Description</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>IM behaviour</strong> (i.e. IM beliefs and values)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>IM qualification</strong> (i.e., knowledge of the IM process and CIS use)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>IM skill</strong> (i.e. level of experience and training)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.
**IM inputs:** the characteristics of information required for the effective operation of the IM processes.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Information certainty</strong> (i.e. assurance of quantitative, qualitative, formal, and/or informal content)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information date</strong> (i.e. historical, present, or future period)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Information detail</strong> (i.e., features of information content for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>Information frequency</strong> (i.e. continuous, planned interval, on demand, and/or occasional supply)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>Information scope</strong> (i.e. connection, pertinence, or relation of information to specific task)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>Information source</strong> (i.e. internal, external, or multiple channels)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.

**IM outputs:** the characteristics of information from the IM processes that are of value to decision makers.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Information content</strong> (i.e., completeness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information form</strong> (i.e., presentation of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Information time</strong> (i.e., timeliness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.

**IM constraints:** the internal and external organizational characteristics that restrict the effectiveness and efficiency of the IM processes.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Information overload</strong> (i.e., amount of excess and unwanted information encountered for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>ICT flexibility</strong> (i.e. information system ability to meet increased variety of user expectations and internal and external retrieval needs, without excessive costs, time, disruptions, or performance losses)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>IM complexity</strong> (i.e., unnecessary complication in the CIS and the management of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>IM cost</strong> (i.e., cost strategy effectiveness and efficiency to manage and store information)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>IM culture</strong> (i.e., IM attitude that influence organizational IM and demonstrated through adversarial attitudes, divergent goals and objectives, functional fragmentation, and self-protective pressures)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>IM interdependency</strong> (i.e., integration of people with the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. <strong>IM legal requirement</strong> (i.e. level of compliance with information codes/laws, and the organization regulations)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. <strong>IM organizational structure</strong> (i.e., hierarchical arrangement that influence information accountability)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.
**IM objectives:** the planned outcomes that assess the organization’s capability to achieve the IM goal.

<table>
<thead>
<tr>
<th>IM objectives</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Information accessibility</strong> (i.e., ease of retrieving information from the CIS for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information accuracy</strong> (i.e., preciseness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Information availability</strong> (i.e., readiness of information for use when needed for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>Information context</strong> (i.e., ease of understanding information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>Information currency</strong> (i.e. up-to-date information with the right timing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>Information relevance</strong> (i.e. appropriateness of information for each task)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. <strong>Information usability</strong> (i.e., ease of information use for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please identify any KPI(s) not included above and/or any specific comments/recommendations to improve the KPIs.
Appendix B: (Chapter 3) Interview survey

PROJECT TITLE: Construction Information Management Assessment Model

RESEARCHER: Ferzon Aziz, PhD. student, University of New Brunswick

PURPOSE: To investigate the effectiveness of developed key performance indicators (KPIs) to holistically assess the organizational level changes in construction organizations’ information management (IM) performance. This interview survey will test the effectiveness of the KPIs to holistically assess the organizational-level IM performance in your organization. Holistic refers to all aspects of IM within a single organization. This interview consists of three to eight questions for each section in the developed model in Figure 1. The reliability of this research greatly depends on the accuracy of your responses to the questions.

Figure 1: Organizational-level IM Framework

SCOPE: This interview will focus on the management of INFRASTRUCTURE DESIGN, CONSTRUCTION, AND MAINTENANCE INFORMATION by you or your team in the organization.

ASSESSMENT PERSPECTIVES: This interview will check the assessment actions you or your team performs on each IM activity and KPI in the performance management cycle. For sections 1 to 8 the actions that will be assessed are defined as:

1. Plan/Identify: the process of developing ways to achieve the desired level of performance
2. Measure/Document: the process of capturing and analyzing the performance
3. Control/Assess: the process of comparing the plan and actual performance for quality achievement
4. Improve: the process of taking corrective actions as needed to refine the performance.

This project has been reviewed by the Research Ethics Board of the University of the New Brunswick and is on file as REB 2012-131.
INSTRUCTION: For the **INFRASTRUCTURE DESIGN, CONSTRUCTION, AND MAINTENANCE INFORMATION** you or your team manages, please state if the IM activities and KPIs in the right column are NOT APPLICABLE to you or your team. If the ACTIVITIES and INDICATORS are applicable, then I will ask you to tell me which of the four *assessment actions* in the left column you or your team performs.

**Information management (IM) process activities:** the IM activities performed by people in each management activity.

<table>
<thead>
<tr>
<th>I or my team</th>
<th>Information needs identification (i.e., determine the information required for each management activity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>1. Information needs identification (i.e., determine the information required for each management activity)</td>
</tr>
<tr>
<td>Measure</td>
<td>2. Information creation and acquisition (i.e., obtain or create information for each management activity)</td>
</tr>
<tr>
<td>Control</td>
<td>3. Information analysis and interpretation (i.e., determine the value of information for each management activity)</td>
</tr>
<tr>
<td>Improve</td>
<td>4. Information organization and storage (i.e., group information for easy storage and retrieval for each management activity)</td>
</tr>
<tr>
<td></td>
<td>5. Information access and dissemination (i.e., retrieve and share information for each management activity)</td>
</tr>
<tr>
<td></td>
<td>6. Information use (i.e., application of information to each management activity)</td>
</tr>
</tbody>
</table>

**Information and communication technology (ICT) resources:** the characteristics of the computer information system (CIS) (software, hardware, and telecommunication) used by people to perform the IM activities.

<table>
<thead>
<tr>
<th>I or my team</th>
<th>Information classification (i.e., standardized classification system to group information in the CIS for retention, retrieval, disposal, or update)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>1. Information classification (i.e., standardized classification system to group information in the CIS for retention, retrieval, disposal, or update)</td>
</tr>
<tr>
<td>Measure</td>
<td>2. Information navigation (i.e., standardized list of keywords (controlled vocabulary terms) to index information in the CIS)</td>
</tr>
<tr>
<td>Control</td>
<td>3. Information traceability (i.e., standardized process to track the changes to information artefact versions in the CIS)</td>
</tr>
<tr>
<td>Improve</td>
<td>4. ICT connectivity (i.e., interconnected networks to transfer information in the CIS)</td>
</tr>
<tr>
<td></td>
<td>5. ICT interoperability (i.e., common standard to exchange and use information between interconnected applications in the CIS)</td>
</tr>
<tr>
<td></td>
<td>6. ICT scalability (i.e., CIS upgrade (software, hardware, and network) to meet current and future information needs)</td>
</tr>
</tbody>
</table>
**Practice resources:** the characteristics used by strategic managers to regulate the functioning of the IM processes.

<table>
<thead>
<tr>
<th>I or my team</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan</td>
<td>Measure</td>
<td>Control</td>
<td>Improve</td>
</tr>
<tr>
<td>1. <strong>Information governance</strong> (i.e., accountability framework for effective and efficient IM process, resources, and information use to achieve the organization's IM goal through business needs prioritization, information system governance, leadership, and roles and responsibilities)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information quality management</strong> (i.e., IM risk mitigation to optimize the quality of information and information flow in the CIS through audit, human resource strategy, needs assessment, system and infrastructure reassessment, and process techniques re-engineering)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>IM service delivery</strong> (i.e., standardized process to communicate and share information effectively and efficiently to meet each management activity needs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>ICT adoption</strong> (i.e., user participation in CIS development to ensure acceptance of implemented changes to the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>ICT quality assurance</strong> (i.e., standardized process to mitigate errors from information storage, access, security, modification, and deletion in the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>IM benefits</strong> (i.e., tangible and visible IM changes to enhance collaboration and seamless user experience of the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. <strong>IM roadmap</strong> (i.e., link the short and long term IM goals to the business goal through change management, management of information as a strategic resource, and the conversion from paper to electronic artifacts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**People resources:** the characteristics of information managers and users required for effective and efficient operation and management of the IM processes.

<table>
<thead>
<tr>
<th>I or my team</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identify</td>
<td>Document</td>
<td>Assess</td>
<td>Improve</td>
</tr>
<tr>
<td>1. <strong>IM behaviour</strong> (i.e., actions that influence changes made to IM and the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>IM qualification</strong> (i.e., knowledge of the IM process and CIS use)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>IM skill</strong> (i.e., experience and training required to use the CIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IM inputs:** the characteristics of information required for the effective functioning of the IM processes.

<table>
<thead>
<tr>
<th>I or my team</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identify</td>
<td>Document</td>
<td>Assess</td>
<td>Improve</td>
</tr>
<tr>
<td>1. <strong>Information certainty</strong> (i.e., validity of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information date</strong> (i.e., period when information is created or modified for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Information detail</strong> (i.e., features of information content for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>Information frequency</strong> (i.e., timing of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>Information scope</strong> (i.e., intended purpose of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>Information source</strong> (i.e., physical location of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IM outputs:** the characteristics of information from the IM processes that are of value to decision makers.

<table>
<thead>
<tr>
<th>I or my team</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identify</td>
<td>Document</td>
<td>Assess</td>
<td>Improve</td>
</tr>
<tr>
<td>1. <strong>Information content</strong> (i.e., completeness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Information form</strong> (i.e., presentation of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Information time</strong> (i.e., timeliness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**IM constraints:** the organizational characteristics that may hinder the effectiveness and efficiency of the IM processes from achieving the IM goal.

<table>
<thead>
<tr>
<th>I or my team</th>
<th><strong>Identify</strong></th>
<th><strong>Document</strong></th>
<th><strong>Assess</strong></th>
<th><strong>Improve</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. <strong>Information overload</strong> (i.e., amount of excess and unwanted information encountered for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. <strong>ICT flexibility</strong> (i.e., capacity of the CIS to meet user expectations and needs for each management activity without excessive costs, time, disruptions, performance losses, or reliance on legacy systems)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. <strong>IM complexity</strong> (i.e., unnecessary complication in the CIS and the management of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. <strong>IM cost</strong> (i.e., cost strategy effectiveness and efficiency to manage and store information)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. <strong>IM culture</strong> (i.e., IM attitude that influence organizational IM and demonstrated through adversarial attitudes, divergent goals and objectives, functional fragmentation, and self-protective pressures)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. <strong>IM interdependency</strong> (i.e., integration of people with the CIS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. <strong>IM legal requirement</strong> (i.e., compliance with organization and government information regulations)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. <strong>IM organizational structure</strong> (i.e., hierarchical arrangement that influence information accountability)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IM objectives:** the planned outcome characteristics that measure the IM processes capability to achieve the IM goal.

<table>
<thead>
<tr>
<th>I or my team</th>
<th><strong>Identify</strong></th>
<th><strong>Document</strong></th>
<th><strong>Assess</strong></th>
<th><strong>Improve</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. <strong>Information accessibility</strong> (i.e., ease of retrieving information from the CIS for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. <strong>Information accuracy</strong> (i.e., preciseness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. <strong>Information availability</strong> (i.e., readiness of information for use when needed for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. <strong>Information context</strong> (i.e., ease of understanding information for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. <strong>Information currency</strong> (i.e., up-to-date information for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. <strong>Information relevance</strong> (i.e., appropriateness of information for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. <strong>Information usability</strong> (i.e., ease of information use for each management activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Open-ended Questions**

Can you identify any additional IM activities and KPIs that you would add to any of the eight IM components?

Please provide the reason(s) for not assessing an IM activity or KPI.

Discussion-type questions to demonstrate how the IM activities and KPIs are assessed within the performance management cycle (using previous actual measurement method and results as evidence).

- What information was managed and assessed?
- What performance metrics were used in the assessment?
- Who managed the information” and “who performed the assessment actions?
- How was the information managed (i.e., the processes and procedures used)?
- How was the assessment actions performed?
- When were the IM assessment activities performed (i.e., as specified in policies and schedules)?
- When were the assessment actions performed?

Do you have any additional comments relating to this study?
Appendix C: (Chapters 4 and 5) Change order process interview survey

PROJECT TITLE: A Construction Information Management Assessment Model

RESEARCHER: Ferzon Aziz, PhD. student, University of New Brunswick

PURPOSE: To investigate the effectiveness of developed information management performance measures to assess a management process within your organization.

SCOPE: This interview will focus on the activities in the CHANGE ORDER PROCESS performed by you in the organization. The change order process is seen to consist of the five management activities as shown in Figure 1.

![Figure 1: Change order process activities](image)

DEFINITION OF DOCUMENT: In the context of this interview a document is referred to the following files:
1. Change order request
2. Contemplated change order form
3. Quote
4. Files within a contract
   - Cost information
   - Schedule (time) information
   - Scope information
   - Safety information
   - Specifications (general and specific)
5. Change order form

The reliability of this research greatly depends on the accuracy of your responses to the questions.

*This project has been reviewed by the Research Ethics Board of the University of the New Brunswick and is on file as REB 2012-131.*

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What percentage of IM issues exists in the change order process?</td>
<td></td>
</tr>
<tr>
<td>2. Please answer the following questions to help identify the possible IM issue?</td>
<td>Rank</td>
</tr>
<tr>
<td>i. How long does it take to retrieve a stored document?</td>
<td></td>
</tr>
<tr>
<td>ii. How many documents contain errors?</td>
<td></td>
</tr>
<tr>
<td>iii. How many documents are not ready for use when needed?</td>
<td></td>
</tr>
<tr>
<td>iv. How many documents are not easy to understand?</td>
<td></td>
</tr>
<tr>
<td>v. How many documents are not up-to-date?</td>
<td></td>
</tr>
<tr>
<td>vi. How many documents are not applicable for use?</td>
<td></td>
</tr>
<tr>
<td>vii. How many documents contain incomplete information?</td>
<td></td>
</tr>
<tr>
<td>viii. How many documents are reviewed per week?</td>
<td></td>
</tr>
<tr>
<td>ix. How many hours are in your workweek?</td>
<td></td>
</tr>
<tr>
<td>3. What additional issues exist that is not included in the above questions?</td>
<td>Please use sheet provided</td>
</tr>
<tr>
<td>4. Please rank the IM issues in question 2 from most to least pertinent.</td>
<td></td>
</tr>
</tbody>
</table>
Curriculum Vitae

Ferzon Aziz

Qualifications
Dip. University Teaching, University of New Brunswick, 2012
M.Sc. Construction Management, University of the West Indies, 2008
B. Eng., Civil Engineering, University of Guyana, 2003
Dip. Tech., Civil Engineering, University of Guyana, 2001

Journal Publications (In Progress)

Conference Proceedings

Conference Presentations and Workshops

Academic Prize and Scholarship
Canadian Society of Civil Engineers General Conference Student Paper Award (3rd Place), University of New Brunswick, 2012.
Canadian Construction Board (NB Chapter) Scholarship, University of New Brunswick, 2011.
Trinidad Cement Limited Award for highest grade in construction materials, MSc., University of the West Indies, 2008.