Feasibility of an Open Source Repository for Increasing the Usage of Best Practices in

the Architecture-Engineering-Construction Industry

by

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ABSTRACT

Effective collection and dissemination of project information, including best practices, help increase the likelihood of project performance and are vital to organizations in the architecture-engineering-construction (AEC) industry. Best practices can help improve project performance, yet these practices are not universally implemented and used in the industry, due to the following: 1) not all practices are applicable to every project or organization, 2) knowledge lost in organizational turnover which leads to inconsistent collection and implementation of best practices and 3) the lack of standardized processes for best practice management in an organization.

This research, sponsored by National Academy of Construction, the Construction Industry Institute and Arizona State University, used structured interviews, a Delphi study and focus groups to explore: 1) potential benefit and industry interest in an open repository of best practices and 2) important elements of a framework/model that guides the creation, management and sustainment of an open repository of best practices.

This dissertation presents findings specifically exploring the term "Practices for Excellence", its definition, elements that hinder implementation, the potential value of an open online repository for such practices and a model to develop an open repository.

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CHAPTER 1: INTRODUCTION

In the architecture-engineering-construction (AEC) industry the term "best practice" generally refers to a method or task that should be implemented for an increased chance of success when managing construction/capital projects. In the AEC industry, there are many organizations (consultancies, associations, universities, etc.) that collect, catalog and disseminate best practices. These practices span various project types, project cycles and organizations.

However the terminology describing best practices is not universal. For instance the terms "best practices", "standards" and "guidelines" are all used in the industry to describe critical practices for project success. With the various databases in the industry, there is a lack of uniformity and fragmentation, which are potential barriers to best practice implementation and use.

1.1 BACKGROUND

1.1.1 NATIONAL ACADEMY OF CONSTRUCTION AND NATIONAL CONSTRUCTION FORUM

The National Academy of Construction (NAC) is a body that consists of active and retired industry members and academics related to the construction industry (NAC 2014). Its members are actively engaged in researching and solving industry problems that in turn help improve the industry.

At the 2011 National Construction Forum (a subset of NAC), industry and academic members convened to discuss three important topics - workforce development, industry image and industry best practices. The Best Practice workstream identified the

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negative impact on project performance due to the inconsistent implementation and use of best practices in the AEC industry. Reasons for the inconsistent implementation and use are that 1) not all best practices are applicable to every project, project type, or organization, and 2) they are not universally applied within individual organizations (National Academy of Construction 2010).

In August 2012, to address the inconsistent implementation and use of best practices, the NAC explored the possibility of developing an online repository of best practices that is open for industry contribution (crowdsourcing) and learning. A research study was created to explore the potential of an online resource that could help increase the use of industry best practices, funded by the Construction Industry Institute and Arizona State University. The resource would act as a clearinghouse for industry best practices that can be accessed globally. This dissertation details the research completed on the potential of an open repository of best practices for the industry.

1.1.2 OPEN REPOSITORY

In this dissertation, the term "open repository" specifically means an online resource (i.e. website) that would collect, organize and disseminate critical practices for project success. There would be global input from subject matter experts in the industry.

The open repository of best practices would provide a dependable resource for the industry, addressing the barriers behind inconsistent implementation and use of best practices.

1.1.3 RESEARCH PROBLEM

Industry best practices increase the likelihood of project performance (cost and time savings addressed in the next chapter), however, despite the availability of such resources for the industry, organizations continue to inconsistently implement and use these practices. There are multiple reasons for usage inconsistency:

1. Not all best practices are applicable to every project, project type, or organization, and they are not universally applied within individual organizations.

2. Knowledge is lost in organizational personnel turnover that leads to inconsistent implementation and use of best practices.

3. Best practice management processes within industry organizations are not effective.

4. Fragmentation across the industry with no "central" location to find such resources.

Despite research demonstrating that best practices increase the likelihood project performance, AEC industry contractors and owners inconsistently use best practices. This problem has negatively impacted the performance of projects in the industry. A possible cause of this problem is the ineffective best practice management processes within organizations. Perhaps a study which investigates the potential of an open sourced repository and identifies effective management tenets of a best practice process using a mix method approach (interviews, Delphi study and focus groups) could help solve the problem.

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1.2 RESEARCH QUESTIONS AND RESEARCH OBJECTIVES

The research problem for the study leads the author to ask the following questions:

1. Is the AEC industry interested in an open repository of best practices?

2. Is there a term that can promote consistency that is inclusive of the term "best practice" and similar terms?

3. What are tenets of effective best practice processes?

4. What steps should be included in a development model for an open repository?

Based on the research questions, the objectives for this study include:

- Assessing best practice terminology.

- Identifying available industry best practice resources.

- Assessing industry interest in an open-access repository for best practices.

- Identifying tenets of effective best practice processes that can serve as the basis of the open repository structure.

- Building a framework/model to guide the development of an open repository of best practices.

The developmental model should also assess granularity of industry practices, identify a collection for starting best practices and identify the target audience of the open repository.

1.2.1 RESEARCH SCOPE

This research study assesses the feasibility of the open repository specifically, along with the critical first steps needed for creation, management and sustainment of the online resource. It is limited to the AEC industry, but excludes the residential

construction market for now. The scope is also limited to developing a feasibility

assessment with development coming later, if at all.

1.3 HYPOTHESES

The research problem led the author to the following hypotheses.

1. The AEC industry has a strong interest in an open repository that is populated by industry experts to increase the implementation and usage of practices critical to the successful management of capital projects.

2. Using input from AEC industry members, a framework/model can be created to guide the creation, management and sustainment for an open repository of best practices.

1.4 POTENTIAL BENEFITS

The author believes that the open repository could benefit in the AEC industry in several ways. First the open repository would help standardize practices and facilitate rapid dissemination in the industry. Standardization of successful practices creates an opportunity to systematically incorporate these practices within industry organizations. If critical practices are standardized and readily accessible in the industry, organizations can capitalize on opportunities for performance improvement.

Also the open repository supports knowledge transfer despite personnel turnover or retirement, in turn allowing organizations to maintain or even improve their performance. Finally, an open repository raises the level of awareness of best practices leading to even larger potential improvements and understanding of the practices themselves.

1.5   STRUCTURE OF DISSERTATION

This dissertation is organized into eight chapters. In addition, the dissertation also includes appendices that provide information on participating organizations, research method instruments and estimated revenue and expenses of creating an open repository.

Chapter One includes a background, research problem and questions. Chapter Two of this dissertation provides an overview of literature significant in the fields of knowledge management, best practices, best practices resources (including resources specific to the AEC industry), project performance and technology needed for effective knowledge management. Chapter Three reviews the research methods for this study. Structured interviews conducted with industry organizations are described in Chapter Four including answers given to specific questions. Chapter Five reviews the two-round Delphi study the author conducted. Chapter Six provides an overview of the focus groups conducted and the findings from the two sessions. The development model for the open repository of best practices is presented in Chapter Seven. Finally, Chapter Eight presents conclusions of the research findings and the author's contributions and thoughts on future work.

CHAPTER 2: LITERATURE REVIEW

A literature review serves several purposes. It reviews the existing scholarship to understand the contributions to the field. It also contextualizes a researcher's study within the body of work completed. For this literature review, the author explored knowledge management and its importance to project performance. A review was also conducted on the knowledge subset of best practices specific to the AEC industry along with available definitions and industry resources. The uniqueness of crowd-sourcing and crowd-sourced information is also reviewed along with the software technology used to house and disseminate best practices.

2.1 KNOWLEDGE MANAGEMENT

Successful management of knowledge is important for any organization whether in or out the AEC industry. Knowledge management involves the "identification, optimization and active management" of intellectual assets (Webb 1998). The purpose for doing so is to create value, increase productivity and gain and sustain competitive advantage for an organization (Webb 1998).

Knowledge is data that when collected becomes meaningful (Bhatt 2001). Knowledge is also in many cases is organization specific. Depending on the organization's industry, market, structure, and culture, the knowledge varies. Despite this uniqueness, knowledge collected can be classified into distinct categories.

2.1.1 KNOWLEDGE TYPES

Knowledge that is collected by organizations can be classified into three categories (Rezgui 2001):

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- Domain: Administration information related to the AEC industry. This information is not proprietary to any organization; it can be thought of as common knowledge. For instance, overall familiarity of project participants with state or city code regulations is needed to be successful in completing a project.

- Organizational: Company specific information that gives the end user instructions on internal procedures and policies. For instance, guidelines to access and use company specific project management software.

- Project: Knowledge related to the completion of projects. This is both formal (specific project information), and informal information (lessons learned by individuals and included in best practices). For instance, a 10 year price database for projects or a database of best practices related to form building for a concrete subcontractor.

The goal of this research is to explore the feasibility of an open repository of best practices to increase the use of practices related to the management of capital projects. Therefore project specific information (explicit and tacit) is the focus of this research. "Explicit" means the information is easy to identify, capture and transfer. "Tacit" means the information is not so easily identifiable thus its collection is not as easy. Subsection 2.1.2 describes tacit knowledge more in-depth.
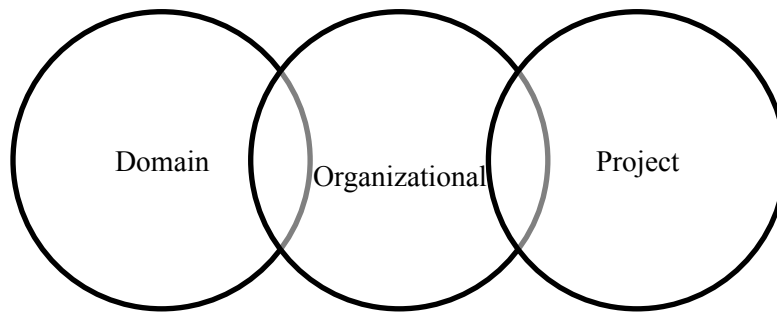
Figure 1: Three Types of Knowledge

Project knowledge is not only collected during and after the project but early on in the project lifecycle as well. Project-related knowledge could also come from outside the project as well. Javernik-Will found (2009) that AEC organizations operating in new, non-domestic territories garner knowledge from various sources such as external organizational partner relationships, consultants and the project client.

Knowledge is also gained over time as projects are started and completed. This knowledge collected by organizations from projects is called "lessons learned." This collected knowledge provides organizations the opportunity to improve management of current projects based on lessons collected from previous projects. In assessing the value of lessons learned programs, the Construction Industry Institute Research Team (RT) 230 set out to explore the implementation and performance of lessons learn programs in the AEC industry (Caldas et al. 2009; CII 2007).
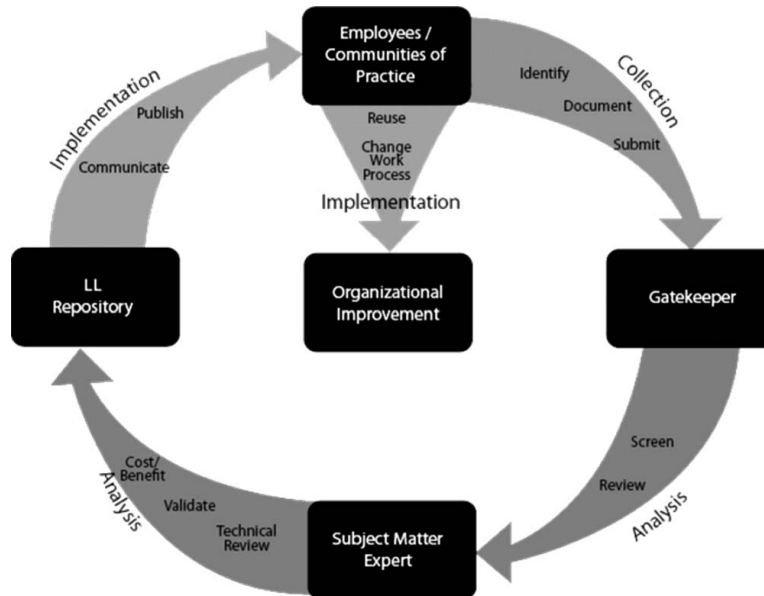
Figure 2: Lessons Learned Process (Caldas et al. 2009)

The research team found that continuous collection and training is needed to fully leverage this knowledge type. Organizations should "teach" and not just collect lessons in their databases. Critical to managing lesson learn programs is effective leadership, culture and a strong implementation strategy. An overview of the lesson learned process is depicted in Figure 2.

2.1.2 TACIT KNOWLEDGE

The knowledge types mentioned so far are explicit. Explicit knowledge is easy to identify, capture and transfer. However, tacit knowledge is not so easily identifiable. An example of tacit knowledge type is the project insight a project manager garners from years of project experience. Tacit knowledge is context specific and highly personal; communicating this knowledge is difficult (Polanyi 1966) . This knowledge is specific to an individual, thus the collection and dissemination of this knowledge is difficult.

Woo et al., (2004) indicate that due to the unique (non-uniform) nature of projects, tacit knowledge is critical to project success in the AEC industry. To help transfer tacit knowledge in the AEC industry, Woo et al., created a Dynamic Knowledge Map. The web application allows users to research explicit (project specific) knowledge but also connects the user with a subject expert specific to that topic for real time connection and discussion.

2.1.3 KNOWLEDGE TRANSFER AND USAGE

As previously mentioned knowledge management is process of identifying, optimizing and actively managing intellectual assets (Webb 1998). Important to knowledge management is the transfer and usage of the knowledge.

The process of transferring knowledge and information is important to organizations (Egbu 2004). The AEC industry is project-based in that the project duration is relatively short-term and the work is task orientated which can hinder continuous learning and transfer of knowledge (Egbu and Botterill 2002). However using technology (software, hardware, etc.) and an effective process can improve the transfer of knowledge. Successful transfer of knowledge is not only dependent on technology but most importantly on the people in organizations that share the knowledge (Argote and Ingram 2000). While an organization might overcome transfer challenges, knowledge must be ultimately used and implemented for benefits to be received. Knowledge management systems should provide benefits (e.g., increased productivity and time savings) to encourage transfer and usage of knowledge (Ardichvili et al. 2003).

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2.2 BEST PRACTICES

The origin of best practices is rooted in the scientific approach to business management (early twentieth century). The book, <u>The Principles of Scientific Management</u>, was an early resource to help managers consistently employ management practices that helped improved project performance (Taylor 1914). Acknowledging the importance of standardization, Taylor is attributed with starting the science of management. The term "best practice" was not used in his book but the principles associated with "best practices" are identifiable.

Taylor provides the following example of a team of bricklayers and their efficiency of work tied to the slowest bricklayer in a work group (1914 pp. 83–84):

> "..no bricklayer could alone increase his speed through their adoption because it will be remembered that in all cases several bricklayers work together in a row and the walls all around a building must grow at the rate of speed. No one bricklayer then can work much faster than the one next to him."

> "It is only through enforced standardization of enforced adoption of the best implements and conditions and enforced cooperation that faster work can be assured."

Taylor uses the example of bricklayers to demonstrate importance of cooperation within a cohesive project team but also the standardization of implements and conditions for faster project performance. The example is simple but the driving force carries over to present day and the purpose of using best practices.

The term "best practice" is used within and outside of the AEC industry but focused on management practices not work practices. At times the term "best practice" is overused, making it difficult to identify and implement relevant practices. Shull and Turner recognized this problem when researching the identification and implementation

of best practices for the US Department of Defense. The authors acknowledged that "many so-called best practices are actually disciplines or 'what to dos' not specific enough to really implement" (Shull and Turner 2005).

2.2.1 INDUSTRY DEFINITIONS OF THE TERM "BEST PRACTICE"

The purpose of this research is to assess the feasibility of an open repository of best practices. A critical step in this process is to first identify best practices. To identify a best practice, its definition must be clear.

To understand to the purpose of the term, which is important when identifying best practices that can potentially populate the repository, it is essential to review the definitions of both words. The word "best" is defined as ("Best - Definition and More from the Free Merriam-Webster Dictionary" 2014):

1. better than all others in quality or value,

2. most skillful, talented, or successful and

3. most appropriate, useful, or helpful

The word "practice" is defined as ("Practice - Definition and More from the Free Merriam-Webster Dictionary" 2014):

1. the usual way of doing something,

2. the activity of doing something again and again in order to become better at it and

3. something that is done often or regularly

From the definitions, a practice is an activity done regularly and often. It is a usual way of completing an action. A "best practice," then, is the most appropriate practice to complete a task that is better than most. Therefore the open repository should target and include practices that are most appropriate and useful for managing projects.

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The following subsection outlines a few of the definitions that were collected in this

effort.

2.2.2   CONSTRUCTION INDUSTRY INSTITUTE (CII)

The Construction Industry Institute (CII), a prominent research organization in the

AEC industry, defines best practices as the following:

> "The CII Best Practices are defined as "process[es] or method[s] that, when executed effectively, [lead] to enhanced project performance." To qualify as a CII Best Practice, a practice must be sufficiently proven through extensive industry use and/or validation" (Construction Industry Institute (CII) 2011).

2.2.3   SOUTH EAST CENTRE FOR THE BUILT ENVIRONMENT (SECBE)

The South East Centre for the Built Environment (SECBE) is a research group in

the United Kingdom organized for improvement of all facets of the built environment in

the region. The group's definition of best practice is as follows:

> "Best Practice is the knowledge that underpins examples of excellence. We can take this knowledge, share it and implement it throughout the construction industry" (South East Centre for the Built Environment 2009).

2.2.4   AMERICAN SOCIETY FOR QUALITY (ASQ)

The American Society for Quality is an organization that promotes the

standardization of techniques for consistent quality performance. The society's definition

of "best practice" is as follows:

> "Best Practice is a superior method or innovative practice that contributes to the improved performance of an organization, usually recognized as 'best' by other peer organizations" (American Society for Quality (ASQ) n.d.).

2.2.5 THE HACKETT GROUP (CONSULTING FIRM)

The Hackett Group is a firm that provides consulting services specific to best practices and benchmarking for organizations across various industries. The firm considers itself a leader in the implementation and use of best practices. The organization's definition of "best practice" is the following:

> "Business best practices, as defined by The Hackett Group, are proven, repeatable, documented techniques that deliver measurable business performance management improvements."

> "Executives look to business best practices benchmarking to help them speed their progress toward enterprise performance management improvement, and to guide them around pitfalls that might otherwise slow or even halt their initiatives" (The Hackett Group 2013).

The Hackett group also has a specific list of characteristics a practice must satisfy to be considered "best." A best practice:

- Aligns with strategy

- Reduces costs

- Improves productivity

- Promotes timely execution

- Enables better decision making

- Leverages/exploits existing/emerging technologies

- Ensures acceptable levels of control and risk management

- Optimizes the skills and capabilities of the organization

- Promotes collaboration across the extended enterprise

2.2.6 WIKIPEDIA'S DEFINITION

Wikipedia is not typically used as an academic reference; however, the Wikipedia definition of the term "best practice" is relevant here because it is an open repository for knowledge which has a structure that can be referenced for the development of the open repository. The definition of the term is given below:

> "A best practice is a method or technique that has consistently shown results superior to those achieved with other means, and that is used as a benchmark" ("Best practice - Wikipedia, the free encyclopedia" 2014).

In summary, reviewing the definition of the term "best practice" is an important step for identifying practices for an open repository. Definitions were different, yet similar themes can be seen. The first theme is that best practices improve or enhance project performance. Second, best practices are proven through research or by peer organizations. Finally, best practices must consistently provide results when used as intended.

2.2.7 BEST PRACTICES AND PROJECT PERFORMANCE

Research has shown the importance and impact of best practices in the AEC industry (Bosfield and Gibson Jr. 2013; Carrillo and Chinowsky 2006; CII 2011; Deshpande et al. 2012). Some of the studies quantify the savings specific to construction projects due to the implementation of best practices. Research conducted by the CII calculates the savings for owners and contractors with high implementation rates of best practices (compared to those with low implementation rates) at an estimated 11 and 12 percent cost savings, respectively.

2.3   AEC BEST PRACTICE RESOURCES

To help improve the implementation and increase the use of best practices, various industry associations have created resources that organizations can reference. Table 1 lists industry resources (repositories) that are used by industry organizations.

The Associated General Contractors of American along with the Associated Specialty Contractors and the American Subcontractors Association created a resource that catalogs their guidelines for constructing a project. The resource is a 70-plus page document that overviews the bidding process, project planning process, and project execution stages. At the time of this dissertation the resource was freely available to members and non-members of the three associations.

The American Institute of Architects (AIA) does not have a definition for the term "best practice". However it created a descriptive list of rules that drives the identification of best practices in its resource. Using its members and related professionals, the AIA uses the following list to drive the purpose of its resource (AIA 2013):

- A compendium of relevant knowledge gained from experience

- Immediately applicable to a task at hand

- Distilled to their essentials

- Usable information

- Linked to related resources

- Kept relevant and up-to-date by inviting feedback from practicing professionals

The Construction Industry Institute is a research organization comprised of owners, contractors and academics. The association uses research methods to understand and solve industry problems. The member contractor and owner organizations use the

research findings to improve project performance. The best practice research by the association is extensive. The association has a list of 15 best practices (see Appendix H). The resources for CII's best practices are for member organizations. Members pay annual dues to have access to this knowledge base, although much of it is publically available for purchase.

The Construction Management Association of America uses the term "Standards of Practice." Below is a list of the CMAA construction management standards. These standards include:

- Project Management
- Cost
- Time
- Quality Management
- Contract Administration
- Risk Management
- Sustainability
- Safety

Independent Project Analysis is an AEC industry focused consulting group that provides service for organizations. The group researches "value-improving practices" (VIPs) that help improve project performance (IPA 2013). The resource for VIPs is proprietary and a consulting fee is required.

The Project Management Institute (PMI) refers to the Project Management Body of Knowledge (PMBOK) as "the sum of knowledge within the profession of project

management, which includes knowledge of proven traditional practices that are widely applied, as well as knowledge of innovative and advanced practices that have seen more limited use, and includes both published and unpublished material" (PMI 2013).

This PMI resources covers topics on the project management, risk, earned value, work breakdown structures, project estimating and scheduling (see Appendix H for the complete list).

Table 1: Sample of AEC Best Practice Resources

Organizations	Industry Resources	Global Terminology Descriptor	Accessibility
The Associated General Contractors of America (AGC), Associated Specialty Contractors (ASC) and American Subcontractors Association (ASA)	Guidelines for a Successful Construction Project (AGC et al. 2008)	"Guidelines"	Open, PDF Available Online
The American Institute of Architects (AIA)	Best Practices (AIA 2013)	"Best Practices"	Restricted, Membership Required
Construction Industry Institute (CII)	Best Practices (CII 2013)	"Best Practices"	Restricted, Membership Required
Construction Management Association of America (CMAA)	Standards of Practice (CMAA 2010)	"Standards"	Restricted, Membership Required
Independent Project Analysis (IPA)	Value Improving Practices (IPA 2013)	"Value Improving Practices"	Restricted, Consulting Fee Required
Project Management Institute (PMI)	PMBOK and Library of PMI Global Standards (PMI 2013)	"Global Standards"	Restricted, Resource Fee Required

In summary, the various resources reviewed illustrate the inconsistency of terms and definitions when describing "best practices". In reviewing the definition of the term specific to the AEC industry, two conclusions can be made. First, despite the universal

use of the term "best practice", its definition is not universal. Second, other terms in addition to "best practice" are used (i.e., "standards" and "guidelines"). These conclusions provide an opportunity for a term inclusive of the term "best practice" and others. A term that is descriptive of practices better that most to improve project performance.

2.4   IMPLEMENTATION OF BEST PRACTICES

In 2006, Carrillo and Chinowsky interviewed six design and contractor organizations (4 large and 2 medium) to understand the implementation of knowledge with organizations. Findings from the study suggest that organizations should identify 1) their most important knowledge assets, 2) a suitable knowledge management strategy, 3) company specific barriers and 4) short and long term goals. The findings from the study are relevant. The study acknowledges that identification of knowledge solely does not guarantee implementation success. A strategy to manage the knowledge, the potential barriers to manage the knowledge and goals are critical to implementation of any type of knowledge. This also holds for best practices.

Kamara et al. (2002) assessed the extent knowledge management had been implemented in the AEC industry. They conducted 32 interviews and concluded the absence of a proactive knowledge management strategy does not fully exploit the intellectual assets of AEC organizations, particularly in the capture and reuse of project knowledge, and in the integration of people and technology-based initiatives.

Gabriel Szulanski also explored hindrances organizations face when internally using and transferring best practices. Szulanski's research "suggest[s] that knowledge-related barriers- recipient's lack of absorptive capacity, causal ambiguity, and the

arduousness of the relationship between source and recipient-are most important impediments to knowledge transfer within the firm" (1996). Although Szulanski's research was focused on organizations adapting internal information, the hindrances identified are relevant here for the implementation of best practices for an open repository.

A strong implementation plan is an important component to overcoming challenges when using knowledge management systems. While researching Project Management Software Systems (PMSS), Arnold and Javernick-Will found that systematic organizational factors hinder implementation of the project software even though the software itself was effective (Arnold and Javernick-Will 2012).

Even though the importance of best practices is clear, to consistently implement and ultimately use them is a challenge for organizations. To spur consistent use of best practices, various technology software and industry resources have been created for the AEC industry.

2.5   OPEN ACCESS INFORMATION

From the industry resources reviewed in the previous section, one resource was readily available and open to the respective members and non-members (*Guidelines for a Successful Construction Project*) (Associated General Contractors of America (AGC) et al. 2008). For a repository of best practices to be globally accessible its use should not be restricted. As such, the dynamics of open information is important and should be reviewed.

2.5.1 WIKIPEDIA/WIKIMEDIA FOUNDATION

The Wikipedia resource is a great and ubiquitous example of global crowdsourcing of knowledge. The online resource, Wikipedia, is a well-known use of the wiki format which is owned by WikiMedia. Wikimedia's mission is to "build free encyclopedias in all languages of the world" (Wikimedia 2012). As of May 2011, there were over 10 million articles in 273 languages in Wikipedia. Since its inception, in 2001 by Jimmy Wales and Larry Sander, there have been over 650,000 users who have made 10 or more edits (Wikipedia 2012). Wikipedia is just one of 10 wiki based learning tools provided by Wikimedia and uses the wiki management software, MediaWiki. In the financial year 2011-2012, the Wikimedia Foundation (WMF) had revenues of $34.8 million; expenses of $27.2 million and reserves of $27.7 million. At the end of the 2012-13 fiscal year, WMF had almost 120 staff members (Wikimedia 2012).

However, WMF faces a number of challenges. One is the lack of knowledge validation. The pages are open for anyone, with or without knowledge, to edit. The information is sometimes not relevant to the topic. Another challenge is the large number of editors needed to review the vast amount of information. Finding experts to edit and validate knowledge can be difficult. Third, continuous procurement of funds is critical to the daily operations for WMF. For any open repository to be impactful, it will need to continuously review and validate practices held in the repository and procure funding streams to support operation.

2.6 TECHNOLOGY SUPPORTING BEST PRACTICES

The open repository of best practices would most likely be hosted on the World Wide Web. As such, it is important to explore the various software knowledge systems

that are available. Knowledge management systems are software programs that can support the creation, organization, transfer and dissemination of organizational information (Alavi and Leidner 2001). The systems may vary in complexity and price depending on the functionality of the system.

There is no dominant software system for knowledge management tools in the industry. However, for a system to be successful, it must complement the user's knowledge and use of that system. Organizations should structure knowledge management strategies to best disseminate the various types of knowledge critical for success (Caldas et al. 2009; Kamara et al. 2002).

Anumba and Pulsifer explored the importance of information technology (IT) investment for successful systems (2010). They concluded that knowledge manage systems should facilitate the "live" capture and reuse of knowledge and effective IT resources can improve the likelihood of such capture and reuse. They also concluded that the continual investment in knowledge management systems enables organizations to effectively and consistently use their knowledge to improve business performance.

Over time knowledge management systems have added collaborative sharing capabilities. A common file-sharing and content management software is Microsoft SharePoint. It is a platform where content can be created and hosted. For example, users could create and share best practice or lessons learned webpages that is hosted on SharePoint ™. Due to Microsoft's dominance in the enterprise software, SharePoint has a large user based. Despite the dominance of SharePoint, other knowledge management applications like Buzzsaw and ProjectTalk are used to house and share best practices.

In recent years, the term Enterprise 2.0 has been used to describe new knowledge software that includes social and networking components. The goal of this type of software is to help facilitate rapid knowledge sharing by allowing users to easily share knowledge with others. Some associated functionality of this kind of software are searches, links, tags, wikis and blogs, to name a few ("Enterprise social software" 2013). One well-used Enterprise 2.0 application, not explicitly geared towards the AEC industry, is Yammer. The concept of the application is similar to Facebook but geared towards enterprises. According the company, there are 200,000 organizations using the application ("Yammer" n.d.).

2.6.1 WIKI INFORMATION MODEL

The term wiki comes from the Hawaiian term wiki, which means fast (Wagner 2004). Today's use of the use word, wiki, is almost synonymous with the free encyclopedia, Wikipedia. Be it Wikipedia or another website, a wiki is a set of linked webpages, incrementally developed and used through collaborative effort by a group of users (Leuf and Cunningham 2001). A wiki gains strength over time because users continuously create knowledge.

Typically to start a wiki, a wiki management software tool is needed. Depending on the scope and intent of the project, this can be open source or proprietary. With open source software, there is an initial low cost (financial) to implementation.

A popular wiki management software tool is MediaWiki. The software is released under the General Public License (GPL). Under GPL, works derived from open licenses software and in turn any derivatives of the must be openly distributed as well (Tsai 2008). This may or may not be the best route to an open repository.

2.7   SUMMARY

The unique nature of projects in the AEC industry makes knowledge capture important. Failure to capture knowledge learned from projects leads to the "reinvention of the wheel", or wasted activity that may weaken project performance (Siemieniuch and Sinclair 1999).

From the literature review presented in this chapter, some conclusions can be made:

- Knowledge management is critical for improved project performance.

- The term "best practice" does not have a consistent definition and terminology in inconsistent.

- Few industry repositories are open to association members and non-members alike.

- Of the open resources, none has fully exploited an Enterprise 2.0 software structure for communication among the global industry.

This research is specifically concerned with the management process of knowledge (best practices) in the AEC industry and the important tenets critical to an effective process (which can serve as the basis for creating an open repository of best practices). These conclusions provide an opportunity for this research to contribute to the existing body of knowledge. The remaining chapters in this dissertation addressed the conclusions above.

CHAPTER 3: METHODOLOGY

The purpose of this research is to explore the feasibility of an open repository that increases the use of industry best practices. To accomplish this, reviewing current industry resources, assessing industry interest, identifying tenets of an effective best practice and building a developmental model are the research objectives. From the literature reviewed, this research serves to close an identified gap, namely an open accessed, crowd-sourced resource for best practices, dissemination and sharing

3.1   RESEARCH METHODOLOGY

Figure 3 illustrates the progression of the investigation and the methods used to more fully understand current 'best practices', their implementation in the AEC industry, and the potential of an open repository. The literature review in Chapter 2 was conducted to review current industry best practice resources available to the industry. Conducting a literature review and convening a steering committee were the focuses early in the process. These two steps were critical to identify gaps and determine the most effective way to move forward with the study.

After identifying the problem through a review of current literature and surveying experts about an open repository through a steering committee, semi-structured interviews were conducted. Interviews were used to identify effective best practice tenets. Next a Delphi study and focus group sessions were conducted to help develop a structure for the open repository. The second round Delphi study built upon the first, along with findings from the focus groups. Individuals who participated in the interviews, Delphi study and focus groups were project managers or project executives with knowledge of

and experience with their internal best practice processes. The final steps in the research

were the synthesis and analysis of the data collected.
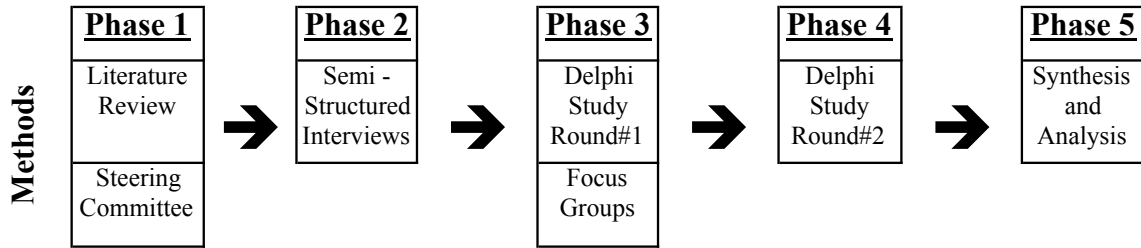
Figure 3: Methodology Activities by Research Phases

Reasons behind the use of each method and its significance are detailed in the subsequent

subsections of this chapter.

3.2   PHASE 1: RESEARCH EXPLORATION

3.2.1   LITERATURE REVIEW

An extensive literature review was first conducted to understand the past

contributions to the body of knowledge. The literature review was the primary focus early

in the research; however, the author continuously reviewed literature related to

knowledge management, best practices, project performance and other relative topics

throughout the research effort.

Motivations for the literature review include, uncovering major contributions to

the study of knowledge management and best practices, identifying research methods to

best answer the research questions and to establish the research contribution of the

author.

3.2.2 STEERING COMMITTEE

The recruitment of steering committee members began in late 2012. An email (see Appendix A) was sent to individuals who had expressed past interest in the research on an open repository of best practices at the 2011 National Construction Forum and the 2012 National Academy of Construction Annual meetings. In total, 10 individuals from the industry and academia volunteered to be on the steering committee. The members of the steering committee are listed in Table 2 along with their title and organization.

Table 2: Steering Committee Members

Member	Title	Organization
Stuart Anderson	Professor	Texas A&M University
Don Cooley	Director	CH2M HILL
Wayne Crew	Director	The Construction Industry Institute
John Dalton	Executive Vice President	Wood Group Mustang
G. Edward Gibson, Jr.	Professor	Arizona State University
Michael Loulakis	President & CEO	Capital Project Strategies, LLC.
J.D. Slaughter	Vice President	S & B Engineers and Constructors, Ltd.
Ray Topping	Director	Fiatech
Jan Tuchman	Editor-in-Chief	ENR
Jim Vicknair	Senior VP	Eichleay Engineers, Inc.

The purpose of the steering committee was to help guide the project in the early stages of the research. Specifically, the steering committee contributed to the research by identifying organizations for the interviews and the Delphi study. The steering committee also provided input on the driving mission of the open repository of best practices. In 2013 several conference call meetings were held with the steering committee.

The inaugural steering committee meeting was held January 9th, 2013. Meetings with the steering committee also focused on the identification and definition of best practices in the industry. Other topics discussed were research goals for the effort along with the initial target audience and purpose of the open repository. In total, four meeting of the steering committee were held over an eight month period.

3.3 PHASE 2: LEARNING INTERNAL REPOSITORIES

3.3.1 INTERVIEWS

For this research, qualitative interviews with industry organizations were used to help identify important tenets for effective best practice processes in the AEC industry (Kvale and Brinkmann 2009; Kvale 1983). Interviews provided an understanding of how organizations defined the term "best practice" and helped identify resources that those organizations used to strengthen internal best practice processes. The interviews also provided an opportunity to initially gauge industry interest in the open repository of best practices.

Individuals from eight organizations were interviewed. The steering committee helped pinpoint early interview participants. Midway through the interviewing process, other recommendations were provided from interviewees on multiple occasions.

Organizations interviewed were willing to share their knowledge management processes specific to best practices. Once an organization was identified, an email was sent to the organization detailing the research background, objectives and interview questions. Interviewees were told the interviews were to last no more than 60 minutes. Once agreed, the author would schedule a call time with the organization. All interviewees agreed to the interview in advance however, to start the interview, organizations were first read a confidentiality statement and were asked if they agreed and if they wanted to continue the interview; all participants continued.

In the study, there were five topics with multiple questions used to spur conversation between the author and the interviewees. The interview instrument created with input

from the steering committee and utilized as part of the current research; it can be found in Appendix C. The topics covered were:

- Best Practice Definition

- Repository Tool and Information Population Process

- Repository Creation and Management

- Repository Usage/Tool Success

During the interview, the author wrote field notes (answers to the open ended questions). After the interview, the author used these notes to code the question responses and identify themes. Specifically, themes were identified by describing the context of the study and data sources and comparing the differences and similarities within the group (Bazeley 2009; Miles et al. 2013). Interview results can be found in Chapter 4.

3.4 PHASE 3 AND 4: DEVELOPING AN OPEN SOURCE REPOSITORY FOR BEST PRACTICES

3.4.1 DELPHI STUDY

A Delphi is "a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (Linstone et al. 1975). The origin of the Delphi method dates back to research studies by the RAND Corporation in the 1950s and 1960s.

The Delphi method is characterized by four important elements (Dalkey et al. 1969; Rowe and Wright 1999):

- Anonymity: It is important to structure the study to encourage open answers from the participants and limit the potential influence of dominant participants.

- Iteration: Multiple rounds in a Delphi study give both the researcher and participant the opportunity for refinement. The number of rounds needed depends on the nature of the questions being asked. However, two or three rounds may be sufficient for most studies. It is important to acknowledge that a study with a high number of rounds might experience a low level of participation.

- Controlled Feedback: In this step, participants are made aware of the group responses. Participants could augment or change their answers.

For this research, the Delphi method was used to question a group of AEC members who had experience developing knowledge repositories in order to understand industry best practices and develop a strategy to create an open online repository. The Delphi study also helped gauge industry interest, pinpoint potential barriers, assess granularity of industry practices and identify the target audience for an open repository. Development of the Delphi study questionnaires started before the conclusion of the structured interviews and input from the steering committee. Early findings from the interviews provided topics for further exploration in the Delphi rounds. With the help of the steering committee and the results from the interviews, the questionnaires for the Delphi study were created. The Delphi study questionnaires can be found in Appendix D and Appendix E.

With the guidance of the steering committee, the author drafted questions for the rounds. Before the questionnaires were sent to participants, the questionnaires were piloted. The pilot was critical to the success of the questionnaire. Specifically in the first round, the author was able to fix technical problems with the portable digital format (PDF) file. If not piloted, the problem would have been detrimental to the data collection

process. The questionnaires were drafted and finalized and emailed out to participants. Panelists were given the option to manually complete the form and mail hard copies or email the completed form back to the author.

After each round, the collected data was synthesized and analyzed. Responses were statistically described and disseminated to the participants. The results of the two rounds can be found in Chapter 5 of this dissertation. Table 3 lists the Delphi study questionnaire topics.

Table 3: Delphi Study – Round 1 and 2 Questionnaire Topics

Round 1	Round 2
Definition and Identification of Practices Critical for Success	Open Repository Structure and Best Practice Criteria
Creation, Management and Sustainment of an Open Repository	Open Repository Funding and Revenue Streams
Potential Barriers and Overall Viewpoint of an Industry Repository	Garnering Industry Interest and Commitment

3.4.2 FOCUS GROUPS

Two focus groups were conducted for this research. The focus groups were organized to validate findings from the interviews and Delphi study (up to that point) and collect more data in addition to the interviews and Delphi study. Focus groups were also used to raise awareness of the open repository with the promise of creating industry "buy in" and interest. These steps were taken to ultimately secure additional industry input on the best way to develop such a resource.

Focus group sessions were held at the National Academy of Construction (NAC) meeting (October 2013), and the National Construction Forum (NCF) meeting (December 2013). The annual meeting had over 75 people in attendance, and 30

academic and industry individuals attended the forum. The NCF is a biannual meeting that brings a subset of NAC members together. The group's mission is to identify important issues the AEC industry faces and collaborate with the industry to address these issues. The goal of the NCF is to "integrate efforts, reduce redundancy, and drive improved efficiency and effectiveness" in the AEC industry (National Academy of Construction 2010).

In the focus group sessions, the author asked participants a list of questions pertaining to the information granularity, open repository management structure, and funding and revenue sources. The presentations for the October and December focus groups can be found in Appendix F and Appendix G.

3.4.3 DEVELOPMENT FRAMEWORK/MODEL CODING

In this dissertation a framework/model is presented that can be used to help in the early development and management stages of the open repository. Using input from the steering committee and all three data collection methods employed (interviews, Delphi study and focus group sessions), the development model was created.

Chapter 7 details the development model for the open repository. There are 10 steps clustered into four categories. Specifically how the model was built and decided upon is just as important to what steps are in the model. The author reviewed the data from the previously mentioned data collection methods: 1) meeting minutes from steering committee meetings; 2) interview field notes and final write-ups; 3) Delphi study comments and 4) focus group session field notes and final write-ups. Table 4 list important themes after the author coded and categorize the raw data. The number of times the theme occurred in various methods were noted and totaled. If the theme

occurred in more than two of the methods, it was deemed important and was included in the framework.

Table 4: Recurring Themes/Topics Across the Data Collection Methods

Critical Recurring Themes/Topics	Methods				
	Steering Committee	Interviews	Delphi Study	Focus Groups	Occurance Total
Industry Involvment	X	X	X	X	4
Repository Management Structure/Business Model		X	X	X	3
Start-Up Funding	X		X	X	3
Repository Revenue Streams	X		X	X	3
Best Practice Identification	X	X	X		3
Best Practice Terminology	X	X	X		3
Industry Demand for Repository		X	X		2
Repository Cost	X			X	2
Repository Mock Up	X			X	2
Repository Population Plan	X		X		2
Knowledge Granularity		X	X		2
Repository Mission			X	X	2
Repository Development		X	X		2
Target Audience	X		X		2
Best Practice Process Tenets		X			1
Importance of Mobile Technology				X	1
Website Design (User Communication)			X		1

3.5   PHASE 5: SYNTHESIS AND ANALYSIS

The final step in the methodology was the synthesis, analysis and writing of the results. The synthesis and analysis took place at each data collection step in the process. The author used coding and theming methods for the qualitative data collected in this research; methods that are well regarded inside the social and educational sciences (Bazeley 2009; Miles et al. 2013). Specifically, interviews and Delphi responses were

reviewed for codes that generated themes and then categories, which were used to explain responses to questions asked.

Quantitative data were calculated using Microsoft Excel ™. General descriptive calculations were used such as mean, mode and standard deviation. To determine consensus of the panel, the author average deviation of the mean (AD), one method of an interrater agreement calculation (Burke and Dunlap 2002; Burke et al. 1999). To describe the spread distribution of the data, a five-point summary was calculated. The minimum, Q1, median, Q3 and max numbers were calculated for each Likert statement. The data are visually displayed using boxplots (see Appendix I).

3.6   STUDY PARTICIPANTS

Individuals from industry companies, associations and academic institutions participated in the feasibility study. In total, over 50 individuals participated in the feasibility study through various methods of interaction (steering committee, interviews, Delphi study and focus group sessions). The participants were from organizations representing various industry sectors (e.g., chemical, commercial building, pharmaceutical, manufacturing and oil industry). The information garnered in the feasibility study is relevant due to 1) the participants' high level of industry experience; 2) the large and complex organizations represented by the participants; and 3) the high number of process improvements performed by respondents related to the management of participants' best practices. Participating organizations are listed in Appendix B.

3.7   SUMMARY

In summary, with the exception of two organizations, the majority of participating organizations in this research were members of the National Academy of Construction or from organizations making up the Construction Industry Institute. The steering committee was critical in identifying participants. The semi-structured interviews were used to learn about best practice processes studying internal repositories of industry organizations. The Delphi study created a developmental model for the open repository, target audience, and the level of granularity of practices. Focus group sessions were used to validate information from the interviews and Delphi study. The sessions also helped identify potential industry associations.

Similar to other research studies, there are limitations. The first in this study is the use of a convenience sample in this study. Organizations in the study were targeted with the help of the Steering Committee. A second limitation included simple size. Of 35 participants identified for the Delphi study, 21 responded to the first round and only 12 completed both. Also, the focus group sessions were planned around events that were challenging to collect data. However, with the limitations, the author believes that the multiple sources of data collected is valuable for understanding industry best practice processes and creating a developmental model for an open repository.

CHAPTER 4: INTERVIEWS

Again, an objective of the research is to understand organizational best practices processes and the tenets for the effectively managing the process. The purpose of the interviews for the research was to identify these tenets. Many of these tenets will carry over into the structure of the open repository of best practices.

From the organizational interviews conducted, many important topics have been discovered. The sections below are some common themes heard throughout the eight structured interviews with industry organizations.

4.1   PARTICIPATING ORGANIZATIONS

The organizations involved in the study included facility owners and contractors alike. Owner organizations hailed from the pharmaceutical, chemical and polymers and oil and gas industries. Contractors focused on civil, federal, power, commercial building, infrastructure, hydro, oil and gas, and transportation facilities, to name a few. The size of the organizations varied as well as their approaches to challenges faced when using best practices. Project managers and project executives were the primary interview participants in this study. These individuals had vast experience of their organization's knowledge repositories, specifically best practices. Table 5 describes the participating organizations.

Table 5: Interview Participating Organizations

Organization	Type	Industry Focus	Number of Interviewees
A	Contractor	Oil and Gas	5
B	Owner	Pharmaceutical	1
C	Contractor		2
D	Owner	Chemical and Polymers	3
E	Contractor	Hydro, Transportation and Power	1
F	Contractor	Commercial Building, Infrastructure and Civil	2
G	Owner	Oil and Gas	1
H	Contractor	Infrastructure and Civil	1
		Total Interviewees	16

4.2   RESULTS

Interviews in this research effort were critical to understanding the blueprint of repositories and potential challenges in the creation and management of those repositories. The author identified four subjects that interviewee should address. Using these four subjects, the author created questions and reviewed them with the steering committee.

The four discussion topics were 1) Best Practice Definition, 2) Internal Repository, 3) Repository Development and Management and 4) Repository Success. A copy of the interview instrument used in the study can be found in the Appendix C.

4.2.1   BEST PRACTICE DEFINITION

To begin the interview, organizations were asked about their processes for identifying best practices. Specifically, interviewees were asked to share their organization's definition of best practice and to describe the knowledge granularity (breadth and depth of knowledge) within their internal repositories. Organizations were

asked to share what practices were captured in the repositories as well. Below are findings from the responses:

Best Practice Definition

- No organization has a proprietary definition of the term "best practice"; organizations deferred to industry associations for a definition and the identification of best practices.

- Organizations pulled their definitions and list of best practices from many different industry sources. Associations and others mentioned in the interviews included:

    o Association General Contractors (AGC)

    o Construction Industry Institute (CII)

    o Construction Management Association of America (CMAA)

    o Independent Project Analysis (IPA)

    o International Organization for Standardizations (ISO) 9000.

    o Project Management Institute (PMI)

    o SAVE International

- *"Best practices must provide time and cost improvements."* (Organization A)

Granularity

- Practices in the internal repositories included

    o Front End Planning

    o Alignment

    o Safety

    o Project procedures specific to the business in various project phases.

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- Organizational specific information and project specific practices were in the repositories.

- Organizations found that with greater information detail, users become overwhelm thus leading to the underutilization of the best practice repository.

- Organizations acknowledged the relationship of information types (lessons learned, best practices, and standard procedures) and time.

- The flow of information can be described by the following diagram.

| Lesson Learned | → | Best Practice | → | Standard Procedure |

Time

Figure 4: Change of Information Type As Time Progresses (Organization B)

Organizations made the following statements regarding granularity:

- Organization A provides the basic overview for the practices but employees decide on level of implementation. "Data sheets with important practices specific to the project stage the include description, cost and benefits analysis and tools to implement the practice are provided."

- Organization D said that granularity of information in their repository "depends on the process and practice."

- Organization F separated its repositories by project management and craft procedure practices. Since the company self performs work, best practices are sometime hard to determine.

4.2.2   ORGANIZATION INTEREST IN OPEN REPOSITORY

Interviewees were asked if the AEC industry would be interested in an open repository of best practices and the potential of such a resource to improve project performance.

- All organizations mentioned there could be potential benefit for the repository; however, organization cautioned that the steps to develop the repository should be well planned.

- Organization A shared the importance of the information in the open repository being vetted and the target audience for the open repository being defined before its creation.

4.2.3   ORGANIZATIONS' INTERNAL REPOSITORY

To learn about internal best practice processes, organizations were asked to describe their internal information repositories in summary and specific to best practices. The author asked organizations to describe the information types housed and the methods used to populate the information in the internal repositories. Organizations were asked to describe the benefits of their internal repositories.

- All eight of the organizations had a structured knowledge system in place, with some more developed than others. The systems house best practices but also domain and organization specific knowledge.

- Two of the six contractor organizations interviewed admitted that their best practices processes needed significant updates. One of these organizations had a robust process years ago; however, the information needs to be updated. Passionate individuals had written the original information. These individuals had

moved on or now have very little time to make significant contributions. Organizations that had robust and successful best practice processes usually had a managing team or committee in place. There were periodic reviews of information and a well-defined plan to update and change this information.

4.2.4 REPOSITORY DEVELOPMENT AND MANAGEMENT

Organizations gave an overview of the creation and management process for their respective repositories. The author asked interviewees to describe the individuals involved and the resources needed to create and upkeep such a system. The author asked organizations for recommendations to create and operate the open repository based on their experience. Below are the key findings for this theme:

- Organizations used both internal and external tools and techniques to implement best practices.

- One of the organizations had dedicated champions with roles solely dedicated to improving the usage of best practices. The champions in other organizations made best practice contribution in addition to their regular job roles.

- When asked, organizations said that there would be value in an industry repository for best practices. Some organizations mentioned that it could be used as another avenue for outside ideas. However, even though organizations agreed that an industry resource would be helpful, many cautioned that it might be difficult to get significant industry participation. The organizations interviewed mentioned that it was a struggle to get its employees to use internal best practices

and lesson learned systems. The human factor is key to successful use of such
systems.

- On numerous occasions, organizations mentioned that a standardized best practice
  structure made it easier to manage employees. Standardized best practices helped
  organizations promote cultural norms. A few contractor organizations mentioned
  that high employee turnover is very hard to manage without standard practices in
  place.

4.2.5 REPOSITORY SUCCESS

Organizations were asked to assess the success of their internal repositories,
specifically the "how" and "who" uses the knowledge in the repositories.

- All organizations identified their repositories were successful in organizing
  practice. Organization B estimated that the cost of not utilizing its repository
  would cost the organization 3-4% on projects (project delays, duplication of work,
  etc.).

- Employees and their resistance to using and implementing best practices were
  identified as a barrier to success. Organizations identified communication of best
  practice benefits as critical to employee "buy-in."

- One respondent from a contractor mentioned that their organization was finally
  able to dedicate needed time and money to thoroughly review project policies and
  best practices. The organization made a commitment to this endeavor by creating
  a new full time position to manage policy and best practices improvement.
  Limited financial resources due to the previous slow economy previously
  hampered repository improvement.

4.2.6 SUGGESTIONS FOR THE OPEN REPOSITORY

Organizations also provided suggestions for the open repository of best practices. These suggestions included 1) providing implementation guidelines for effective use of practices; 2) providing clear information on the practices; 3) providing a repository that is focused solely on best practices and one that avoids overwhelming users with too many choices and options; 4) directing users to in-depth implementation guides and resources outside of the open repository; 5) providing enhancing multimedia (video) on the repository website to better engage users and 6) sharing implementation and usage strategies for best practices.

4.3 SUMMARY

To conclude, the lessons that can be learned from the interviews are the following: (1) a standardized best practice process is essential, (2) a team or committee is needed to successfully manage the information, (3) a standardized plan for best practice processes must be in place and (4) the absence of adequate resources can cripple development and or operations of a repository.

CHAPTER 5: DELPHI STUDY

The purpose for conducting a Delphi study was to query industry experts in order to identify steps critical to developing the open repository of best practices. In this chapter the results of the two round Delphi study are detailed.

5.1   DELPHI STUDY RESPONSE TYPES AND VALIDATION

Panelists were asked various questions on best practices, repository management structure and repository potential and sustainment. Delphi panelists rated Likert statements, ranked and selected best options, and responded to open-ended questions. In total, panelists rated six Likert statements, and answered nine questions in Delphi round one. In round two, panelists rated four Likert statements and answered six questions. Table 6 and Table 7 detail the sections, questions and question types for both rounds of the Delphi study.

Table 6: Delphi Round One - Sections, Questions and Questions Type

Questionnaire Section		#	Question	Question Type
A	Panelist Background Information	-		-
B	Definition and Identification of Practices Critical for Success	6	B1 – Industry Value of "Practices for Excellence"	L
			B2 – Effective and Adequate Definition of "Practices for Excellence"	L
			B3 – Accuracy of "Practices for Excellence" Definition	L
			B4 – Practices that Increase Likelihood of Project Success	OP
			B5 – Resources Used to Research Industry Practices	OP
			B6 – Challenges to Adapting and Implementing Practices Effectively	OP
C	Management and Sustainment of an Open Repository	6	C1 – Industry Reception of an Open Repository	L
			C2 – Potential for Open Repository to Be Viable Resource	L
			C3 – Initial Target Audience	S
			C4 – Topic Granularity	OP
			C5 – Challenges Populating the Open Repository	OP
			C6 – Management Structure	R
D	Potential Barriers and Benefit of Open Repository to The AEC Industry	3	D1 – Top Challenges to Creation, Implementation, Management and Sustainment of an Open Repository	S
			D2 – Benefit of Open Repository to AEC Industry	L
			D3 – Additional Topics Important Open Repository Success	OP
L - Likert Scale, OP - Open Question, R - Rank Option(s), S - Select Best Option(s)				

Table 7: Delphi Round Two - Sections, Questions and Questions Type

Questionnaire Section		#	Question	Question Type
A	Repository Structure and Best Practice Criteria	6	A1 – Structure of Practices Submitted in Open Repository	L
			A2 – Information Sought When Using External Sources	OP
			A3 – Initial Industry Sectors	OP
			A4 – Submission Template for Practice in Open Repository	L
			A5 – User Interaction Potential	L
			A6 – Subject Matter Review Panel	L
B	Open Repository Funding and Revenue Streams	2	B1 – Start-Up Funding Sources	OP
			B2 – Additional Revenue Streams	OP
C	Garnering Industry Interest and Commitment	2	C1 – Steps to Garner Industry Interest and Commitment	OP
			C2 – Industry Organizations for Potential Collaboration	OP
L - Likert Scale, OP - Open Question, R - Rank Option(s), S - Select Best Option(s)				

For questions that required panelists to selected or ranked answers, the frequency of the results are reported in this chapter. For the open-ended questions, the author reviewed the responses for themes, which are reported in this chapter along with important quotes. The Likert statements were rated on a seven-point scale, one represented "Strongly Disagree" and seven "Strongly Agree." In addition to rating the Likert statements, panelists also left comments, which detailed their rating.

The author evaluated Likert responses in two ways. The author first used descriptive statistics (mean, median and mode) to give an overview of the panel's average, middle scores and most frequent scores. Next the author use interrater reliability (IRR) statistics to help explain panel agreement (consensus) of the scores. The IRR statistic attempts to explain if variance in rated scores is due to "true" variance or due to measurement error among panelists (Novick 1966). For instance, an IRR measurement of 0.80 would specify that 80% of an observed variance is due to a true score variance (panelist consensus) and the 20% is due to error variance (Hallgren 2012).

There are several measurements of IRR available (Burke and Dunlap 2002; Burke et al. 1999; James et al. 1984; Landis and Koch 1977). In this research, the author decided to use the Average Deviation Index (AD) from the mean (Burke and Dunlap 2002; Burke et al. 1999). The AD index is calculated by finding the absolute deviation of

each rating from the group mean and averaging the deviations. The measure of acceptable agreement for the AD index is computed by taking the number of response options (seven for the number of Likert scale) divided by six (Burke et al. 1999). In this study there were seven Likert response options; therefore the calculated AD index is 1.167 (7 divided by 6). If the AD index for the Likert question is equal to or less than 1.167 there is consenus among the panelists. Even though consensus is important, here in this study is was not the only goal. Comments from panelists were equally important as their ratings. For statements with an AD $\geq$ 1.167 (no consenus), the author relied upon panelists comments for further clarification.

5.2 DELPHI PANELISTS

Thirty-five individuals were identified for the Delphi study with input from the steering committee and supervising professor. Of the 35, 21 completed the first round questionnaire. Of those who completed the first round questionnaire, 12 completed the second round questionnaire. Table 8 describes the Delphi study panelists.

Table 8: Delphi Panelists Background Description

Average industry experience	29 Years
Role of Panelist	Contractors, Academics, Owners and Consultants
Involvement in process improvements related to the collection, dissemination and/or management of best practices, lessons learned, benchmarking or similar knowledge types	Yes (14), No (7)
Average Number of Process Improvements panelist has been involved with:	31 (one panelist with over 200)
Area of expertise of panelists	Best practices processes, construction/project management, front end planning, commercial building, public procurment, construction, software development, chemcial enginnering, academic research and transportation

5.3 DELPHI ROUND ONE RESULTS

Again, the Delphi first round focused on the definition and identification of practices, management of an open repository, potential barriers and interest in an open industry repository. The first round results are detailed in the following subsections.

5.3.1 DEFINITION AND IDENTIFICATION OF PRACTICES CRITICAL FOR SUCCESS

One conclusion from the literature review was the lack of a universal term and definition of the term "best practice" and similar terms (i.e., standards and guidelines). To address this conclusion, the author asked Delphi panels to evaluate three statements on a new term inclusive of "best practice" and similar terms. Panelists' results for the three statements (B1, B2 and B3) are presented next.

5.3.1.1 STATEMENTS B1, B2 AND B3

The Delphi panelists were asked to the first read the definition of the term "Practices for Excellence" and evaluate statements B1, B2 and B3. With help from the steering committee, the term was created to address the lack of a universal term for "best practices" and similar terms (see literature review in Chapter 2). The definition of the term is presented here.

> **"**Practices for Excellence are specific processes and actions, with proven benefits (from research or past performance), that when repeated and documented, result in an increased probability of management or operational improvement throughout the construction/capital project lifecycle."

5.3.1.2 B1 – INDUSTRY VALUE OF "PRACTICES FOR EXCELLENCE"

The Delphi panelists were asked to the first read the definition of the term "Practices for Excellence" and rate if the newly created term would add value to the industry.

The Delphi panelists rated the statement with a mean response of 4.2. The most frequent rating to the statement from panelists was 4 on the Likert scale (see Table 9), meaning the panel was neutral on the value added of creating a new term. Only 38 percentage of panelists agreed the term would add value. Consensus on this statement was not established with an average deviation value of 1.34 (above the 1.167 cutoff).

In addition to rating the statement, panelists were allowed to leave comments. Additional comments included:

- "The term "best practices" is already widely used and its definition is clear in the industry."

- "The term (PFE) is not helpful."

- "The effort needed to explain the new term, PFE, is great and the difference between it and best practices is small."

- "The industry will continue to use the term best practices."

From the responses and additional comments provided by the panelists, the existing term "best practice" is adequate. Introducing "Practices for Excellence" would require much effort and the industry would probably continue to use "best practice."

5.3.1.3 B2 – Effective and Adequate Definition of "Practices for Excellence"

In the second statement, panelists were asked to rate if "Practices for Excellence," encompasses the tem "best practices" and other similar terms.

The mean response was 5.2 with a mode response value of 6 (see Table 9). Panelists agreed the definition of "Practices of Excellence" encompassed "best practices" and similar terms. Sixty-seven percent of the panel agreed with the term; however, there was not full consensus among panelists ($1.18 \geq 1.167$). A panelist that did not agree with the statement commented that "management or operational improvement" in the PFE definition should be replaced with "improvement" and further commented that "project improvement should not be narrowed." Panelists in agreement with the statement commented that the definition is "appropriate" and the "words are fine."

5.3.1.4 B3 – Accuracy of "Practices for Excellence" Definition

Once again, panelists were asked to rate the definition of "Practice for Excellence." Specifically, the phrase "increased probability" in the definition was rated.

The average panelist response for this statement was 5.1 out of 7 with a mode response value of 5 (see Table 9). In addition 86 percent of the panel agreed with the phrase in the definition; the panel also found consensus on the statement ($0.69 \leq 1.167$). Panelists who did not agree with the statement left no additional comments.

Table 9: Likert Responses for Statements B1, B2 and B3 – Panel Score and Consensus Summary

Item	N	Panel Scores				Consenus (IRR)	Comments
		Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)	
B1 – Industry Value of "Practices for Excellence"	21	4.2	4.0	4.0	38%	1.34	Yes
B2 – Effective Definition of "Practices for Excellence"	21	5.2	6.0	6.0	67%	1.18	Yes
B3 – Accuracy of "Practices for Excellence" Definition	21	5.1	5.0	5.0	86%	0.69	No

5.3.1.5 B4 – PRACTICES THAT INCREASE LIKELIHOOD OF PROJECT SUCCESS

There are practices the industry deems critical to the management of projects. Panelists were asked to identify practices needed to increase the likelihood of project success. Having a list of practices would serve as a starting point for the open repository. Panelists are asked to identify seven practices needed to increase the likelihood of project success. Table 10 lists the 10 most frequently identified practices given by panelists.

Table 10: Top 10 Critical Practices by Frequency (N=21)

PRACTICE	FREQUENCY
Front End Planning	15
Project Team Alighnment/Team Building	14
Safety	13
Constructibility	11
Risk Management	11
Change Management	10
Quality control	9
Materials Management	6
Scope Definition	6
Partnering	4

From the list, 15 panelists identify front end planning as the most critical practice that increases the likelihood of success. Having an aligned team working together on a project is also critical as there were 14 responses.

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5.3.1.6 B5 - RESOURCES USED TO RESEARCH INDUSTRY PRACTICES

Understanding resources the industry currently uses is important because it identifies opportunities an open repository can provide to users. Panelists were asked to identify the various resources they use to research industry practices.

The most frequent responses in order included: 1) industry associations; 2) internal knowledge; 3) online web based resources, such as Google, Wikipedia, Google Scholar; 4) knowledgeable industry colleagues; and 5) industry consultants.

From the responses, panelists identified that resources from industry associations are used the most when researching best practices. Internal knowledge resources are the second most commonly used. Also, online resources outside of an organization or industry association are used. For instance panelists identified Google Search, Google Scholar and JSTOR (academic digital library). Industry colleagues knowledgeable in the specific practices were also identified as resources when researching industry practices. Finally consultants were also identified as resources organizations used to better understand practices.

5.3.1.7 B6 – CHALLENGES TO ADAPTING AND IMPLEMENTING PRACTICES

    EFFECTIVELY

Identification of practices is important; however, practices are sometimes not used consistently or in the right manner. Panelists were asked to identify challenges to adapting and implementing practices effectively in AEC organizations. Panelists responded with the following.

The most frequently identified challenge to adaption and implementation of best practices is the quality of information on practices, specifically insufficient details and

instruction. The unclear "intent" or purpose of practices to the end user is a second challenge. Individuals that are responsible for adapting and implementing practices lack agreement on the practices. The lack of a clear champion in an organization is also challenge. Panelists acknowledged that resources are sometimes "too generic" for an organization's specific sector. Finally, the lack of time was identified has a hindrance to the implementation of practices.

5.3.2 MANAGEMENT AND SUSTAINMENT OF AN OPEN REPOSITORY

The start-up of any resource is challenging; however for success, management and sustainment of the open repository should be addressed in the start-up phase. The following provides the responses from the panelists on this topic.

Delphi panelists were asked to evaluate the potential reception of the open repository by the industry and its potential to gain traction. The results from the panelists are detailed in Table 11.

5.3.2.1 C1 - INDUSTRY RECEPTION OF AN OPEN REPOSITORY

The average rated response from panelists on the industry reception of an open repository was 5.4 with a frequent response of 5. Eighty six percent of panelists agreed that the open repository could potentially be well received by the industry. Consensus was established with an average deviation of 1.17. Panelists provided suggestion that could improve industry reception of an open repository.

- "The effort needs qualified and experienced contributors to populate the repository."

- "A standardized repository structure and best practice information flow is important."

- "Participant dialog is important as best practices cannot be applied in a silo. (LinkedIn and AAECI are resources examples with dialog components.)"

- "Incorporating restricted intellectual industry information in the repository would be valuable."

5.3.2.2 C2 – POTENTIAL FOR OPEN REPOSITORY TO BE VIABLE RESOURCE

Panelists rated the potential of the open repository being a viable resource an average of 5.2 on the Liker scale; the most frequent response was a 7 ("Strongly Agree"). Unlike industry reception of the open repository, only 67% of panelists agreed the statement. It was important to investigate why the panelists were neutral or disagreed with the statement because there was not consensus among panelists ($1.53 \geq 1.167$). Panelists identified two important areas of concern. Panelists were concern about "potential push back" from organization that have developed current established resources (CII, IPA, PMI, etc.) and the organizations that pay for those resources. Another concern was validation of information in the open repository.

Table 11: Likert Responses for Statements C1 and C2– Panel Score and Consensus Summary

Item	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)	Comments
		Panel Scores				Panel Consenus (IRR)	
C1 – Industry Reception of an Open Repository	21	5.4	6.0	5.0	86%	1.17	Yes
C2 – Potential for Open Repository to Be Viable Resource	21	5.2	5.0	7.0	67%	1.53	Yes

5.3.2.3 C3 – INITIAL TARGET AUDIENCE

Also in the first round of the Delphi study, panelists were asked input on the target audiences at the initial start of the open repository. Table 12 details the top three

audiences the open repository should initially target. Of the 21 panelists, 15 indicated that

practices in the repository should target project engineers. Also with a response rate of 15

panelists, practices specific to senior project/construction managers should be initially

target. Third, with a response frequency rate of 13, practices that owners can use should

be included at the start of open repository.

Table 12: Open Repository Initial Target Audience (N=21)

TARGET AUDIENCE	FREQUENCY
Project Engineers	15
Senior Project/Construction Managers	15
Owners	13

5.3.2.4 C4 – TOPIC GRANULARITY

Panelists were asked to give their opinion on the breadth and depth of practices

inside the open repository. Panelists were also asked for their opinions on project

lifecycle coverage and the level of detail in the repository. Panelists said the following:

- Include practices related to the management of capital projects (practices directly impacting project professionals).

- "Project cycles overlap and rarely have definitive endings". Include all project cycles from initial objective setting through start up.

- Construction tasks may be too granular at repository start-up.

- Over time it would get more granular – design practices, construction techniques, business practices (project accounting, etc.).

- Include case studies.

- Include degree of best practice implementation.

5.3.2.5 C5 – CHALLENGES POPULATING THE OPEN REPOSITORY

Once created, populating the repository is important. Panelists were asked to share their opinions on foreseen challenges of populating information into the open repository. Panelists identified four main challenges; they are the following:

- Identifying best practices - practices in the repository should be object and unbiased and should be applicable to various project types. Creating criteria to identify practices for the repository is essential.

- Finding industry experts - identifying and recruiting subject matter experts to volunteer and share practices is essential to the success of the open repository.

- Intellectual Proprietary Restrictions – the open repository could possible contain practices and other information that is proprietary. Having rules to limit proprietary information or gain clearances to use them is important.

- Content Management –management and upkeep of the information is critical to continued use of the open repository.

5.3.2.6 C6 – MANAGEMENT STRUCTURE

The open repository is intended for the betterment of the industry and steady management of it is required for long-term viability. Panelists were asked to rank the best management option for the open repository. More that half of the panelists (12 of the 21) indicated that creation and management of the open repository should be connected with an established industry entity (perhaps an industry association). With established entity, the open repository can potentially gain more interest initially compared to being a stand-alone entity. Also, being with an industry association, the repository would be independent and non-bias to any one industry entity.

5.3.3 POTENTIAL BARRIERS AND BENEFIT OF OPEN REPOSITORY TO THE AEC INDUSTRY

When barriers are identified early, solutions can be worked to overcome them. There are many potential barriers to success for the open repository and the Delphi study is one method to detect these barriers. In the Delphi first round, the potential benefit of the open repository is rated as well.

5.3.3.1 D1 – TOP CHALLENGES TO CREATION, IMPLEMENTATION, MANAGEMENT AND SUSTAINMENT OF AN OPEN REPOSITORY

With any new project, there will be initial challenges to overcome. Panelists were asked to identify the biggest challenge the open repository will encounter. Panelist provided the three top responses:

- Lack of industry commitment and involvement (7)

- Resources, including money or time (6)

- Inconsistent use of repository (3)

5.3.3.2 D2 – BENEFIT OF OPEN REPOSITORY TO AEC INDUSTRY

If properly managed and sustained, the open repository could be beneficial to the AEC industry. For this statement, panelists' average response was 5.4 with a median score of 6 and a most frequent response of 7. Seventy six percent of the panelists agreed the open repository could be beneficial to the industry.

However, panelists also were cautious about the future. Panelists who were neutral or disagreed with the statement gave reasons for their responses: 1) existing industry resources; 2) potential inconsistent use by the industry and 3) effort needed to

develop, manage and sustain the repository. One panelist commented, "pulling this off would expend more energy than benefit."

Table 13: Likert Responses for Statement D2 – Panel Score and Consensus Summary

| | | | | | | Panel Consenus (IRR) | |
| | | | Panel Scores | | | | |
Item	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)	Comments
D2 – Benefit of Open Repository to AEC Industry	21	5.4	6.0	7.0	76%	1.28	Yes

5.3.3.3 D3 – ADDITIONAL TOPICS IMPORTANT OPEN REPOSITORY SUCCESS

Panelists commented that the additional topics should be reviewed in addition to the previous statements rated. Panelists stated the repository "should not drive new content but organize existing content." The repository should have a clear process of identifying best practices. One panelist commented that the repository should avoid "garbage in, garage out."

5.4 DELPHI ROUND TWO RESULTS

The second round of the Delphi study built on the first and introduced a new topics for panelists to consider. There were three sections in the second round of the Delphi study. They were 1) Open Repository Structure and Best Practice Criteria, 2) Funding and Revenue Streams and 3) Industry Interest and Commitment.

5.4.1 REPOSITORY STRUCTURE AND BEST PRACTICE CRITERIA

Important to successful population of practices in the open repository is the structure (rules) for information submitted. Just as important is the criteria to select best

practices. The following subsections details round two of the Delphi study regarding structure and best practice criteria.

5.4.1.1 A1 – STRUCTURE OF PRACTICES SUBMITTED IN OPEN REPOSITORY

Based on first round responses, the author created a five step criteria for practices in the open repository. Practices should: 1) increase the likelihood for project success, 2) reside in one or more project life cycle phases, 3) have demonstrable benefits for project improvement, 4) include documented steps of implementation and 5) apply to one or more industry sectors (e.g., commercial, industrial and heavy).

Panelists were asked if the aforementioned five step criteria should be used when evaluating practices in the open repository. The average response was 4.8 (a "Neutral" on the Likert scale) with a frequent response of 4 and a median response of 5. Of the 12 panelists, 58 percent, or 7, agreed with the suggested criteria with non consensus (1.19 above the 1.1.67 cutoff) (see Table 14). Panelists suggested that "clearly defined" and "obtainable" should be added to the criteria.

5.4.1.2 A2 – INFORMATION SOUGHT WHEN USING EXTERNAL SOURCES

In round one, panelists identified sources external to their organization for best practice research. Knowing the alternatives to the open repository is important. Of the external sources for best practices listed in the first round (see question B5), the author wanted to know what type of information was sought and the benefits of the external sources compared to those available.

According to the panelists, the external sources are used to seek information on best practices and implementation tactics, general strategy and guidelines to using the

practices. Panelists also commented on the benefits of external resources. Specifically panelists said:

- "External sources can be more beneficial in that there's a wider array of experiences contributing. Other times, internal sources are better since they are 100% applicable to your type of projects. So the answer is, it depends."

- "Other information may be less rigorous and non-analytical, and just "garbage in," creating the potential for "garbage out." That being said, I do search non-traditional sources and then make my own evaluation of how logical it is to me in rendering an opinion on its use as a best practice."

5.4.1.3 A3 – INITIAL INDUSTRY SECTORS

Having the best practices specific to important industry sectors is one way to target users in the initial stages of the open repository. Knowing these specific sectors is essential. Based on panelists initial sectors for the repository (grouped into four groups) include:

- Industrial (plants, manufacturing, etc.)

- Buildings

- Heavy Civil

- Oil and Gas (transmission and distribution)

One panelist responded with "public vs. private" and another with "sustainability." Theses are not sectors, but these topics could potentially be addressed in the open repository. A panelist also commented that the open repository should target sectors with the "greatest need" and sectors where information is "readily available" but those sectors were not identified.

5.4.1.4 A4 – SUBMISSION **T**EMPLATE FOR **P**RACTICE IN **O**PEN **R**EPOSITORY

Based on round one responses, the author created a template that could be reference when a practice is submitted to the open repository. Panelist were asked to rate, the submission template which included the following:

1. Definition and description of best practice.

2. Reason(s) why the process is a best practice.

3. Case studies or examples of the practice in use.

4. Explanation of the practice applied in different project situations

5. Benefits and value added explanation related to the practice.

6. List of references

The average rating for the statement was 4.6 (a "Neutral" rating on the Likert scale). However the most frequent rating was 5. Of the 12 panelists, 58 percent agreed with the submission template. The consensus of the statement is acceptable at 0.99, which is lower than the 1.167 (see Table 14). Of the five panelists that disagreed or were neutral, it was suggested that the template include descriptions of alternatives to the submitted best practice. Also a description of circumstances when the practice should or should not be deployed is a good addition to the template.

5.4.1.5 A5 – USER **I**NTERACTION **P**OTENTIAL

Panelists were asked to rate the need of users to interact with other repository users through chat rooms, blogs or forums on the open repository website. Panelists average rating of the statement was 5.0 with a most frequent rating of 5 (see Table 14). Of the 12 panelists, 9 or 75 percent agreed that repository users should have the ability to

interact with other users through the open repository website. However, panelists also expressed cautioned; comments are given below:

- "I think this is worthwhile, but I'm concerned over whether "smart" people on the subjects will participate."

- "I don't think interactions beyond those described on the website is necessary. Personal interaction is always preferable and desirable but not necessary."

5.4.1.6 A6 – SUBJECT MATTER REVIEW PANEL

Validation of practices in the open repository ensures that information is most useful. In round one, a panelist commented that a validation process should be created to review information. Based on this suggestion panelist rated the need for and the members of a potential review panel.

In round two, Delphi panelists were asked if a review panel of subject matter experts, tasked to review and validate practices, should be created. The average response to the statement was 5.1 with a frequent rating of 6. Seventy five percent of panelists agreed that a panel should be in place to review practices in the repository (see Table 14). However panelists did not find consensus (AD of 1.25 above the 1.167 cutoff). Panelists commented that "validation is important" but also cautioned that the subject matter expert panel "can be a really challenging effort to devote time to." It was suggested that "construction suppliers and construction equipment manufacturers" should be recruited for the panel to spur innovative insight.

Table 14: Likert Responses for Statement A1, A4, A5 and A6 – Panel Score and Consensus Summary

Item	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)	Comments
			Panel Scores			Consensus (IRR)	
A1 – Structure of Practices Submitted in Open Repository	12	4.8	5.0	4.0	58%	1.19	Yes
A4 – Submission Template for Practice in Open Repository	12	4.6	5.0	5.0	58%	0.99	Yes
A5 – User Interaction Potential	12	5.0	5.0	5.0	75%	1.00	Yes
A6 – Subject Matter Review Panel	12	5.1	5.5	6.0	75%	1.25	Yes

5.4.2 OPEN REPOSITORY FUNDING AND REVENUE STREAMS

5.4.2.1 B1 – START-UP FUNDING SOURCES

Vital to any new venture is start-up funding. Panelists were asked to identify sources for potential start-up funds and steps that could be taken to raise such funds.

Academic universities were identified as a potential source of funding. Universities that provide construction related degrees might be willing to contribute. Another revenue sources identified were owner and contractor organizations that might have similar goals as those of the open repository. It was also suggested that non-cash donations at start-up could be an option as well. For instance, one panelist suggested the repository could benefit from donated time from industry organization. For example, a software developer that donated hours to help create a repository mock-up.

5.4.2.2 B2 – ADDITIONAL FUNDING STREAMS

Through various data collection methods the author identified various funding streams for operation of the open repository. Round two panelists given examples of funding streams (advertising, promoted articles and association sponsorship) and they

were asked if any additional revenue streams should be considered. It was also suggested that donations from end-users could be another revenue stream (perhaps website donations).

5.4.3 GARNERING INDUSTRY INTEREST AND COMMITMENT

5.4.3.1 C1 – STEPS TO GARNER INDUSTRY INTEREST AND COMMITMENT

Increasing industry commitment prior to and after start-up of the open repository is necessary for short and long-term viability. Panelists identified the following steps to make this happen.

1. Secure funding from industry organizations to ensure a level of commitment.

2. Identify specific ways in which the open repository provides value for organizations and its members or employees.

   - "For example, AACEI has a very active and committed membership which is largely voluntary and very little dues are involved. I believe the level is high because members derive value from participation and from the materials."

3. Allow users to interact with other open repository users.

   - "Allowing users to post questions and interact will help with the continued use of the tool. Training and other additional opportunities will also provide a level of constant usage."

5.4.3.2 C2 – INDUSTRY ORGANIZATIONS FOR POTENTIAL COLLABORATION

To help increase demand and commitment for the open repository, industry organizations will to be involved for support and the identification of them is important before start-up. Panelists were asked to list organizations that could potentially collaborate with management of the open repository prior to the start-up. Panelists identified the organizations list below.

- Association for the Advancement of Cost Engineering International (AACEI)

- Construction Industry Institute (CII)

- Construction Management Association of America (CMAA)

- Design Build Institute of America (DBIA)

- Independent Petroleum Association of America (IPAA)

- Mechanical Contractors Association of America (MCAA)

- National Institute of Standards and Technology (NIST)

- Project Management Institute (PMI)

5.5 DELPHI RESUTLS REVISTED

To investigate the Delphi Likert results more in depth, the author examined the results of the study by removing the top and bottom 10 percent rating values (limiting the results to the middle 80 percent). The purpose is to limit the influence of outliers. With the bottom and top outliners removed, the updated statistics could possibly better reflect the panelists' viewpoints.

5.5.1 ROUND 1 – RESULTS WITHOUT TOP AND BOTTOM 10 PERCENT

Once again, there were 21 panelists in round one of the study. Rounding to the nearest whole number, the author excluded the two lowest and highest responses (10 percent of 21 being 2.1). In total there were 17 responses examined.

Table 15 compares the first round Delphi results for the 17 panelists along with the original 21 panelists. Looking at the middle 80 percent of the responses, statistics describing centrality (mean, median and mode) are very similar to that of the original 21 panelists. For all round one statements, the mean values slightly increased and the median

remained the same. As for the mode, only statement D2 had a change; the value decreased from 7.0 to 6.0. Otherwise mode values for the other statements remained the same.

Regarding panel agreement and consensus, the values are quite different. Since the sample size is smaller (17 instead of 21), the percentage of agreement calculation increased for all statements except B1. For statement B1, 35 percent of the 17 panelists agreed that the term PFE was valuable to the industry; three percent less than the original 21 responses. Regarding consensus, the AD index cutoff for the seven-point Likert scale is 1.167. Five of the six statements (C2 excluded) are less than AD index cutoff, implying that the 17 panelists are in agreement with the statements. Hence, there was little change in the results.

Table 15: R1 Delphi Results – Reduced Panelists Rating Values

		Panel Scores (80% of Panelists)				Panel Consenus (IRR)		Panel Scores (100% of Panelists)				Panel Consenus (IRR)
Item	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)
B1 – Industry Value of "Practices for Excellence"	17	4.2	4.0	4.0	35%	1.01	21	4.2	4.0	4.0	38%	1.34
B2 – Effective Definition of "Practices for Excellence"	17	5.4	6.0	6.0	71%	0.92	21	5.2	6.0	6.0	67%	1.18
B3 – Accuracy of "Practices for Excellence" Definition	17	5.3	5.0	5.0	94%	0.50	21	5.1	5.0	5.0	86%	0.69
C1 – Industry Reception of an Open Repository	17	5.7	6.0	5.0	94%	0.78	21	5.4	6.0	5.0	86%	1.17
C2 – Potential for Open Repository to Be Viable Resource	17	5.5	5.0	7.0	82%	1.20	21	5.2	5.0	7.0	67%	1.53
D2 – Benefit of Open Repository to AEC Industry	17	5.6	6.0	6.0	94%	0.96	21	5.4	6.0	7.0	76%	1.28

5.5.2 ROUND 2 – RESULTS WITHOUT TOP AND BOTTOM 10 PERCENT

Twelve panelists completed the second round of the Delphi study. To analyze the middle 80 percent of the panelists' response, the author removed the lowest and highest responses from the original responses (10 percent of 12 is 1.2; the author rounded to the nearest whole number). In total, values from two panelists were removed.

Table 16 displays the statistics for the responses from the 10 panelists and the original 12 panleists. Regarding centrality of Likert statement ratings, the ratings of the middle 80 percent of panelists compared to the original 12 panelists are very close. There was a slight increase in the mean values for all four Likert statements. However the median and mode values stayed the same.

With the bottom and top responses removed, the percentage of agreement for panels increases. The percentages increased because of the reduced sample size (10 compared to 12). Limiting the responses to the middle 80 percent, it is expected that AD index values would decrease for each Likert statements. Each AD index value for the four statements was below the cutoff of 1.167 indicating consensus among the 10 panelists.

Table 16: R2 Delphi Results – Reduced Panelists Rating Values

Item	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)	N	Mean	Median	Mode	% of Panelists that Agreed	Average Deviation (AD)
		Panel Scores (80% of Panelists)				Panel Consensus (IRR)		Panel Scores (100% of Panelists)				Panel Consensus (IRR)
A1 – Structure of Practices Submitted in Open Repository	10	4.9	5.0	4.0	60%	0.92	12	4.8	5.0	4.0	58%	1.19
A4 – Submission Template for Practice in Open Repository	10	4.7	5.0	5.0	60%	0.76	12	4.6	5.0	5.0	58%	0.99
A5 – User Interaction Potential	10	5.2	5.0	5.0	80%	0.68	12	5.0	5.0	5.0	75%	1.00
A6 – Subject Matter Review Panel	10	5.2	5.5	6.0	80%	1.00	12	5.1	5.5	6.0	75%	1.25

Removing the bottom and top 10 percent values from the both rounds of the Delphi study revealed some findings. First, the middle 80 percent of round 1 mostly agreed with the statements except on the potential value of the term "Practices for Excellence (statement B1) and there was consensus among panelists. In round 2, the middle 80 percent of panelists' agreement with the statement was only slight more than the original 12 panelists.

5.6   SUMMARY

In the first round, the objective of the Delphi study was to understand industry best practices and develop a strategy to create an open online repository. To achieve this objective, the first round of the Delphi study proposed to:

- Develop consensus on a universal term inclusive, "Practices for Excellence", of the term "best practice" and similar terms.

- Identify industry key practices universally critical to project success.

- Assess granularity of industry practices for the open repository.

- Identify the initial target audience for the open repository.

- Gage industry interest and pinpoint potential barriers to the creation and use of the open repository.

In summary, the term "Practices for Excellence" encompasses the term "best practice" and other similar terms but panelists felt the use of the term would add little value to the industry. In the opinion of the panelists, the term "best practices" is sufficient for the industry and the open repository.

Key practices identified critical to project success are front end planning, safety, risk management, constructability, project team alignment and change management. Practices in the open repository should start with those related to the management of capital projects for all project life stages. The open repository should initially target project engineers, senior project managers and owners.

The author must acknowledge the time limitation of the Delphi study. The study stopped at two rounds due to time and panelist fatigue. However, that does not mean the

information learned is not valuable to the research. The author acknowledges that perhaps there were too many topics in the Delphi study.

General consensus of panelists is that there is interest for an open repository of best practices; however, lack of industry commitment and involvement, resources (time and money) and inconsistent use of the repository are barriers to initial and continued success.

CHAPTER 6: FOCUS GROUPS

Focus group sessions were the third data collection method used in this research effort. The method allows participants to openly collaborate and give immediate feedback. The method served two purposes for this research, 1) it provided additional industry input and 2) it served as validation of the findings from the interviews and Delphi study. This chapter highlights the findings from the two focus group sessions.

6.1   FIRST FOCUS GROUP

6.1.1   NATIONAL ACADEMY OF CONSTRUCTION ANNUAL MEETING

The first focus group session was held at the National Academy of Construction (NAC) annual meeting on October 20, 2013 in Phoenix, Arizona. The author identified the meeting as an opportunity to reach a wider audience of actively involved individuals from the architecture-engineering-construction (AEC) industry and academia. This group of individuals was identified as being ideal to give insight into the potential of the open repository.

In the hour before the focus group session began, the author gave a 15-minute presentation to NAC members in attendance at a plenary session. The presentation provided an overview of the research effort to date and most important, the research goal of assessing AEC industry interest in the open repository of best practices. The author also shared findings from interviews conducted and input from first round Delphi panelists. The plenary presentation concluded with an invitation to the audience to participate in one of three focus group sessions to discuss the open repository of best practices, construction workforce development and construction workforce image. The

audience members then decided whether or not to attend the focus group. Ten members participated in the session.

6.1.1.1 TOPICS

Several weeks prior to the focus group session, the author prepared questions for participants to answer. The questions were based on interviewees and Delphi panelists' responses. The questions were grouped into the following themes/topics:

1. Creation/Management Scenarios

2. Business Scenarios for Repository

3. Potential Revenue Streams

4. Industry Involvement

The focus group session started with a brief overview of the research effort and progress to date. Participants were encouraged to be open with their thoughts as the session was used to brainstorm possibilities for the open repository. Participants were also told that all responses were welcome and that there were no "wrong" answers. For reference, the document used in the focus group session is found in Appendix F.

It should be noted that the allotted time for this focus group session was limited to 45 minutes. Participants were very enthused with the first topic; there was a healthy discussion on the creation and management of the open repositories. The remaining topics were not covered in as much detail as the first due to the limited session time. Also, discussion on associated start-up and operational costs of the open repository was planned, but due to time constraints the topics were never discussed.

6.1.2 RESULTS

The group was prompted with questions on the previously mentioned topics generated during the focus group session. In this section responses to the questions are given; the responses are grouped into the four aforementioned categories.

6.1.2.1 CREATION AND MANAGEMENT SCENARIOS

The group was prompted with the following question:

"If agreed upon and created, the repository will need to be managed to ensure continued success. The resource is intended for the industry; however, ultimately, an entity will need to create and manage the information and operations of the resource. In your opinion, which of the following scenarios is the best option?

A. The creation and management of the repository should be affiliated with a neutral

party (perhaps an academic institution).

B. The creation and management should be connected with an established industry

entity (perhaps an industry association).

C. The creation and management of the repository should be created and managed as

a stand-alone entity (perhaps non-profit) from its inception.

D. Other (please explain) "

The group's answer to this question was not definitive; however, the group primarily focused on options B and C. The group acknowledged that the open repository should be neutral and non-partial to any one organization. However, the group also mentioned that a connection with an established neutral party would be beneficial for the open repository to overcome the lack of name recognition (common to new entities).

6.1.2.2 POTENTIAL REVENUE STREAMS

For the long-term operation, the open repository of best practices will need to have viable revenue streams. The group was asked to identify potential revenue that could be explored when assessing the feasibility of the open repository. The group was asked the following:

> "If agreed upon and created, the open repository will need to be financially viable for sustainment. In your opinion, what are some potential revenue streams that seem viable for the open repository of best practices?"

Potential revenue streams identified were government entities such as the National Institute of Standards and Technology (NIST). Another stream identified were sales from articles/readings in the open repository. One participant suggested a internet revenue model similar to Expedia (Rappa 2000). Revenue is generated from the open repository matching users with requested practices. The open repository would serve as a "middle-man" for best practices and charge for efficiently organizing and conveniently supplying best practices. A yearly subscription to an open repository mobile application was another revenue stream identified. Applications for all three big mobile platforms (Android, iOS and Windows Mobile) would generate revenue if users found value in the open repository.

6.1.2.3 INDUSTRY INVOLVEMENT

Interviewees and Delphi panelists mentioned lack of industry commitment and involvement as potential barriers for a successful open repository. The focus group was asked the following:

"Based on the data collected from the Delphi study regarding the open repository, lack of industry commitment and involvement was identified as a primary barrier. If agreed upon and created, in your opinion what actions can be taken to garner commitment and involvement from the industry?"

From the focus group input, the following actions should be taken:

- Communication with industry associations and organizations

- Identify ways the open repository flows to industry associations information

- Demonstrate a working model of the open repository that "provides knowledge not value judgment."

- Create a strong business model

  o Decide the final information IT format for the open repository.

  o Development of a mobile application is critical.

6.1.2.4 ADDITIONAL RESULTS

Worth noting are additional ideas the focus group provided outside the four categories. As the group generated discussion in response to the prompted questions, additional topics and ideas emerged. Below are important additional insights taken from the discussion:

- Information must be relevant to end users and should include references for additional research.

- Instruction on how to use the information along with a disclaimer to end users should be provided.

- Rules to handle intellect property (IP) need to be in place.

- Granularity of Information – What best practices?

- o Big Impact Areas

- o Focus on universal practices (i.e. safety, project planning, etc.)

- o Proprietary Information concerns

- Open Repository Structure

- o Website Format – Wiki or Other

6.2 SECOND FOCUS GROUP

6.2.1 NATIONAL CONSTRUCTION FORUM BI-ANNUAL MEETING

The National Construction Forum bi-annual meeting was held December 10 and 11th, 2013 in Washington, DC. The meeting was held for a subset of NAC members. In addition to the topic of best practices, the meeting also focused on workforce development and the construction image.

Similar to the NAC meeting in Phoenix, the author gave a presentation on the best practice research effort and progress made up until December 2013. Once again, the author invited the audience to the focus group session that followed the presentation. In total, seven individuals participated in the session.

6.2.1.1 TOPICS

The discussion in the second focus group session concentrated on the following topics:

- Business Model

- Funding

- Granularity – Breadth and Depth of Information

- Open Repository Mission

Unlike the first focus group session, there was ample time for group discussion; the session was 3 hours long. Participants gave insightful contributions on the topics. The results from the session are given in the next sub-sections.

6.2.2 RESULTS

Similar to the first focus group, the author created questions (as prompts) in advance to encourage discussion for the second focus group session.

6.2.2.1 BUSINESS MODEL

In the first focus group session, participants had narrowed the creation and management of the open repository to options C and D. The author asked the question to second group for additional input. The following question was asked (similar to the first session):

"Should the open repository be tied to the NAC?

    A. The creation and management of the repository should be affiliated with a neutral party (perhaps an academic institution).
    B. The creation and management should be a connected with an established industry entity (perhaps an industry association).
    C. The creation and management of the repository should be created and managed as a stand-alone entity (perhaps non-profit) from its inception.
    D. Other (please explain)"

The second focus group chose option B. The open repository of best practices should be connected with an established industry entity. The group agreed that the open repository should be tied to the NAC. It was suggested that the NAC create a development board to garner industry involvement, procure start-up funding and steer the software development of the repository.

6.2.2.2 FUNDING

The first focus group identified potential revenue streams for continued operation. The second focus group was asked to identify funding sources for the start-up of the repository (software development, marketing, entity formation, etc.). Two questions were asked:

> "What are some potential avenues for funding the creation and start up of an open repository?"

> "Who are the industry organizations/individuals that should be targeted?"

According to the focus group, two rounds of revenue streams for the open repository were needed. To start up the open repository, funding sponsorship from industry associations would need to be the main source of revenue. For continued operation of the open repository, the group identified advertising and promoted articles ("pay to play") as revenue sources.

6.2.2.3 GRANULARITY – BREADTH AND DEPTH OF INFORMATION

End users will ultimately decide if practices in the open repository are beneficial. The repository should include practices that improve the management of capital projects. However, the granularity of the information should be at a level that does not overload the end user but subsequently is not vague either. The following questions were asked:

> According to the results of the 1st round Delphi study, most participants mentioned that the CII list of best practices could be the initial focus of the repository. In your opinion what best practices should be included in the open repository?

> Are these practices "universal"?

The group agreed that Construction Industry Institute (CII) best practices could serve as a starting list of practices (see Appendix H). In addition practices in the open repository should focus on global, complex construction projects (e.g., commercial, industrial, manufacturing, transportation). The group suggested that safety should be the first practice crowd-sourced in the open repository because it is universal to the industry. Critical to the type of practices in the open repository are the individuals who populate the open repository. The focus group answered this question:

> "Who should be involved to populate the open repository with Practices For Excellences (PFEs)? What method should be used to ensure updated information?"

Industry subject matter experts (SMEs) should be targeted to write articles on best practices. These individuals can be from within industry companies, associations, government agencies and academic institutions. The focus group mentioned that validating SME credential is important (i.e., listing the number of industry and subject years of experience of SMEs).

To ensure updated and relevant information a guide should be created for SMEs to follow before contributing to the open repository. The input should include: 1) relevant best practice; 2) project phase; 3) direction for outside sources and 4) added value for implementation and using practice.

6.2.2.4 MISSION FOR OPEN REPOSITORY

Important to any undertaking is a clear mission. The focus group was asked to give their opinion on the general purpose of the open repository for the AEC industry.

"In the October session, it was said that the open repository should "provide knowledge not judgment". In your opinion what should be the overall mission for the open repository?"

The provision of a centralized open-access best practice resource that improves the implementation of such practices and ultimately increases the use of such practices specific to the AEC industry should be the mission of the open repository. It was felt that the open repository can promote "thought leadership."

6.3   SUMMARY

Focus groups provided insight on the business model, revenue streams, industry involvement, granularity and mission of the open repository. Overall, the open repository should be a resource for the industry to learn and also provide instruction on the implementation and use of best practices. It should provide knowledge not judgment.

According to the focus group convened in October 2013 the open repository should be either connected with an established industry entity or should be created as a stand-alone entity. The group suggested charging for yearly subscription to access the open repository on mobile platforms (Andriod, iOS and Windows Mobile). In addition, the open repository could serve as a "middle-man" between best practice established resources and AEC members. To garner industry involvement, the open repository entity must communicate with AEC association and organizations. The entity must also demonstrate a working model of the open repository. The practices in the open repository should be universal and impactful on important AEC subject matters.

The second focus group concluded that the open repository should be an independent entity with the NAC acting as an honest broker. Industry associations and

government grants will be the primary funding streams at start-up for the open repository. Operating revenue streams include advertising and promoted articles on the open repository website. The second focus group also agreed that starting practices should be universal. The groups suggested that "safety" should be the pilot practice.

The findings from the focus groups are in line with the interviews and Delphi study. The focus groups provided additional insight as well. For instance, the concern about intellectual property, the legality of the practices the open repository provides that might not be properly implemented and the development of open repository for mobile platforms, were all areas that added to the data collected through interviews and the Delphi study.

CHAPTER 7: DEVELOPMENT MODEL FOR AN OPEN REPOSITORY

Data from interviewees, Delphi panelists, and focus group participants have given

the author a model to complete the development of the open repository of best practices.

The model detailed in this chapter is based on the research data sources. In addition,

estimated costs for the first three years of the repository are detailed in this chapter.

7.1   ELEMENTS OF THE OPEN REPOSITORY DEVELOPMENT MODEL

The findings from the research interviews, Delphi study and focus group sessions

have all led to this development model for the open repository. Figure 5 illustrates 10

steps for developing an open repository of best practices.
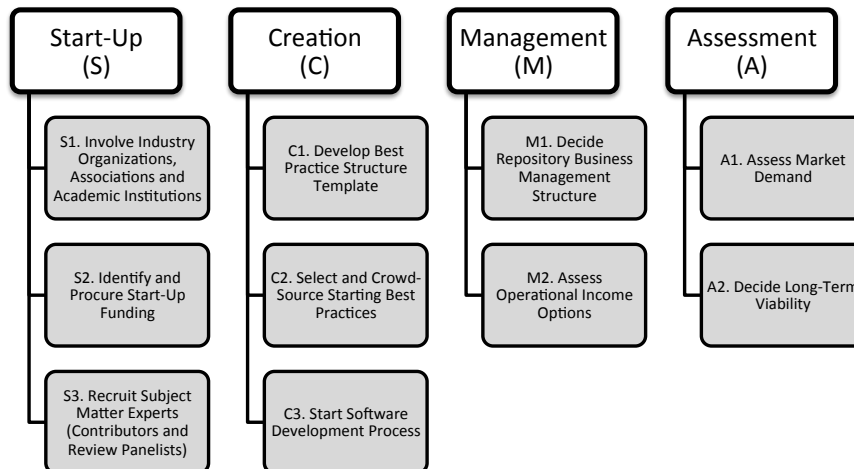
Figure 5: Ten Step Model for Open Repository

The steps are grouped into four categories based on the action location in the

development process (start-up and creation) and the activity type (management and

assessment). The steps are detailed in the subsequent subsections.

7.2 DEVELOPMENT MODEL OVER TIME

The model steps are given in the following diagram, which depicts the relationship of each step within a process. The steps given in the model are not linear in nature. Some steps are iterative and will need to be continually reviewed over the three-year period. Some steps can be completed simultaneously with others. Table 17 details the model steps over time.

Table 17: Model Steps Over Time

	Framework Steps	Year 1	Year 2	Year 3
S1	Involve Industry Organizations, Associations and Academic Institutions	▓	▓	▓
S2	Identify and Procure Start-Up Funding	▓	▓	
S3	Recruit Subject Matter Experts (Contributors and Review Panelists)	▓	▓	▓
C1	Develop Best Practice Structure Template	▓		▓
C2	Select and Crowd-Source Starting Best Practices	▓		
C3	Start Software Development Process	▓		
M1	Decide Repository Business Management Structure	▓		
M2	Assess Operational Income Options	▓	▓	▓
A1	Assess Market Demand	▓	▓	▓
A2	Decide Long-Term Viability	▓		▓

7.2.1 START-UP

For any project or business, a successful start-up increases the chance for future success. The following steps should be completed at the start of the development process for the open repository.

7.2.1.1 S1: INVOLVE INDUSTRY ORGANIZATIONS, ASSOCIATIONS AND ACADEMIC INSTITUTIONS

Central to the initial and continued success of the repository is the involvement of industry associations, academic institutions and government entities. Industry involvement should begin immediately upon the start of the development process,

Presentations at conferences and association meetings can be given to share the intent and progress on the open repository. To grow interest and "buy-in", communication will need to be continuous. Below is a starting list of organizations and research participants that have been identified. In addition to this list, some academic institutions that should be targeted are Arizona State University and the University of Texas-Austin.

- Associated General Contractors of America (AGC)

- Association for the Advancement of Cost Engineering International (AACEI)

- Design Build Institute of America (DBIA)

- The Construction Industry Institute (CII)

- Construction Management Association of America (CMAA)

- Fiatech

- National Institute of Standards and Technology (NIST)

- Project Management Institute (PMI)

- Mechanical Contractors Association of America (MCAA)

- Independent Petroleum Association of America (IPAA)

7.2.1.2 S2. IDENTIFY AND PROCURE FUNDING

An estimated $2.1 million is needed for a three-year start-up and operational period for the open repository (see Table 18).

Table 18: Income and Expense 3-Year Model

	Year 1(a)	Year 1(b)	Year 2	Year 3	Total	Notes
Number of Best Practice Articles		30	45	45	120	
Income						
Operational Income (Advertising, Promoted Articles & Consulting/Training)	$ -	$ 80,000	$ 270,000	$ 400,000	$ 750,000	(a), (b) and (c)
Sponsorship (Industry Associations/Organizations, Academic Organizations, Grant Funding, etc.)	100,000	293,000	670,000	260,000	1,323,000	(d)
Total Income	$ 100,000	$ 373,000	$ 940,000	$ 660,000	$ 2,073,000	
Expense						
Repository Development, Maintenance & Cloud Storage	$ 10,000	$ 279,000	$ 740,000	$ 430,000	$ 1,459,000	(e) and (f)
Business Support	90,000	92,000	150,000	150,000	482,000	(g), (h), (i) and (j)
Administrative	-	2,000	50,000	80,000	132,000	(k) and (l)
Total Expense	$ 100,000	$ 373,000	$ 940,000	$ 660,000	$ 2,073,000	

Appendix J details the estimate inputs and gives corresponding assumptions in the notes. The estimate takes a conservative cost and revenue approach. Once steps in the model are taken, more variables are known and the estimate can be narrowed down.

- Important line items in the estimate includes:

- Legal entity formation,

- Intellectual property

- Detailed design mockup of the repository.

- Personnel management and support.

7.2.1.3 S3. RECRUIT SUBJECT MATTER EXPERTS (CONTRIBUTORS AND REVIEW PANELISTS)

Critical to the success of the open repository is the identification and contribution (crowd-sourcing) of subject matter experts. To date, some participants from the feasibility study have expressed interest in contributing to the open repository. Project engineers, senior construction/project managers and owners should be targeted initially to

crowd-source the repository. These individuals can be recruited by sharing the opportunity with industry associations. The leaders of these associations can help spread the message on behalf of the National Academy of Construction. Perhaps various Community of Practices (COP) groups other associations can be recruited as well.

To ensure the integrity of the crowd-sourced information, a review panel is necessary. Review panelists should be in place during the development of the online repository, prior to its initial launch. The panel can include subject matter experts in the industry (contractors, owners, consultants, etc.) and academics.

7.2.2 CREATION

To create the software and content for the open repository, the steps below are required.

7.2.2.1 C1. DEVELOP BEST PRACTICE STRUCTURE TEMPLATE

An input template for practices submitted should be created to guide the input process. Based on input from participants, the elements for submittals should include the following:

- Definition and description of best practice.
- Reason(s) why the process is a best practice.
- Case studies or examples of the practice in use.
- Explanation of the practice applied in different project situations (e.g., fixed price compared to reimbursable contract).
- Benefits and value added explanation related to the practice.
- List of references (including online website links).

From the study, a participant suggested a section describing the circumstances of when the best practice should or should not be deployed.

7.2.2.2 C.2 SELECT AND CROWD-SOURCE STARTING BEST PRACTICES

Practices at the start of the repository should initially include only those practices specific to the management of capital projects. The repository should initially include the listed practices. These practices can be universally applied to various sectors in the industry. Also, if the initial practices are widely applicable, identifying and recruiting subject matter experts to crowd-source the repository is less challenging. Specific practices identified in the Delphi study and focus groups:

- Safety

- Front End Planning

- Constructability

- Risk Management

- Project Team Alignment/Team Building

- Change Management

7.2.2.3 C3. START SOFTWARE DEVELOPMENT PROCESS

The software development process of the repository heavily depends on the skills of IT individuals. The software programmer and user experienced developer teams are critical to a functional and user-friendly repository. The early identification of these individuals will improve the development process. Also, the relationship between the

Repository Development Board (RDB) and IT personnel must be open to encourage
continuous communication.

- Process Phases

- Plans and Requirements

- Product Design

- Programming

- Detailed Design

- Coding and Testing

- Integration Testing

- Continued Maintenance

7.2.3   MANAGEMENT

7.2.3.1 M1. DECIDE REPOSITORY BUSINESS MANAGEMENT AND STRUCTURE

The creation and management of the open repository should be connected to the
National Academy of Construction in some form. A steering committee, the Repository
Development Board, is needed to carry out the start-up stage of the repository.
Specifically, the board/committee must focus on industry buy-in, start-up funding,
intellectual property rights (repository branding, etc.) and IT developer recruitment.

7.2.3.2 M2. ASSESS OPERATIONAL INCOME OPTIONS

Appropriate and effective income streams should be assessed by the RDB at start-
up and during operations. For continued operations, potential revenue streams for the
repository include:

- website advertising

- promoted articles

- industry association & academic organization sponsorship

- best practice consulting/training

- promoted articles ("pay to play")

Other income streams should be explored in conjunction with the development board.

7.2.4 ASSESSMENT

Continuous assessment of the market demand and viability of the open repository are essential to responsible development.

7.2.4.1 A1. ASSESS MARKET DEMAND

Continual market assessment is important to an endeavor such as the open repository. Demand and interest for the open repository must be continually monitored for duplication of efforts. In this feasibility study, we reviewed various platforms for best practices but none were open. However, there should be caution. It is important to monitor the demand for the open repository to avoid the "build it and they will come" fallacy. At times there is a tendency for the creators of a resource to believe that a built project will be used. The board must be aware of this pitfall.

7.2.4.2 A2. DECIDE LONG-TERM VIABILITY

The final step in the model is to decide the long-term viability of the open repository. The authors recommend that the RDB assess long-term viability and make a final "Go/No Go" decision at the end of Year 1 (before significant software development investment) and at the end of Year 3. Strong industry repository demand, increasing

income streams, and growth potential are indicators to consider if the open repository is to succeed long-term.

7.3   SUMMARY

The input from research participants is at the foundation of this development model. In addition, the model incorporates business concepts for start-ups (marketing and market demand assessment). The model provides a structured approach to the development process of the open repository. It provides guidance on the process as well. The approach can be iterative and must be applied continuously over the three-year evaluation period. It is projected that $2.1 million is needed for the open repository for the three year period. Most of the cost is related to software development. Once again, the associated income and expense for the repository are detailed in Appendix J.

CHAPTER 8: CONCLUSIONS

This dissertation used a literature review, interviews, a Delphi study and focus groups to explore industry interest of an open repository of best practices and a development model for its creation, management and sustainment. Through these various methods the author can make various conclusions and answer the initial research questions and hypotheses. This chapter reviews the dissertation findings, answers the questions presented in Chapter 1 and gives suggestions for future work.

8.1 OBJECTIVES

Five research objectives were developed for this study. The first object was to assess best practice terminology. The author accomplished this objective through the literature performed early in the study along with subsequent industry input. Identifying available best practice resources was the second objective and this list and sources were further refined with input from industry experts. Available resources are listed in the literature review. Conducting structured interviews, a two round Delphi study and two focus groups the author was able to assess industry interest in the open repository, the third objective. The fourth objective was to identify tenets for effective best practice processes. The structure interviews the author conducted, detailed in Chapter 4, satisfy this objective. The final objective was to build a model to guide the development of an open repository. The author successful completed this as outlined in Chapter 7.

8.2 RESEARCH QUESTIONS AND OBJECTIVES

Before concluding, a review of the research questions and objectives listed in Chapter 1 must be reviewed and answered.

8.2.1 QUESTIONS

1. *Is the AEC industry interested in an open repository of best practices?*

   Yes, from the interviews, Delphi study and focus groups (and industry input from various presentation by the author), the industry sees a need for an open repository of best practices.

2. *Is there a term that can promote consistency that is inclusive of the term "best practice" and similar terms?*

   Yes, Delphi study panel agreed the term "Practices for Excellence" was inclusive of "best practice" and similar terms. However the panel felt that a new term was not needed and would add little value.

3. *What are tenets of effective best practice processes?*

   Based on the organizational interview results, effective best practices included 1) standardization 2) iteration and 3) communication.

4. *What steps should be included in a development model for an open repository?*

   The starting practices pertain to the management of capital projects. A starting list includes safety, front end planning, constructability, change management and project team alignment.

The immediate steps for the development of the open repository are the following:

    I.   Identify Repository Development Board (RDB)

   II.   Procure Funding for Early Development Costs

  III.   Engage Industry Associations

  IV.   Begin Recruitment of Subject Matter Experts

   V.   Decide the Development End Date

8.3   RESEARCH FINDINGS

8.3.1 LITERATURE REVIEW

In reviewing the literature, the importance of knowledge capture and management and that of project performance is clear. Failure to capture best practices, project specific knowledge, leads to the "reinvention of the wheel", or wasted activity that may weaken project performance (Siemieniuch and Sinclair 1999). After conducting the literature review, the author came to the following conclusions:

- Knowledge management is critical for improved project performance.

- The term "best practice" does not have a consistent definition and terminology is inconsistent.

- Few industry repositories are open to association members and non-members alike.

- Of the open resources, one is focused on the management of capital projects and none is fully exploited an Enterprise 2.0 software structure for communication among the global industry.

8.3.2 INTERVIEWS

Interviews were conducted to learn about best practice processes from industry organizations. In total, eight organizations were interviewed (16 individuals). Organizations with experience on various different project types were interviewed.

From the interviews, organizations commonly struggled with outdated information, outdated best practices in their internal repositories, inconsistent process champions and outdated software systems. Tenets of an effective best practice process include the standardization of processes, a team of champions for the process and iterative continuous upkeep of the practices.

8.3.3 DELPHI STUDY

For this research project, a Delphi study was conducted to query a panelist of experts a development plan for the open repository. Twenty-one individuals participated in the first round of the study. Of the first round panelists, 12 participated in the second round. Panelist were asked rate Likert statements (six in round 1 and four in round 2) and answer questions regarding best practices, potential of the open repository and creation and management of the repository.

Panelists concluded that "Practices for Excellence" might not add immediate value to the industry (fragmentation was a concern). However, panelists did agree with the definition of the term. Starting practices for the open repository include: Front End Planning, Alignment, Constructability and Risk Management. The open repository should initially target project engineers, senior project/construction managers and owners. Panelists agreed the open repository would benefit the industry; however, the lack of resources and industry commitment are the primary barriers to success.

8.3.4 FOCUS GROUPS

Conclusion of the focus groups made clear that the open repository should be a neutral resource that does not provide judgment but knowledge. The open repository should be created as an independent entity that has backing from the National Academy of Construction. Yearly subscriptions on mobile devices, along with advertising and promoted contented should be considered as potential revenues streams. To start-up the repository, government grants and industry association contributions should be used. The starting practices for the open repository should be universal across various industry markets.

8.4 HYPOTHESES REVISITED

The research problem that is at that has driven this research is the inconsistent implementation and use of best practices in spite of the available industry resources. The reasons being that not all practices are applicable and universally applied; knowledge is lost to personal turnover and not all best practice processes are effective.

The hypotheses at the beginning of this research were: 1) the AEC industry has a strong interest in an open repository of best practices and 2) with the input from the AEC industry a framework/model can be created to guide the creation, management and sustainment of an open repository.

The Delphi study results indicate that the AEC has an interest in the open repository. Statements C2 and D2 in Delphi round one, had a mean score of 5.2 and 5.4 respectively on the seven-point Likert scale with percentages of agreement of 67 and 76

and AD index values of 1.53 and 1.28 respectively. Majority of the 21 panelists agreed there is potential for the open repository in the industry and there is benefit of having the open repository in the industry; however there is full panel consensus (AD index values higher than 1.167 cutoff).

However, panelists expressed concerned. Panelists indicated that existing resources; extraordinary effort needed to develop the repository; potential push back from organizations that own and operate current industry resources (CII, IPA, PMI, etc.); information validation and potential inconsistent use are reasons why the open repository would not been traction or benefit the industry. One panelist commented, "pulling this off would expend more energy that benefit." This statement reiterates the caution and thoughtful planning that is needed if creation of the open repository were to move forward.

The research conducted has answered the second hypothesis. With input from the AEC industry a model to assist in the creation, management and sustainment of the open repository has been created. The steps in the model are the following:

- Start-Up:
    - S1: Involve Industry
    - S2: Identify and Procure Funding
    - S3: Recruit Subject Matter Experts
- Creation
    - C1: Develop Best Practice Structure Template
    - C2: Select and Crowd Source Starting Best Practices
    - C3: Start Software Development Process

- Management

    o Decide Business Management and Structure

    o Assess Operation Income Options

- Assessment

    o Assess Market Demand

    o Decide Long-Term Viability

8.5 CONTRIBUTIONS

Reflecting upon the research completed in this dissertation, the author notes her following contributions to knowledge.

1. Based on the literature review conducted, the thorough review of best practice resources available in the AEC and an overview for each contributes to knowledge.

2. A framework/model that assists in the development of a repository is also a contribution of the author. The model does not only serve the industry as a whole, but can also be used in organizations that seek to start, better manage and or sustain their knowledge repositories.

3. Based on structured interviews, tenets of an effective best practice process and the associated challenges are benefits and contribute knowledge.

8.6 FUTURE WORK

There are several ways future work can extend this research. The author highlights the need for future work on the following:

1. Analysis of the implementation and usage rates of best practice once the open repository is created and operational.

2. If created, an analysis of the development model presented in this dissertation should be compared to that of the model that is used to create the open repository.

3. The financial impact of an ineffective online knowledge management system for organizations in the AEC industry.

8.7 CONCLUSION

The purpose behind knowledge manage is to improve project performance by limiting the duplication of work; by not "reinventing the wheel" (Siemieniuch and Sinclair 1999). Collection of best practices alone does not improve project performance. However an iterative best practice process is critical to the increased implementation and usage of best practices.

The industry has done a good job of identifying best practices, researching the benefits and cataloging these practices, however, consistent implementation of these practices is the key to increase usage and ultimately improve project performance industry wide. Even if the open repository is not created, this dissertation provides a development model that industry organizations can use internally for the start or continuance of their best practice repositories.

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APPENDIX A

STEERING COMMITTEE INVITATION EMAIL

Subject: Best Practices Implementation Steering Committee
To:

          -Wayne Crew   -Don Cooley
          -William Grosshandler   -Jim Vicknair
          -David Mendes   -Jan Tuchman
          -J.D. Slaughter   -Ray Topping
          -John Dalton

The researchers for the Best Practice Implementation Project are inviting industry and academia members to participant on the research project's steering committee. The research project, funded by Arizona State University and the Construction Industry Institute, was formed to help organize and share architecture- engineering-construction (AEC) industry best practices. The objective is to create an informational repository for industry best practices. There are two specific actions for project success. The first is the collection of best practices and the second is the repository tool creation. The research project has already commenced with the start of a literature review, with critical steps advancing next year.

Industry and academia input is crucial to success. A strong steering committee will help guide discussion on the inclusion of specific industry best practices. The committee will also give advice on key topics (i.e. legal ramifications, repository tool design, information management, etc.). Responsibilities of the steering committee include participation in the following:

- **Conference Call Discussions** (once every two months).
  -December 2012
  -February 2013
  -April 2013
  -June 2013
- **Interviews and Case Study Instrument Development** (best practice definition and repository design/startup/management)
- **Repository Design**

The next step in the research process is to engage with the project steering committee. A conference call is schedule on **December 7th at 11:30 am EST**. On the call, the project scope, research steps and project timeline with be discussed. Attached in this email is the project charter which details research steps. If you (or your organization) would like to participant, please respond by November 30th with your decision.

Thank You,

Edd Gibson: edd.gibson@asu.edu
Roberta Bosfield: rbosfiel@asu.edu

APPENDIX B

STEERING COMMITTEE AND PARTICIPATING ORGANIZATIONS

Committee Member	Organization
Stuart Anderson	Texas A&M University
Don Cooley	CH2M HILL
Wayne Crew	The Construction Industry Institute
John Dalton	Wood Group Mustang
G. Edward Gibson, Jr.	Arizona State University
Michael Loulakis	Capital Project Strategies, LLC.
J.D. Slaughter	S & B Engineers and Constructors, Ltd.
Ray Topping	Fiatech
Jan Tuchman	ENR
Jim Vicknair	Eichleay Engineers, Inc.

One or more individual from the following organizations participated in this study.

- Air Products

- Architect of the Capitol

- Arizona State University

- Burns and McDonnell

- Capital Project Strategies LLC

- CH2M HILL

- Eastman Chemical

- Eichleay Inc.

- Eli Lilly and Company

- ENR

- Fiatech

- Ford, Bacon, & Davis LLC.

- Granite Construction

- S & B Engineers and Constructors, Ltd.

- Saudi Aramco

- Stanford University

- Sundt Construction

- Texas A&M University

- The Construction Industry Institute

- University of Colorado at Boulder

- University of Texas at Austin

- Valency Inc.

- Virginia Tech University

- Wood Group Mustang

- WorleyParsons

APPENDIX C

INTERVIEW QUESTIONNAIRE

National Academy of Construction (NAC)/ National Construction Forum (NCF)
Best Practice Research Project

In-depth structures questions to explore "best practice" definition and repository creation and management. The questions were created for interviews with organizations that express interest in sharing experience.

Organization/Name: _____   Phone #: _____

Position Title: _____

Date & Time: _____

Interview Script:
  Introduction
      a. Who we are and what we are doing
          i. *Thank you for meeting with us today. Before we get started we want to give some more insight about the research project. We are involved with National Construction Forum research project regarding best practices in the (architecture, engineering and construction) AEC industry. Our research project is group effort by CII and ASU.*

      b. Let the organization know that the interview will focus on the creation and management of its internal information repository
          i. *Currently the research project is in the infancy stage. Through structured interviews, we hope to understand the term "best practices" and the management of this information.*

      c. Interview Structure
          i. *The interview we will cover four main topics: best practice definition information repository design/creation information collection process, and industry management of the repository.*

      d. Interview is confidential
          i. *Most importantly before we start the interview we want to read to you the confidentiality clause:*
              1. *Thank you for participating in the interview regarding best practices within your organization. Your input will be a valuable piece of the process to complete our research goals. We promise that individual and organization names will not be included in research publications. Also, anything said in the interview will not be disclosed. Finally upon completion of research, we will share the results in our final publication.*
              2. *In order to continue with the interview, please indicate that you understand the clause and give permission to continue.*

                  Company Name   *Permission to Continue:*
                                                              ☐ YES   ☐ NO
                  _____

1. Topic: Best Practice Definition

Onto the first interview topic. The following questions will help us get an understanding of your organization's definition of the term "best practice".

    a. CII defines Best Practices as **"process[es] or method[s] that, when executed effectively, [lead] to enhanced project performance"** is that a good definition?

    b. How does your organization define the term "best practice" or its equivalent?

    c. How does your organization handle best practice definition granularity (specific difference definition details rules)? For instance, according to CII, Front End Planning, Team Building and Safety are considered best practices? Is there a difference among the given examples? Should there be rules when selecting best practices (activities versus practices)?

    d. Is there a difference between lessons learned and best practices?

    e. If available, would you organization use an open industry best practice information resource?

2. Topic: Organization's Repository Tool and Information Population Process
The next section of the interview will cover your organization's best practice information, the information collection process and the tool itself.

      a. Please describe your organization's information repository?
          i.   What is the purpose of the tool?
      b. What type of information is in the tool (project management, contract documentation, project safety, etc.)?
      c. What methods were used to populate the repository?
      d. How extensive is the information in the repository?
      e. Does your organization consider some of the information industry "best practices"?
      f. Can you give some benefits of having the tool within your organization?

3. Topic: Repository Creation and Management

Continuing the topic of the last two questions, we would like to ask about the information management of the repository.

      a. Can you walk through the repository creation process?
          i. How long was the creation process (planning, tool population, testing, etc.)?
          ii. What were some reasons behind the tool creation?
          iii. Who was involved in the process?
          iv. Was a third party hired to help create the repository (software, hardware, etc.)?
      b. What resources are needed for the tool creation and management (money, time, human capital, etc.)?
          i. It is an expense, how does your organization justify the expense?
          ii. Have you calculated a ROI on the tool?
      c. Who is involved in managing the information in the repository?
          i. Is there a single person or is there a management team?
          ii. What is the process for editing information? Who is involved?
      d. What suggestions can you give in creating an effective information repository?

4. Repository Usage/Tool Success
The following question is the last of the interview.

        a. Is the informational repository successful? (How do you define success)?
        b. How do you track your organizations usage of the tool?
        c. When and how is the repository used?
        d. Who uses it the most and why?

5. Close Out/Thank You/Last Thoughts

Thanks for participating the interview. We know it's sometimes difficult to make time for activities such as these. We truly appreciated your organization's participation not only in this interview but also in the brief survey earlier this year. Before the interview ended are there any parting words on about best practices?

Would your organization be interested in participating on the best practice steering committee?

APPENDIX D

ROUND 1 DELPHI STUDY QUESTIONNAIRE

DELPHI ROUND 1 QUESTIONNAIRE

Please answer the questions in the following sections to the best of your knowledge. Your detailed responses will help us better assess the industry's understanding and use of best practices. The questionnaire will also help us assess interest of an open repository (clearing house) for these practices.

Within this questionnaire, your validation of answers will include the rating of multiple statements on a one to seven point Likert scale. On the scale, one represents "Strongly Disagree" and seven "Strongly Agree." Please note that your written comments in addition to your numeric ratings will assist us and the other experts on the panel to fully understand your perspective. Your comments are encouraged especially if you choose to rate a statement with a score of three (option "Conditionally Disagree"), four (option "Neutral"), or five (option "Conditionally Agree"). In these cases, an explanation of your "condition" is required. In addition, you are invited to identify (a) crucial practices for project success, (b) resources used when researching practices, (c) challenges to effective implementation of practices and (d) potential barriers to an open industry repository. If not enough space is available for your comments, please feel free to attach extra sheets as necessary.

The questionnaire is divided into four sections: (A) Background Information; (B) Successful Practices Definition and Identification; (C) Creation, Management and Sustainment of the Open Repository; and (D) Potential Barriers.

Please know that the confidentiality of this questionnaire will be maintained. Your identity will not be linked to the responses provided, unless we ask your permission. In addition, data will not be placed in any permanent record, and will be destroyed when no longer needed by the researchers. We would like to thank you in advance for the time and effort involved in your participation for this study.

Please return this questionnaire via email or by mail to the following address:

Roberta Bosfield – Arizona State University
Del E. Webb School of Construction   Email: rbosfiel@asu.edu
PO Box 870204   Phone Number: (480) 727-6768
Tempe, AZ 85287-0204

Section A: Background Information

Below is a list of questions to help understand the background of participants. In addition to name and organizational details, Section A also asks participants about their expertise area and experience regarding best practices, lessons learned, knowledge management and similar areas.

A.1)   Name: _____

A.2)   Organization: _____

A.3)   Describe Organization (type, sector, etc.): _____
_____

A.4)   Current Position/Title: _____

A.5)   How many years have you worked in the Architecture-Engineering-Construction (AEC) industry?

Number of years: _____

A.6)   Your areas of expertise (check all that apply):

Project Management	Executive Management	Knowledge Management
Risk Management	Project Controls	Operations
Project Planning	Consulting	Legal

Other: [_____]

A.7)   During your AEC industry experience, have you been involved with process improvements related to the collection, dissemination and/or management of best practices, lessons learned, benchmarking or similar knowledge types, within your organization?

Yes   No

A.8)   If you answered "No" to question A.7, skip to question B.1. If you answered, "Yes" to question A.7, how many and what was/were your role(s) during the experience(s)?

Number of Process Improvements: _____

Process Role(s) Description:

[

]

Section B: Definition and Identification of Practices Critical for Success

In the early stages of this study, the term "best practice" was extensively researched. It was discovered that the term is generic in nature and is mostly used to describe necessary steps or practices needed for project success. It was also discovered that various organizations use different terms synonymous with "best practice (value improvement practices, guidelines, etc.). With multiple terms for the relatively similar concepts, there is a level of confusion. Please devote sufficient time to read and understand the definition, as you will also be asked to endorse and/or provide your feedback on it.

In order to organize and unify the concepts for the possibility of an open repository resource, an all-inclusive term is needed. The term "Practices for Excellence" is an attempt to encompass not only "best practices" but all practices needed to help increase the likelihood of success and other similar terms.

DEFINITION

Practices for Excellence (PFE) are *specific processes and actions, with proven benefits (from research or past performances), that when repeated and documented, result in an increased probability of management or operational improvement throughout the construction/capital project lifecycle*.

B. 1)   As explained above, <u>the term</u> "**Practices for Excellence (PFE)"** adds value to the industry and encompasses the term "best practice" and other similar terms. ***Please check the box that indicates your level of agreement.***

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Conditionally Disagree	Neutral	Conditionally Agree	Agree	Strongly Agree

Comments/Feedback (If any):

B. 2)   *The definition* of the term "**Practices for Excellence (PFE)"** previously given is effective and adequately encompasses the term "best practices" and other terms (guidelines, improvement practices, etc.) in the industry. ***Please check the box that indicates your level of agreement.***

1————————2————————3————————4————————5————————6————————7

Strongly   Disagree   Conditionally   Neutral   Conditionally   Agree   Strongly
Disagree   Disagree   Agree   Agree

Comments/Feedback (If any):

B. 3)   *The definition* of PFE includes the phrase "increased probability". In the context of the definition, the aforementioned phrase accurately describes the purpose behind the effort of collecting and disseminating practices. ***Please check the box that indicates your level of agreement.***

1————————2————————3————————4————————5————————6————————7

Strongly   Disagree   Conditionally   Neutral   Conditionally   Agree   Strongly
Disagree   Disagree   Agree   Agree

Comments/Feedback (If any):

One main purpose of this study is to identify practices crucial to success in construction/capital lifecycle. However, there are different project types, various participants (e.g., owner, designer, contractor) and project phases (e.g. detailed scope, design, construction). Based on this premise, please answer the following.

B. 4)   In your opinion, what are seven (7) practices (*see Appendix A for examples of industry practices*) needed to increase the likelihood of success for a construction project. ***Please give a list of practices*** (***in no order of importance***) that are critical for any organization and indicate the lifecycle stage(s) associated with the practice.

No.	Name of Practice	Lifecycle Stage(s) where Practice is Employed (Detailed Scope, Design, Construction etc.)
1.		
2.		
3.		
4.		
5.		
6.		
7.		

When approaching a new or unfamiliar project, either formal or informal research is conducted to learn more about a practice that can help mitgate the project risk. The following questions are asked to better understand the type of information researched and the resources (internal or external to an organization) the industry uses in these situations.

B. 5)   What specific resources (internal or external to your organization) do you use to research industry practices? (Internal knowledge databases, Construction Industry Institute (CII) Best Practices, Independent Project Analysis (IPA) Value Improvement Practices, Industry Associations, Wikipedia, etc.) ***Please list the major resources (ranked in order of effectiveness)*** that you use to learn about industry practices

No.	Name of Resource
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

B. 6)   In your experience, when using the resources that you listed in question B.5, what are the challenges to adapting and implementing the practices effectively. Also, please indicate what changes could be made to improve the effectiveness of the resource?

Comments/Feedback:

121

Section C: Creation, Management and Sustainment of an Open Repository.

There are other resources that the industry can use to research best practices and similar knowledge. To avoid creating an under-utilized resource, assessing the industry's interest in an online repository is needed.

A critical step in assessing the feasibility of the online repository is to gage interest from the industry. This section explores the need and potential use in the industry for the repository if created. The questions in this section are asked to also help determine the necessary steps needed to create, manage and sustain the repository.

C. 1) Given the current industry resources available on best practices, lessons learned, and similar knowledge, the addition of an open online repository, that is based on open sharing and learning, is a resource that could potentially be well received in the industry. *Please check the box that indicates your level of agreement.*

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Conditionally Disagree	Neutral	Conditionally Agree	Agree	Strongly Agree
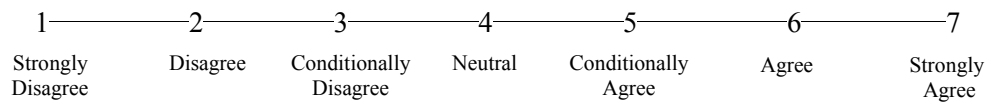
Comments/Feedback (If any):

C. 2)   An open online repository has the potential to gain industry "traction" and could, in your opinion, be a viable resource for those researching best practices or similar knowledge for construction/capital projects. ***Please check the box that indicates your level of agreement.***

1————2————3————4————5————6————7

| Strongly Disagree | Disagree | Conditionally Disagree | Neutral | Conditionally Agree | Agree | Strongly Agree |

Comments/Feedback (If any):

C.3)   In your opinion, if created, what target user(s) should the level of information in the repository be _initially_ focused towards? Please identify the user(s) you think would use the repository in the early stages. ***Please mark three (3) choices.***

Craft Labor
Foremen
Project Engineers
Senior Project/Construction Managers
Academic Users
Executives
Owners
Other:

We feel that he topic of granularity is an important subject regarding the practices held in a repository. Specific to this study, granularity refers to the type of best practices (breadth) and the level of detail (depth) that should be included in the repository. For instance, should the repository include practices only specific to the management of construction projects (i.e. Constructability) or should it also include task specific information on a job site (i.e. Formwork design)? Should the repository be extended to business practices (i.e. Accouting)?

Best Practice Information Structure

If created and once best practices are identified, the proposed breadth for the practices held in the repository includes those that improve the delivery of construction/capital projects. The proposed depth structure for the best practices in the repository is the following:

1. The *definition* of the practice.
2. The *associated place in the lifecycle* the practice fits (e.g. front end planning, design, etc.) of the practice.
3. The *major process steps* of the practice.
4. The *value added* when the practice is implemented.
5. A *list of references* for the practice for users to find additional information and detail

C.4) Based on the *topic of granularity* and the proposed *information structure* above, in your opinion, what breadth and depth should be in the online repository resource? What specific project lifecycle(s) and level of detail should be initially included in the repository?

Comments/Feedback:

C.5) In your opinion, what challenges do you foresee populating the information (best practices, lessons learned and similar knowledge) in the online repository (e.g., finding industry experts to write on specific practices; creating a structured approach to organize the information, managing the quality content, etc.)?

Comments/Feedback:

If agreed upon and created, the repository will need to be managed to ensure continued success. The resource is intended for the industry; however, ultimately, an entity will need to manage the information and operations of the resource.

C.6) From the list below, *please rank* (*number "1" being best option)* management options for the repository.

Rank No.	Scenarios	Description
	A	The creation and management of the repository should be affiliated with a *neutral party* (perhaps an academic institution).
	B	The creation and management should be a connected with an *established industry entity* (perhaps an industry association).
	C	The creation and management of the repository should be created and managed as a *stand-alone entity* (perhaps non-profit) from its inception.
	D	Other (please explain):

Section D: Potential Barriers and Overall Viewpoint of an Industry Repository

In this section, possible potential barriers are discussed. The industry impact of the open repository is asked.

D.1)   As with any new project, there will be challenges to creation, implementation, management and sustainment of this effort. If an open repository is to be pursued, in your own opinion, what would be the biggest challenges. ***Please mark only one (1) choice.***

Resources, including money or time
Lack of industry commitment and involvement
The difficultly raising startup funds
The "not one more resource" sentiment
Inconsistant use of repository
Other

D.2)   The idea of an open source repository could be beneficial to the AEC industry. It is a resource, that if properly managed and sustained, can greatly impact the industry. ***Please check the box that indicates your level of agreement.***

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Conditionally Disagree	Neutral	Conditionally Agree	Agree	Strongly Agree
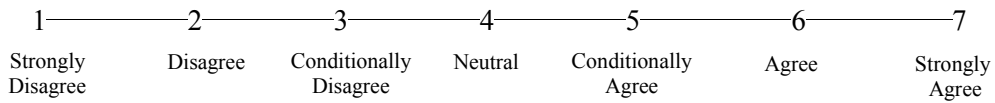
Comments/Feedback (If any):

D.3)   Are there topics, not addressed in this first round questionnaire, regarding the
        feasibility of   the best practice repository that should be addressed? If so, please
        explain.

Comments/Feedback (If any):

Again, Thank you very much!
Please return to Roberta Bosfield at rbosfiel@asu.edu. Or mail to **PO Box 870204 Tempe, AZ 85287-0204**

APPENDIX E

ROUND 2 DELPHI STUDY QUESTIONNAIRE

DELPHI ROUND 2 QUESTIONNAIRE

Please answer the questions in the following sections to the best of your knowledge. If needed, you can refer to the summarized Delphi Round 1 results document which is provided in addition to this questionnaire (file titled "**Delphi R1 Summarized Results**"). Your detailed responses in this second round questionnaire will help us better assess the information provided by the Delphi panel and new topics regarding the open repository for best practices.

The questionnaire is comprised of three sections (**10 questions**): (1) SECTION A – Open Repository Structure and Best Practice Criteria; and (2) SECTION B – Open Repository Funding and Revenue Streams; and (3) SECTION C – Garnering Industry Interest and Commitment. Within this questionnaire (like the first round), your validation of answers will include the rating of multiple statements on a one to seven point Likert scale. On the scale, one represents "Strongly Disagree" and seven "Strongly Agree." Please note that your written comments in addition to your numeric ratings will assist us and the other experts on the panel to fully understand your perspective. Your comments are encouraged especially if you choose to rate a statement with a score of three (option "Conditionally Disagree"), four (option "Neutral"), or five (option "Conditionally Agree").

Please know that the confidentiality of this questionnaire will be maintained. Your identity will not be linked to the responses provided, unless we ask your permission. In addition, data will not be placed in any permanent record, and will be destroyed when no longer needed by the researchers.

Please return this questionnaire via email or mail by **Friday March 21, 2014**

Roberta Bosfield –Arizona State University
Del E. Webb School of Construction
PO Box 870204
Tempe, AZ 85287-0204
Email: rbosfiel@asu.edu
Phone Number: (480) 727-6768

Section A: Open Repository Structure and Best Practice Criteria

DEFINITION

Practices for Excellence (PFE) are *specific processes and actions, with proven benefits (from research or past performances), that when repeated and documented, result in an increased probability of management or operational improvement throughout the construction/capital project lifecycle.*

A.1)   In the first round of the Delphi study, panelist were asked to assess the new term "Practices for Excellence" (PFE) (see definition above). Based on first responses from panelists, the introduction of the new term to the industry would add little value. However, based on the panelists input, <u>practices in the repository should meet the following criteria</u>:

1. Increases the likelihood for project success.
2. Resides in one or more project life cycle.
3. Has demonstrable benefits for project improvement.
4. Includes documented steps of implementation.
5. Applies to one or more industry sector (e.g. commercial, industrial, manufacturing, etc.).

Do you agree that these five characteristics can be used to grade practices in the open repository? ***Please check the box that indicates your level of agreement.***

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Conditionally Disagree	Neutral	Conditionally Agree	Agree	Strongly Agree
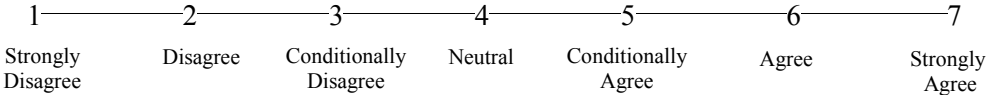
Comments/Feedback (If any):

A.2)   In the first round, panelists were asked to name sources external to their organization used to locate   industry practices. Typically, when using these sources (industry or non-industry focused) <u>what type of information do you seek</u>? (e.g., best practices, "tips and tricks", lessons learned, etc.). In your opinion, <u>how are external sources more or less beneficial compared to other available sources</u> (i.e., internal sources)?

Comments/Feedback:

A.3)   Based on first round responses, panelists mentioned that the repository should initially include only practices specific to the management of capital projects. With the practice type identified, <u>in your opinion, which industry sectors should be address first during the initial implementation of the open repository</u> (i.e., heavy civil, industrial, buildings)?

Comments/Feedback (If any):

A. 4) In the first round of the Delphi study, a panelist proposed a structured template that could be used for best practice write-ups for the open repository. This structure includes:

1. Definition and description of best practice.
2. Reason(s) why the process is a best practice.
3. Case studies or examples of the practice in use.
4. Explanation of the practice applied in different project situations (i.e., fixed price compared to reimbursable contract).
5. Benefits and value added explanation related to the practice.
6. List of references.

In your opinion, <u>the above structured template is adequate and should be followed</u> when documenting a best practice in the open repository. ***Please check the box that indicates your level of agreement.***

1————————2————————3————————4————————5————————6————————7

| Strongly Disagree | Disagree | Conditionally Disagree | Neutral | Conditionally Agree | Agree | Strongly Agree |

Comments/Feedback (If any):

In the first round, panelists agreed that an open repository based on open sharing and learning, is a resource that could potentially be well received in the industry. However panelists mentioned that participant dialog is an important element to the repository.

A.5)   In your opinion, repository users <u>should be able to have interactions </u>with other repository users, in addition to information provided on the website (e.g., chat rooms, blogs, forums, etc.). ***Please check the box that indicates your level of agreement.***

1————2————3————4————5————6————7

| Strongly Disagree | Disagree | Conditionally Disagree | Neutral | Conditionally Agree | Agree | Strongly Agree |

Comments/Feedback (If any):

In the first round, panelists mentioned that validity of information is an important aspect when choosing external sources for best practices. For instance the Construction Industry Institute (CII) validates information through academic research and industry input.

A. 6) In your opinion, a <u>panel, or panels, made up of subject matter experts should be in place</u> to review and validate information in the repository. This panel(s) should consist of industry (contractors, owners, consultants, etc.) and academic members. ***Please check the box that indicates your level of agreement.***

1————————2————————3————————4————————5————————6————————7

| Strongly Disagree | Disagree | Conditionally Disagree | Neutral | Conditionally Agree | Agree | Strongly Agree |

Comments/Feedback (If any):

Section B: Open Repository Funding and Revenue Streams

B.1)   From responses from the first round of the Delphi study and two workshops with industry participants, it is clear that *financial funding for start-up* costs (designing, developing and testing repository, information population, etc.) is critical for start-up success of the open repository. <u>Please identify sources for potential start- up funding and steps that the NAC should take to gain funding for the start-up the open repository</u>.

Comments/Feedback:

B. 2)   In industry workshops, the researchers also explored *potential revenue streams for continued funding*. Potential revenue streams explored for the open repository were advertising, promoted articles ("pay to play") and industry association sponsorship. <u>In addition to those previously mentioned, are there other revenue streams you feel could work for the repository?</u> <u>Do you see any challenges to these revenue streams</u>?

Comments/Feedback:

Section C: Garnering Industry Interest and Commitment

Creating industry interest and commitment is critical to the initial and continued success of the open repository for best practices. In the next few months, the National Academy of Construction will identify and ask industry organizations and associations for their input and support for the open repository.

C.1)   In the first round, panelists mentioned numerous times that a potential pitfall for the open repository would be lack of industry commitment leading to inconsistent use of the open repository. In your opinion, <u>what specific steps can the NAC take to garner industry interest and commitment prior to and after the start-up of the open repository</u>?

Comments/Feedback (If any):

C. 2)   In your opinion, <u>what are some potentially interested organizations that the NAC should collaborate with prior to the start-up</u> of the open repository to help increase demand and commitment?

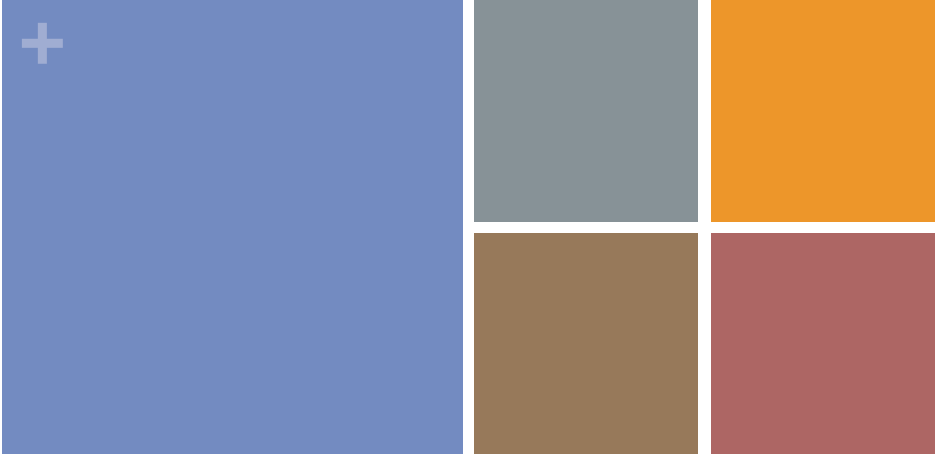| No.	Name of Organization
1.	
2.	
3.	
4.	
5.	

With your background, experiences, and your participation as a Delphi panelist in this study, would you willing to participant in a future steering committee or contribute as subject matter expect (SME) prior to start-up of the open repository?

Yes   No

This is the end of the questionnaire. Again, Thank you very much!
Please return to Roberta Bosfield at rbosfiel@asu.edu. Or mail to **PO Box 870204 Tempe, AZ 85287-0204**

APPENDIX F

OCTOBER 2013 FOCUS GROUP PRESENTATION

National Construction Forum:
Best Practices Breakout Session

October 20th, 2013
Phoenix, Arizona

+ Focus Group Agenda

- Discussion Topics
  - Creation/Management Scenarios
  - Business Scenarios for Repository
    - Potential Revenue Streams
    - Associated Costs
  - Industry Involvement

- Time
  - 40 Minutes

Discussion Topic 1: Creation/Management Scenarios

- If agreed upon and created, the repository will need to be managed to ensure continued success. The resource is intended for the industry; however, ultimately, an entity will need to create and manage the information and operations of the resource. In your opinion, which of the following scenarios, listed on the next page, is the best option?

Study Objectives

- Better Understand
  - Creation/Management Scenarios
  - Business Scenarios for Repository
    - Potential Revenue Streams
    - Associated Costs
  - Industry Involvement

- Discussion Topics Important When Assessing Feasibility of Open Repository

- Confidentiality and Privacy Protections:
  - The confidentiality of this survey will be maintained and your identity will not be linked to the specific data, unless first asked. Your survey responses will be strictly confidential and data from this research will be comprehensively reported. In addition, data will not be placed in any permanent record, and will be destroyed when no longer needed by the researchers.
  - All publications will exclude all of your identification information. During the study, the researchers will notify you of any new information and changes that might affect your decision to remain in the study.

Discussion Topic 1: Creation/Management Scenarios

Scenario	Description
A	The creation and management of the repository should be affiliated with a neutral party (perhaps an academic institution).
B	The creation and management should be a connected with an established industry entity (perhaps an industry association).
C	The creation and management of the repository should be created and managed as a stand-alone entity (perhaps non-profit) from its inception.
D	Other (please explain)

Discussion Topic 2: Potential Revenue Streams

- If agreed upon and created, the open repository will need to be financially viable for sustainment. In your opinion, what are some potential revenue streams that seem viable for the open repository for best practices?

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Discussion Topic 4: Industry Involvement

- Based on the data collected from the Delphi study regarding the open repository, lack of industry commitment and involvement was identified as a primary barrier. If agreed upon and created, in your opinion what actions can be taken to garner commitment and involvement from the industry?

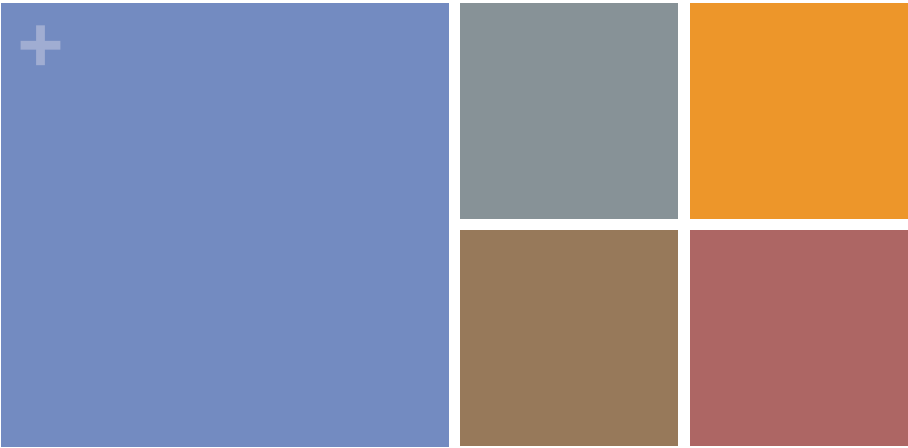## Discussion Topic 3: Key Associated Costs

- Based on the revenue streams identified earlier, in your opinion, what key costs are associated with the start-up, management and sustainment of the open repository for best practices?

Conclusion

- Conclusion
  - Feasibility Report
    - Distributed Once Complete

- Contact Information
  - Roberta Bosfield
    - Roberta.Bosfield@asu.edu
  - G. Edward Gibson, Jr.
    - GEdwardGibsonJr@asu.edu

- Once again all publications will exclude all of your identification information.

- Thank you for your time and valuable input

APPENDIX G

DECEMBER 2013 FOCUS GROUP PRESENTATION

National Construction Forum:
Best Practices Breakout Session

December 11th, 2013
Washington, DC

Best Practice Break Out

- Agenda (3.5 Hours)
  - 10:00 am - October Recap/Goals
  - 10: 30 am – Discussion Topics
    - 12:00 pm – **BREAK**
  - 12: 30 pm – Discussion Topics
  - 1:35 pm – Finalize Report Out
    - Future Workstreams/Spin Offs
    - Path Forward
  - 2:00 pm – **BREAK**

- Discussion Topics
  - NAC October Discussion Themes
  - Mission for Open Repository
  - Initiation to Start-Up Timeline

October Recap – Themes Discussed

- Business Model of Open Repository
  - Should NAC be "honest broker" or a stand alone third party?

- Funding for Open Repository
  - Conception Phase
  - Start-Up

- Granularity of Information – What best practices?
  - Big Impact Areas
  - Focus on universal practices
  - Proprietary Information concerns

- Open Repository Structure
  - Website Format – Wiki or Other
  - Population Method
  - Mobile Application Development

Discussion Topic 1:
Business Model of Open Repository?

- Should the open repository be tied to the NAC?

Scenario	Description
A	The creation and management of the repository should be affiliated with a neutral party (perhaps an academic institution).
B	The creation and management should be a connected with an established industry entity (perhaps an industry association).
C	The creation and management of the repository should be created and managed as a stand-alone entity (perhaps non-profit) from its inception.
D	Other (please explain)

Discussion Topic 3:
Granularity– Breadth and Depth of Information?

- According to the results of the 1st round Delphi study, most participants mentioned that the CII list of best practices could be the initial focus of the repository. In your opinion what best practices should be included in the open repository?
  - Are these practices "universal"?

- What method should be used to populate the open repository with Practices For Excellences (PFEs) and ensure updated information? Who should be involved?

Construction Industry Institute (CII) Best Practices

Alignment

Benchmarking & Metrics

Change Management

Constructability

Disputes Prevention & Resolution

Front End Planning

Implementation of CII Research

Lessons Learned

Materials Management

Partnering

Planning for Startup

Project Risk Assessment

Quality Management

Team Building

Zero Accidents Techniques

Discussion Topic 2:
Funding for Open Repository?

- What are some potential avenues for funding the creation and start up of open repository ?

- Who are the industry organizations/individuals the workstream should target?

- What is the targeted dollar amount?
  - Open Repository Costs
    - Technology: Website and Mobile Application Creation
    - Creation/Management Team Salaries
    - Development and Commissioning Costs (avoid www.HealthCare.gov mishap)

Discussion Topic 4:
Mission for Open Repository?

- In the October breakout session, it was said that the open repository should "provide knowledge not judgment". In your opinion what should is the overall mission for the open repository?

Discussion Topic 5:
Open Repository Timeline?

- The feasibility and interest of the open repository was assessed in 2013. If the development of open repository moves ahead, in your opinion, what is a responsible timeline to create, population, commission and launch the open repository?

Action	Time
Initiate "Go/No Go"	
Create	
Populate	
Commission	
Launch	

APPENDIX H

INDUSTRY BEST PRACTICES, STANDARDS AND GUIDELINES

Construction Industry Institute (CII):
Best Practices

1. Alignment
2. Benchmarking and Metrics
3. Change Management
4. Constructability
5. Disputes Prevention & Resolution
6. Front End Planning
7. Implementation of CII Research
8. Lessons Learned
9. Materials Management
10. Partnering
11. Planning for Start-up
12. Project Risk Assessment
13. Quality Management
14. Team Building
15. Zero Accidents Techniques

Construction Management Association of American (CMAA): Standards of Practice
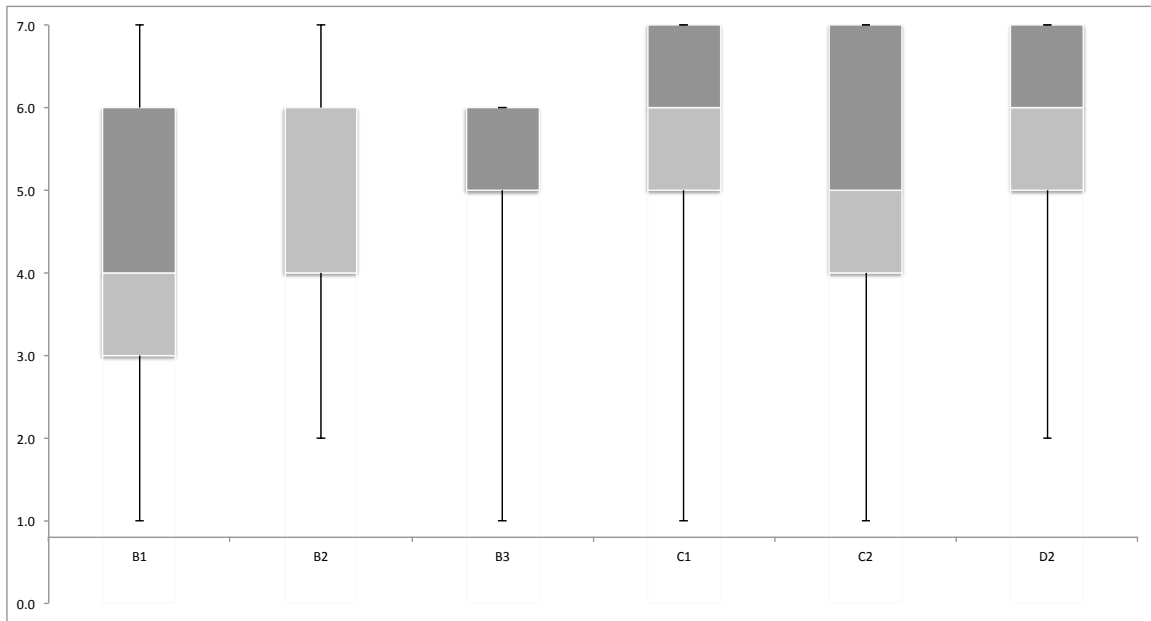
1. Project Management
2. Cost
3. Time
4. Quality Management
5. Contract Administration
6. Risk Management
7. Sustainability
8. Safety

Project Management Institute (PMI): Project Management Body of Knowledge (PMBOK)

1. The Standard for Program Management
2. The Standard for Portfolio Management
3. Organizational Project Management Maturity Model (OPM3®)
4. Practice Standard for Project Risk Management
5. Practice Standard for Earned Value Management
6. Practice Standard for Project Configuration Management
7. Practice Standard for Work Breakdown Structures
8. Practice Standard for Scheduling
9. Practice Standard for Project Estimating
10. Project Manager Competency Development Framework

Independent Project Analysis (IPA):
Value Improving Practices (VIPs)

1. Technology Selection
2. Classes of Facility Quality (Project Value Objectives)
3. Minimizing Standards and Specifications/Practices
4. Process Simplification
5. Waste Minimization
6. Process Reliability Modeling
7. Design to Capacity
8. Predictive Maintenance
9. Constructability
10. Energy Optimization
11. Value Engineering
12. 3-D CAD Design

APPENDIX I

DISTRIBUTION STATISTICS AND CHARTS (BOX PLOTS)

FOR DELPHI STUDY

Delphi Round One

Questionnaire Section		Question	Mean	Median	Mode
B	Definition and Identification of Practices Critical for Success	B1 – Industry Value of "Practices for Excellence"	4.2	4.0	4.0
		B2 – Effective and Adequate Definition of "Practices for Excellence"	5.2	6.0	6.0
		B3 – Accuracy of "Practices for Excellence" Definition	5.1	5.0	5.0
C	Management and Sustainment of an	C1 – Industry Reception of an Open Repository	5.4	6.0	5.0
		C2 – Potential for Open Repository to Be Viable Resource	5.2	5.0	7.0
D	Potential Barriers and Benefit of Open Repository to The AEC Industry	D2 – Benefit of Open Repository to AEC Industry	5.4	6.0	7.0

Delphi Round Two
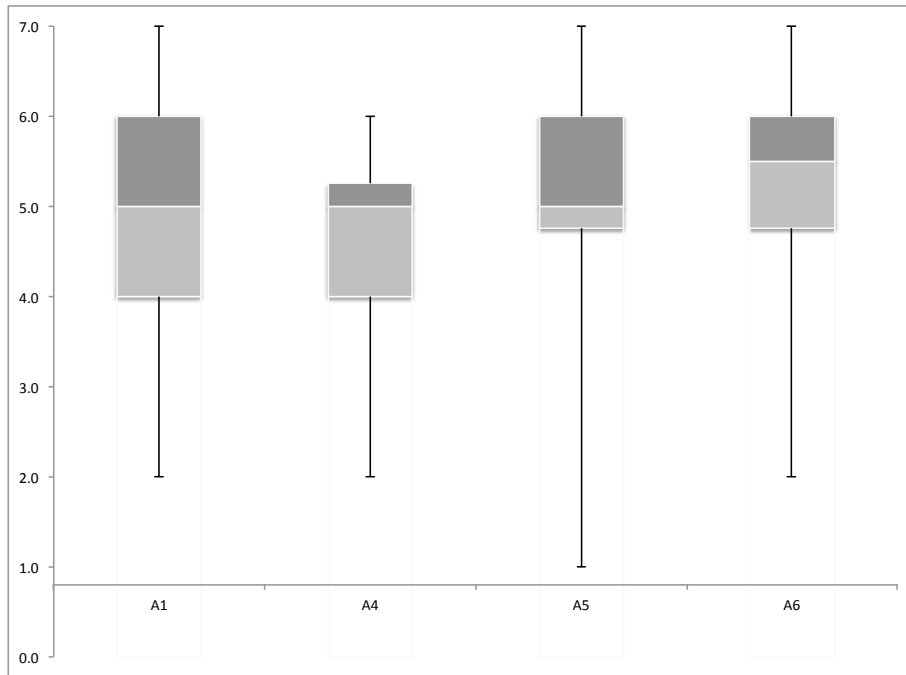
Questionnaire Section		Question	Mean	Median	Mode
A	Repository Structure and Best Practice Criteria	A1 – Structure of Practices Submitted in Open Repository	4.5	4.5	4.0
		A4 – Submission Template for Practice in Open Repository	4.6	5.0	5.0
		A5 – User Interaction Potential	5.0	5.0	5.0
		A6 – Subject Matter Review Panel	5.1	5.5	6.0

APPENDIX J

OPEN REPOSITORY INCOME AND EXPENSE ESTIMATES AND

CORRESPONDING NOTES

	Year 1(a)	Year 1(b)	Year 2	Year 3	Total	Notes
Number of Best Practice Articles		30	45	45	120	
Income						
Advertising	$ -	$ 45,000	$ 180,000	$ 225,000	$ 450,000	(a)
Promoted Articles (Sponsored Content)	-	7,500	22,500	22,500	52,500	(b)
Best Practice Industry Consulting/Training	-	20,000	60,000	60,000	140,000	(c)
Sponsorship (Industry Associations/Organizations, Academic Organizations, Grant Funding, etc.)	56,000	301,320	665,580	338,800	1,361,700	(d)
Total Income	$ 56,000	$ 373,820	$ 928,080	$ 646,300	$ 2,004,200	
Expense						
Planning & Design	$ 5,000	$ 39,400	$ 103,600	-	$ 148,000	
Software Programming	6,000	75,400	264,600	-	346,000	
Detailed Design	-	48,300	112,700	-	161,000	(e)
Coding & Test Unit	-	65,100	151,900	-	217,000	
Integration & Testing	-	40,800	95,200	-	136,000	
Annual Maintenance	-	-	-	410,000	410,000	
Information Cloud Storage	-	4,320	10,080	14,400	28,800	(f)
Legal Entity Formation (i.e., formal naming, corporation registration, taxes, etc.)	3,000	-	3,000	3,000	9,000	(g)
Digital Online Property (i.e., domain name, social media accounts, etc.)	1,500	-	-	-	1,500	(h)
Business Development (travel, marketing, etc.)	3,000	3,000	18,000	18,900	42,900	(i)
Repository Operating Manager	-	60,000	120,000	126,000	306,000	(j)
Office and Related Services	-	-	24,000	24,000	48,000	(k)
Support Personnel	37,500	37,500	25,000	50,000	150,000	(l)
Total Expense	$ 56,000	$ 373,820	$ 928,080	$ 646,300	$ 2,004,200	

(Expense categories: Repository Development, Business Support, Administrative)

	Year 1(a)	Year 1(b)	Year 2	Year 3		Notes
Projected Needed Personnel						
Repository Development Board Participants	10	10	10	10		(m)
Subject Matter Expert Panelists	10	10	15	15		(n)
Subject Matter Expert Contributors (1 article/SMEC)	15	15	45	45		
Projected Volunteer Time (Yearly Hours/Individual)						
Repository Development Board (RDB) Participants	60	60	60	60		(o)
Subject Matter Expert Panelists	24	24	24	24		(p)

Notes

(a)	Five (5) ads/month at an estimated advertising rate of $3000/ad. Three months operational Revenue for Year 1(b). An 25% increase for Year 3
(b)	Twenty percent of all articles contributed are promoted at a rate of $2500.
(c)	Services to help organizations structure their best practice processes. Two clients in Year 1 and six clients in both Year 2 and 3.
(d)	Yearly sponsorship is the balance needed when comparing income streams and total expense. Over time the need for sponsorship will decrease as the operating income streams increase.
(e)	Development expense is based on a structured project type with 15 thousand delivered source instructions (KDSI) with an monthly cost of $10,000. Annually, 5 KDSIs are added and modified. Eleven to twelve months of development (CSG 2014).
(f)	The total cost of running steady-state web application through Amazon hosting services at $1200 per month.
(g)	Forecasted business and tax reporting costs.
(h)	Online intellectual property for all years will be procured at start-up.
(i)	Business development (mainly travel) f is estimated at $1500 per trip. Four (4) trips in Year 1, 12 in Year 2. Year 3 is 5% more than the pervious year.
(j)	Operating manager is responsible for all operational responsibilities (and business development) and reports to the Repository Development Board. The salary is in line with a head operating officer in a similar FT position with a 5% annual increase.
(k)	Monthly office rental cost and associated costs (telecom, supplies, etc.,) at $2000.
(l)	Office support personnel at $50,000 per year. Support in Years 1 & 2 are expected to be lower than Years 3, cost is half of total.
(m)	It is expected that members on the RDB will change annually; continuous recruitment is necessary.
(n)	It is estimated that a SME panelist would review 3 articles.
(o)	Five hour monthly hour committeemen for a RDB participant (if a full time operating manager is hired).
(p)	Two hour monthly commitment for a SME panelist.