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Web-based collaboration in horizontal construction

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by

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ABSTRACT

Web-based collaboration tools offer many benefits in the management of construction projects. These systems have become increasing popular in the vertical construction sector; however, they have not been widely implemented in the horizontal construction sector. Research was completed to determine how prevalent the use of web-based collaboration software is with state departments of transportations (DOT) and what needs exist within state DOTs for web-based collaboration.

To learn how web-based collaboration could be implemented within state DOTs a pilot project was conducted with the Iowa DOT. This project focused on identifying the Iowa DOT's project management needs on bridge projects and implementing web-based project management systems (WPMS) to meet these needs. Systems were implemented using an action research methodology in an iterative nature in order to meet the immediate needs of the Iowa DOT while working towards a long term solution. Through this process a commercial solution was selected and pilot tested on bridge construction projects. Based on previous iterations and a functional analysis of the Iowa DOT's needs this solution focused on the management of contract documents, shop drawing submittals, and requests for information.

Results of this pilot project and research will help provide the horizontal construction sector with information for successfully implementing WPMS. By targeting specific construction documents and beginning by initially implementing smaller scale systems, organizations may be able to improve the success of WPMS implementations and reduce the initial cost and risk of implementing WPMS.

CHAPTER 1: INTRODUCTION

1.1. Background

Communication and the transfer of information on construction projects is becoming increasingly complicated. Projects are incorporating more participants and these participants are often quite geographically diverse. Shrinking project durations, complex details, and innovative contracting methods are also requiring project participants to effectively and efficiently communicate and share project information.

In horizontal construction new construction methods such as Accelerated Bridge Construction (ABC) are compressing schedules. The accelerated schedules and constructability issues require more communication between the owner, contractor and designer (WA DOT 2009). Additionally, with design-build construction becoming more prevalent in horizontal construction effective communication is becoming even more important. In the Federal Highway Administration's (FHWA) (2006) report on the effectiveness of design-build construction they highlight communication as a key lesson learned from previous projects and something that is very important to improving design-build programs.

As project participants face these challenges the need to improve communication has become critical. Communication is an integral part of project success and effectively communicating has been shown to be an important factor in the success of a project (Chassiakos and Sakellaropoulos 2008). One way that project participants can further facilitate and improve communication is through the use of Information Technology (IT). Specifically within IT initiatives web-based project management (WPMS) has developed as a way to help project teams communicate and transfer information.

The general idea of WPMS revolves around the use of the Internet to facilitate rapid exchange and access to project information through web-based collaboration. By utilizing the Internet information is centrally stored and can be easily accessed by project participants. This access allows project participants to collaborate during design and construction more easily. By using the Internet over other mediums of communication users are able to take

advantage of common standards to help overcome compatibility issues of different programs (O'Brien 2000). Web-based Project Management Systems may be referred to by many names, two other commons ones are, Project Specific Website and Project Information Management System (Nitithamyong and Skibniewski 2003).

WPMS have grown over time but typically work to manage information in four main areas: financial, project, design, and management. The financial portion of a system manages information such as cash flow projections, contract status reports, and the general ledger. The project information contains descriptive information about the project; this may include photos, participant directories, and a project description. Design information typically manages contract drawings and specifications. Finally, the management information area contains many construction documents such as meeting minutes, Requests for Information (RFIs), submittals, and progress reports (Mead 1997).

Utilization of WPMS offers many benefits with the primary one being improved access to project information (O'Brien 2000). Some of the other benefits touted by proponents of WPMS include a reduction in documentation errors, better financial control, increased speed of work, increase transparency, and reduced cost (Nitithamyong and Skibniewski 2004; Nikas et al. 2006). The resulting goal of these benefits is ultimately to improve communication and information transfer between project participants and hopefully project success.

As these systems have developed the number of them commercially available has dramatically increased. A brief search of the Internet will show dozens of WPMS solutions. These systems vary greatly in terms of their features, cost, and licensing and hosting options. The variety of options allows a project or organization great flexibility in selecting a solution that best meets their needs. Recently the development of licensing these programs as part of a Software as a Service (SaaS) agreement has greatly increased their availability (Nitithamyong and Skibniewski 2004).

With such a wide variety of options available in WPMS the selection of a solution is critical. One of the primary setbacks of these systems is the difficultly of successfully

implementing them into organizations. Many solutions, while technically sound, fail due to the organizational, human, implementation, and change factors influencing the success of a WMPS. The most common reasons for failing to receive the full benefits from a WPMS are: poor capture of user requirements, lack of strategic approaches, lack of proper planning, user resistance to change, lack of user involvement, and technical characteristics (Erdogan et al. 2008). Of these reasons, five of the six relate to how the solution is chosen or developed and how it is implemented. Three of the six reasons directly relate to the users of the system. For these reasons it is critical for the success of a WPMS to understand the organizational and project needs, goals, and cultures.

1.2. Problem Statement

When WPMS were introduced they were heralded as a something that would dramatically change how projects were managed. Since that time the level of adoption of these systems has been somewhat low. Research by Engineering News Record (ENR) (2005) in the 2005 showed adoption levels of WPMS to be less than 20%. Additionally, a survey by ENR (2004) in 2004 showed that 80% of readers involved in information technology purchases felt that improving communication and collaboration was the most important contribution of technology to their company in the next five years. Thirdly, in 2005 the FHWA conducted a focus group to look for innovations in the vertical construction industry that could be applied to the horizontal construction industry. One of the recommendations was for the increased use of WPMS within the horizontal construction industry.

Considerable research has been done to investigate the benefits of WPMS and also to examine what affects the success of WPMS implementations. Since the FHWA report was completed in 2005 little has been done to specifically investigate what level of adoption of WPMS exists in the horizontal construction sector and what the industry's specific needs are.

1.3. Research Objectives

To learn more about the needs and implementation of WPMS in the horizontal construction industry work was completed to quantify the level of adoption within the

horizontal construction industry and also investigate what needs exist for WPMS. To do this, state DOTs were targeted to sample the horizontal construction sector. This sample was surveyed to find out the level of implementation of WPMS. This sample was also surveyed to find out which project participants would benefit most from access to WMPS and what construction documents the DOTs thought could be best managed by WPMS.

State DOT's were targeted since owners are often the drivers of implementation and are typically the most successful at implementing WPMS (Dossick and Sakagami 2008). The goal of surveying the state DOTs was first of all to learn more about the level of adoption within the horizontal construction industry. Secondly, a goal was to learn more about what needs existed in horizontal construction in order find out how to more effectively implement solutions.

Finally, pilot testing of WPMS on bridge construction projects was conducted with the Iowa DOT. Work with the Iowa DOT was completed to investigate their needs to help them best implement WPMS. To best serve the Iowa DOT this research was conducted using the method of action research to allow the greatest benefits to the Iowa DOT while also conducting research. The nature of action research allowed for multiple iterations of WPMS to be implemented to meet the immediate needs of the Iowa DOT while working towards a long term solution. The results of this case study could be beneficial in helping other DOTs implement or evaluate WPMS for their own use.

1.4. Report Content

The remaining chapters of this report are organized as follows. Chapter 2 contains a literature review of work previous completed on WPMS and the research methods utilized in the case study with the Iowa DOT. Chapter 3 is written in the style of a technical note for an academic journal on the level of implementation of WPMS in the horizontal construction industry and the desire for project participants to have access to WPMS and manage certain construction documents with WPMS. Chapter 4 is written in the style of an academic journal article on the case study of implementing WPMS in the Iowa DOT. It describes the iterative process of implementing WPMS on bridge projects using the methods of action research and

rapid application development. Chapter 5 contains the report submitted to the Iowa DOT for the first year of the research project on pilot testing WPMS on Iowa DOT bridge projects. Chapter 6 contains the summary of work completed and conclusions along with research limitations and recommended future work.

CHAPTER 2: REVIEW OF LITERATURE

2.1. Introduction

The use of the internet to facilitate the management of construction projects through technologies such as web-based project management systems has become quite prevalent. These programs have been widely used within the vertical construction industry to assist in the management of projects. However, the use of these programs has not been as prevalent in the horizontal construction industry. In 2005 the FHWA initiated a tour of vertical construction projects and companies for a group of horizontal construction professionals. The goal of this tour was to look for innovations in the vertical construction industry that could be applied to horizontal construction. One innovation recommended for further implementation in horizontal construction was web-based project management systems (WPMS) (FHWA 2005).

2.2. History of Web-based Project Management

The use of project management software to assist managers is not something new to the construction industry. Project management software has been used for decades to manage many types of information from financial data to scheduling to document management (Suchaic 2001). The use of project management software and its applications has been steadily changing over time to help better meet the needs of the industry. Throughout the history of project management software there have been a number of outside factors that have dramatically changed the way that software has been used. In the early 1990's the increased availability of personal computers allowed project management software to be much more readily available to individual users and more recently abundant access to the Internet has made the transfer of information much more efficient.

With the advent of widespread access to the Internet in the 1990's information could be exchanged in new ways, which, created a great change in use of project management software. Utilizing the Internet, companies were able to transfer documents much quicker and cheaper than before (Anumba et al. 2007). By incorporating the internet into project management programs users were able to collaborate by sending and receiving information

much faster, thus helping reduce unnecessary delays. This use of web-based collaboration was designed to help overcome the chaotic nature of communication in construction that often leads to lapses in communication, poor understanding, conflict, and cost and schedule overruns (O'Brien 2000).

As web-based collaboration matured it allowed the development of project websites in the late 1990's. The idea behind project the website was that each project would have its own unique website which would serve as a centralized location to store information so that it would be easily accessible to the project participants (O'Brien 2000). By using a project website for this task information became more accessible then through other mediums of communication such as fax, mail, and email. This increased availability was because the project website stored the information on central servers which were connected to the Internet. This allowed all project participants access to the same information at any time (Mead 1997). The improved accessibility and transfer of information allowed for collaboration between project participants during the design and construction process. Ultimately the idea was that improved collaboration and access to projects information would lead to improved project performance.

Initially the implementation of project websites was quite limited in the construction industry. Anumba (2007) suggests that this maybe have been due to the fragmented nature of the construction industry and also because project websites were not meeting the needs of projects. An additional factor that may have hindered the implementation of project websites was their cost. In the mid 1990's costs for project websites were often over $40,000 per project, however by the year 2000 costs were usually below $10,000 (O'Brien 2000).

Since the introduction of project websites as a means for collaboration in the 1990's the use of these systems has been steadily increasing (Nitithamyong and Skibniewski 2004). A survey by the Construction Financial Management Association (CFMA) in 2004 showed 80% of owners believed project collaboration software could help improve communications. In this same survey 62% of owners listed "More effective communications" as the most important factor to improve project delivery (ENR 2004). With owner's viewing

collaboration software as a viable way to improve communication on their projects the use of web-based project management should continue to increase.

2.3. Web-based Collaboration

The basic premise of a web-based collaboration system is that there is a website specific to the project that allows users to access the project management software through any internet connection (Johnson 2004). The project website "provides a centralized, commonly accessible, reliable means of transmitting and storing project information" (Nitithamyong and Skibniewski 2004). Beyond this definition, WPMS vary significantly among their features and setup.

When talking about project websites and WPMS it is important to differentiate these systems from other systems that allow the transfer of information via the internet, one of the most common these is the FTP site. These sites allow the posting of files in a folder structure similar to those in internal networks. However, these systems do not track who does what in the system and the user interface is typically not very user friendly. Because of this project websites offer many benefits that FTP sites lack (Johnson 2004).

WPMS can be broken down into three main categories. The first type is the Project Collaboration Network (PCN). PCN solutions focus on facilitating project management by assisting project participants with sharing documents, communications, and workflows. The system also tracks what is accessed and when, and manages the versions of documents. The second type of system is the Project Information Portal (PIP). These systems are usually free and are used to track codes, permits, economic trends, cost data, and project planning information. The third type of solution is the Project Procurement Exchange (PPE). PPE are used to electronically manage bidding and procurement (Nitithamyong and Skibniewski 2003).

When discussing WPMS there are three primary options for acquiring a system: it can be developed and hosted by the system owner, it can be purchased and hosted "in-house" by the system owner, or it can be purchased as service while a vendor hosts the system (Nitithamyong and Skibniewski 2004). Developing an in-house solution can work well for a

large firm working far in advance of the need. However, developing an in-house solution can be quite expensive depending on the circumstances. Purchasing software and self-hosting can serve as a middle ground when owners do not want to develop software, but want the information to reside on their own servers. This generally has a reduced initial cost when compared to custom developed software, but still requires a significant amount of in-house technical know-how and equipment. The final option is to lease the software in an Application Service Provider (ASP) or Software as a Service (SaaS) agreement. In this arrangement the owner typical pays a monthly fee for a third party to host and maintain the system. This option is gaining popularity because it requires minimal, technical, financial, and human resources to develop and operate. It also allows for the most rapid deployment of the system. Often this option is most viable for small to medium size companies who lack significant technical resources (Nitithamyong and Skibniewski 2004; Chan and Leung 2004).

Regardless of the hosting situation access to WPMS are usually password protected to prevent unauthorized access to information contained on the site. The use of a user login also serves an additional purpose. By requiring users to login, the system can track what each user does in the system and also restrict what users have access to (Nitithamyong and Skibniewski 2004). The benefit of this can be an increase accountability and reduction of errors in communication.

The application of WPMS varies significantly from system to system. In general there are four main areas that WPMS are designed to address: project information, design information, management information, and financial information (Mead 1997). The project information category contains general project information, photos, and directories of project participants. Design information contains contract drawings, revisions, and specifications. Management information contains meeting minutes, submittals, change orders, as built drawings, Requests for Information (RFI), logs, schedules and, financial information, which includes information relating to the accounting of the project. Systems can be designed to cover one or all of these areas. Other areas such as bidding and procurement have been incorporated in to systems more recently (Nitithamyong and Skibniewski 2004).

Workflow management is an important part of project websites. By incorporating workflow into a project website, users can set a predetermined route for information. For example, a workflow can be setup that will allow the project manager to assign "tasks" to users, such as responding to an RFI. When the user has completed their task the system automatically prompts the next task for that item and the user who is affected (Chan and Leung 2004).

Finally it is important for collaboration systems to be able to integrate with other systems within a company. By allowing the integration of systems WPMS can allow automatically retrieve information such as the meta-data from documents to help simplify the transfer of information from one system to another. This can greatly reduce the effort required to move information (Chan and Leung 2004).

To demonstrate what a commercially available WPMS looks like some screen shots have been included in Appendix A. The solution shown in the screen shot is Attolist, a commercially available WPMS (attolist.com). These screenshots show a basic overview of the system and also depict the submittal process. The RFI process, not shown, is very similar to the submittal process within the system.

2.4. Benefits

The primary advantage of using WPMS over other forms of project management solutions is the availability of the information. Initial project websites sought to use the Internet to provide superior means of communication. Using the Internet allowed for better access to information then means such as phone, fax, overnight mail, and email (O'Brien, 2000). Ideally this improved method of communication would lead to improved project results.

This increased availability allows anyone with a computer and an Internet connection to access the project website. This is becoming much more important as project teams are gaining geographic diversity. Also, since all project participants are accessing the same site they all have access to the same information. This means that everyone sees the same

version of drawings, which, helps increase the accuracy as well as the accessibility of information for project participants (Thorpe and Mead 2001)

Another major benefit of web-based collaboration is increased efficiency. Utilizing WPMS allows for more rapid transmittal of information. This can also help project participants deal with large volumes of information quickly (Mead 1997). Additionally, by managing information through a single web-based system all of the steps of a process can be documented in one place, and workflows can be set up to dictate the flow of information. This allows for better documentation and controls of information (Nitithamyong and Skibniewski 2006).

As projects management needs change, web-based project management systems can help construction professionals better manage a number of factors in the changing environment of construction management. These factors include: globalization, economical forces, increasing project complexity, the need to achieve faster results, rapid changes to project scope, new procurement practices, and client sophistication (Alshawi and Ruikar 2002).

2.5. Issues Affecting the Success of systems

To maximize the benefits of WPMS the proper selection and implementation of the system is critical. Regarding the implementation of IT initiatives the failures of these systems are rarely found to be technical. The majority of the time they are related to change, implementation, human and organization factors, and the roles of the management and end users (Erdogan et al. 2008). Because of this a focus on the selection and implementation of solutions is critical to the long term success of a WPMS

According to Erodgan (2008), the most common reasons for failing to receive the full benefit from collaboration systems are: poor capture of user requirements, lack of strategic approaches, lack of proper planning, user resistance to change, lack of user involvement, and technical characteristics. Of these reasons, five of the six relate to how the solution is chosen or developed and how it is implemented. Three of the six reasons directly relate to the users of the system.

To successfully implement a WPMS the first step is to evaluate the need for a system. “Most of the IT systems are usually introduced because of operational requirements, and therefore most of these fail due to the lack of alignment with the strategic and business requirements and long term goals” (Erodgan et al. 2008). When evaluating the need for WPMS some factors that should be considered are: the number of project participants, the number of physical locations of project participants, volume of information that needs to be shared, the amount of time required to set up a system, access to the Internet and computers for users, existing contracts for WPMS, user technological experience, and previous experience with WPMS (Johnson 2004). Comparing project types, it should be noted that WPMS have been mostly used on commercial projects. Nitithamyong and Skibniewski (2006) theorize this may be due to the increased amount of relatively simple drawing, such as submittals and RFIs, on commercial projects compared to heavy and industrial projects. This difference has allowed commercial project to most easily transfer documents via WPMS.

When selecting a system it is important to select a WMPS that has the same functionality as required by the project or organization. The functionality may vary based on the phase of project requiring web-based collaboration: conceptual planning, design, construction, or program management. The type of information flow required in the system: one-way or two-way and, the expense of the system and also the general type of system, file sharing or construction management. Based on these initial functions systems can be evaluated based on their features. Some important features to evaluate include are shown in Table 2.1, as listed by Johnson (2004).

Table 2.1: WPMS Features

Important Features Typically Provided in a Project Website
24/7 access to the system by secure login/password
Home page with directory and project images/logos
Team directory and calendar
Institutive easy to understand user interface
Ability of system to be minimally functional at dial-up speeds (56k)
Website secured by username/password access, firewall, and regular data backup

Table 2.1: (Continued)

Important Features Not Always Provided
Ability to search and find documents by filename, author, or text keywords
Ability to set up and customize project sites by an internal administrator
Ability to archive all stored information at the end of the project on a CD
Ability to organize and name folders as needed for document management
Email notification of posted documents with a link to the issue
Good quality customer support system including email and phone support
Drawing review and mark-up capability
Accountability: Name, time stamp, action of person accessing files on system
Storage of large amounts of data on a secure server
Important for Construction Projects
Customizable workflow for tracking documents such as RFI's
Documents management and review capability, built in file viewer
Nice-to-have Features
Executive dashboard: Ability to see hot issues across projects on one screen
Compatibility with hand-held computers for some functions
Drawing management system with secure checkout procedures
Ability to integrate new system with legacy systems
High security (encrypted) data transmission using certificates
Vendor & Internal Issues
Expected long-term viability of vendor software/ASP provider
Large customer base and number of projects under management
Mature software product, relatively bug-free, infrequent upgrades expected
Do major software upgrades include data-transition to new version?
Minimum expected changes to the software over time that require re-training
Efficient access speed - DSL/T1 line desirable
User and Situation-dependent Issues
Efficiency advantage over non-web-based existing collaboration systems
Affordable and justifiable cost
Clear value of system to critical users, such as the contractor or owner
Existing PW vendor agreement or internal PW development capability?

When comparing systems it is also important to consider the amount of unnecessary features included. The ideal system will only have the necessary functions required by the user; unnecessary functions can hinder the user friendliness of the system (Johnson 2004). Other issues that can affect a WPMS and should therefore be considered include the

reliability of the system, the security of the system, legal issues of transactions on the system, and the ownership of data at the end of the project (Nitithamyong and Skibniewski 2004).

Throughout both the evaluation of needs and selection of the system, users must be taken into account and involved. People are generally resistant to change, however the majority of people are pragmatists and are willing to accept change if they can be showed the proof of benefit (O'Brien 2000). One issue with this is it can be difficult to quantify the benefits and cost of WPMS (Nitithamyong and Skibniewski 2004). Some of most effective ways to help reduce problems with users in the system include the following two ideas. First, involve users early on in the life cycle of a WPMS, this can help reduce the end user resistance to the system. Second, predefine people's roles within the system so they know how to use the system, this can also help reduce user resistance (O'Brien 2000).

Another issue affecting the success of WPMS can be password access to the site. The use of a password implies that decisions must be made as to who can use the system. This can create boundaries within the project team. Along these lines, the degree of collaboration the website allows is an important factor in its success, truly collaborative work requires a non-hierarchal approach. Often times some control is needed in the hierarchy of systems, but this must be balanced carefully (O'Brien 2000). Additionally, while project websites are superior to many means of communication, they do create another channel of communication users must manage. Finally, the different needs of project participants must be considered, not all participants have the same needs. So while a project website may be convenient for the owner, it may also be a hindrance to the contractor.

2.6. How To Maximize Benefits

Awareness of the issues affecting the success of WPMS is critical in planning for the success of a system. There are a number of specific recommendations for working to overcome obstacles that may reduce the effectiveness of a system. Beyond addressing issues regarding the selection and implementation of a system it is important to get upper management support for the system. This should include designating a "Champion", someone who personally takes responsibility for the WPMS. Also, the website needs to be

explicitly defined prior to the project and these definitions and guidelines for use need to be enforced. The roles of people need to be laid out and users must understand that not everyone may personally benefit from the use of the solution. Generally, WPMS should not be imposed on a project already in progress (O'Brien 2000).

Proper training of system users also serves as a way to help improve the success of a system. When training system users it is important to make sure the system performs properly during the training seminar. Also including the system "Champion" in the training can help improve success. Providing training for critical users prior to the training general users can also be helpful. The training should focus on the parts of the system the users will be using and should be completed near the use of the system, ideally within two to three weeks of use. Finally, trainers should follow up with trainees after the training to find out how they are doing (Johnson 2004).

Erodgan (2008) has identified nine steps for successfully implementing collaboration:

1. Recognize need for a new system
2. Feasibility analysis
3. User requirements capture
4. Design of technical system
5. Planning the adaption process
6. Choosing the optimum amount the adaptive alternatives
7. Testing and evaluation
8. Implementation
9. Fine tuning

2.7. Future

As web-based project management continues to mature a number of trends are expected. Firstly, there will be a reduction in the number of available solutions. Additionally, there will be a standardization of features, more integration between systems, a decrease in price, and an increase in data security (Nitithamyong and Skibniewski 2004). This will be seen as WPMS solutions work their way further down the ladder from the large projects and contractors to medium and smaller ones. As the benefit of these systems are

more widely recognized they will be more widely incorporated in projects, and a "new era of productivity will be begin to unfold" (Nitithamyong and Skibniewski 2003).

2.8. Action Research

Action research as a research method has been widely used in the social sciences. Action research is used because it allows research to be conducted while investigating and solving actual problems. Action Research differs from traditional research in that its emphasis is to "improve" rather than "prove". The goal of action research is to help better understand situations and thus resolve problems that arise (Hauck and Chen 1998).

Utilization of the model of action research described by Susman and Evered has been used to research software (Olesen and Myers 1998). This action research method includes five steps: diagnosing, action planning, action taking, evaluation, and specifying learning. The first step, diagnosing, involves identifying the problems that need to be addressed. The second step, action planning, entails determining what actions will be taken to eliminate the identified problems. Thirdly, in the action taking step the planned actions are implemented. In the fourth step, evaluation, the results of the actions are reviewed and compared to their intended results. Finally, in the specifying learning step, the knowledge captured during the process is specified and communicated to both the organization participating in the research and the scientific community. The cyclical nature of this method allows the benefit of conducting multiple iterations (Susman and Evered 1978).

Action research has served as a good method for many information technologies. By allowing researchers to test theories, gain feedback, and modify the theory through close work with developers and system action research allows researchers to address immediate concerns. The iterative nature also allows knowledge learned in the research to be directly applied back into the project. This emphasis on collaboration makes action research well suited for information technology research (Olesen and Myers 1999).

While action research has been praised for the relevance of its results it has also been criticized for its lack of rigor (Davison, 2004). Because of this, researchers must make sure they are explicit with their aim, theory and method to protect the integrity of their research.

If the work that is lacking in these areas that is at risk for being considered as consulting rather than research work (Olesen and Myers 1999).

2.9. Rapid Prototyping

To help meet the demands of a faster pace economy rapid application development (RAD) has become an increasingly popular route for the development of software. The goal of this technique is to accelerate the design and deployment of prototype solutions. RAD accomplishes this by actively involving users in the design and by accelerating the phases of the solution development and deployment to decrease the time until users see working solutions (Whitten et al. 2000).

Utilization of RAD offers many benefits. RAD almost always results in a lower cost of software development and often better quality. Using RAD on projects can help better meet business needs, fit user capabilities, reduce system bugs, improve human factoring, and create systems that can continuously evolve (Martin 1991).

2.10. Surveys

Surveys can be used to collect information about a variety of topics. Using surveys serves as a good way to gather information directly for groups of people (Fink, 2006). They can be conducted through various mediums and in various formats to obtain information (Tull and Hawkins 1980). The format and medium of a survey can greatly impact its results, so it is important to evaluate how a survey will be conducted.

Surveys can be conducted as structured or unstructured depending on how close the interviewer sticks to the wording of the questions and instructions of the questionnaire. Structured interviews reduce interviewer bias which can help control the responses of interviewees. Unstructured interviews allow the interviewer more control in the administration of the questionnaire. This type of interview is best suited to a topic where less is known about the subject being investigated. Because of this unstructured interviews are often used in exploratory interviews (Tull and Hawkins 1980).

Surveys are also differentiated by the way the interview questions are presented to interviewees, direct or indirect. In direct interviews, interviewees are aware of the purpose of the questions they are asked. This help make the response easier to interpret. Indirect questions mask the purpose of the questions. Indirect techniques are generally used when direct questions are not available (Tull and Hawkins 1980).

When designing a questionnaire there are a number of considerations that must be taken into account. Seven areas to consider are: preliminary considerations, question content, question wording, response format, question sequence, physical characteristics of the questionnaire and the pretest. Moving through these categories in developing the questionnaire serves as a good way to make sure that a survey has been designed in a manner to provide good results (Tull and Hawkins 1980). Properly creating a survey will help insure a reasonable response rate and also accurate results.

Once the results of a survey and have been received and compiled analysis of the results must be conducted to gain insight into the results. Statistical analysis can be conducted to find correlations, regressions and descriptive statistics (Fink 2006). Using the results of the survey and analysis, graphs and figures should be created to visually depict the results of the survey.

2.11. Summary

Based on the literature review, previous research has identified many benefits associated with the use of WPMS. This research has also investigated what affects the success of WPMS. However, research has not been conducted to find out what the specific needs of the horizontal construction industry are, or what level of implementation exists within the horizontal construction sector. Conducting surveys could serve as away to investigate the level of adoption of WPMS within the horizontal construction industry. Additionally, the methods of action research and RAD could serve as ways to investigate how WPMS could improve project management within the horizontal construction sector, and help implement solutions.

CHAPTER 3: WEB-BASED PROJECT MANAGEMENT IN HORIZONTAL CONSTRUCTION

3.1. Introduction

The size and complexity of large construction projects present many unique challenges. Along with the increased cost of these projects there is a substantial increase in number of shop drawing submittals and RFI's that are processed. The quantity of these documents and others can make their management difficult. Utilization of web-based project management systems (WPMS) on projects to transmit, track, and store these documents can help simplify their management. The benefits of using web-based project management to manage these documents can include decreased transmittal time, decreased documentation errors, increased transparency, and faster access to data for project participants (Nitithamyong and Skibniewski 2004; Nikas et al. 2006). This ultimately has the possibility to help all project participants better manage projects.

As the Internet came of age in the new millennium it was predicted to revolutionize the way that information would be managed (Anumba and Ruikar 2001). Among many areas, project management was seen as an area that could be greatly affected by the Internet in the near future (Alshawi and Ingirige 2003). A survey conducted for Adobe Systems in 2005 regarding the means of communication in architecture, engineering, and construction found that only 17% of respondents used WPMS to exchange files. In 2005 separate survey by Engineering News Record (ENR) showed that 80% of readers involved in information technology (IT) purchases felt that improving communication and collaboration was the most important contribution of technology to their company in the next five years (Sawyer 2006).

A scanning team of horizontal construction professionals was created by the FHWA in 2005 to tour vertical construction projects and companies. The goal of scanning team was to look for innovations in the vertical construction industry that could be applied to horizontal construction. One innovation recommended for further implementation in horizontal construction was WPMS (FHWA 2005).

Researchers at Iowa State University sought to find out how prevalent the use of WMPS is in the horizontal construction industry and in what applications did owners most desire the features of WPMS. Since the use of WPMS is often driven by the owner of a project, researchers surveyed state departments of transportation (DOTs) to answer several questions.

3.2. Previous Research on Web-Based Collaboration

Past research identified many benefits associated with the use of WPMS. The most widely anticipated benefit of using WPMS is improved communication. Communication has been shown to have a direct impact on the success of a project and its associated productivity (Chassiakos and Sakellaropoulos 2008). Improved communication on projects results in benefits in a multitude of areas. Nitithamyong and Skibniewski have stated some of these benefits to be increased quality of documents and speed of work, better financial control, and simpler and faster access to common data as well as a decrease in documentation errors (2004). Furthermore, increased transparency, time savings, and cost savings have also been attributed to improved communication through web-based collaboration (Nikas et al. 2006).

One of the major issues limiting the success of WPMS is in the implementation. When implementing WPMS many concerns must be considered beyond the technical aspects of the system. Erdogan (2008) states that many systems fail due to a lack of focus on factors related to change, implementation, human and organizational factors, and management of end user. Because of this, many systems that are technically sound ultimately fail upon implementation. Additionally, as with many information technology initiatives, it is difficult to quantify the benefits of using WPMS. Technical issues such as system security and reliability as well as legal issues can also hider the success of a WMPS (Nitithamyong and Skibniewski 2004).

A review of literature has shown that the benefits of WMPS and the barriers to successfully implementing them have been already researched and are fairly well grasped. Research has also been done as to how to overcome these barriers (Dossick and Sakagami 2008). However, since the FHWA published their report recommending further use of

WPMS in the horizontal construction sector, not much has been written about the level of adoption. Additionally, changes in the WPMS market have made them much more widely available and cost effective for smaller companies and projects. This has specifically been seen with the recent influx of WPMS marketed through Software as a Service (SaaS) agreements, where the vendor hosts the solution and customers purchase on-demand licenses (Nitithamyong and Skibniewski 2006).

3.3. Implementation of WMPS in Horizontal Construction

In the fall of 2008, researchers from Iowa State University along with personnel from the Iowa Department of Transportation conducted a survey among state DOTs. The DOTs were surveyed to find out if they were using WPMS to manage construction projects, and if so, in what capacity the systems were being used. Based on the responses of these surveys, researchers sought to get a baseline understanding of the prevalence of WMPS in the horizontal construction sector.

Surveys were sent out to 51 different Chief Constructions Engineers at state DOTs and the District of Colombia's DOT. Surveys were emailed directly to the Chief Construction Engineers with blank spaces provided for their answers. This format was chosen to make the survey user friendly for the respondents.

Of the 51 surveys sent out, 27 responses were received. Among the states responding to the survey, only three states, or 11%, indicated that they used WMPS on projects in order to collaborate with project participants from multiple organizations. Another six states, or 22%, identified using project management software, but only internally.

A follow up with these three respondents that use WMPS external to the DOT showed that each of the three was currently in the process of implementing the system and did not have it fully operational as of the fall 2008. These respondents were implementing a variety of solutions, both custom and commercial. Additionally, these respondents planned to use the systems on all projects, not just select large and complex projects.

3.4. Functional Needs for WMPS

In the fall of 2009 Iowa State University researchers conducted a second survey of the Chief Construction Engineers from state DOTs to find out in what areas they felt WPMS could assist them with in the management of their projects. The survey asked the respondents questions in two areas. First they were asked which construction documents were the best candidates for WPMS assistance. Second, respondents were asked which project participants would be best served by access to WMPS.

The survey listed various construction document types and typical project participants and asked respondents to rate whether or not they felt that web-based collaboration would be beneficial for their management or benefit. Respondents were asked to state their agreement with statements using a five point Likert scale regarding the possible benefit of managing each document type with WPMS or granting a project participant access to WPMS. As with the previously described survey, researchers again contacted the Chief Construction Engineers of the 50 state DOTs and the District of Colombia DOT through email. In total, eighteen responses were received providing a response rate of 35%.

A review of the responses to the first set of questions regarding the value of managing various construction documents with WPMS indicated that the average response to the questions was 3.7 out of 5. Removing the responses regarding two the questions relating to document types that are not common in horizontal construction, Leadership in Energy and Environmental Design (LEED) credit documentation and Architect's Supplement Instructions (ASI), the average response rose to 3.8. This showed a general interest in WPMS and the feeling that WPMS could help better manage many types of construction documents.

Based on the survey answers, areas that respondents felt could be best aided by WPMS were in the management of shop drawing submittals, RFI, and progress reports. The only area where respondents indicated WPMS would not aid them, shown by an average score of less than three, was in the management of LEED documentation. This was expected since LEED certification is more applicable to vertical than horizontal construction projects.

Architect's Supplemental Instructions (ASI) was one question that received a high ranking of importance unexpectedly since this is not a common construction document type in horizontal construction. It is hypothesized that ASI's were ranked highly since they are often synonymous with an equivalent document for horizontal construction. These two questions were included in the survey to better gauge the relative importance of construction document types. A graph of the average response for each document is shown Figure 3.1. The ranking values correspond to 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree with respect to how much each feature could assist in project management.

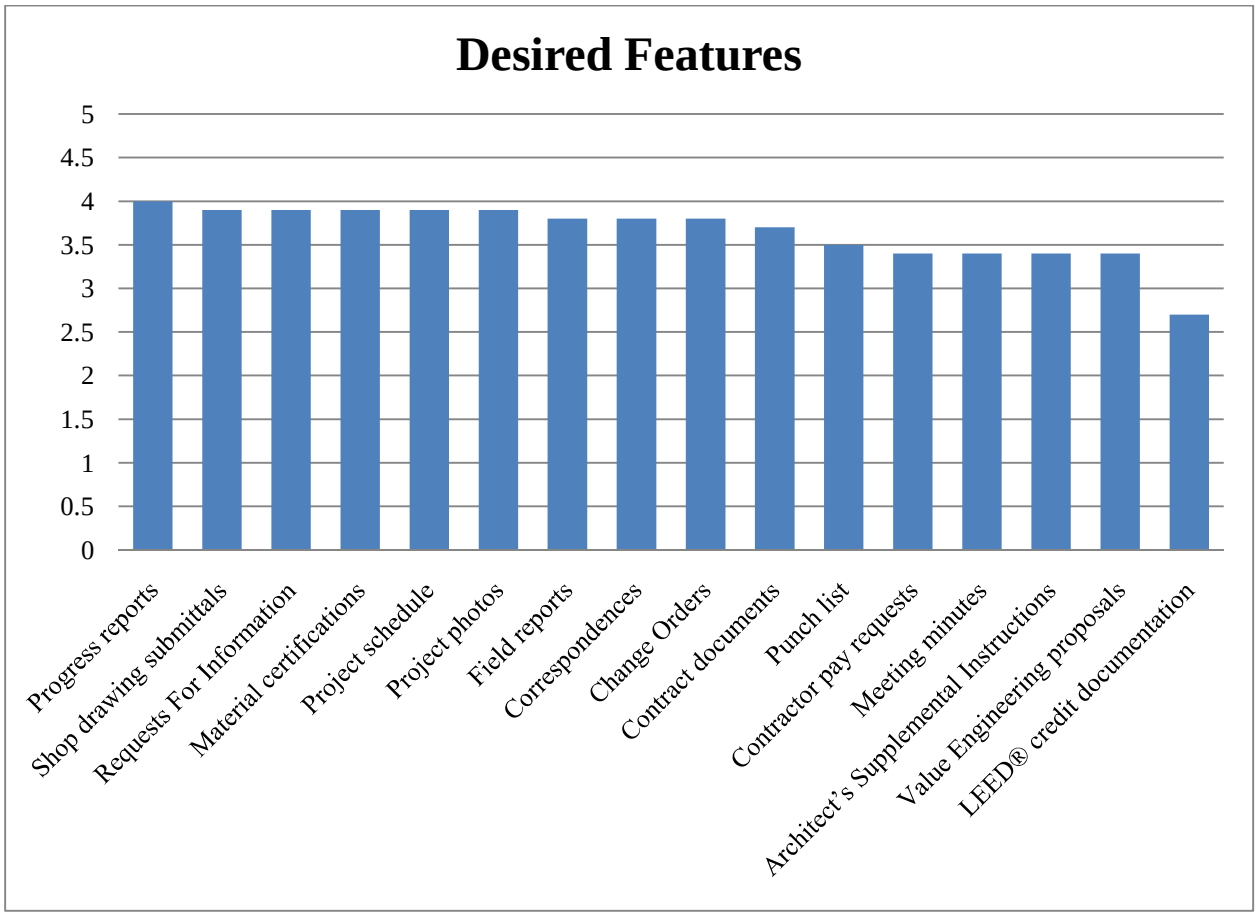

Figure 3.1: Desired Features of WPMS

In the second part of the survey, respondents were asked who on the project team would most benefit from the implementation of WPMS. Respondents to the survey gave an average ranking to this set of questions of 3.8, again showing a general interest in providing

WPMS and the feeling that it would aid most project participants in the management of projects.

Respondents indicated that both office and field members of the owner's organization and the prime contractor would be most benefited by access to web-based collaboration. Strong preference was also given to the consultant, subcontractor, and material testing agency. One participant with surprising results was the architect. The high importance given to architects, who often are not involved in horizontal projects, may be because the survey respondents assumed that the term *architect* was synonymous *designer*. A graph of the average response for each user is shown Figure 3.2. The ranking values correspond to 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree with respect to how much each participant would benefits for access to WPMS.

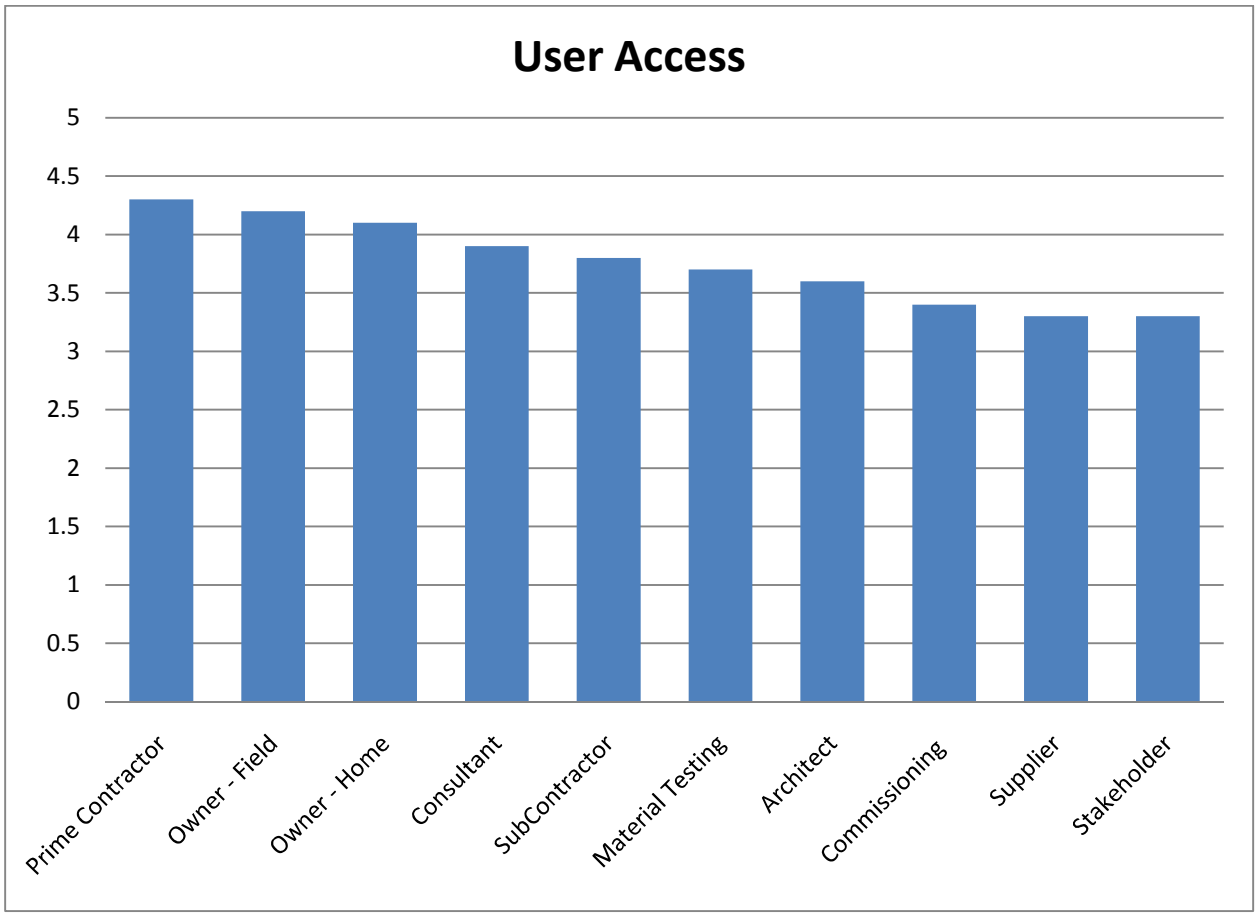

Figure 3.2: User Access to WPMS

3.5. Discussion

The current implementation rate of 11% for WPMS by state DOT's versus an implementation rate of 17% by respondents to the 2005 survey conducted for ENR indicates that the use of WPMS in the horizontal construction sectors is less than in other sectors. However, while only 11% of the state DOTs responding to our survey indicated that they use WPMS for project management, the use of these systems by state DOTs seem to be increasing. Additional interviews by researchers with personnel from the state DOTs that responded to the survey have shown that at least two states have subsequently begun implementing WPMS on select large bridge projects or when innovative contracting methods are used. Sometimes the use of these systems is even driven by the contractor, which in turn exposes the state DOT to the use of WPMS for future use. Some of the states responding to the survey that had previously only used project management software internally were beginning to branch out and allow other project participants access to the systems. These results show that the implementation of web-based collaboration in horizontal construction is increasing.

The construction documents listed in the first part of the second survey are managed by most commercially available WPMS. As WPMS systems have matured they have grown to encompass the management of most construction documents. With the average response exceeding three, indicating that WPMS could help manage that particular document, for fifteen of sixteen construction document types WPMS seems poised to meet the project management needs of the DOTs. Furthermore, the contractor was given the highest importance of project participants who would benefit from access to WPMS showing the increasing need for external access to project information. This will make systems such as WPMS even more appealing in the future.

Examining the highest categories rated by the respondents in both parts of the second survey could serve as an effective way to begin to implement WPMS. By targeting only a three documents and four project participants state DOT's may be able to begin to implement WPMS more easily. Based on the results of the survey the best documents to begin with would be shop drawings submittals, RFI's, and progress reports. The project participants to initially focus on include the owner's main office and field office, consultant, and contractor.

Reducing the number of documents and project participants initially involved in an implementation effort would likely help implementers focus on issues that may hinder the success of a WPMS while simultaneously reducing the effort required to implement one.

3.6. Conclusion

While the current level of adoption of WPMS among state DOTs is lower than the rest of the construction industry, the level of adoption is changing rapidly. During the time elapsed between the two surveys researchers noted an increase in the number of states utilizing WPMS. As more states become exposed to WPMS and learn how their organization can benefit from it, the level of adoption should continue to increase.

As states begin to evaluate their need for WPMS and implement it the results of these two surveys could serve as a way to help the DOTs focus initial efforts implementing a system. By utilizing WPMS to manage key construction documents and connect key project personnel, state DOTs could more easily initially implement basic versions of WMPS to help manage projects. This could allow organizations to test WPMS with reduced cost and risk. Additionally, focusing on only a couple documents could serve as a way to expose WPMS to project participants with simpler interfaces, thus possibly reducing user resistance. Ultimately helping organizations better implement WPMS to meet their needs.

In conjunction with these surveys researchers conducted a case study with the Iowa DOT. To assist the Iowa DOT in managing large bridge project researchers worked to implement WPMS. Researchers began with only a two construction document types and four of user types. To meet the Iowa DOT's needs researchers implemented a system to help mange shop drawing submittals and RFIs. The Iowa DOT already has a system to manage progress reports. Access was given to Iowa DOT personnel both in the field and in the main office, contractors, and consultants.

Workings with these initial needs researchers were able to implement a preliminary WPMS to meet the Iowa DOT's needs. Use of a preliminary solution allowed researchers to rapidly implement a system with reduced cost and risk. Additionally, this allowed researchers to better identify needs for a more permanent solution and investigate issues that could hinder the success of a solution.

CHAPTER 4: WEB-BASED PROJECT MANAGEMENT ACTION RESEARCH

4.1. Introduction

As construction projects incorporate more complex details and schedule durations shrink, the management of these projects becomes more complex. Additionally, as project teams become more geographically diverse, communication between team members becomes an increasing challenge. The use of web-based project management systems (WPMS) can help unite project teams and enhance their effectiveness; these solutions can be used to manage bids, schedules, budgets, documents, and construction administration. The result is more rapid transmittal of information, more accountability and transparency between team members, and easier access to information for project participants in comparison to other collaboration methods. Ultimately, WPMS offers the prospect of improved project success for all participants.

In 2008 the Iowa Department of Transportation (DOT) initiated a five year period in which the construction of several complex bridges would occur. As construction began on the first of these bridges, the agency became aware that their current project management practices were insufficiently effective for these larger projects. The size of these projects meant that a DOT Engineer would be overwhelmed with thousands of scattered emails for a single project that had to be rethreaded in order to understand the underlying issues. An investigation showed that the primary cause of this information overload to be related to the management of shop drawing submittals and Requests for Information (RFI). The need to effectively manage information on these large bridge projects without an increase in personnel resources drove the Iowa DOT to consider the utilization of WPMS.

To evaluate and implement WPMS, researchers began investigations using the method of action research: an iterative process of continuous improvement. This allowed researchers to not only evaluate the effectiveness of WPMS as a solution to project management needs, but also to develop temporary work around techniques that addressed immediate project needs and served as a test bed for subsequent full WPMS implementation. Since the Iowa DOT has considerable in-house information technology expertise, partial

custom WPMS solutions were developed as part of early action research iterations. This incorporated the method of Rapid Application Deployment (RAD) on the bridge projects that were currently in need of the solutions. This not only helped the Iowa DOT better manage these projects, but also gave researchers initial feedback on the feasibility of WPMS as an improved management tool for bridge projects. Utilizing these processes, researchers have worked through two full action research iterations with the Iowa DOT and at this writing are in the process of executing a third iteration.

4.2. Theoretical Basis

As the technology has developed and costs have decreased, the use of WPMS in the construction industry has become more prevalent. Additionally, the improved communication associated with WPMS is increasingly being viewed as a necessity to projects. A survey conducted in 2005 by Engineering News Record (ENR) showed that 80% of readers involved in information technology (IT) purchases felt that improving communication and collaboration would be the most important contribution of technology to their company in the next five years (Sawyer 2006). This push for collaboration on projects is compelling an increase in the use of WPMS. In the past, web-based collaboration solutions were primarily used for long-term, high-budget projects (Sawyer 2004). More recently the influx of WPMS solutions have been marketed as part of a Software as a Service (SaaS) agreement, where the vendor hosts the solution and customers purchase on-demand licenses, have made WPMS much more widely available and cost effective for smaller companies and projects (Nitithamyong and Skibniewski 2006).

Many benefits have been attributed to the use of WPMS, with the most widely anticipated benefit being improved communication. Communication has been shown to have a direct impact on the success of a project and its associated productivity (Chassiakos and Sakellaropoulos 2008). Improved communication on projects results in benefits in a multitude of areas. Nitithamyong and Skibniewski (2004) have stated some of these benefits to be increased quality of documents and speed of work, better financial control, and simpler and faster access to common data as well as a decrease in documentation errors. Furthermore,

greater transparency, time savings and cost savings have also been associated with improved communication through WPMS (Nikas et al. 2006).

While WPMS offers great possibilities, many implementations of such solutions fail to realize their full benefit. One of the main reasons for the failure is the lack of focus on concerns related to change, implementation, human and organizational factors, and management of the end user. Therefore, many systems that are technically sounds ultimately fail upon implementation (Erdogan et al. 2008). The success of WPMS also may be hindered by the difficulty of quantifying cost and benefits, system reliability and security, ownership and legal issues, and Internet access (Nitithamyong and Skibniewski 2004).

Because collaboration solutions sometimes fail to achieve their full benefits, their proper selection and implementation is critical to ensure success. Recent research has identified a number of factors affecting the success of an implementation. When implementing a system, is it important to align the goals of the system with long term strategic goals of the organization. Additionally, significant attention must be given to the end user. The requirements of the users must be met by the system and the users should be involved in its implementation. As part of this process user resistance to change must be addressed (Erdogan et al. 2008). Consideration of not only the functionality of the system to the project, but also the functionality for the users is necessary for WPMS to be successful.

4.3. Research Method

Throughout this project researchers met the immediate needs of the sponsor and started working toward the implementation of a long term solution. To meet both of these aspects, researchers chose to use action the research methodology and also incorporate RAD into the creation of custom partial WPMS. By using both methods researchers were able to quickly implement partial solutions while using these and future implementations as stepping stones for an ultimate solution to meet future project management needs.

This investigation was guided by the action research methodology outlined by Susman and Evered (1978), a process entailing five steps:

1. Diagnosing: Identification of the problems that need to be addressed
2. Action Planning: Determination of what actions will be taken
3. Action Taking: Planned actions are implemented
4. Evaluation: The results of the actions are reviewed
5. Specifying Learning: Knowledge captured is specified and communicated

This project utilized the cyclical nature of this method to take advantage of the continuous improvement through multiple iterations.

Within the action research method, the custom development of solutions was driven by the RAD technique. The goal of this technique is to accelerate the design and deployment of prototype solutions. RAD accomplishes this by actively involving users in the design and by accelerating the phases of the solution development and deployment to decrease the time to implementation (Whitten et al. 2000). As with the overriding action research process, RAD is also iterative allowing continual improvement of prototypes. RAD served as an excellent complement to the action research method used. Together, the methods addressed immediate needs while working toward a long term solution.

While the literature includes several theoretical explanations and case study examples regarding action research and RAD, none address in detail how the first one or two iterations may be started, especially within a construction context. This article addresses that gap by offering a case study about how a team initiated action research during the early stages of a state transportation authority funded research project by involving the sponsor's technical advisory committee (TAC) and the research team during the initial stages of the investigation. The TAC members shown in Table 4.1 helped developed the first two solutions, participated in the pilot projects, and served on the committee for the development and issuance of an Request for Proposals (RFP) for a more permanent solution. The process used here may be generalized elsewhere, because many investigations are conducted that include a research team that is guided by a TAC in an effort to help identify or develop a new process that benefits a sponsor.

Table 4.1: Technical Advisory Committee

Technical Advisory Committee Membership
4 DOT Construction Engineers
2 DOT Bridge Engineers
7 DOT Information Technology Specialists
2 Consultant Engineers
2 Contractors
1 FHWA Representative

Concurrently with the first and second iteration, the research team executed some of the diagnosing and action planned steps of the third iteration. This included systematically conducting interviews to document workflow, reviewing possible solutions, and developing a rating system for the selection of proposals that would be tendered in response to a future RFP that would result from the third iteration. The evaluation phase of the first and second iterations contributed to the research team's understanding of the workflow and necessary functionality for that was needed for planning the third iteration.

4.4. First Iteration

The first iteration began shortly after the agreement between the research sponsor and the research team was established. The research sponsor charged the research team with helping the sponsor to select an appropriate WPMS tool; it was anticipated the such a tool would have the ability for all project participants to upload and download documents such as submittals and RFIs, facilitate the workflow as such documents are reviewed, and track the status of each document in a fully automated fashion. It was expected that over the course of a year, the required functionality would be established and that a solution for pilot test would be selected using a competitive, open RFP processes. However, the research team and sponsor's TAC decided to look for opportunities to quickly develop partial solutions to provide a test bed by actually using an improved process that had partial functionality.

4.5.1. Diagnosing

The I-80 Bridge over the Missouri River was one of the larger bridges the Iowa DOT has constructed in the last decade. The large size of the bridge and complex design details related to its function as border bridge in the interstate system generated a large number of correspondences that complicated its management. The chairman and several members of the TAC were managing this project and the chairman received over 5000 emails related to it alone. The project had a large number of contract documents and managing changes was difficult for all project participants. Revisions to documents necessitated distribution of hard copies for emailed electronic copies of the new plans. Sometimes, the revised drawings were not passed on to all subcontractors and suppliers. Also in some cases, plans were given directly from Iowa DOT to subcontractors, leaving the prime contractor "out of the loop." Correspondence regarding plan changes was a noticeable part of the email problem; therefore, the chair of the TAC desired a way to improve transmittal and access to contract documents. Meetings with the full TAC were conducted to establish the needs of the different users. TAC members discussed their needs, current issues, and management practices. Members also discussed their concerns with web-based collaboration how these concerns could be addressees. These discussions lead to an initial set of needs and considerations for a system. Thus, the diagnosis for the first iteration was based on the personal experience of the TAC and limited anecdotal evidence. Although this was a modest and admittedly non-rigorous diagnostic effort, it was commensurate with the modest efforts that were contemplated for the remaining steps in the first iteration. In addition, the remaining steps in first iteration quickly provided the researchers actual experience on which to base later iterations.

4.5.2. Action Planning

Since the need for a system for the management of these documents was identified mid-way through the I-80 bridge project, it was critical for researchers to act quickly in order to implement a solution within the limited timeframe that would benefit project participants. Furthermore, researchers were concerned that there may be increased user resistance to the system, because it represented a change in the middle of a project. Based on these

considerations, plans for a system that was easy to develop and use were desirable. Since the Iowa DOT had the in-house capability to develop modest web based solutions, researchers planned to assist the Iowa DOT in developing such a solution. Using Iowa DOT's own webpage development expertise also eliminated the need to go through a time consuming process of engaging additional outside expertise though a competitive process. While utilizing the existing Iowa DOT website for development allowed for the most rapid development and deployment of the solution, limitations on staff time limited the scope of the action that could be planned. It was decided to develop a webpage that would only allow for the posting of all documents by the Iowa DOT, and none of the other project participants. No interactive capabilities were envisioned. However, this limitation was not problematic, because the Iowa DOT staff members generated all of the contract documents and was able to post them themselves.

4.5.3. Action Taking

The focus of this iteration shifted to the actual development of a solution to manage contract documents. Iowa DOT staff developed a password protected webpage as part of the Iowa DOT's website. Utilization of the existing DOT webpage templates helped to decrease the amount of time required to get the project webpage up and running. After the webpage was initially developed, the researchers and TAC members performed a review. After minor changes were made, the password was given to other project participants and they started to utilize the webpage. In addition to contract documents, the Iowa DOT also decided to post approved shop drawings and meeting minutes on the web page. Iowa DOT monitored the use of the web pages while the research team and the TAC collected anecdotal evidence on the effectiveness of new system. Figure 4.1 shows the workflow for a Contract Document on the I-80 Bridge Project. Manual transfers within the system are shown with outlined boxes.

Figure 4.1: First Iteration WPMS Workflow

4.5.4. Evaluation

As the project progressed, researchers interviewed a variety of project participants to understand what had worked and what hadn't with the project webpage. Many of the TAC members were users or developers of the system, so some of the evaluation could occur during TAC meetings. Post project interviews were conducted with system users including DOT personnel, consultants, and contractors. Interviews were informally conducted over the phone and in person to learn how they had used the system and what problems and successes they had had with the system. Based on the interviews researchers were able to make some observations. In general, project participants appreciated having the project webpage, which allowed them easier access to project information. However, the project webpage lacked considerable functionality, which project participants required. Participants wanted the features of a truly collaborative WPMS; including the ability upload documents to the webpage, post questions, render decisions and track progress.

Utilization of the Iowa DOT website served as a good way to rapidly implement a solution for this project. Its ability to serve as a location where the Iowa DOT could upload and post shop drawings, contract drawings, and meeting minutes for project participants to access met the immediate needs of the project well. However, the inability of the website to allow for two-way communication between project participants indicated the need for improvements in future iterations.

4.5.5. Specifying Learning

After implementing the first solution on the I-80 Bridge project researchers were able to learn valuable lessons for future implementations. Participants found that there was value in posting contract documents and were able to use the web page to access these items. While making project information accessible for project participants via the Internet was important, it was concluded that allowing for future implementations true collaboration would be critical. Furthermore, a solution that was designed for two-way communication would allow users to communicate back and forth to review shop drawings and RFI's. This would move the shop drawing submittal review and RFI process away from email and on to the project webpage, addressing the Iowa DOT's primary need. This would make these

processes more efficient, but would also make them more transparent and create more accountability.

4.5. Second Iteration

4.5.1. Diagnosing

Moving forward from the I-80 Bridge project a second project was chosen to further explore WPMS. For this second iteration a smaller bridge, $5 million construction budget, was chosen for the implementation. While this bridge was considerably smaller then the first bridge, it was anticipated to generate more submittals and RFIs then an average Iowa DOT bridge project due to its curved steel girder construction, pile driving requirements near sensitive structures, and aesthetic details. Thus it was diagnosed as being a good candidate for an experimental system to be developed during the second iteration. An important aspect regarding the selection of this bridge was the time frame: construction on this bridge started shortly after the end of the first iteration, which allowed for the second iteration to be done shortly following the first and in time to benefit the third iteration. The bridge was identified by using the TAC chair's knowledge of bridge projects statewide.

4.5.2. Action Planning

Following the implementation on the first project additional interviews were conducted with potential project participants. The results of these interviews showed that interviewees agreed with the users of the solution for the first iteration: the need to fully manage both submittals and RFI's through a collaboration solution in a user friendly yet effective manner.

Based on this, the focus of planning for the second iteration was to envision a system where users could upload shop drawing directly to the site for review and create RFI's within the solution and submit them for review. Along with these features it was necessary to set up an alert system to notify users when new information had been posted on the site. With timing again being an important part of this pilot project, it was necessary to rapidly develop and implement a solution. To again avoid a lengthy procurement process and provide a solution within two months, a custom solution was developed by the Iowa DOT IT Staff.

4.5.3. Action Taking

In a manner similar to that the first iteration, existing Iowa DOT webpage templates were utilized as the backbone of the solution. To complement the project website, an FTP site was setup for the uploading of shop drawings by the project participants. Using the FTP site, users could transfer large files to the Iowa DOT that would have otherwise been too large for email. Upon review of a shop drawing, the redlined versions would then be posted by the DOT on the project webpage. To further aid project participants in collaboration a web application that is hosted by Google called "Google Groups" was utilized to manage RFI's and project correspondence. The application has a forum where users can post questions or information to start threaded discussions. A "group" was created for this project and project participants were given password protected accounts. Another feature of this application is it can email users when new information had been posted on the site. Since this application was not part of the project webpage, a link was created from the Iowa DOT's project webpage to the Google Groups application. This combination of applications allowed users to complete the whole submittal and RFI processes within the WPMS. Figure 4.2 shows the lifecycle of a submittal on the second iteration's system. Manual transfers within the system are represented by the outlined boxes.

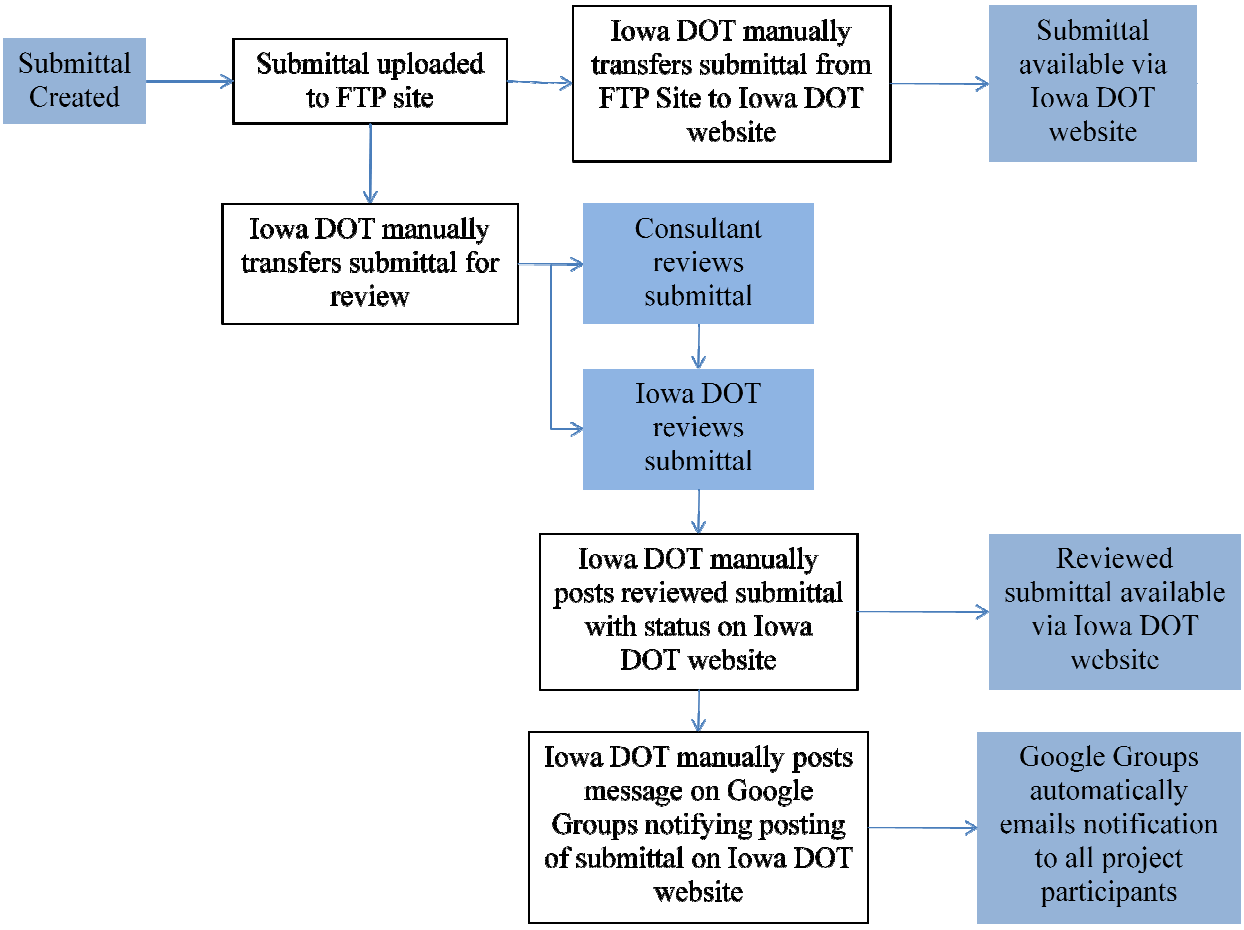

Figure 4.2: Second Iteration WPMS Workflow

4.5.4. Evaluation

As this second project was nearing completion a post project survey, utilizing open and closed ended questions, was given to 25 project participants to gauge their views of the project website. Responses to the survey showed that approximately 80% of participants felt the system used on this project made the submittal and RFI processes easier for them, increased the transparency of document management, decreased the review time of documents, and made relevant project information more available. Particularly, users appreciated the functionality of the system that allowed for two-way communication. However, responses from those who were administering the website showed that the utilization of this particular setup was not feasible for future projects due to the large amount

of administrative time spent transferring documents between the project website and the FTP site. A DOT employee would need to spend approximately half an hour per document managing its workflow during its lifecycle. Figure 4.2 shows that five events exist where manual information transfers are required for each submittal that is cycled through the system. Another issue was that while notifications indicating that new information was posted on the Google Groups project website were beneficial, some users received irrelevant emails which cluttered their inbox.

4.5.5. Specifying Learning

The second iteration of WPMS showed great improvement over the first, but also highlighted the need to refine much of the functionality. Most notably the introduction of applications allowing users to actually upload submittal themselves to the webpage was successful in making the application truly collaborative. The results of the post project survey showed that respondents had an interest in using of WPMS on future projects, and also showed a number of areas where improvement was needed. The main desired improvement was to ensure that future systems will be more autonomous. It is not feasible for administrators to manually transfer documents behind the scenes. Figure 4.3 shows a more autonomous system where administrator time is greatly reduced in comparison the system used on the second iteration: only one event in the process requires a manual transfer of information (outlined box). Additionally, while email notifications were helpful, they need to be more selective in targeting users as to not overload users with notices that are irrelevant to them. This will greatly add to the efficiency of the solution for users and administrators.

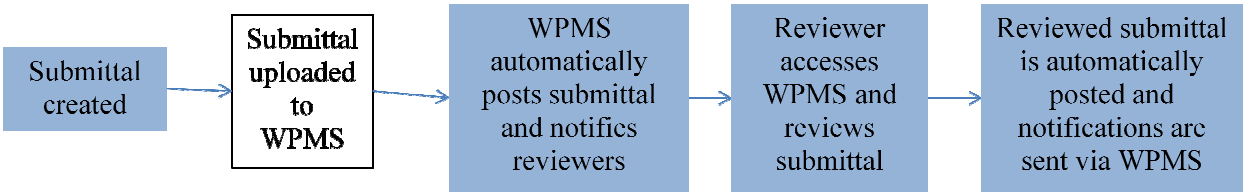

Figure 4.3: Automated WPMS Workflow

4.6. Application of Specified Learning for the Third Iteration

Having completed two iterations, the research team and the TAC confirmed exactly what functionality project participants needed from a WPMS. With the needs identified the researchers sought to implement a full featured solution that could possibly be implemented beyond this iteration. This solution would need to address the short comings of the first two solutions in order provide a viable long term solution.

4.6.1. Diagnosing

With more complex bridges in the near future and a desire to implement WPMS within the DOT and from contractors, consultants, and suppliers the Iowa DOT needed a full featured solution that could autonomously manage contract documents, RFI's, submittals, and meeting minutes. This system would need to be both user friendly and effective in meeting the needs of the Iowa DOT.

4.6.2. Action Planning

With knowledge gained from the first two iterations, the researchers sought out a more permanent solution to pilot test. Speaking with industry professionals and reviewing over thirty five commercially available WPMS, the researchers concluded that most of the functionality required by the Iowa DOT already existed in commercially available solutions. Furthermore, developing and deploying a custom solution to meet the Iowa DOT's needs would take more than a year for a fully operational system. The solution was required in less than a year. Therefore in-house custom development was not feasible and planning began for the selection of a commercially available solution.

Among commercial solutions there is great variation in many aspects of these systems, one of these being licensing options. One of these licensing options is known as Software as a Service (SaaS) agreement. In this agreement a service provider hosts and maintains the solution so that project participants can access it via the Internet. Because of this, a solution can be deployed in a matter of days or weeks, and project participants need only an email account and internet browser to access the system. Not only does this decrease

the implementation time, but it also can help reduce initial costs. For these reasons a SaaS type agreement was seen as the most advantageous way to pilot test a full featured WPMS.

Since a commercially available solution was desired for pilot testing, a formal procurement process was required in order to make sure that a solution was fairly selected. In order to do this, researchers worked with the Iowa DOT and members of the TAC to develop and issue an RFP. Using knowledge obtained from previous iterations and research an RFP was developed that specified the functionality that the Iowa DOT needed. By publically issuing this RFP, the Iowa DOT will allow for a fair chance for any company to compete to have its solution selected for the pilot testing program.

As of this writing, the researchers and the TAC are conducting the action taking step of the third iteration and are pilot testing the selected solution on an actual construction project. Since the scope of this paper is to demonstrate the initial iterations of the action research method for construction in a case study, the narrative description of the case study will end here. The following discussion and conclusions will summarize the lessons learned from this case study that can be applied to other similar projects.

3.7. Discussion

The results of the first two action research iterations for WPMS on the Iowa DOT projects showed that even though the functionality of pilot tested systems was quite limited that they did have a positive impact on the projects that they served. Users appreciated many of the features provided by the systems, but indicated that for future implementations, more robust systems would be needed. This response from the users encouraged researchers to continue the development of WPMS for Iowa DOT projects, but also indicated the need to continue to implement systems with greater capability in comparison to the solutions used in the first to iterations.

For the initial testing, the use of the iterative prototyping served as an efficient way to test WMPS. Since the Iowa DOT staff members were unfamiliar with this technology and did not know their exact needs, implementing basic, customized applications served as an effective way to test the feasibility of WPMS. By applying the principles of RAD to the

process of developing the initial solutions, the Iowa DOT was able to development solutions that not only tested the effectiveness of WPMS, but also created a positive impact on current projects. Furthermore, the use of the action research methodology worked well by helping create initial solutions that served as test beds to aid in the development of a long term strategic solution.

Additionally, utilizing the iterative process for implementing the WPMS within the Iowa DOT allowed researchers to become aware of factors during the earlier iterations that could possibly inhibit success of later iterations. Since the success of a system is very dependent on how it aligns with the needs of an organization and its users, developing a good understanding of these issues is critical. The major concerns that arose during the first two iterations were a focus on user friendliness and the need for a perceived benefit by all project participants using the system. Based on these comments researchers were able to craft the RFP so that those factors were considered during the selection of a solution.

Information obtained during the first two iterations was helpful in drafting an effective RFP, because the research team and the TAC were able to explicitly and confidently state the needs of Iowa DOT. It was expected that such an RFP would help improve the quality of proposals; therefore, providing the best response from which to make a wise selection.

3.8. Conclusion

Implementing WPMS using the action research method provided an effective way for the Iowa DOT to improve project management. By beginning with small scale systems researchers were able to meet immediate project management needs and refine understanding of Iowa DOT's long term needs and challenges were with regard to WPMS. By refining the needs of the DOT, researchers and the TAC were also better prepared to write a RFP for the procurement process that would help the Iowa DOT select a more long-term solution. This combination of short-term and long-term benefit made the action research model a good choice for developing and implementing WPMS within the Iowa DOT.

The results of the first two iterations of this project show great potential for WPMS to serve as a tool to improve project management on Iowa DOT projects. By pilot testing WMPS on Iowa DOT bridge projects researchers have been able to test these solutions as a tool to assist in the management of complex bridges and also evaluate how to successfully implement them. Researchers will be continuing to investigate WPMS by moving forward with the RFP process and selecting a solution for long-term pilot testing. As the Iowa DOT continues to expand their use of these systems and more project participants become exposed to these systems, many of the benefits of improved communication and collaboration should be further realized.

Based on the results of this research a number of lessons were learned that could be applied to other situations:

- Diagnosing and planning for initial iterations can be based on hunches and informal observations and analysis of research team members and members of the research sponsor's organization that are familiar with the area that is to be improved.
- During initial iterations, actions taken to provide partial or expedient solutions can be evaluated to specify learning that can be applied to improve later iterations.
- TAC members can become an integral part in the diagnosing, action planning, action taking, evaluation, and learning specification during the first iterations
- Members of the research sponsor's staff may be involved in the initial action taking, even though they may not have the time or expertise to become involved in later and more time consuming iterations.
- The first iterations of action research can occur concurrently with diagnosing and action planning for later iterations.
- The first iterations of action research can be part of the diagnosing and action planning steps for later iterations.

CHAPTER 5: 2009 REASEARCH REPORT

5.1. Introduction

5.1.1. Problem Statement

Bridge construction projects are becoming increasingly complex as the demand for context-sensitive solutions, aesthetic designs, and accelerated bridge construction becomes more prevalent. In addition, the Iowa Department of Transportation (Iowa DOT) is entering a phase of design and construction of large border bridges, such as the I-80 (let 2008 for $56 million) and US 34 bridges over the Missouri River and I-74 over the Mississippi River.

Compared to typical construction projects, these bridges generate more contractor Requests for Information (RFIs), Value Engineering (VE) proposals, Requests for Changes (RFCs), and shop drawings. Management of these submittals is a significant challenge for Resident Construction Engineers (RCEs) and other Iowa DOT staff. In addition, some submittals require cross-departmental and project consultant reviews. Commercially available software exists for managing submittals and project collaboration teams; in-house solutions may also be possible. Implementation is intended to speed construction submittal review time, reduce incidence of delay claims, and free up Iowa DOT staff from project management administrative tasks.

5.1.2. Research Objectives

Researchers from Iowa State University (ISU) working with the Iowa DOT conducted a multi-pronged approach to indentify a web-based collaboration solution for Iowa DOT bridge projects. An investigation was first launched to determine the functional needs of the Iowa DOT. Researchers sought to determine the current needs and practices of the Iowa DOT and other potential users of the collaboration solution. Researchers also needed to determine what would promote or hinder the success of the solution.

Concurrently, commercial software programs were evaluated to identify commercially available functionality. Researchers then worked to determine if commercially

available solutions met the Iowa DOT's functionality requirements. In many cases, commercially available solutions had capabilities beyond the functionality requirements identified by the Iowa DOT. Such excess functionality might be valuable but overlooked by potential users because they are unfamiliar with the capabilities of commercial solutions. Therefore, researchers also investigated these capabilities and considered them as possible additions to the list of functional requirements.

A comparison of required functionality and available functionality was used to make a recommendation to the Iowa DOT for an electronic collaboration solution to be used on two pilot projects. Successful utilization of the selected solution on a pilot project should serve as validation for the research and also provide lessons learned for future wide-scale implementation. Ultimately, this research will help provide the knowledge necessary for the Iowa DOT to implement a long-term solution to assist all project participants in the management of Iowa DOT bridge projects. Other government agencies in the State of Iowa could also use the results of this research in their own implementation of web-based collaboration solutions on their projects.

5.1.3. Implementation of Solutions

To initially test the functionality of web-based collaboration solutions, two pilot projects were launched prior to the formal investigation of the Iowa DOT's functional needs. First, a webpage on the Iowa DOT's website was launched for the I-80 bridge project in Council Bluffs. This website served as a place where contract documents, working drawings, and meeting minutes were posted. Following this project, a project website was launched for the Jackson 108 bridge project. This project utilized an FTP site along with the Google Groups application to create a collaborative environment for the project participants. Both of these projects demonstrated some of capabilities for collaborative solutions and the need for a more robust, full-featured solution.

Following the conclusion of the investigation of functional needs and commercially available options, a Request for Proposals (RFP) was released for a "software as a service" (SaaS) solution, or a solution hosted by the vendor as part of an on-demand agreement, to be

used on a number of pilot projects. The goal was to implement a robust, full-featured solution on a number of pilot projects in order to fully test the capabilities of web-based collaboration for Iowa DOT bridge projects. Additionally, lessons learned from these pilot projects can be applied to the development of a long-term collaboration solution for the Iowa DOT. The actual selection and implementation of the solution for pilot testing will occur in the fiscal year 2010 research period.

5.2. Identification of Functional Needs

5.2.1. Interviews

To investigate the functionality required by the Iowa DOT for a web-based collaboration solution, interviews were conducted with users who would be affected by the proposed system. Interviews were conducted with Iowa DOT employees, consultants, contractors, and suppliers. Additionally, interviews were conducted with industry professionals from other construction sectors because these professionals had more experience with electronic collaboration systems than Iowa DOT users. A survey was developed and conducted to determine the processes of other state departments of transportation (DOTs). Also, contractors and consultants with more knowledge on this subject were interviewed to determine what they had found to be important.

Interviews were conducted using a relatively ad hoc format. A questionnaire was developed based on research done by other researchers, initial contacts with Iowa DOT personnel, and initial research on commercial solutions. The questionnaire utilized primarily open-ended questions so as to not limit the responses of the interviewees and to gain the most information. Researchers also expanded some questions at their discretion to maximize the knowledge gained from the interviewees. Appendix A displays the general format of the questionnaire. Appendix B provides a list of interviewees and their employers.

5.2.1.1. Iowa DOT

Interviews of Iowa DOT personnel showed that few of them had any exposure to web-based collaboration solutions. After giving the interviewees a brief overview of typical web-based collaboration solution capabilities, most were very receptive to implementing one. Generally, most interviewees felt that a solution like this would help them considerably. Potential benefits that interviewees expected included improved turnaround time for submittals and RFIs, more accountability, easier tracking, better documentation, less paper, improved communication, and easier archiving of documents.

Concerns recognized by Iowa DOT personnel fell into two categories: user-friendliness and Internet connectivity. A widely identified possible stumbling block for successful implementation was a non-user-friendly solution. A collaboration solution should be sufficiently convenient so that people want to use it. Additionally, it is important that occasional users, such as subcontractors, are not so overwhelmed that they try to circumvent the solution. The second main concern dealt with the Internet connectivity of field offices. Slow download times from the Iowa DOT servers hinders the paperless transition. Connectivity is especially an issue with printing for the Iowa DOT; printing a 100-page document can take four hours in the Iowa DOT field offices due to how their networks are setup. Other concerns are that a solution will need to maintain the “look” of the Iowa DOT website and that security standards could make third party hosting difficult.

5.2.1.2. Contractors

Interviews of prime contractors on the technical advisory committee showed a very positive response to implementing a collaboration solution. These contractors also had limited experience with collaboration solutions but were positive when discussing the possibilities. Advantages for the contractors include possibilities for less paper consumption, easier communication with subcontractors and suppliers, faster processing of submittals, and the potential to only have to submit one copy of each submittal. Additionally, incorporating a preloaded list of required submittals into a web-based collaboration solution would be very

helpful. Concerns were mostly related to technological capabilities of contractors and user-friendliness. The general response was that most contractors who might need to use this solution would have the capabilities to use it.

5.2.1.3. Consultants

Most of the Iowa DOT consultants who were interviewed had considerable knowledge about web-based collaboration solutions, including what solutions are available and how to best use them. One of the points emphasized by the consultants who were interviewed was that it is important to make sure that the selected solution is not unnecessarily complex. Solutions with unnecessary features are usually very difficult to use, especially for occasional users. One consultant cited an example of a collaboration solution that contractors were not comfortable in using, so they relied on clerks for all data entry. Additionally, it is important to specify not only that the solution will be used in the contract but also how it will be used. When setting up a solution, it is important to include the project management team in the discussions so that current workflows and terminology can be incorporated into the solution. After the project is running, it is necessary to have someone take ownership of the solution to make sure that it is being used correctly and that participants are not working outside of the solution. The setup of the initial program can be quite involved, depending on the solution and modules used. However, once the solution is set up, maintenance is usually low, and it is typically easy to add new projects.

5.2.1.4. Suppliers

During the interviews, suppliers indicated that they transmit most of their shop drawing submittals via postal mail. However, they indicated that they are comfortable with transmitting them electronically and believe it would be quite easy for them to use one of these systems. Some of the suppliers said it is actually easier for them to electronically submit shop drawings.

Only one of the suppliers interviewed did not currently have the technology required to electronically submit shop drawings. The supplier indicated that in order to electronically

submit documents, which would not be a problem in the future, the equipment would need to be updated.

5.2.1.5. Other Construction Sectors

The Facilities Planning and Management staff at ISU were interviewed to assess their experience with collaboration solutions. ISU has used the software program Centric to manage its projects for eight years and has been satisfied with the solution. That being said, it is open to considering that there may be a solution that is currently on the market that may better fit its needs. Some reported advantages of Centric include the fact that ISU personnel have found it is easy to keep internal "conversations" private and to manage user interfaces so that only certain users can see certain items (e.g., budget). Approximately two years ago, ISU encountered problems with insufficient bandwidth. Now that broadband service is more readily available to external users, bandwidth limitations have not been an issue. If ISU were to consider an alternative system, its decision makers would put a greater emphasis on ensuring solution compatibility with handheld computers such as Blackberries. Finally, unlike other organizations, ISU does not preload submittals because participants have found out that this action results in too many "unused" submittals that clog up the submittal log and make it difficult to find which submittals are actually outstanding.

To gain a broader perspective on ISU's use of Centric, a contractor currently working for the university was interviewed. M. A. Mortenson Company is acting as the construction manager on the Hach Hall Chemistry Building being constructed on the university's campus. At the time of interview, Mortenson had used Centric for three to four months to manage the project. Overall, Mortenson feels that the program works quite well. However, Mortenson has chosen to duplicate all of Centric's documents in its own system. One of the reasons for this is due to the way Centric is setup; Mortenson is unable to turn an RFI document directly into a Change Order. The system is set up so only ISU employees can set up Change Orders. Because of this workflow, there is no way to track an issue in Centric from the time an RFI is answered to when the Change Order is created. This discontinuity in documentation has caused Mortenson to independently track all issues on its internal system so as to prevent an

error in this transition phase between documents. An additional problem for Mortenson is that it needs to have its own backup copy of data. In order to accomplish this, all documents are printed from Centric for filing.

Another commercial construction company that was interviewed was the Ryan Company. Ryan is currently in the final stages of implementing Meridian System's Proliance. This is an "Enterprise" solution that is used for tasks beyond just document management. Ryan's recent implementation of this system provides insight into the challenges of implementing one of the more complex electronic collaboration systems.

Beginning in early 2006, Ryan started searching for a new system for managing its finances and documents. The company spent most of 2006 evaluating the functionality of available systems before deciding on one in November 2006. The entire calendar year of 2007 was spent customizing the system. Finally, the system was rolled out during the first half of 2008.

Ryan's system has over 500 users, including approximately 150 project managers. To support the system, Ryan dedicated four full-time information technology (IT) specialists; some Ryan employees think they would benefit by having an additional four. All of the employees using the system received approximately one week of initial training, followed by ongoing training.

To obtain additional perspective from a company that has a well-established collaboration system, researchers interviewed an employee from the Weitz Company. Weitz has been using Prolog software for over 11 years to manage its projects; the software is used to manage issues such as RFIs and submittals and to track cost changes from Change Orders. Weitz has found that employees do not need any formal training in order to use Prolog because it is sufficiently user-friendly. While Weitz uses Prolog to manage its projects, it is not set up in a web-enabled capacity, and, therefore, RFIs and submittals are still transmitted via email or postal mail. Weitz has found that only about half of its subcontractors are comfortable with electronically managing these documents.

5.2.1.6. Other State Departments of Transportation

To find out what other state DOTs are using for electronic collaboration software, a survey was developed. The survey first asked if the DOT used an electronic collaboration solution. If it did, subsequent questions asked which solution was used, what projects it was used on, who entered the data, and who hosted the program. This survey was then sent out to all of the states. The results of the survey can be seen in Table 5.1. Of the 27 responses, 10 states reported they are currently using an electronic collaboration solution. Only three of the ten DOTs relied on people outside of their staff to enter data. Each of these three is currently in the process of developing and implementing its system. Because the systems are not up and running, limited system information was available from these DOTs.

The three DOTs that are currently implementing electronic collaboration systems for external use are Texas, New York, and the District of Colombia. All three are planning to use these systems on all of their projects, and they will be used primarily for document management. The Texas Department of Transportation is customizing FileNet by IBM for its own use, while the District of Colombia Department of Transportation is customizing SharePoint. The New York Department of Transportation is in the process of implementing Contract Manager by Primavera. All three will be self-hosted.

Responses from the survey and follow-up interviews with many of the DOTs yielded a broad range of information on the use of collaboration solutions. Some of the major concerns expressed by many of the DOTs using collaboration systems included the cost of the solution and how the solution interfaced with existing applications. Due to the variety of ways the DOTs are using collaboration solutions it is difficult to make generalizations about the solutions.

Table 5.1: State Survey

State	Web-based Collaboration Used?	Used on All Projects?	Contractor Entry?
New Mexico	No		
Oregon	No		
Wyoming	No		
South Dakota	No		
North Dakota	No		
Mississippi	No		
North Carolina	No		
Virginia	Yes	Yes	No
West Virginia	No		
Illinois	No		
Montana	No		
Arkansas	No		
Mass	No		
Alaska	No		
Hawaii	No		
Georgia	Yes	Yes	No
Vermont	No		
Minnesota	Yes	No	No
Kentucky	No		
Texas	Yes, Implementing Now	Yes	Yes
Kansas	Yes	Yes	No
Colorado	No		
D.C.	Yes, Implementing Now	Yes	Yes
New York	Yes, Implementing Now	Yes	Yes
Nevada	Yes	No	No
Ohio	Yes	No	No
Washington	Yes, Implementing Now	No	No

The Wisconsin Department of Transportation (WisDOT) was interviewed due to its recent use of Primavera Expedition (now Contract Manager) to manage the Marquette Interchange. The use of this system was supported by URS, Inc., a consulting engineering company. This system was not web-based, and WisDOT avoided connectivity problems by having a fiber cable installed at the jobsite along with an on-site server. Because this solution was not web-based and extensive training was required to learn the solution, clerks were employed to enter data into the system. On this $800 million project, 12 people were required

to manage and enter data into the system. Additionally, a technician reviewed the specifications and preloaded all of the submittal requirements into the system. Given the investments required, WisDOT indicated that it would only use Primavera Expedition on projects with a construction cost of $25 million or more.

WisDOT used Expedition for four tasks: management of change, issues, budget, and schedule. Due to the size of this project, the Federal Highway Administration required a very comprehensive management process to avoid errors and omissions, and this system helped to meet those requirements. Overall, WisDOT was very happy with Expedition and had no complaints. WisDOT found that the following capabilities of Expedition were helpful: linking issues and meeting minutes to RFIs and submittals, linking submittals to the schedule, and tracking correspondences.

5.2.2. Required Functionality

Compiling the information from all of the interviews gave a broad range of information on the Iowa DOT's needs. Researchers worked to condense this information into a list of the functional needs for the Iowa DOT. In order to best incorporate the results of the interviews into the selection of a web-based collaboration solution, researchers sought to develop a concise list of needs that could easily be transferred into questions for the sales representatives of the potential solutions. Researchers accomplished this by determining the most important needs, the frequency of certain responses to certain questions, the experience of the interviewee, and the interviewee's potential level of involvement in the future system. As a result of this process, the following list of functional needs for a web-based collaboration solution was developed:

- Is an online web-based solution
- Is specifically designed to handle construction documents
- Able to hide comments on submittals
- Able to alter workflow of documents
- Able to work outside of solution and enter information later
- Does not have excessive features if they add to complication
- Able to work with available bandwidth
- Can be accessible with only an Internet browser

- Has “ball-in-court” feature
- Has a “dashboard” to show new and outstanding documents
- Able to meet Iowa DOT “look” and ADA requirements
- Able to mark up documents without original software
- Able to work with existing Iowa DOT software
- Able to allow customization to fit Iowa DOT terminology
- Able to send email reminders
- Maintains Iowa DOT workflow
- Has a search feature
- Has a document history that is accessible to users
- Allows documents to be linked together

After this list was created, it was validated by the project’s technical advisory committee’s review. Members on this committee consisted of Iowa DOT personnel, contractors, and consultants. This list of functional needs was then used as part of the comparison between the available functionality of commercial solutions and the required functionality for the Iowa DOT.

5.3. Functionality of Available Solutions

5.3.1. Identifying Commercially Available Solutions

To investigate which electronic collaboration solutions were commercially available, a comprehensive search was carried out. Researchers sought to develop a complete list of available solutions that covered the spectrum of available functionality. Solutions were identified by searching the Internet, speaking with experienced industry professionals, and reading journal articles. The initial investigation yielded over two dozen possible solutions. Further research has identified another two dozen solutions.

The investigation of solutions focused on identifying web-based project management solutions designed specifically for the construction industry. Key words such as “collaboration,” “construction,” “project management,” and “web-based” were used. Internet search results, interviews, and publications were filtered to ensure the identified solutions met the minimum criteria. Researchers compiled a list of all of the identified programs for investigation. This list can be seen in Appendix C.

5.3.2. Categorizing Software Programs

As researchers began to investigate commercially available solutions, they noticed some primary differences between solutions. Researchers grouped solutions by these differences prior to investigating the Iowa DOT's functionality requirements. By grouping the solutions, researchers were able to more easily short-list and later evaluate appropriate solutions. These groups helped researchers better match the required Iowa DOT functionality with available functionality.

Hosting is a primary differentiating factor between solutions. Typically, commercial solutions can be self-hosted by the owner or hosted by the vendor (Nitithamyong and Skibniewski 2004). For a self-hosted solution, the solution is hosted by the owner, and all of the information resides on the owner's system. In the vendor hosting option, the vendor hosts the solution, and all of the information is kept on the vendor's system. This arrangement is typically part of a SaaS agreement. Factors influencing an organization's hosting choice can include the existing IT infrastructure, timeframe for development, and the functional needs of the company (Chan and Leung 2004). In order to most effectively test a collaboration solution on a pilot project, the authors recommended using a commercially available solution in a SaaS agreement. This would allow Iowa DOT personnel to test the solution on pilot projects with a minimal initial investment and start-up effort.

Two main functional categories existed in the identified solutions: an "Enterprise" category and a "Document Management" category. The "Enterprise" category includes software that will manage documents, schedules, and budgets. Although these programs have greater capabilities, they can be more complex for users. The programs in the "Document Management" category have been developed primarily to manage documents and construction administration. These solutions usually present less complexity to users than "Enterprise" solutions. Some programs fall in the gray area between these two categories because they do include some budget tracking (some users consider budget tracking to be linked to the "Document Management"), but the solutions do not have the level of customizability and functionality researchers associated with "Enterprise" solutions. For the

pilot projects, researchers suggested that a "Document Management" system would most likely meet the needs of the Iowa DOT. These systems contain the functionality the Iowa DOT requires without added unnecessary functionality that could cost more and reduce user-friendliness. This emphasis on user-friendliness was deemed critical by the authors based on the responses of interviewees and also work done by other researchers (Nitithamyong and Skibniewski 2006). An "Enterprise" system could more than meet the Iowa DOT's functional needs for a pilot project, but concerns with possible higher costs and challenges with the user interface may prevent such solutions from being preferred.

The licensing structure of a solution was another differentiating factor. The two most common ways to price a solution are a fixed cost for a project or a cost per license. A fixed project cost is often a fee paid based off of the total project construction cost. This is can be represented by a percentage of the construction cost. For a document management system, a typical range is 1/8% to 1/4% of the project construction cost (see Appendix D). This sort of price structure is most often associated with SaaS software and usually allows an unlimited number of users for a project. The other option is a per license fee. This fee structure can be associated with licenses specific to each person or licenses that limit the number of users that can be logged into the solution at once. This structure is most often associated with self-hosted programs. For the Iowa DOT pilot projects, the fixed cost price method would be preferred. This would allow the maximum number of users to interface with the collaboration system in order to learn the most from the pilot project. Using a solution with a limited number of licenses may limit the number of project participants that can be directly involved in the web-based collaboration and the lessons learned for future projects.

The structure of the workflow of documents can vary greatly from solution to solution. Some solutions use a very rigid workflow where documents have a predetermined and unchangeable path they must follow. Other solutions have a very flexible workflow where the document creator chooses the document's path. Along this path, users can reroute the document as necessary. Other solutions use a gatekeeper. In this setup, the gatekeeper controls the flow of all documents between the contractors and the owner or consultant. For the Iowa DOT, it was determined that a combination of these options would best preserve the

current workflow, which was important as identified during the interview process. For the pilot project, researchers recommended that the RCEs act as the Iowa DOT gatekeepers; this would best preserve the existing Iowa DOT workflow and would provide a structure that would encourage RCEs to stay informed on project progress. Researchers also recommended that reviewers have the flexibility to reroute documents in case they need to be reviewed by a person with greater expertise. The Iowa DOT does have a predetermined workflow for submittals, but since all of the submittals would be funneled through the RCE, a flexible workflow would allow the RCE to customize the workflow somewhat without sacrificing a reasonable amount of supervision by a knowledgeable Iowa DOT representative.

The amount of allowable customization varies from solution to solution. Some solutions allow significant customization so that the solution can interface with existing programs to automatically transfer information on budget, etc. to and from the solutions. Other systems only allow changing terminology on the user interface and reports. Typically, the larger programs that are self-hosted allow the largest amount of customization, while the SaaS solutions offer the least amount of customization. For the pilot project, a minimal amount of customization will be required. It would be beneficial to change terminology to maintain consistency with the current Iowa DOT practices. Some minor changes may also need to be made to the forms and workflow of the system. This amount of required customization is consistent with what is available from most SaaS solutions.

5.3.3. Review of Solutions

With over two dozen programs identified during the initial investigation, it was necessary to narrow the list of programs that would be fully evaluated. The researchers worked to pare down the list of programs for evaluation to around one dozen to ensure that the evaluation of the remaining WPMS solutions would be comprehensive. The researchers identified which programs initially seemed to best meet the Iowa DOT's needs. This initial evaluation was done by reviewing vendor websites. Solutions that were not specifically geared for the construction phase of projects were eliminated. Additionally, programs that did not meet the Iowa DOT's basic functionality needs identified during the interview

process were eliminated. The result of this short-listing process was a list of 12 programs that initially met the Iowa DOT's requirements.

After a list of programs for further evaluation was developed, a review process was devised to objectively compare the short-listed solutions. Using the functionality requirements of the Iowa DOT along with a list of concerns about implementation and cost, a set of questions was developed to be used to review each solution. The questions were developed to be sufficiently objective to allow the most direct comparison between solutions. Prior to the evaluation of the short-listed solutions, demonstrations were conducted with four vendors to assist researchers in gaining a basic understanding of what was commercially available in order to develop questions that would best compare the solutions.

In order to review of the 12 short-listed solutions, researchers observed web meeting demonstrations (with an audio connection provided by a simultaneous conference call) with each of the vendors. Vendors presented the functionality of their solution, and the researchers followed up with questions in order to complete the questionnaire. Each of the vendors was allotted an hour and was given similar prompts regarding the Iowa DOT's needs and the issues driving the project. Upon completion of all of the demonstrations, the questionnaires were combined into one matrix to assist in comparing the solutions. This matrix can be seen in Appendix D.

An analysis indicated that many of the solutions were quite similar. Furthermore, multiple solutions appeared to meet the requirements of the Iowa DOT. In order to make the selection of the solution objective, the researchers chose to issue an RFP for the actual software selection for pilot testing. The RFP was developed by the researchers and the Iowa DOT and issued by the Iowa DOT. This process ensured that all vendors had an equal opportunity to submit a proposal for their solution to be selected for use on the pilot projects. Due to this decision, no recommendation was made for a specific solution based on the review process.

5.4. Limited-Scale Pilot Projects

5.4.1. I-80 Project

The I-80 bridge replacement project in Council Bluffs (project number NHS-080-1(318)0—11-78) is one of the largest bridge projects the Iowa DOT has recently managed. The size and complexity of this project generated more shop drawing submittals and RFIs than the Iowa DOT typically manages. Due to the large number of submittals, the Iowa DOT needed to develop a method to track the project documents different from the typical method of tracking through email. In an attempt to address this challenge, the Iowa DOT IT Division developed a project website for this bridge.

The project website was a page built on the Iowa DOT's website. This page required users to log in with a password-protected user ID. The website served as a location for the Iowa DOT to post contract drawings, working drawings, and meeting minutes.

The website served as a worthwhile partial solution for the challenges presented by the I-80 bridge project, but it only allowed a minimal amount of collaboration. Users were able to obtain many documents and other useful information on the site, but they were unable to interface with the site or receive notification when new information had been placed on the site. Additionally, document could not be reviewed within the site; the site only allowed the posting of final drawings.

5.4.2. Jackson 108 Project

To test some of the capabilities of web-based collaboration systems, a pilot project was launched on the Iowa DOT's bridge replacement project located at the US 52 crossing of ICE Railroad and Mill Creek in Jackson County (project number BRF-052-1(70)—38-49). This project is more commonly referred to as the Jackson 108 bridge. The Jackson 108 bridge was chosen for a pilot project due to the timing of its construction and the amount of submittals and collaboration required to construct it.

The system used for electronic collaboration was a combination of the Iowa DOT website and the Google Groups application. A publically accessible webpage for the Jackson 108 bridge was set up on the Iowa DOT website (www.iowadot.gov/jackson108/plans.html). This webpage posted the proposal, plans, addendums, special provisions, specifications, plan revisions, vibration monitoring reports, and meeting minutes for the project. The webpage also had a link to upload shop drawings via an FTP site. To facilitate further collaboration, the "Jackson 108" group was set up using the Google Groups application and linked to the Jackson 108 webpage. The Google Groups application created a password-protected place where project participants could upload RFIs for review and collaborate on project issues through online discussions.

For the Jackson 108 Bridge, the combination of the Iowa DOT website and Google Groups application served as a simple way to pilot a web-based collaborative environment. The two components of this pilot project did not require a large investment of time and allowed the project participants a simple way to electronically submit shop drawings. While the collaborative environment created for the Jackson 108 project worked well, there were many areas that required additional improvement. Some of the issues that arose on the project were the inability to keep conversations on Google Groups private, the lack of a "ball-in-court" or "dashboard" features to allow participants to know who was working on what, and the inability to control what emails participants received from Google Groups. Due to the inability to privatize conversations and other issues, not all of the submittals on the project were managed through the Google Groups application. Another issue with the FTP site was the amount of time Iowa DOT engineers had to spend transferring documents that had been uploaded to the website. The full process of uploading a drawing could take an Iowa DOT engineer 30 minutes. On large projects with considerable drawings and revisions, this administrative function would become very time consuming. Due to the amount of staff time required to service an FTP site, Iowa DOT personnel deemed this approach not feasible for future projects. Except for the aforementioned issues, so far the system developed for the Jackson 108 project, while limited in its capabilities, has worked well. However, the

limitations of this system would make it impractical for a project where considerably more submittals and collaboration were required.

5.4.3. Lessons Learned

The limited-scale pilot projects served as a good initial test of the possibilities of web-based collaboration. Users were shown to be quite receptive to the solutions. Some initial issues, such as participants working around rather than through the pilot solutions, have demonstrated the importance of user-friendliness and making sure that the selected solution is sufficiently convenient so that users want to use it rather than avoid it.

One of the benefits of the limited-scale pilot projects was having a single location where project information resided for all project participants. The websites also served as a place for posting documents that were too large for email. The Google Groups application showed the benefits of actual web-based collaboration along with the importance of users being able to easily determine what they need to do and the status of documents.

The biggest issue with the limited-scale pilot projects was the amount of user interface required to keep the site up to date. Iowa DOT personnel constantly had to manually transfer data and update the site in order to keep it current. Additionally, while there were some notification emails from the Google Groups application as part of the Jackson 108 project, users had little control over the interface. Overall, these two projects showed the possibilities for web-based collaboration but also emphasized the need for a more full-featured, robust solution.

5.5. Full-Implementation Pilot Project

5.5.1. Pilot Projects

The full-implementation pilot projects will serve as a test bed for a full-featured commercial solution. Two pilot projects have been selected for testing with the possibility of one to two more projects being added at a later date. Lessons learned from the limited-scale

pilot projects will be applied to these projects to continue to improve the quality of the solutions being offered to the project participants. The solution used for these projects will be selected using the previously described RFP process (further details will be provided below) and will be hosted in a SaaS agreement. The use of a full-featured collaboration solution on these projects will allow the researchers to investigate the use of comprehensive solutions for future projects. Lessons learned from these projects will assist the Iowa DOT in the implementation of long-term collaboration solutions. These pilot projects will also provide lessons for managing future large and complex bridge projects with web-based collaboration.

5.5.1.1. Broadway Viaduct Bridge

The US 6 Broadway Viaduct in Council Bluffs (Pottawattamie 210, project number BRF-006-1(113)—38-37) was selected as the first pilot project. This bridge will be a prestressed, pretensioned concrete beam bridge to be let in the winter of 2010, with a construction cost of approximately $25 million. This bridge was selected because foundation and aesthetic details will create a significant number of shop drawings. The quantity of these documents will make this a desirable pilot project.

5.5.1.2. Iowa Falls Arch Bridge

The US 65 arch bridge over the Iowa River in Iowa Falls (Hardin 110, project number BRFN-065-6(42)—39-42) was selected as the second pilot project. This will be a steel arch bridge to be let in the summer of 2010, with a construction cost of approximately $12 million. This project was selected because the non-standard design of the bridge will result in numerous submittals and RFIs. The quantity of these documents will make this project a good pilot project.

5.5.2. Request for Proposals

To select a solution for the Iowa DOT to use on the full-implementation pilot projects, Iowa DOT personnel decided to issue an RFP. Researchers worked with the Iowa DOT to create the RFP in a manner so that the selection process was transparent and

objective. The RFP was devised to allow all interested vendors to participate and to clearly communicate the needs of the Iowa DOT to the vendors. Researchers assisted in drafting the RFP and the Iowa DOT issued it.

The RFP was developed by researchers to model previous RFPs issued by the Iowa DOT for technology services. Researchers consulted with Iowa DOT personnel in multiple departments for questions and content reviews. The RFP (Appendix E) outlined the scope of the project and listed the requirements of a web-based collaboration solution. At the end of the fiscal year 2009 research period, researchers had developed and issued the RFP but were still waiting for vendor responses.

5.5.3. Special Contract Provision

To ensure that not only is a solution properly selected but that it is also properly used, a special contract provision was developed for use on the pilot projects. The researchers worked with existing Iowa DOT requirements and special contract provisions, other state contract specifications, and the results of interviews to create a special contract provision requiring the proper use of the solution by contractors, subcontractors, and suppliers. The researchers had contractors on the technical advisory committee review the special contract provision on behalf of the Associated General Contractors of Iowa to ensure that the contractors felt the special contract provision was reasonable. The special contract provision, which will be issued with the contract documents for both full-implementation pilot projects, will be reviewed by the office of contracts before it is issued this fall; a draft is included in Appendix F.

5.6. Summary

Work on the electronic construction collaboration project has focused on two main areas: determining the functional needs of the Iowa DOT and evaluating software and solutions that are currently available to meet those needs. Functional requirements have been determined by researchers by examining current issues faced by the Iowa DOT, identifying the needs of Iowa DOT project stakeholders, and learning how others are using collaboration

solutions. The researchers have also worked to identify commercially available solutions and review them to determine the suitability of a commercial solution for use by the Iowa DOT on pilot projects.

Through this investigation, the researchers have recommended that a "Document Management" system set up as part of a SaaS agreement would best meet the Iowa DOT's needs for pilot testing. This solution should be able to manage contract documents, shop drawing submittals, RFIs, and meeting minutes. Additionally, this solution should consider the workflow of the Iowa DOT, user-friendliness, and data security. Researchers working with the Iowa DOT have developed and issued an RFP to select the solution for use on two pilot projects.

Additionally, limited-scale pilot projects were launched on the I-80 bridge in Council Bluffs and the Jackson County 108 bridge using a combination of the Iowa DOT website and the Google Groups application. These pilot projects were successful in giving project participants an initial exposure to the concepts of electronic project collaboration but demonstrated the need for a more robust, full-featured collaboration solution.

Thus far, the results of this research have focused on the assessment of the Iowa DOT's functional needs and the selection of a solution for pilot testing. Future work will focus on selecting, implementing, and reviewing a solution for pilot projects. Ultimately, this project should prepare the Iowa DOT for implementing a long-term collaboration solution. It will also assist the Iowa DOT in the management of future complex bridges using a web-based collaboration solution. Finally, the results of this project could help other government agencies in the State of Iowa move toward web-based collaboration on their construction projects.

5.7. Research for Phase II

Research for the second phase of this project will focus on selecting and implementing a web-based collaboration solution for pilot projects. Researchers working

with the Iowa DOT will begin by reviewing responses to the RFP issued during the first research period. The review team will short-list the vendors from the original responses and then make a decision on which solution to pilot test. Upon selection of the software, researchers will work with the Iowa DOT to customize and implement the software to best meet its needs.

Once the solution is operational, researchers will develop a user's manual for the pilot project participants to use. The researchers will also finalize the special contract provision developed during the previous research period so that it can be issued with the bid documents for both pilot projects. The researchers will then assist the Iowa DOT throughout the duration of the pilot projects occurring in fiscal year 2010 to ensure the solution is being effectively used. Both pilot projects will be evaluated through the use of both pre- and post-project surveys that will be administered to the project participants.

Finally, a formal evaluation of the Jackson 108 pilot project will be completed. A report will be submitted to the Iowa DOT detailing the results of the Jackson 108 pilot project. This report will include the results of a post-project survey with project participants to evaluate the success of the project. Researchers will work with the technical advisory committee to adjust future work on this project to best meet the Iowa DOT's needs.

CHAPTER 6: CONCLUSION

6.1. Summary

While the rate of adoption of WPMS in the horizontal construction industry is relatively low, its usage appears to being increasing. Subsequent interviews after the initial survey of state DOTs regarding WPMS usage have already indentified that the number of agencies utilizing WPMS is increasing. Additionally, research into which project participants would be best served by access WPMS and what construction documents would benefit from being managed by WPMS shows a general interest in WPMS as a tool to improve project management.

The case study of the Iowa DOT bridge projects allowed researchers to test small scale implementation of WPMS on projects. Following an action research model researchers were able to conduct multiple iterations of WPMS with increasing benefit to the Iowa DOT. While this project has not been fully completed results from the first and second iterations show that WPMS has had a positive impact on the organization and its management process. Project participants from the pilot projects have shown a general interest WPMS and indicated that WPMS has the capacity to improve the management of Iowa DOT bridge projects.

The case study with the Iowa DOT allowed researchers to begin implementing WPMS on a single project with a minimal investment. Conducting successive iterations allowed for researchers to better determine the exact needs of the Iowa DOT before expanding the use of WPMS in future iterations. By applying the lessons learn for the initial iterations researchers were able to better meet the needs of the Iowa DOT in the subsequent larger scale iterations

6.2. Conclusions

WPMS has yet to see considerable adoption in the horizontal construction industry, but WPMS appears to be poised to meet the management needs of the horizontal construction industry. The functionality of commercially available solutions matches the desired functionality of the horizontal construction industry. Additionally the rate of adoptions is

increasing quickly and should continue to as more organizations become familiar with this tool.

Results of the Iowa DOT case study and survey of specific needs of state DOT's could help the horizontal construction industry better implement WPMS. Initially targeting the areas where WPMS is most needed in organization, such as submittals and RFI's, could potentially help improve the success of the system while allowing for the implementation of smaller scale systems. This could help reduce the initial investment in the system and allow the organization to better evaluate how WPMS could assist them in the future. Additionally, this should also allow the organization to identify and investigate what organizational factors could inhibit the success of WPMS in order to help overcome these factors in future implementations. Ultimately this could help organizations better implement WPMS to improve its success and benefit for the organization.

6.3. Research Limitations

The validity of the results from the surveys conducted could be affected negatively in two primary ways. First, after following up with survey respondents it became apparent the many people were generally unaware of WPMS. This lack of familiarity may have made it difficult for respondents to identify their needs and how they could benefit from WPMS. Secondly, the response rate to the surveys was only 35% for one survey and 53% for the other. It would be reasonable to assume that percentage of non-respondents would find less benefit in WPMS than those that responded; factoring in the non-respondents would most likely decrease the amount of perceived benefit in WPMS by state DOTs.

While the research methodology outlined in the case study worked well for the Iowa DOT, the applicability of the results from the case study will depend on how closely other organization's needs align with the Iowa DOT's. For organizations with very similar needs the case study may prove very valuable. However, for organizations with much different needs than the Iowa DOT this case study may not prove to have much benefit.

6.4. Future Work

Research in this report focused on the needs of state DOTs as the focus for WPMS implementation in the horizontal construction industry. Future investigations could target other owners to identify their specific needs and how they compare to those of state DOTs. Additionally, for the most benefit, WPMS should improve communications for all of the project participants. An investigation of the needs of other project participants such as contractors, designers, and suppliers would beneficial in further understanding how WPMS can best assist the entire project team.

Work into quantifying the benefits of using WPMS would also be beneficial in better determining the need for these systems. By showing a quantifiable benefit, organizations could better know how to implement these systems in their organizations and where they gain the most benefit from their use. Demonstrating a financial benefit of WPMS would greatly increase their implementation.

Finally, examinations could be conducted using smaller scale systems for small projects to investigate the impact of WPMS on these projects. This could help increase the availability of WPMS for smaller project sizes that are more typical within DOTs. Also, since documents must be managed throughout the full lifecycle of a project from bidding to operation it would be beneficial to investigate how WPMS could be incorporated to better manage information throughout this full life cycle instead of only during the construction phase.

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APPENDIX A. SAMPLE WEB-BASED PROJECT MANAGEMENT SYSTEM

The following figures show screen shots from Attolist, a commercially available WPMS (attolist.com). These screenshots show a basic overview of the system and also depict the submittal process. The RFI process, not shown, is very similar to the submittal process within the system.

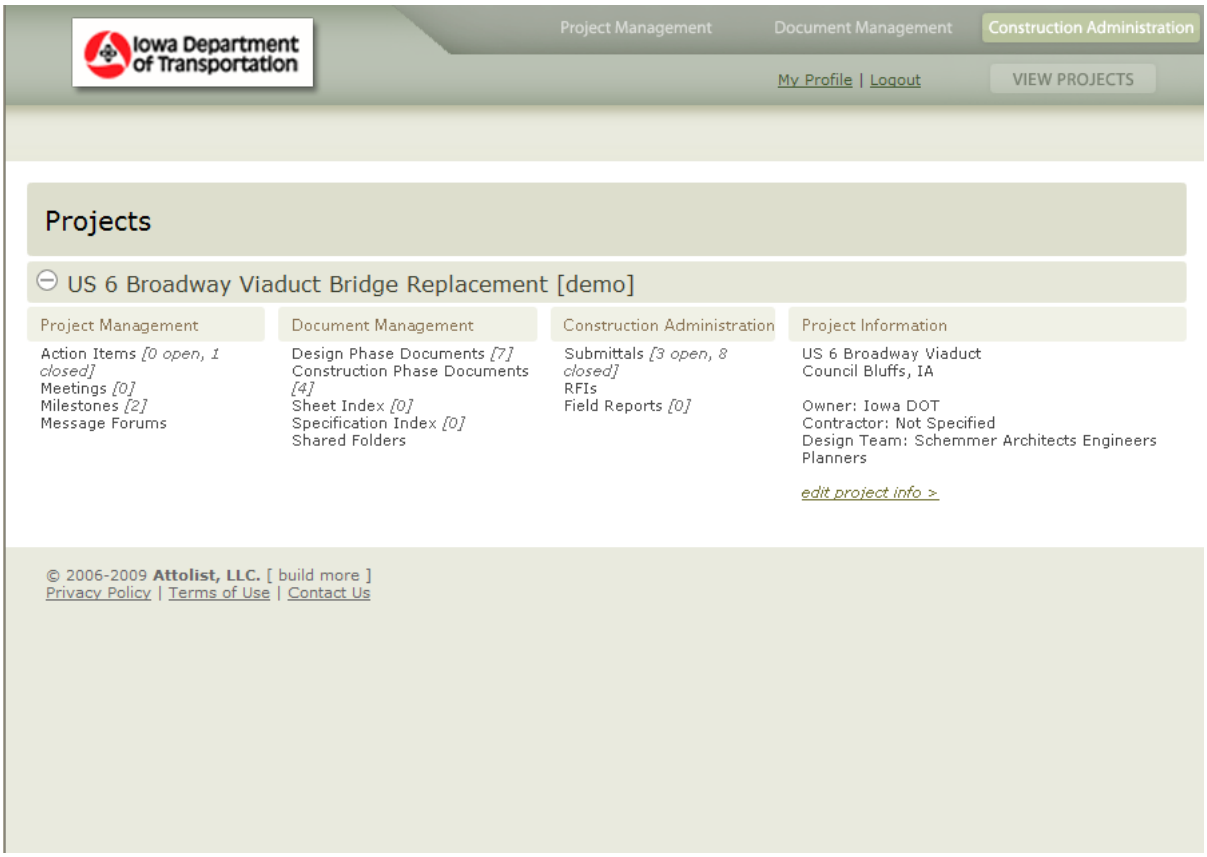


Figure A.1: Project Entry Screen

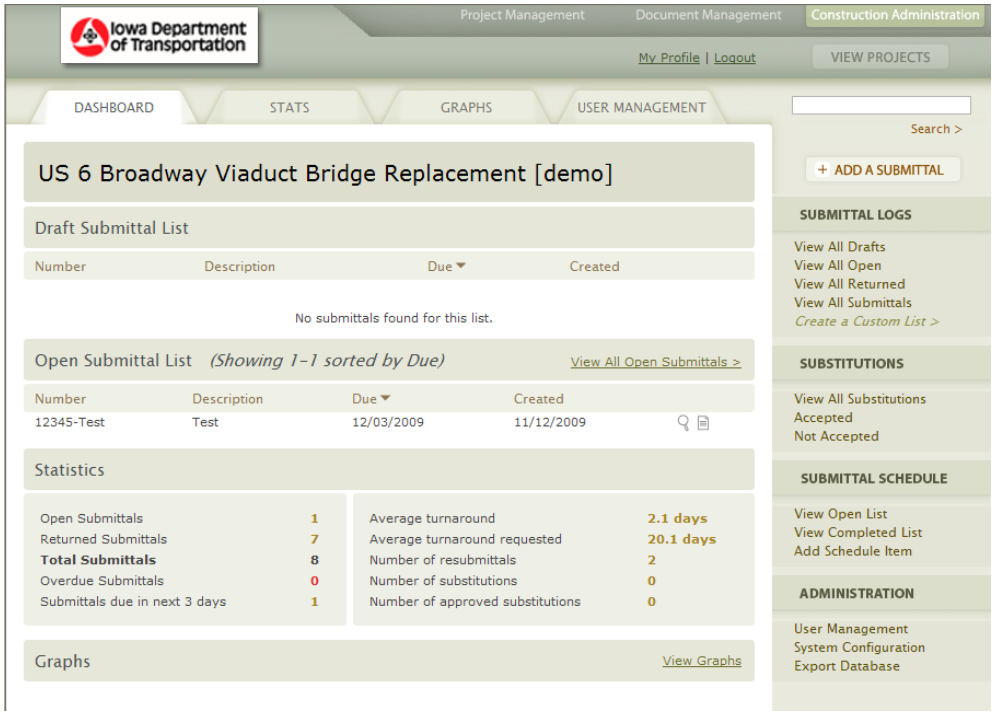


Figure A.2: Submittal Dashboard

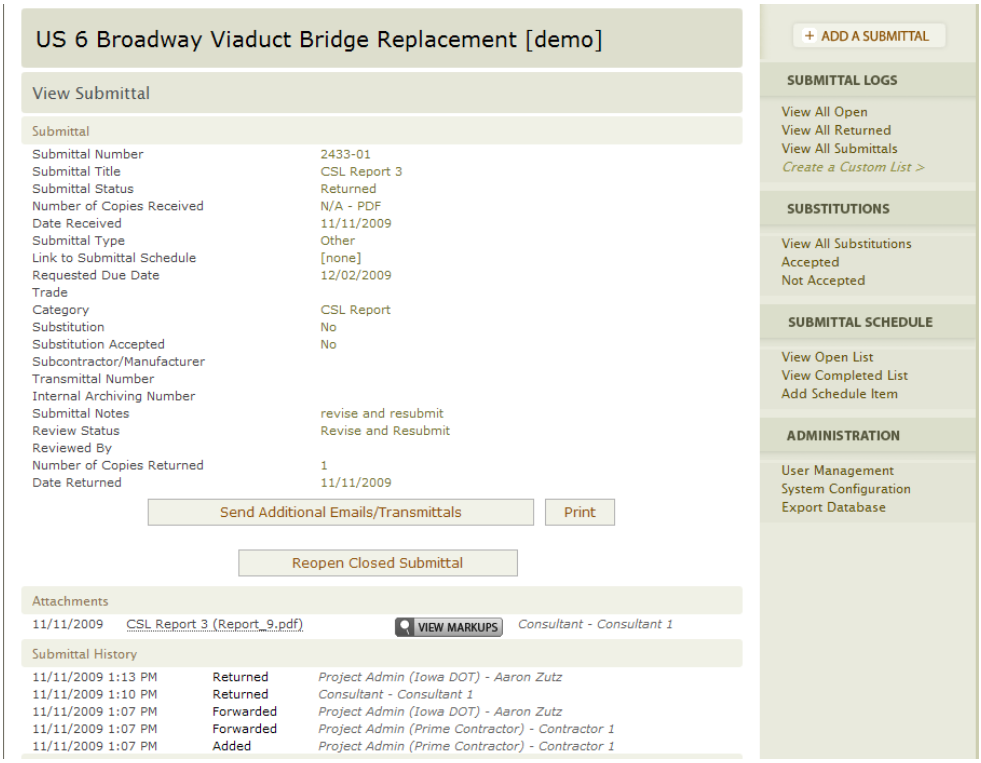


Figure A.3: Sample Submittal

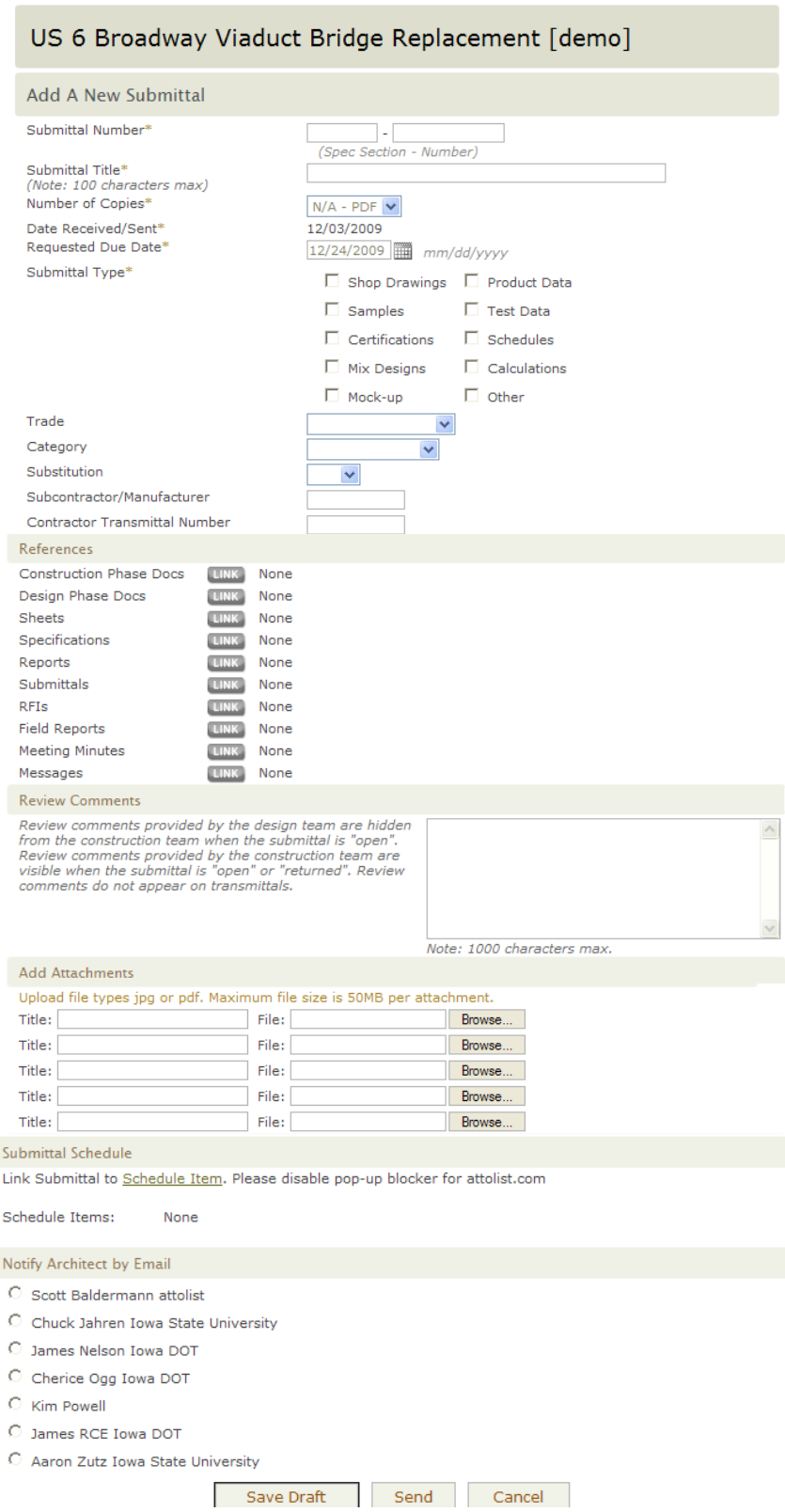


Figure A.4: New Submittal Form

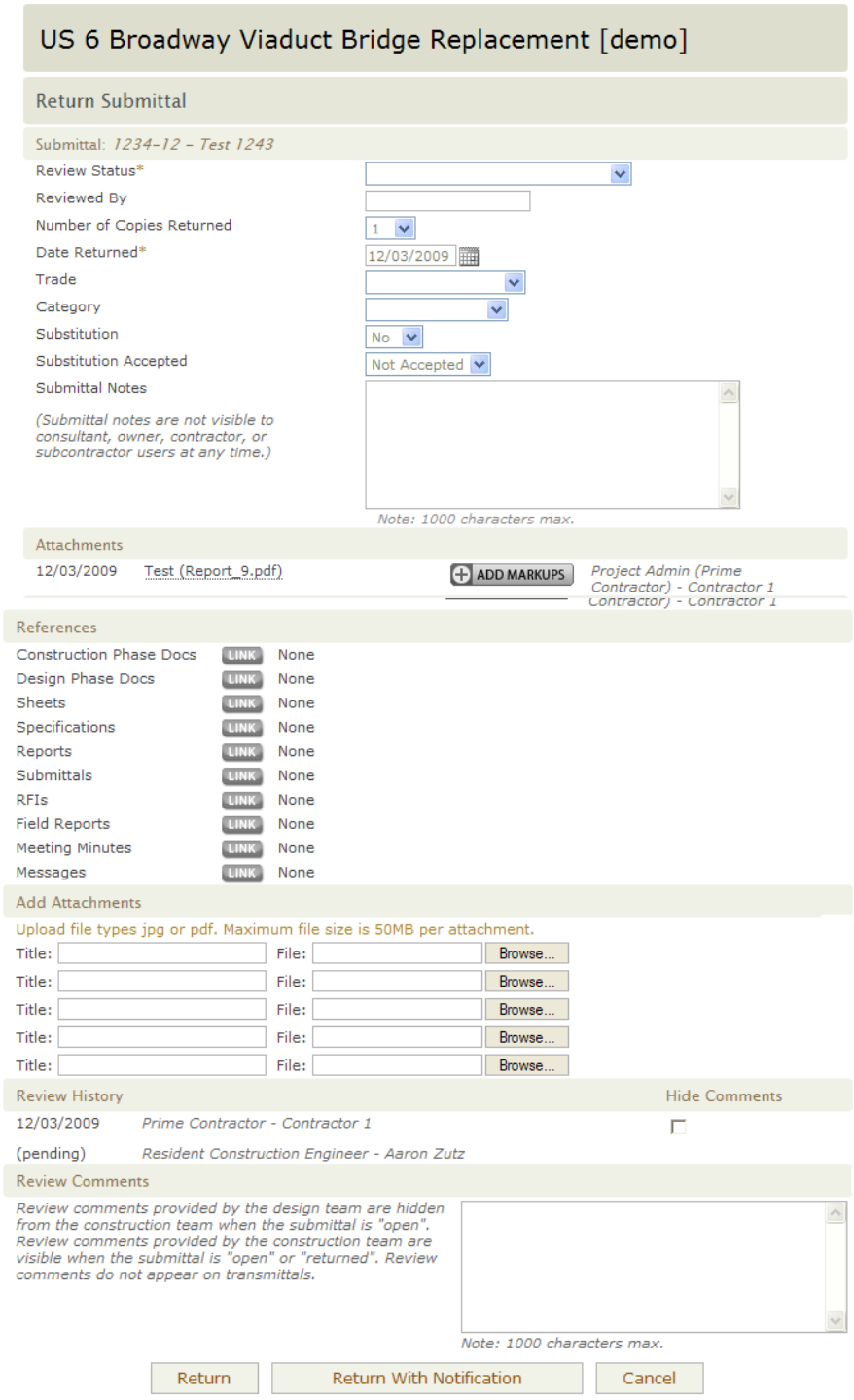


Figure A.5: Submittal Review Form

APPENDIX B. GENERAL INTERVIEW QUESTIONS

Electronic Collaboration Interview Questions:

General Information Questions:

1. What is your name and position?
2. What is your role on DOT bridge projects?
3. Do you have any experience with electronic collaboration systems?
4. If so, was it a web based system?
5. What mediums of communication do you rely on to get information (email, blackberry, etc)?
6. How much of your day do you have access to the Internet?

Electronic Collaboration System Proposal Questions:

1. What is your initial reaction to implementing a system like this?
    a. Potential benefits
    b. Disadvantages
2. How would a system like this specifically impact you?
3. Can you think of a time in the past when a system like this would have been very useful?
4. What areas does this have the potential to make the most impact (i.e., submittals, RFIs, etc)

Implementation Questions:

1. Are you familiar with DOT I-80 website, if so what are pro's/ cons of this website?
2. Can you make any recommendations for commercially available software?
3. Do you know of any compatibility issues that may arise during this project?
4. Based on your knowledge what size of project would warrant implementing this system for you?
5. Do you have any recommendations for a pilot project and how it should be implemented?

Other Questions:

1. Do you have any other questions or comments?

APPENDIX C. LIST OF INTERVIEWEES

- George Feazell-Iowa DOT
- Orest Lechnowsky-Iowa DOT
- Kevin Merryman-Iowa DOT
- Kyle Frame-Iowa DOT
- Mark Brandl-Iowa DOT
- Tom Jacobsen-Iowa DOT
- Wes Musgrove-Iowa DOT
- Cherice Ogg-Iowa DOT
- Keith Norris-Iowa DOT
- Kim Powell-Iowa DOT
- Wayne Sunday-Iowa DOT
- Jim Webb-Iowa DOT
- Sam Mousalli-Iowa DOT
- Ahmad Abu-Hawash-Iowa DOT
- Dan Timmons-Jensen
- Mark Leusink-Cramer
- Steve Sandquist-United
- Robert Cramer-Cramer
- Doug Jackson-HDR
- Linda Rolfes-HNTB
- Peter Graf-LPA
- Andrews Prestressed
- Delong Steel
- HiWay Products
- PDM Bridge
- Iowa State University
- M. A. Mortenson
- Ryan Company
- The Weitz Company
- Union Pacific
- New York Department of Transportation
- North Carolina Department of Transportation
- Wisconsin Department of Transportation
- Texas Department of Transportation
- Nevada Department of Transportation
- Ohio Department of Transportation
- Minnesota Department of Transportation
- District of Columbia Department of Transportation

APPENDIX D. INDENTIFIED COMMERICAL SOLUTIONS

Active project	http://activeproject.com/
Aconex	http://aconex.com/
Attolist	http://www.attolist.com/
Bidx	https://www.bidx.com/
BIW	http://www.biwtech.com/
Buildpoint (isqft)	http://www.isqft.com/
Buzzsaw	http://usa.autodesk.com/
Centric	http://www.centricsoftware.com/
Citadon	http://www.sword-ctspace.com/
CMiC	http://www.cmic.ca/
Construction Communicator	http://www.constructioncommunicator.com/
Constructware	http://usa.autodesk.com/
Eadoc	http://www.eadocsoftware.com/
Ebuilder	http://www.e-builder.net/
FACS	http://facsware.com/
Inquest	http://www.inquesttechnologies.com/
Ironspire	http://www.ironspire.com/
Newforma	http://www.newforma.com/
Omega PIMS	http://www.omega.no/
Primavera Contract Manager	http://www.oracle.com/primavera/
Procore	http://www.procore.com/
Project Center	http://projectcenter.com/
Project Dox	http://projectdox.com/
Project EDGE	http://www.projectedge.com/
Project Grid	http://projectgrid.com/
Project Solve	http://www.projectsolve2.com/
Project Village	http://projectvillage.com/
Projectmates	http://www.projectmates.com/
ProjectWise	http://www.bentley.com/
Prolog	http://www.meridiansystems.com/
Skire	http://www.skire.com/
Spectrum	http://www.dexterchaney.com/
Spitfire	http://spitfireconstruction.com/
Submittal exchange	http://www.submittalexchange.com/
Timberline	http://www.sagecre.com/
TRACSepm	http://www.tracsepm.com/
Trimble Connected Community	http://www.trimble.com/
Tririga	http://www.tririga.com/home/
Viecon	http://www.bentley.com/
View Point V6	http://www.viewpointcs.com/
Vista 2020	http://www.marketstreet.com/

APPENDIX E. SOFTWARE REVIEW MATRIX

Software Program	**CMiC-Project Management**
Functionality:	*2.13.09*
How many functions are there?	Cost/Budget, Bidding, Document Management, Site Management
How much of the solution is document management?	1 of 4 functions
How is the workflow setup (i.e., rigid or flexible)?	Standard predetermined workflows
Can workflow easily be customized?	Yes, if the user has the correct security privilege
Is the system designed for multiple-party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes, through different security privileges for each tab
Can documents be linked to other documents?	Yes, RFIs, etc. can be linked to change orders
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Yes, users can email in and out of the system
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes, new items sent to users are bolded in menu
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	List attached to each document
Technical:	
How is the system hosted?	Self-hosted, SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	4–6 weeks to customize
How many DOT hours are required to implement?	Depends on customization
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	5 days for a DOT system "expert"

Software Program	**CMiC-Project Management**
Technical (continued):	*2.13.09*
How many hours of training are required for occasional users?	2–3 hours
How is the solution priced?	For SaaS: $20,000 to customize, $200 mo/user for core users, $100 mo/user for collaborative users
How is system support and maintenance set up?	On demand, included in license fee
What bandwidth have users found adequate?	Broadband or 3G
How are projects achieved, what file format?	For SaaS: archived by CMiC, also can export read-only csv file
To what extent can the system be customized?	Designed to integrate with many systems
What other programs can this system interface with?	Depends on customization
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	Would probably want to move from SaaS to self-hosting due to cost
General:	
What is the history of this system?	35 year old company, 20,000 users, A/E/C industry, started as accounting software
Who are the primary users of this system?	A/E/C- Turner, Walsh, Beck
What have other users said about this system?	
Other comments?	Heavy emphasis on financial Looks very powerful California Department of Transportation has been evaluating CMiC System is designed to easily integrate with other programs

Software Program	**Attolist**
Functionality:	*2.24.09*
How many functions are there?	Document Management, Site Management, Construction Administration
How much of the solution is document management?	1 of 3 functions
How is the workflow set up (i.e., rigid or flexible)?	Flexible, with one point person controlling the document flow
Can workflow easily be customized?	Point person can alter the workflow
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes, collaboration comments deleted when submittal is approved
Can documents be linked to other documents?	Yes, RFI's link as they are revised
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Yes, can email links to files in Attolist
Is there a "dashboard" feature?	Yes
Is there a "ball-in-court" feature?	Yes, users can create reports to show any outstanding items
Can users manipulate which emails they receive?	Yes, but only can control if weekly updates are emailed
How is the document history displayed?	Bottom of each document
Technical:	
How is the system hosted?	SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	1 month depending on customization
How many DOT hours are required to implement?	Very little, depends on customization
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	Couple hours formal training

Software Program	**Attolist**
Functionality:	*2.24.09*
How many hours of training are required for occasional users?	One hour formal training
How is the solution priced?	Expect no more than $1,000/ mo for one project, unlimited users, cost to customize varies
How is system support and maintenance setup?	On demand, included in license fee
What bandwidth have users found adequate?	Broadband or 3G
How are projects achieved, what file format?	Stored by Attolist, also exported on DVD
To what extent can the system be customized?	Designed to work off the shelf, owner can do some customization
What other programs can this system interface with?	None
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Unknown
Who are the primary users of this system?	Vertical A/E/C
What have other users said about this system?	
Other comments?	DWG changes are linked to an index sheet System has a large upgrade in May 2009 Has a nice search function Custom tracking reports looks very useful Would need to replace CSI submittal numbering with DOT specification numbering system

Software Program	**Prolog/ Project Talk**
Functionality:	*2.26.09*
How many functions are there?	Cost, Purchasing, Document Management, Field Administration
How much of the solution is document management?	1 of 4 functions
How is the workflow set up (i.e., rigid or flexible)?	Flexible, send documents to groups or individuals
Can workflow easily be customized?	Yes
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Can email out pdfs of documents in AIA format
Is there a "dashboard" feature?	Yes
Is there a "ball-in-court" feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	With each document
Technical:	*2.26.09*
How is the system hosted?	Self-hosted, Vendor-hosted, or SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	2–3 Weeks
How many DOT hours are required to implement?	Depends on customization
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	2–3 days, more for an administrator
How many hours of training are required for occasional users?	1/2 day
How is the solution priced?	Per user per month, concurrent licenses; full-user or partial-user

Software Program	**Prolog/ Project Talk**
Technical (Continued):	*2.26.09*
How is system support and maintenance setup?	On demand, depending on agreement may be included in license
What bandwidth have users found adequate?	Broadband or 3G
How are projects achieved, what file format?	Exported on a DVD
To what extent can the system be customized?	Will work off the shelf, can be extensively customized
What other programs can this system interface with?	Depends on customization
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	Move to self-hosting
General:	
What is the history of this system?	Over 12 years old, extensively used by the industry
Who are the primary users of this system?	A/E/C HDR, Weitz
What have other users said about this system?	
Other comments?	Uses Citrix

Software Program	**Projectmates**
Functionality:	*3.6.09*
How many functions are there?	Document Management, Construction Management, Contracts, Cost
How much of the solution is document management?	1 of 4 functions
How is the workflow set up (i.e., rigid or flexible)?	Flexible w/point person
Can workflow easily be customized?	Yes, can reroute documents
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	No
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Yes, can email out
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	With each document
Technical:	
How is the system hosted?	Self-Hosted or SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	Less than a week
How many DOT hours are required to implement?	2 days
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	1–2 days
How many hours of training are required for occasional users?	No formal training
How is the solution priced?	Per project per user, $10-15 mo/project/user, $950 setup, plus training
How is system support and maintenance setup?	Included in pricing, support only if user had paid training

Software Program	**Projectmates**
Technical (continued):	*3.6.09*
What bandwidth have users found adequate?	Broadband/3G
How are projects achieved, what file format?	Archive online at anytime and can download
To what extent can the system be customized?	Change labels and interface with other programs, etc.
What other programs can this system interface with?	Depends on customization
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	Move to self-hosting
General:	
What is the history of this system?	25,000 users currently
Who are the primary users of this system?	Owners 50%, Architects 20%, Contractors 20%
What have other users said about this system?	
Other comments?	Currently submittals labeled by CSI

Software Program	**Contract Manager (Primavera)**
Functionality:	*3.4.09*
How many functions are there?	Budget, Schedule, Construction Administration
How much of the solution is document management?	1 of 3 functions
How is the workflow set up (i.e., rigid or flexible)?	Flexible w/ point person
Can workflow easily be customized?	Yes
Is the system designed for multiple party reviews?	Yes, kind of complex method
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	No, could link a third party software such as Brava
Can users work outside of the system?	Yes, can email out
Is there a "dashboard" feature?	Yes
Is there a "ball-in-court" feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	With each document
Technical:	
How is the system hosted?	Self-hosted or SaaS by Load Spring (through Catalyst)
Is more than an Internet browser required?	No
How long does it take to get this system running?	2 weeks
How many DOT hours are required to implement?	1–2 days
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	1–2 days
How many hours of training are required for occasional users?	2–3 hours
How is the solution priced?	Per user, one license type, need a separate license for every user
How is system support and maintenance setup?	Additional cost (SaaS hosting also is) bundled with user fee

Software Program	**Contract Manager (Primavera)**
Technical (continued):	*3.4.09*
What bandwidth have users found adequate?	Broadband/3G
How are projects achieved, what file format?	Can download data, formats: pdf, Excel, csv
To what extent can the system be customized?	Depends on customer needs
What other programs can this system interface with?	Oracle, can be customized to interface with others
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	Move to self-hosting, further customization
General:	
What is the history of this system?	Previously was called expedition
Who are the primary users of this system?	A/E/C
What have other users said about this system?	See WisDOT comments
Other comments?	Can import contact information from Excel

Software Program	**ebuilder**
Functionality:	*3.10.09*
How many functions are there?	Budget, Forms, Document Management, Schedule
How much of the solution is document management?	1 of 4 functions
How is the workflow set up (i.e., rigid or flexible)?	Flexible or rigid depending on how system is set up
Can workflow easily be customized?	If it is set up flexible
Is the system designed for multiple party reviews?	Yes, if set up correctly
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Yes, can email or fax out
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	With each document
Technical:	
How is the system hosted?	SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	6–8 weeks
How many DOT hours are required to implement?	Varies, 1–3 days expected
How many DOT hours are required to start new project?	1/2 Day or less
How many hours of training are required for everyday users?	2 days for "power users"
How many hours of training are required for occasional users?	2–3 hrs by "power users"
How is the solution priced?	Per user (starts with 10 users) $1,000/user/year (may vary for pilot project)+ customization (only users creating forms needs a license)
How is system support and maintenance setup?	On demand included in fee

Software Program	**ebuilder**
Technical (continued):	*3.10.09*
What bandwidth have users found adequate?	Broadband/3G
How are projects achieved, what file format?	Retained by ebuilder, can download into excel or get a DVD
To what extent can the system be customized?	Change labels, workflows, can interface with other systems
What other programs can this system interface with?	Depends on customization, i.e., could interface with MS Project or accounting software
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Unknown
Who are the primary users of this system?	A/E/C
What have other users said about this system?	
Other comments?	Can email or drag and drop directly into folders Can create own reports If workflow is setup flexible, history is tracked to assist in setting up a rigid workflow later

Software Program	**Submittal Exchange**
Functionality:	*3.13.09*
How many functions are there?	Document Management
How much of the solution is document management?	Main function
How is the workflow set up (i.e., rigid or flexible)?	Typically rigid for submittals (because preloaded) and flexible with point person for RFIs
Can workflow easily be customized?	Yes, (system is set up so subcontractors need to go through GC then to Point Person then to reviewer)
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	No
Can files be marked up without their native software?	No
Can users work outside of the system?	Yes, can email out link
Is there a "dashboard" feature?	Yes
Is there a "ball-in-court" feature?	Yes, items are highlighted red
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	Bottom of each document
Technical:	
How is the system hosted?	SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	3–5 days, including uploading submittals
How many DOT hours are required to implement?	1/2 day
How many DOT hours are required to start new project?	3–5 including uploading submittals
How many hours of training are required for everyday users?	1 hr
How many hours of training are required for occasional users?	Less than an hour

Software Program	**Submittal Exchange**
Technical (continued):	*3.13.09*
How is the solution priced?	Per Project, starts at $1,000 (for a $25 million project would be around $8,000) varies depending on number of submittals, etc
How is system support and maintenance setup?	On demand included in fee
What bandwidth have users found adequate?	Broadband/3G
How are projects achieved, what file format?	DVD in html format
To what extent can the system be customized?	Change tabs, labels, forms
What other programs can this system interface with?	None
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Unknown
Who are the primary users of this system?	A/E/C-KJWW
What have other users said about this system?	
Other comments?	Preloads list of submittals based on specs

Software Program	**eadoc**
Functionality:	*3.23.09*
How many functions are there?	Document Management, Budget, Field Management, Construction Administration
How much of the solution is document management?	1 of 4 functions
How is the workflow set up (i.e., rigid or flexible)?	Depends on how it is setup, typically both
Can workflow easily be customized?	Yes
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	No, because would require active X
Can users work outside of the system?	Yes can email out
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	Bottom of each document
Technical:	
How is the system hosted?	SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	1–2 weeks
How many DOT hours are required to implement?	1/2–1 day
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	3 hours
How many hours of training are required for occasional users?	No formal training
How is the solution priced?	Per project, 0.11% of construction cost

Software Program	**eadoc**
Technical (continued):	*3.23.09*
How is system support and maintenance setup?	On demand included in fee
What bandwidth have users found adequate?	Broadband/3G
How are projects achieved, what file format?	Download to FTP site, or DVD
To what extent can the system be customized?	Change files, tabs, etc.
What other programs can this system interface with?	Can be customized to interface with accounting systems
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Unknown
Who are the primary users of this system?	A/E/C
What have other users said about this system?	
Other comments?	Contractor manages subcontractor accounts Shows flow charts of linked documents Can track materials

Software Program	**Buzzsaw (Autodesk)**
Functionality:	*3.30.09*
How many functions are there?	Document Management, Construction Administration, Bidding
How much of the solution is document management?	1 of 3 functions
How is the workflow set up (i.e., rigid or flexible)?	Depends on how it is setup, typically uses a point person to control the document flow
Can workflow easily be customized?	Yes
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Yes
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	Can markup .dwg files, should be able to markup pdfs soon
Can users work outside of the system?	Yes, can email out
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	Bottom of each document
Technical:	
How is the system hosted?	SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	2–3 weeks, with "quick start"
How many DOT hours are required to implement?	Varies, 1–3 days expected
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	1–2 days, +2–3 days for administrator
How many hours of training are required for occasional users?	1–3 hours
How is the solution priced?	Per user, named user, expect $500–600 user/year + implementation and training

Software Program	**Buzzsaw (Autodesk)**
Technical (continued):	*3.30.09*
How is system support and maintenance setup?	On demand included in fee
What bandwidth have users found adequate?	Broadband/3G
How are projects achieved, what file format?	Download to desktop
To what extent can the system be customized?	Tabs, forms, names, etc.
What other programs can this system interface with?	Usually none, but possibly could. If this is important, should use Constructware not Buzzsaw
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
<u>General:</u>	
What is the history of this system?	
Who are the primary users of this system?	A/E/C
What have other users said about this system?	Penn. Turnpike
Other comments?	MS style layout, lots of buttons and menus Can configure forms with MS info path Second Autodesk program Constructware is more database driven and works better with budgeting Need to check box in RFI form in order to email out

Software Program	**Centric**
Functionality:	*3.31.09*
How many functions are there?	Schedule, Budget, Document Management, Bidding, Construction Administration
How much of the solution is document management?	1 of 5 functions
How is the workflow set up (i.e., rigid or flexible)?	Depends on how it is setup
Can workflow easily be customized?	Depends on how it is setup
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	Could, would need to attach separate document with restricted access
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Yes, can email out
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	With each document
Technical:	
How is the system hosted?	Self-hosted or SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	1–2 weeks
How many DOT hours are required to implement?	1–2 days
How many DOT hours are required to start new project?	1/2 day or less
How many hours of training are required for everyday users?	1/2 day
How many hours of training are required for occasional users?	No formal training
How is the solution priced?	Per user, named license, subscription fee for SaaS, and implementation
How is system support and maintenance setup?	Included in subscription fee

Software Program	**Centric**
Technical (continued):	*3.31.09*
What bandwidth have users found adequate?	3G/Broadband
How are projects achieved, what file format?	html, download or DVD's
To what extent can the system be customized?	Tabs, forms, names, etc.
What other programs can this system interface with?	Yes
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Unknown
Who are the primary users of this system?	A/E/C
What have other users said about this system?	ISU, Kiewit
Other comments?	None

Software Program	**Project Center**
Functionality:	*4.14.09*
How many functions are there?	Construction Administration, Document Management, Bidding
How much of the solution is document management?	1 of 3 functions
How is the workflow set up (i.e., rigid or flexible)?	Depends on how it is setup
Can workflow easily be customized?	Depends on how it is setup
Is the system designed for multiple party reviews?	Yes
Can users collaborate on issues using restricted conversations?	No
Can documents be linked to other documents?	Yes
Can files be marked up without their native software?	Yes
Can users work outside of the system?	Could print to pdf and then email
Is there a “dashboard” feature?	Yes
Is there a “ball-in-court” feature?	Yes
Can users manipulate which emails they receive?	Yes
How is the document history displayed?	With each document
Technical:	
How is the system hosted?	SaaS
Is more than an Internet browser required?	No
How long does it take to get this system running?	1–3 Days
How many DOT hours are required to implement?	1/2 day to 1 day
How many DOT hours are required to start new project?	Less than 1/2 day
How many hours of training are required for everyday users?	No formal training, 3 hrs for administrator
How many hours of training are required for occasional users?	No formal training
How is the solution priced?	Per project per year; $5,940 for 5Gb, $15,000 for 20Gb
How is system support and maintenance setup?	Included in subscription fee
What bandwidth have users found adequate?	3G/ Broadband
How are projects achieved, what file format?	Zip download or cd, all folders are archived

Software Program	**Project Center**
Technical (continued):	*4.14.09*
To what extent can the system be customized?	Labels and forms
What other programs can this system interface with?	Could be modified to interface with other programs, but probably wouldn't make a lot of sense
Does this system meet the DOT/ADA requirements?	Appears to meet ADA requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Developed in 1997
Who are the primary users of this system?	A/E/C
What have other users said about this system?	
Other comments?	Used on Lucas Oil Stadium Can export calendar to outlook

Software Program	**ProjectWise DCS**
Functionality:	*5.12.09*
How many functions are there?	Construction Administration, Document Management
How much of the solution is document management?	1 of 2 functions
How is the workflow set up (i.e., rigid or flexible)?	Flexible
Can workflow easily be customized?	Yes
Is the system designed for multiple party reviews?	May require customization
Can users collaborate on issues using restricted conversations?	Would require customization
Can documents be linked to other documents?	Yes, in ProjectWise
Can files be marked up without their native software?	No
Can users work outside of the system?	Must add users through ProjectWise
Is there a “dashboard” feature?	Has "To Do" List
Is there a “ball-in-court” feature?	“To Do” List
Can users manipulate which emails they receive?	May require customization
How is the document history displayed?	With each "Issue"
Technical:	
How is the system hosted?	Self-hosted
Is more than an Internet browser required?	Excel for Transmittal Form
How long does it take to get this system running?	2 months
How many DOT hours are required to implement?	Varies
How many DOT hours are required to start new project?	1/2 day
How many hours of training are required for everyday users?	2–3 days
How many hours of training are required for occasional users?	1 day
How is the solution priced?	There would be an additional cost beyond the existing Enterprise Licensing Agreement
How is system support and maintenance setup?	Depends on licensing agreement
What bandwidth have users found adequate?	3G/ Broadband

Software Program	**ProjectWise DCS**
Technical (continued):	*5.12.09*
How are projects achieved, what file format?	Information would reside on DOT servers
To what extent can the system be customized?	Extensively
What other programs can this system interface with?	Unknown
Does this system meet the DOT/ADA requirements?	Appears to meet ADA Requirements
What changes would be required to go to full implementation?	None
General:	
What is the history of this system?	Only a couple months old
Who are the primary users of this system?	A/E/C (Europe)
What have other users said about this system?	
Other comments?	This solution would require extensive customization

APPENDIX F. REQUEST FOR PROPOSALS

The following excerpt is from the "Request for Proposal For Web-based Construction Collaboration Services" issued by the Iowa Department Transportation and let on July 22nd, 2009. Section 3 lists the project specification and was jointly developed with the Iowa Department of Transportation. The entire request for proposal document can be accessed as an appendix of the report "Electronic Construction Collaboration – Phase I" at www.intrans.iastate.edu.

Section 3 Project Specifications

3.1 Project Background

In order to effectively assist project participants in the management of the bridge projects specified in this proposal, the project website will need to be accessible to many levels of project participants. Project participants who will need to interface with the project website will include Iowa DOT personnel, contractors, subcontractors, consultants, and suppliers. Since many of the project participants will only need to occasionally access the website user-friendliness will be important.

The Iowa DOT is targeting implementation of this solution for the end of the summer 2009. It is anticipated that project websites will be implemented on two to four projects totaling $36 to $75 million in project construction costs. It is expected that there will be 30 users within the Iowa DOT and 20-30 external users per project. The first two projects targeted for implementation are:

1. US 6 Broadway Viaduct Bridge replacement in Council Bluffs. Estimated Construction Cost - $24 million to be let January 2010. Estimated project duration is thirty (30) months.
2. US 65 over Iowa River Arch Bridge Replacement in Iowa Falls. Estimated Construction Cost - $13 million to be let July 2010. Estimated project duration: is eighteen (18) months.

3.2 Scope of Work (SOW)

Vendor responses must address the following mandatory requirements and optional website features for the proposed project website. Information required will include but not be limited to, detailed, service/feature information, including how each requirement will be met.

3.2.1 Web Site Features –mandatory requirements

The project website design must have the capacity to process the requested data in a timely manner. The site must be simple to use, yet powerful enough to satisfy the core user base.

Website design features and functionality must include:

1. Specific templates for Submittals, RFIs, Contract Documents, and Progress Reports and Meeting Minutes. (Details are below in 3.2.2).
2. Ability for originators of submittals and RFIs to directly upload documents to the site. **See Attachments A and B for workflows and terminology.**
3. Tracking of documents in the Submittal and RFI sections.
4. Website continuity for workflow of submittals and RFIs. It should also use current DOT terminology as part of the review process**. See Attachments A and B for details on typical workflows and terminology.**
5. A "dashboard" or "ball-in-court" feature to allow users to quickly track new and overdue items.
6. Ability to send external emails to users. Some instances which users may need to be notified of would be new, overdue, or items requiring the user's attention.
7. User's ability to view history of each document.
8. Maintain version control of all documents.
9. Authorized user ability to link related documents.
10. Accessibility by all common browsers such as Internet Explorer, Safari, and Firefox.
11. Website shall meet Iowa DOT accessibility guidelines. Details can be found at: http://www.iowadot.gov/accessibility.html.
12. Accessibility through an Iowa DOT provided ".gov" web address (URL).
13. The ability to post a disclaimer on the website stating that users should only place non-confidential data on the website.
14. Administrative functions that let the Iowa DOT administer user accounts.
15. User authentication through an encrypted sign on to ensure password protection.

3.2.2 Optional Features

Vendors may provide design details as to how these desired features could be implemented.

1. Website functionality to view, redline, and print documents within the project website without needing the native software application.
2. The ability to restrict comments on certain documents so only certain users could view them.
3. Reports that can be run on document activity.
4. Website compatibility with web enabled "smart" phones.
5. The ability to brand the website with the Iowa DOT logo.
6. The ability to create ad hoc workflows for documents as needed.
7. A content management system that would allow select Iowa DOT users to make

minor changes to the site.
8. Access to data for archiving by Contractors

3.3 Website Content and Architecture

The web site shall contain divisions, pages or tabs for organizing project information.

3.3.1 Contract Documents

The contract documents are the bid documents provided by the DOT and potential plan revisions. All contract documents are in PDF format and consist of the following:

1. Proposal – one to five documents, sized 8.5x11, up to 2 MB[1] each
2. Plans – one to five documents, sized 11x17, up to 40 MB each
3. Addendums – zero to five documents, sized 8.5 x 11, up to 1 MB each
4. Special Provisions – zero to ten documents, sized 8.5 x 11, up to 10 MB each
5. Developmental Specifications - zero to ten documents, sized 8.5 x 11, up to 2 MB each
6. A hyperlink to the Iowa DOT Electronic Reference Library (ERL)[2]
7. Plan revisions – one to five documents, sized 11x17, up to 4 MB each

Items one through six are loaded at the beginning of the project and static for the duration of the project. Item 7 plan revisions are added during the course of the project as necessary by the DOT.

3.3.2 Meeting Minutes and Project Reports

Weekly or bi-weekly progress meeting minutes and any designated project reports shall be uploaded to the web site by the Iowa DOT for the duration of the project. Expected PDF file sizes are 8.5 x 11, up to 1 MB each.

3.3.3 Working Drawings/Shop Drawings

The ease of uploading submittals consisting of working drawings and shop drawings to the web site electronic collaboration system is paramount to the success of the project. The system should be intuitive to contractors, sub-contractors, fabricators and suppliers so that minimal training or assistance is required. The system should also provide a transparent organization so that submittal status is easily ascertained. **See Attachment A.**

Electronic PDF submittals on a recent $56 Million (construction cost) bridge project ranged from one to one hundred pages sized both 8.5x11 and 11x17 and sized up to 60 MB for an individual set. The final shop drawings consisted of nearly 100 sets of shop drawings with a total size of about 600 MB. Some shop

[1] Document sizes listed are maximums. Many documents are half that size or smaller.
[2] The Electronic Reference Library (ERL) contains the DOT standard specifications, standard plans, instructional memorandum and other relevant contract documents. http://www.iowadot.gov/erl/index.html

drawings were processed in a single iteration while some drawings required multiple iterations of revision and re-submittal.

3.3.4 Requests for Information (RFI)

RFI will be processed through the DOT Resident Construction Engineer (RCE) as a gatekeeper. Ease of routing RFI for technical review to single or multiple DOT engineers and potentially consulting engineers is a key to the project. The RCE will be responsible for assembling the final DOT response to RFI. **See Attachment B.**

RFI on a recent $56 Million (construction cost) bridge project numbered over 100 RFI but less than 150. Most RFI were submitted either via email or in PDF attachments to emails. RFI with PDF attachments were typically sized 8.5x11 but occasionally included 11x17 drawings. Nearly all submitted RFI were less than 1 MB each.

3.4 Vendor Technical Requirements

The vendor shall provide the following minimum requirements.
See also Section 4 - Personnel

1. A list and short descriptions of successfully completed projects by the vendor similar in nature to the project website in the last three (3) years.
2. A list of any subcontractors involved in the project and those who would have access to the data.
3. A statement regarding the management of data security and website security.

3.5 Hosting Information

Webhosting shall reside on a vendor server. Third party hosting is acceptable. Regardless of the hosting option, by vendor or third party provider, the physical location of the data must be disclosed. Upon the issuance of a contract, the vendor must agree to web inspection and security audits to be performed by the Iowa DOT or a third party acting on their behalf. Vendor proposals shall include their solution pricing structure.

3.6 Vendor Responsibilities

Contract award will be dependent on the successful bidder's ability to provide and host a web-based construction collaboration system that meets the requested needs of the Iowa DOT, including but not limited to;

1. The selected vendor will be required to complete proposed customizations. Costs associated with each customization shall be broken down and included in the vendor's bid response.
2. Assist the Iowa DOT in the implementation of the project website as specified.
3. Maintain, update and support the website throughout the duration of the contract.

See Section 3.11

4. Upon completion of project, archive the project and transfer data to the Iowa DOT in a predetermined format. PDF is preferred, other formats shall be reviewed. Vendor proposals shall detail how archived information will be transferred to the Iowa DOT. After the Iowa DOT has communicated that they have received the archived files in a usable condition the vendor will be required to completely remove all project information from their system as agreed upon.

3.7 Project Management

A project manager will be assigned by the vendor for the duration of the contract. This project manager will work with the Iowa DOT project managers to customize and implement the web-based collaboration solution to ensure the website successfully meets the needs of its many users. Project managers will discuss all aspects of development to determine system performance measures and design modifications in a test environment before deployment.

Other project management requirements are, but not limited to:

1. Acceptance of reasonable website design modification requests from the Iowa DOT based on Iowa DOT staff requests or public feedback.
2. Submit a proposed project website customization and implementation schedule with the bid proposal. Upon award, this schedule may be updated prior to contract execution.
3. The Iowa DOT may require administrative, maintenance or modification responsibilities to the website beyond user account administration. Vendor staff will work with the Iowa DOT's Information Technology Division project manager to train Iowa DOT personnel to perform tasks as agreed.
4. Vendor staff must provide training for Iowa DOT personnel if Iowa DOT will be responsible for any maintenance or modification to the project system. The vendor will also be responsible for training the Iowa DOT project manager and primary project stakeholders on the use of project applications and tools.

3.8 System Access

Project participants require uninterrupted access to the project website. The vendor shall clearly state a minimum percentage of time that the website shall be accessible by users. Vendor must notify the Iowa DOT project manager of any and all planned outages. System users may work evening and weekends, planned system outages should accommodate this work schedule.

3.9 Testing

System testing will occur and be conducted in accordance with the terms of the contract to be negotiated between the Iowa DOT and the successful vendor.

3.10 Training

The vendor shall propose training options and levels of training for system users and DOT administrators along with the associated costs.

3.11 Maintenance

The vendor shall propose a monthly maintenance fee for project web site operation. An itemized fee structure and hourly rate is required and shall be provided in the Schedule of Prices. If additional work outside the scope of the project is required, the Schedule of Prices shall referenced for rates.
Phone support and any other items included in the monthly maintenance shall be described.

3.12 Iowa DOT Responsibilities

3.12.1 Project Administration

3.12.1.1 Contract Administration

Contract administration will be the responsibility of the Office of Procurement and Distribution, Purchasing Section, Renee R. Shirley, Issuing Officer.

3.12.1.2 Points of Contact

Two (2) Iowa DOT project managers will be assigned to this project.

Office of Bridges and Structures – Jim Nelson
Information Technology Division– Kim Powell

3.12.2 Monthly Status Meetings

Monthly status meetings or conference calls between Iowa DOT Project Manager and/or Iowa DOT representative(s) and the vendor will be held. Meetings shall assess risk and review progress of work assignments.

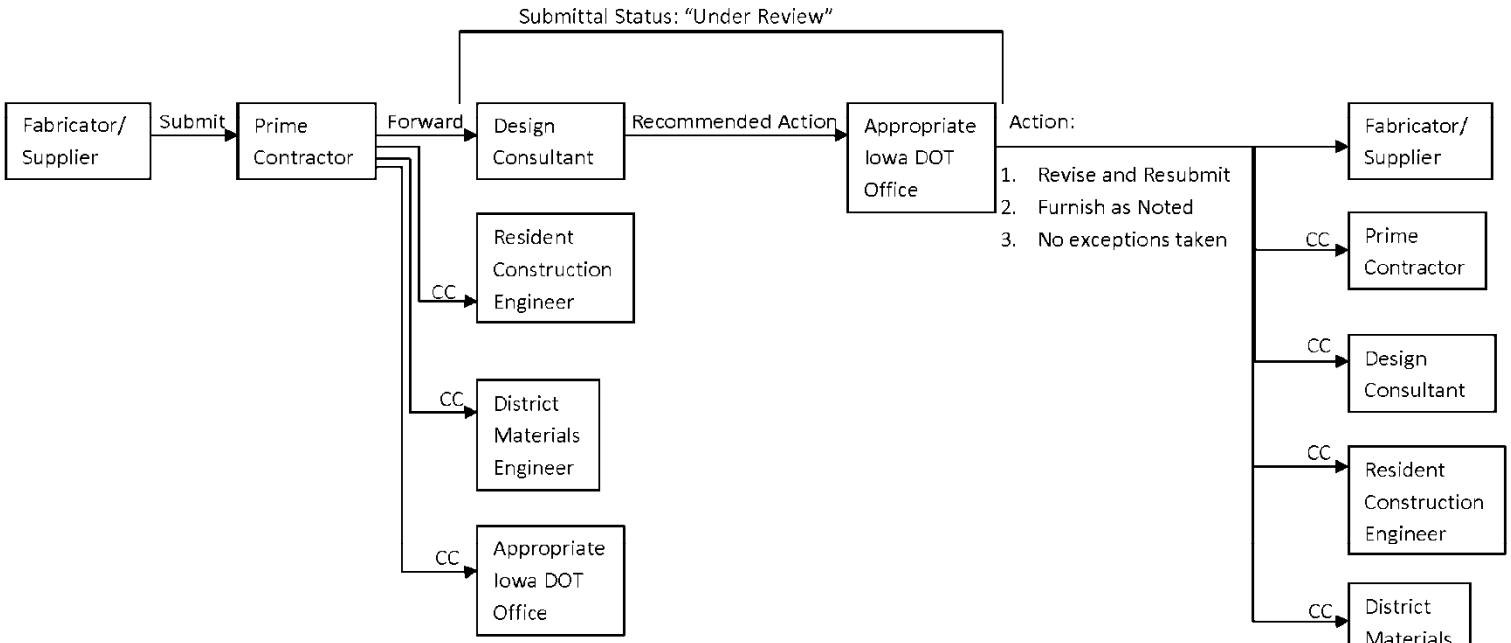
The frequency of these meetings may, at the discretion of the Iowa DOT Project Manager and/or Iowa DOT representative(s) be changed.

3.12.3 Data Ownership

The Iowa Department of Transportation shall retain ownership of the data on the website.

Attachment A:

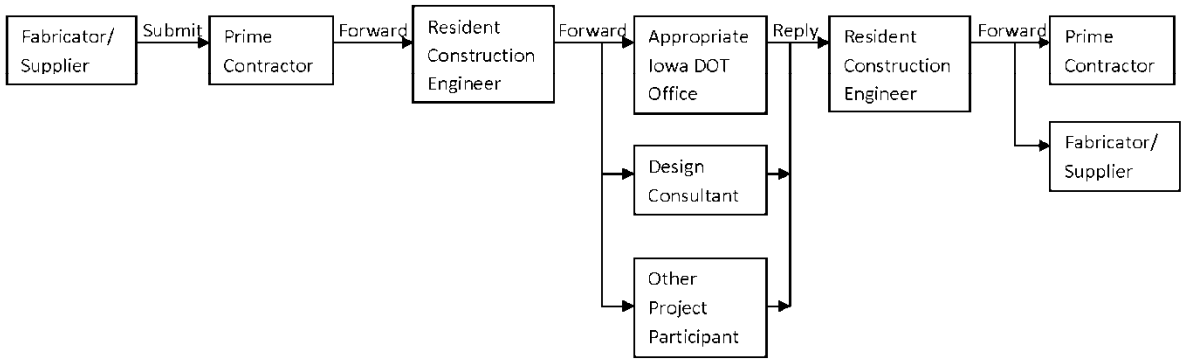
Electronic Shop Drawing Review Process (Consultant Design):



1. Resubmitted shop drawing shall be linked to the original submittal and displayed as a thread, or in such a manner that the submittal and review history are easily understood.
2. Appropriate Iowa DOT office for submittals is outlined in Specification Section 1105.03
3. User Permissions shall be designed to require subcontractors and suppliers to upload and submit shop drawings to the prime contractor. Only the prime contractor will have the user permissions to submit shop drawing to the design consultants or Iowa DOT.
4. All arrows in the flow chart will have an associated email notifying the party that is receiving the information as to alert them without having to directly access the project website.

Attachment B:

Electronic Request For Information (RFI) Review Process:



1. RFIs shall be linked to any applicable documents such as contract documents or shop drawings residing on the project website.
2. For all RFI's the Resident Construction Engineer (RCE) shall act a gatekeeper controlling the transmittal of information between contractors and designers. The RCE will have discretion determining the most appropriate party to forward the RFI to.
3. User Permissions shall be designed to require subcontractors and suppliers to upload and submit shop drawings to the prime contractor. Only the prime contractor will have the user permissions to submit RFI's to the RCE.
4. All arrows in the flow chart will have an associated email notifying the party that is receiving the information as to alert them without having to directly access the project website.

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