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Electronic collaboration for highway projects under $10 million

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Electronic collaboration for highway projects under $10 million

by

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A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Civil Engineering (Construction Engineering and Management)

Program of Study Committee:
Charles T. Jahren, Major Professor
Jennifer Shane
Vernon Schaefer

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ABSTRACT

This thesis describes the action research process of identifying a web-based project management system (WPMS) for the Iowa Department of Transportation's (Iowa DOT) highway projects under $10 million. Noticing the advantages that a WPMS solution implemented for complex large bridge projects, the Iowa DOT sought to identify a WPMS solution for the shop drawing approval process of smaller highway projects.

Action research, an iterative approach used to solve problems, was the methodology used by the researchers to identify possible solutions that met the Iowa DOT's needs and requirements until, ultimately, reaching the final solution. Throughout this investigation, the research team developed several workflows for various shop drawing approval processes. These workflows represent the requirements that the Iowa DOT has established for the process as well as the parameters sought in a solution.

After several iterations, the researchers selected a web-content management system, Microsoft SharePoint, as the solution for development and implementation for the small highway projects. Problems were encountered during the early stages of the SharePoint development process due to a license restriction that did not allow external users from the Iowa DOT network access the SharePoint page and documents. To solve this problem, it was recommended to acquire the external license.

Throughout the entire identification, development, and implementation process it was noticed that action research is an effective method to identify and select a WPMS. It was also concluded that communication played an important role for the success of the development and implementation of the solution. The communication has to occur between the development and implementation team members. It was also found that the selected solution has to be integrated with existing software applications and programs that are currently in use at the Iowa DOT.

CHAPTER 1. INRODUCTION

Theoretical Background:

There are some communication problems that the construction industry is facing. Until recently, the construction business has relied on traditional methods of communications that consists of paper based document exchange and face-to-face meetings. (Stewart and Mohamed 2004). Even though there has been an increase of new technology being implemented in construction projects, much of the construction industry sometimes still operates using hard copy document transfer more often than the exchange of electronic files (Alshawi and Ingirige 2003). Therefore it can be said that construction documents could be classified as difficult-to-access, out-of-date, and incomplete when relying on the traditional information exchange methods (Stewart and Mohamed 2004). By using poorly coordinated information exchange systems, projects can be affected by wasted time and added costs by the inaccuracy, inappropriateness, inconsistency, and timeliness of the information (Stewart and Mohamed 2004).

Another problem that affects the communication is the fragmentation that the construction industry faces. According to Nitithamyon and Kibniewski (2006), fragmentation in the construction industry exists because of the industry's multidisciplinary nature. This can cause problems with the communication and information process which can cause project delays (Nitithamyon and Skibniewski 2006). Fragmentation can also occur due to the geographic locations from which different project team members operate. Geographic fragmentation is caused because most of the construction project teams are based on temporary collaborations between designers, contractors, and suppliers (Chan and Leung 2004). Lastly, the fragmentation found in the construction industry can also be caused by the number of stakeholders that are involved in a project. This fragmentation has led to adversarial relationships between the different parties involved in the projects (Nitithamyong and Skibniewski 2004). A way to solve the communication problems is to implement web-based project management systems that can help integrate the team and communication process.

The Internet is a tool that helps bring together project team members dispersed geographically (Alshawi and Ingirige 2003). Nitithamyong and Kibniewski (2004) discuss some benefits that can be seen by implementing Internet applications in construction projects:

- document transfer can occur faster and more efficiently;
- provides opportunity to work in teams;
- share documents over the web.

These project team members can be then coordinated with available tools (Alshawi and Ingirige 2003) such as web based project management systems (WPMS). WPMS can:

- improve the coordination and collaboration within a project;
- increase the document's quality and speed of work;
- develop control over project finances and communication;
- provide faster access to the project's documents;
- decrease in documentation errors (Nitithamyon and Skibniewski 2006).

When implementing WPMS during the project's design and construction phases there are added benefits:

- reduced errors and rework in the project documents;
- reduced time in the request for information response;
- document and versioning tracking online;
- improvement in the team's communication;
- collaborative environment due to the online collaboration;
- improvement of the project's processes;
- focused project strategy according to the project's needs;
- motivation of the team to work on the project due to the enhanced collaboration;
- ability to track the project's progress online (Alshawi and Ingirige 2003).

There are three types of WPMS available that can help the communication process as well as the document exchange in construction projects: a fee based solution, a build-it-yourself solution, and a web-enabled solution. The fee based solution is provided by information technology companies, referred to as application service providers. The implementation cost is lower, the system requirements are modest and this type of system is easy to upgrade. The negative aspect about the fee based web system is that it is operated by a third party (Chan and Leung 2004). The build-it-yourself solution is built in-house to meet its own requirements. This type of solution requires more investment and a longer development time (Chan and Leung 2004). Usually a commercial WPMS package is purchased and installed and served internally in the company (Nitithamyong and Skibniewski 2004). Lastly, the web-enabled solution consists of web-based software owned by the construction company that is not operated by a third party. All the information is retained within the company. The limitation found by using this type of solution is that the initial cost might be higher and the staff working with the system has to be knowledgeable about the system (Chan and Leung 2004).

Previous Work:

This research project builds on past implementation of the web-based project management system, AEC Sync, in complex bridge projects over $10 million conducted by Aaron Zutz (2010). Action research, an iterative research approach, was the methodology used to identify a WPMS that was able to meet the requirements from the Iowa Department of Transportation (Iowa DOT) for the request for information (RFI) submittal and shop drawing approval process on the large complex bridge projects.

Action research is an iterative approach that tries to find a solution to a problem using the lessons learned from the previous iteration (Susman et al. 1978). The first iteration for the large bridges WPMS implementation project consisted of developing an in-house webpage that was password protected. This site allowed the project participants the ability to upload and share documents, but it lacked the capacity to provide collaborative alternatives to the user. The term collaborative means to provide the users the capacity to not only share documents, but to edit and make changes to the document in real time.

This motivated the team to continue with a second iteration to provide a more collaborative solution.

The second iteration included the use of web alternatives that offer a collaborative solution. It involved the use of a free online application provided by Google called Google Groups and a File Transfer Protocol (FTP) site. Even though these solutions were collaborative, it lacked automation. Files had to be manually transferred from the FTP site into the Google Groups for review.

The team sought to identify an automated WPMS solution. This led the Iowa DOT to use AEC Sync, formerly known as Attolist. The implementation was positive and it was noted that smaller projects could benefit also from a WPMS implementation.

More information regarding the previous work and how it relates to the research being discussed in this report can be found in Appendices 1 and 2. Appendix 1 is a conference proceeding presented at the Canadian Society of Civil Engineers Annual Conference held in June 2011 in Ottawa, ON. It is a chapter from Aaron Zutz (2010) thesis that was edited to also include the work performed on the smaller highway projects. Appendix 2 corresponds to the analysis of the post-project surveys for both of the pilot projects from the complex project phase. Even though the evaluation documents the value that users received from improvements made during previous phase of this project, the surveys were conducted during the current project phase.

Problem Statement:

Having concluded that the implementation of a WPMS for large, complex bridge projects was beneficial, the Iowa DOT considered implementing a similar solution for smaller highway projects. Implementing AEC Sync in the smaller highway projects was not feasible because the cost per project page was judged to be too high in consideration of the duration of these short projects. For this reason, the Iowa DOT encouraged the research team to identify a WPMS that is more modest in scope and lower in cost for smaller projects.

Research Objectives:

This thesis documents the development of a web-based project management system for smaller highway projects that are under $10 million. To accomplish this objective, the Iowa Department of Transportation (Iowa DOT) collaborated with the research team to identify projects that could benefit from a WPMS implementation. The focus was to provide a solution that eased the shop drawing approval process on these projects. A Technical Advisory Committee (TAC) was developed to provide assistance and guidance throughout the identification, development, and implementation process. This TAC was primarily composed of engineers that are engaged in the shop drawing approval processes of the smaller projects and information technology specialists from the Iowa DOT, and researchers from Iowa State University. Action research, an iterative approach (Susman et al. 1978), was used to identify the available solutions available until the one selected for implementation was reached. Each iteration is based on the lessons learned from the previous iterations.

An objective that was involved in this research project was to document the workflows for the working and shop drawings documented in the Iowa DOT's Specifications Section 1105 (Iowa DOT 2011). Documenting these workflows will ease the implementation process of the selected WPMS solution in these different types of projects. These workflows will provide an overall understanding to the Iowa DOT engineers on how the shop/working drawing process takes place. It also provides an opportunity to re-engineer some of their processes, if need be. Other agencies that go through a similar process of shop/work drawing approval processes can use the procedure and methodology used to document the workflows for their processes.

An additional objective was to document the process involved in the development and implementation of the solution. By doing so, it can help with the implementation of similar solutions in other state highway or similar agencies by providing a guide and examples based on the implementation process in the smaller highway projects. Research conducted by Zutz (2010) noted that 11% of the State Transportation Authorities that replied to the survey indicated use of WPMS on their projects. 22% of

the respondents only used a WPMS internally, within the agency. These state agencies that only use a WPMS internally and the state agencies that have not implemented a WPMS on their projects could benefit from the documentation of the WPMS implementation underwent for the Iowa DOT smaller highway projects.

Content Organization:

Chapter 2 consists of a paper that forms part of the proceedings of the 2011 Mid-Continent Research Symposium. The paper addresses the action research process of identifying a WPMS for small Iowa DOT highway projects, specifically sign-truss projects.

Chapter 3 is a technical note. The chapter is about the development of workflows for small highway projects. It goes through the process of creating workflows for the implementation of web-based project management systems. These workflows can be used as a tool for identifying WPMSs that are able to meet the project's requirements as well as the user's expectations. In addition, the workflows are a tool to develop and modify the selected solution. This chapter important because it goes over the integral part for the identification and implementation of WPMS for smaller highway projects. The scope of work discussed, also corresponds to the researcher's primary responsibility.

Chapter 4 is also written as a technical article with intentions for publication. It describes the communication of software, users, developers, and computer programs. This article provides a guide and reference for future implementation of similar WPMSs in state highway or similar agencies.

There are three appendices in this thesis. The first Appendix corresponds to a paper presented at the Canadian Society of Civil Engineers 2011 Annual Conference. This paper is based on a chapter of a previous student who researched WPMS implementation in complex bridge projects (Zutz 2010). This paper was edited and information regarding the current project phase was added. The second Appendix corresponds to the survey

results of past WPMS implementation on the complex bridge projects. The third
Appendix documents all the workflows for the Iowa DOT smaller highway projects.

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CHAPTER 2. WEB-BASED PROJECT MANAGEMENT ACTION RESEARCH FOR HIGHWAY PROJECTS UNDER $10 MILLION

Modified from a paper submitted to the 2011 Mid-Continent Research Symposium in Ames, IA

Jose A. Perez Reboredo, Charles T. Jahren

Abstract

This paper reports on action research performed to develop a web-based project management system (WPMS) for the Iowa Department of Transportation's (DOT) smaller highway project (< $10 million). In 2008, the Iowa DOT was undergoing a construction period that included several complex bridge projects (>$10 million). They sought a WPMS that was able to ease the document management of requests for information (RFIs) and shop drawings for these projects. After having implemented the WPMS solution for complex projects, they were looking for a simpler WPMS that can be implemented in smaller highway projects (under $10 million), with capabilities of expanding its usage to additional Iowa DOT projects.

Action research, an iterative process of continuous improvement, was the methodology used to identify and test WPMSs that met the Iowa DOT's needs. Through this process the research team, alongside a technical advisory committee (TAC), evaluated the effectiveness of possible WPMS solutions.

This paper describes the process of identifying a WPMS for smaller highway projects. This process involved the development of the workflow for the Iowa DOT's document management. The workflow was developed for sign truss projects; this helped the researchers understand the document management of smaller DOT highway projects. Subsequently, several WPMSs were studied and were compared to the workflow. From these, SharePoint was selected as a possible solution for implementation. Currently, further studies and tests are being performed to SharePoint before being pilot tested.

Introduction

The Iowa Department of Transportation (Iowa DOT) began a phase of complex bridge construction projects in 2008. Having realized that the management of construction documents, such as requests for information (RFIs) and shop drawings, was consuming more time than traditional bridge projects, they approached the research team to help identify and implement a Web-Based Project Management System (WPMS) that could ease the management of such documents. For the first three phases of the project, the research team underwent the task of identifying and implementing different WPMS for complex bridge projects. For the current project phase, the research team was assigned the task to identify a WPMS for smaller highway projects.

The construction industry's document management is based in traditional communication methods. The communication method and document exchange, in its majority, consists of hard-copy paper documents transmittal and approval. This can result in wasted time and money due to a poor document management and coordination (Stewart and Mohamed 2004). Because of this, the information that is being exchanged within the industry can be classified, in some cases, as "difficult-to-access", outdated, or incomplete (Stewart and Mohamed 2004). Web-based project management systems try to mitigate some of the problems caused by this traditional information exchange system and provide additional benefits. The benefits are: coordination with other email or collaborative solutions, decrease of problems related to communication, improvement of the project's processes, ability to track the project's process and information through the internet (Alshawi and Ingirige 2003), increased coordination between the project team members (Alshawi and Ingirige 2003 and Nitithamyong and Skibniewski 2004), increase in work speed and document quality, decrease in documentation error, and provide easier and faster access to project information (Nitithamyong and Skibniewski 2004).

Methodology

This research project involved the use of action research. Action research is an iterative approach of identifying a problem or requests that need to be addressed and solved

(Susman et al. 1978). It is a continuous learning process where the lessons learned from previous iterations are applied to subsequent project iteration. The steps involved in the action research process are the following:

- Diagnosing: The problems are identified and defined.
- Action Planning: The actions required to solve the problem are determined.
- Action Taking: The plan is implemented.
- Evaluation: The implementation is reviewed and the consequences are measured.
- Specifying Learning: The lessons learned from the evaluation are recorded and used for future iterations. (Susman et al. 1978).

After a cycle is completed, the iteration is completed. The lessons learned from the Specifying Learning are used as part of the Diagnosing stage of the next of iteration. This process is depicted in Figure 1. The action research stages are represented in the cycle and the different iterations are identified in the arrow placed after the Specifying Learning stage.

The first iteration for the smaller highway projects used the lessons learned from the previous iterations performed on the identification and implementation of WPMS for complex bridge projects. Using Susman's action research approach, several iterations to find a WPMS solution for smaller highway projects, specifically sign truss projects, were performed. Recommendations were presented to the Iowa DOT with the findings and suggested solutions. A Technical Advisory Committee (TAC) was created to provide input and make recommendations during the entire iterative cycles. This TAC is primarily composed of engineers and information technology (IT) specialists from the Iowa DOT as well as researchers from Iowa State University.
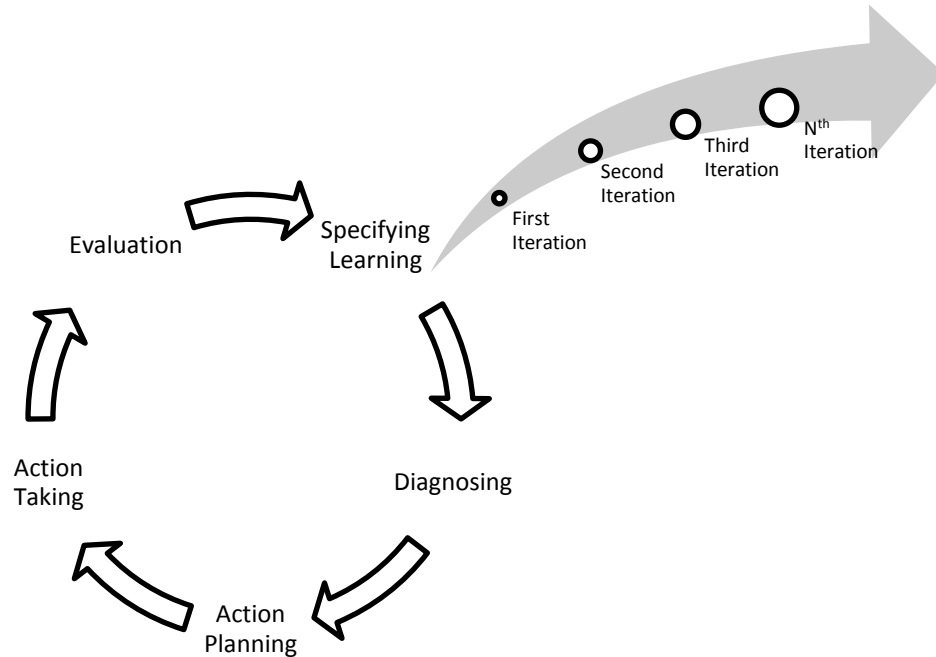
Figure 1. Action research flow

First Iteration

Diagnosing

It was established by the TAC to implement the WPMS solution first sign truss projects. The researchers went ahead to establish the required tasks and actions that the solution had to offer for this type of project. For this, the researchers met with the engineers from Traffic and Safety division and Bridges and Structures division from the Iowa DOT, to identify the steps and workflow of the review process for the shop drawings submittals in sign truss projects. The established workflow can be seen in Figure 2. The workflow involves different Iowa DOT departments, depending on the type of shop drawing sent for review. It is important the WPMS solution has the capacity of sending automatic notifications to the corresponding parties involved in the process. The WPMS should also have a log-in requirement, where user access to the site is restricted and a username

and password is required to access the page. Also, another requirement to satisfy the workflow is that the WPMS must keep track of the different document versions, especially when the shop drawing has to be resubmitted. Lastly, the WPMS should have the capacity to have an approval option or a comment section where the documents can be categorized as "No Exceptions Taken" or "Make Corrections Noted" (documents do not need to be resubmitted) or as "Revise and Resubmit" (were the documents need to go through the workflow process again). These categories are the Iowa DOT's response and evaluation to the shop drawings submitted by the prime contractors.
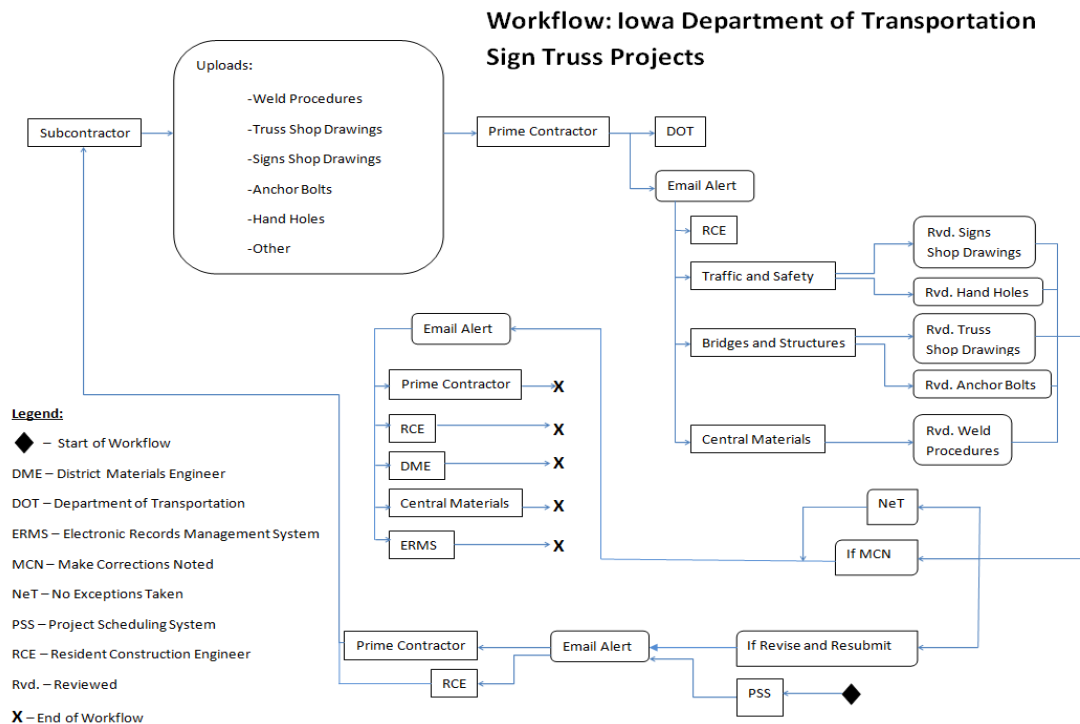
Figure 2. Sign truss shop drawing workflow

Action Planning

Having established the needs and requirements of the WPMS, a plan was developed in order to identify the different existing solutions available. The basic strategy was to find existing online solutions that focused mostly on document management and file sharing.

The evaluation criteria in which all the identified WPMS were going to be tested was established. The criteria used for each of the WPMS evaluation are the following:

- project capacity
- storage capacity
- document tracking history
- accessibility
- notification
- approval option
- price
- capacity to recreate the workflow and requirements provided by the Iowa DOT

Action Taking

The researchers sought commercial WPMSs that met the requirements established by Iowa DOT engineers. The researchers began identifying solutions with an interface familiar to the end user: the DOT staff and project team members. For this reason, the researchers studied social and professional connection websites and used these as a backbone for identifying the different WPMS solutions for the sign truss projects.

The WPMS identified were Huddle, Google Applications, TeamWork Live, TeamWork Project Management, and Sosius. Each one of these web-based project management systems were tested by creating different e-mail accounts, representing different parties that are identified in the workflow for the sign truss shop drawing approval process. These emails were set up as different user accounts for each of the solutions being tested. The restrictions on the WPMS were set based on the established workflow and the requirements presented by the Iowa DOT.

Evaluation

After all the possible solutions were tested, each of them were compared and evaluated based on the evaluation criteria established in the action planning stage. A matrix was

developed to make the comparison of the WPMS easier. Table 1 shows how each
solution performed against the evaluation criteria.

Table 1. Evaluation of first iteration solutions

	Huddle	Google Applications	TeamWork Live	TeamWork Project Management	Sosius
Project Capacity	25 Projects	Unlimited	Unlimited	35 Projects	Unlimited
Member Capacity	Unlimited	Unlimited	25	Unlimited	Unlimited
Managers	1	Unlimited	1	1	1
Storage Capacity (Group)	25 Gb	100 Mb	50 GB	10 Gb	25 Gb
Storage Capacity (Personal)	NA	NA	NA	NA	250 Mb
Document Tracking History	Yes	No	Yes	Yes	Yes
Ease of Accessability to the Site	Yes	No	Yes	Yes	No
Document Approval Option	Yes	No	Yes	No	No
Email Notification	Yes	Only for folder created	Yes	Yes	Yes
Calendar Option	Yes	Yes	Yes	Yes	No
Price	$200/month	Free	$149/month	$49/month	$100/month
Capacity to Reproduce DOT Workflow	Yes	No	Yes	Yes	No

From these, the one that was chosen for further testing in the next iteration was Huddle, a
collaboration and content management solution. Huddle had the most user friendly
interface, was the easiest to learn how to use as well of having all the requirements
presented in the sign truss workflow. Even though the sign truss shop drawing approval
workflow could be recreated in this solution, it lacked the capacity of being fully
customizable. This reduces the capability of having other uses and applications in other
projects and integration with other communication systems, such as email.

Specifying Learning

From this iteration several lessons learned can be identified:

- Establishing the workflow with the necessary functions and requirements
  before identifying solutions or alternatives proves to be the most efficient way
  of selecting a WPMS. The workflow not only establishes the requirements

needed but it distinguishes the relationships between the document management and the different parties involved in the project.

- Most of the commercial WPMS solutions available have established tasks, interfaces, and workflows.

- Several commercial WPMS solutions meet the sign truss workflow requirements. Huddle meets these requirements. This WPMS has an already established workflow and allows little to no room of adjusting it in order to provide a customizable solution to the end users. A solution that has the option of allowing the creation of customized workflows could be more beneficial for the Iowa DOT since it can be implemented in other Iowa DOT projects.

Second Iteration

Diagnosing

Using the lessons learned from the first iteration, the researchers sought a solution that was more customizable and allowed for workflows. This enables the research team and the Iowa DOT to implement the WPMS solution effectively, not only on sign truss projects, but if decided in the future, in other types of projects. Also, as established in the first iteration, an automated solution that has the capacity of sending email notifications to the respective party reviewing the shop drawings was still of importance for this iteration.

Action Planning

The researchers will compare Huddle, the WPMS from the first iteration, to Microsoft SharePoint, a web-content management system, based on the requirements of sign truss projects. The evaluation criteria for this iteration are the same as those in the first iteration.

SharePoint can be integrated with other personal content management systems and email services, such as Microsoft Outlook. Also a SharePoint expert can customize workflows

in a SharePoint Depending on the Microsoft license, user access can be restricted. If the license owner has the internal license, only users who are in the internal network and have permission can access the SharePoint page. However, with an additional fee, an external license can be acquired and allows external users into the system.

Action Taking

A SharePoint page was developed by the research team using the SharePoint server space provided by the College of Engineering at Iowa State University. Based on of the sign truss shop drawing review process workflow developed in the first iteration, the SharePoint page, the document libraries, and restrictions were established. Since the SharePoint page is limited to users within the University network, the external email accounts developed in the first iterations could not be used. University email accounts were created to be used as project users within the SharePoint page. The researchers then sought a solution to grant external users access to SharePoint or provide them with an option to at least export and import documents to and from, respectively, the SharePoint project page.

Microsoft Outlook and an FTP website were considered as possible solutions. Each of them were evaluated and proposed to the TAC so a decision could be made for the third iteration. Interest was placed in developing an alternate way for external users to access the information within SharePoint, because the current license that the Iowa DOT holds does not allow granting permission to users outside of their network. Given the scope of this iteration was to only find a customizable solution and compare it to the first iteration, the decision regarding the alternative for external user access is considered as part of the third iteration.

Evaluation

As done in the previous iteration, the Microsoft SharePoint page developed was evaluated and compared with Huddle, the first iteration solution. The SharePoint solution was able to provide the opportunity of the development of the exact workflow established

in the first iteration in a successful manner. Table 2 summarizes the evaluation process
and comparison with Huddle.

Table 2. Evaluation of second iteration solution and comparison with huddle

	Huddle	Microsoft SharePoint
Project Capacity	25 Projects	Depends on server space
Member Capacity	Unlimited	Unlimited- Approved by Adm.
Managers	1	1
Storage Capacity (Group)	25 Gb	Depends on server space
Storage Capacity (Personal)	NA	NA
Document Tracking History	Yes	Yes
Ease of Accessability to the Site	Yes	Yes
Document Approval Option	Yes	Yes
Email Notification	Yes	Yes
Calendar Option	Yes	Yes
Price	$200/month	Depends on License
Capacity to Reproduce DOT Workflow	Yes	Yes
Costumizable Workflow & Terminology	No	Yes

As it can be seen in Table 2, the performance of the two solutions is very similar with the
only difference being the price of the solution. From these two, the one selected for
further research and study was Microsoft SharePoint. The main decisive element was the
ability of creating the customized workflow, document library and folders as well as
having the option of implementing Iowa DOT terminology into the system. This WPMS
allows the page developer to set all the requirements and page restrictions which can
enhance the implementation of this solution to not only sign truss projects, but other Iowa
DOT projects.

Specifying Learning

For this iteration, as it was in the first iteration, there were some lessons learned that are worth noting:

- A WPMS that enables the creation of customized workflows instead of a solution with an already established workflow has a better capability of meeting the needs of the users and the project. Since the web-page developer or administrator can create different functions and restrictions to meet the project needs, each page can be developed for particular needs.
- The solution selected, Microsoft SharePoint, can cause some difficulties, depending on the license restrictions, when it comes incorporating people outside of the server's network into the WPMS system. For this reason, a way to mitigate this situation should be addressed in order to provide to all project team members the benefits of a WPMS. An external license would be the most advantageous solution.

Third Iteration

Diagnosing

Microsoft SharePoint proved to be a good solution for sign truss projects and other small (less than $10 Million) highway construction projects. Some difficulties that have to be overcome involve allowing external project team members access to the SharePoint page. This access allows them to upload and access shop drawings.

Action Planning

One of the main tasks is to meet with TAC to discuss options and identify ways to allow external users to upload and retrieve documents from the Iowa DOT SharePoint page. The easiest way to allow this access would be to acquire the external license. A second option is to develop an FTP site with log-in restrictions that allows external users to upload and access SharePoint. A third option is to develop an email communication system so users could send and receive project documents.

Another main task is to test SharePoint in Iowa DOT sign truss projects, and a final task
is to evaluate the effectiveness of SharePoint and identify areas for improvement.
Surveys will be used for this evaluation.

Action Taking

This is the current stage of the project. Meetings have been held to identify the best way
to allow external users access the documents in SharePoint. Attempts have been made to
identify the feasibility of acquiring the external license. Other alternatives have been
considered to reduce the drawbacks of not having the external license. The chosen
alternative was to develop an FTP website and integrate it with the SharePoint page.
This will provide the external users a central place where the project documents, in this
case shop drawings, will be stored. The Iowa DOT staff developed a workflow
incorporating the effects of the FTP site with the already established sign truss workflow.
The workflow in Figure 2 establishes how the FTP and SharePoint page meet the
requirements for the shop drawing review process of sign truss projects.
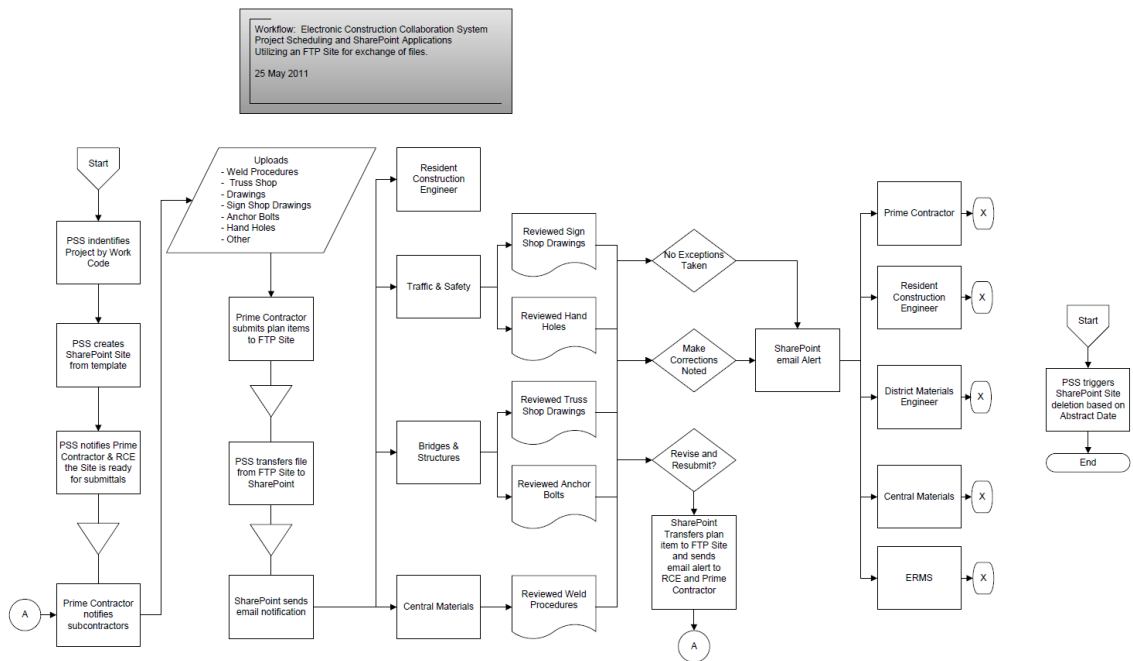
*Workflow courtesy of Karla Hocker, Iowa DOT

**Figure 2. Workflow for SharePoint and FTP site implementation on sign truss
projects**

The SharePoint page for sign truss projects is currently under development. Once that it is developed, meetings with the TAC will be held in order to establish the evaluation criteria for the sign truss project SharePoint page and identify sign truss projects that can benefit from the implementation from a WPMS.

After implementation, surveys will be distributed to both DOT staff and external project team members.

Conclusion and Lessons Learned

- Action Research is an effective method to identify, test, and implement a web-based project management system.
- Establishing a workflow before identifying solutions helped the researchers identify and test the solutions that met the requirements of the Iowa DOT. The workflows allowed the research team to understand the required tasks and actions that were required for this type of project.
- There are different types of commercial solutions available. The WPMS studied and analyzed by the research team can be categorized into two types of WPMS solutions: one with established workflows that allowed some customization and others with fully customizable workflow capabilities.
- Microsoft SharePoint, a WPMS that allows for workflow customization, was chosen as the solution to be implemented in the Iowa DOT sign truss projects because it could replicate the exact sign truss workflow.
- Having a TAC was an important component when identifying specifications needed in the solution to be implemented. The TAC was also important in testing the different solutions. After implementation and evaluation of the final solution by the researchers, the TAC can still perform several iterations, either to apply the solution in other types of projects or make adjustments to the solution workflow.
- Identifying the roles and responsibilities of each project team member at the early stages of the project, helps accelerate the development and

implementation process of a WPMS solution.

Awknowledgements

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CHAPTER 3. WORKFLOW DEVELOPMENT

Introduction

This technical note reports on the documentation of workflows involving the shop/working drawings review process within the Iowa Department of Transportation (Iowa DOT). The workflow documentation is one of the main steps of a research project that investigates the identification and implementation of a web-based project management system (WPMS) for small (under $10 million) highway Iowa DOT construction projects. Identifying workflows for each of the various work processes is an important step in the effort to identify an available commercial system that meets the Iowa DOT requirements. Each proposed commercial system can be tested against these workflows, in order to select the final solution for implementation. Lastly, these workflows can be used as a guide for future WPMS implementation that the Iowa DOT might encounter.

Workflows are being used to manage complex processes that are internet and virtual-based (Müller et al. 2004). Workflows are able to document, regulate, separate business and office work activities into defined tasks, roles, rules, and procedures (Georgakopoulos et al. 1995).   According to Casati et al. (1997), tasks are work units within the workflow model that are assigned to agents to perform, also referred to as the agent's role within the workflow process model. Workflows can be used to reengineer information and automated business processes within an organization (Georgakopoulos et al. 1995).   Three types of workflows available:

- Material process workflows: model the assembly and delivery of physical products.
- Information process workflows: model automated tasks that are involved in the creation, process, and management of information. It usually involves systems that provide basic technological infrastructure that support information processes.
- Business process workflows: model market-centered processes within an

organization.   (Georgakopoulos et al. 1995).

Methodology

A Technical Advisory Committee (TAC) was established to guide and collaborate, alongside the research team, with the identification of a WPMS for implementation in smaller highway projects. One of the important aspects of documenting Iowa DOT workflows for future WPMS implementation is to identify different work components or projects that could benefit from a WPMS implementation. After a discussion with the TAC, the decision was made to document the workflow for all the shop drawings or working drawings that are documented in the Iowa DOT Specifications Section 1105, "Control of Work". The following table, Table 3, based out of Table 1105.03-1: Review Offices for Working Drawings (Iowa DOT 2011), lists the different work/shop drawings with the respective main review office.

After the different shop/working drawings that could benefit from a WPMS implementation were identified, interviews were held with the different review offices. These interviews helped the research team identify the required tasks and their relationships involved in these drawings approval process. An important aspect about these interviews was that they were held independently and individually per office. This gave the research team the opportunity to understand and better capture the approval process for each of the respective offices and offer a workflow that best suited their needs. After conducting these initial meetings, the research team developed the workflows based on the requirements found during the interviews and specifications for each of the corresponding working/shop drawings. Follow up meetings were also established in order to review the documented workflows for accuracy with the respective offices.

 All the workflows were created in a word processing software, such as Microsoft Word, using the drawing tools option. Arrows were used to connect the different tasks and symbols, as it can be seen in Figure 3, were used to represent different tasks, actions, and processes within the workflow.

Table 3. Working/shop drawings for Iowa DOT projects and their respective Review Office (Iowa DOT 2011)

Description	Review Office
Falsework for slab bridges	Bridges and Structures
Cofferdam design	
Reconstruction of substructure	
Steel Structures	
Detail plans for falsework or centering support of steel structures	
Steel and aluminum pedestrian hand rails	
Precast concrete	
Tower lighting	
Bridge components	
Pre-engineered steel truss recreational trail bridge	
Removal of box girder bridges	
Structural erection manual	
Temporary shoring	
Temporary sheet pile retaining wall	
Safety grates for RCB culverts	
Highway lighting	Traffic and Safety
Highway signing steel breakaway posts	
Traffic signalization	
Highway signing – Type A and B signs	
MSE, segmental, and modular block retaining walls	Soils Design Section
Soil nail and tie-back retaining walls	
Intermediate foundation improvement (IFI)	
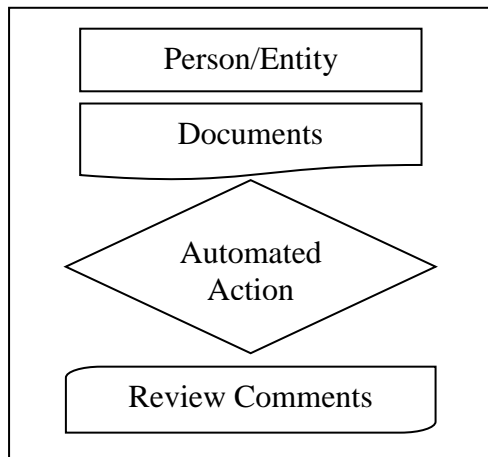
Figure 3. Legend of symbols

Results

After the researchers met with the different offices within the Iowa DOT responsible for the corresponding shop drawing review, the workflows were established and documented. These workflows are used to identify and evaluate WPMSs that could ease the document management and working/shop drawings review process. Later, after identifying a WPMS that could be implemented, these workflows can be used as the model to develop the different processes and pages for the selected WPMS.

An interesting observation found during the workflow interviews, is that even though there are multiple working drawing process, many of these share the same tasks, relationships, and processes. These can clearly be seen with the shop drawings that have to be reviewed by Bridges and Structures office. There are 15 shop drawing review processes for which this office is responsible, but these can be categorized into five different workflow models. The first of these workflow models corresponds to the Falsework for slab bridges, Detail plans for falsework or centering support of steel structures, Structural erection manual, Precast concrete, Removal of box girder bridges, and Pre-engineered steel truss recreational trail bridge. Figure 4 corresponds to the Structural Erection Manual workflow.

The second workflow model corresponds to the Handrails and Steel Structures and the Bridge components workflow. This workflow model is somewhat similar to the first model, but it incorporates an extra office, Central Materials, that reviews the drawings. This model is represented in Figure 5.

The third model also is derived from or similar to the first workflow model. The biggest difference is that it includes an alternate process that is used if the drawing has to be reviewed by the Soils Design office. If the drawing has to be reviewed by the Soils Design office, it has to be reviewed by this office before Bridges and Structures, the responsible office for the shop drawing, can begin the document's review process. This process is identified in the workflow with dashed lines. There are two shop drawing

process that share this model: Cofferdam design and Reconstruction of substructure. This third model can be seen in Figure 6.

The fourth model involves two additional offices, aside from the Bridges and Structures office, to revise the shop/working drawings. This model corresponds to drawings that also involve the review of the Central Materials and Traffic and Safety offices. The components that need to be reviewed are sent for review to the pertinent office. For example, the weld procedures are sent to the Central Materials office for review. Figure 7 presents the workflow for these types of projects: Safety Grates, Highway sign support structures, and Tower lighting.

The fifth and last model corresponds to the Sheet pile retaining walls and Temporary shoring systems. These are different from the previous ones, since they first have to be reviewed by the Soils Design division, to then be reviewed by the Bridges and Structures office. The workflow model is depicted in Figure 8.

The same observation was found in the other shop/working drawings to be reviewed by the other Iowa DOT offices. In the case of the Soils Design office, the three working drawings were represented in two models. For the working drawings under the responsibility of the Traffic and Safety office, there were four workflows, represented in two models. For brevity, these models are not shown in the paper. However, all the workflows investigated for this project are displayed in Appendix 3.

Workflow: Structural Erection Manual
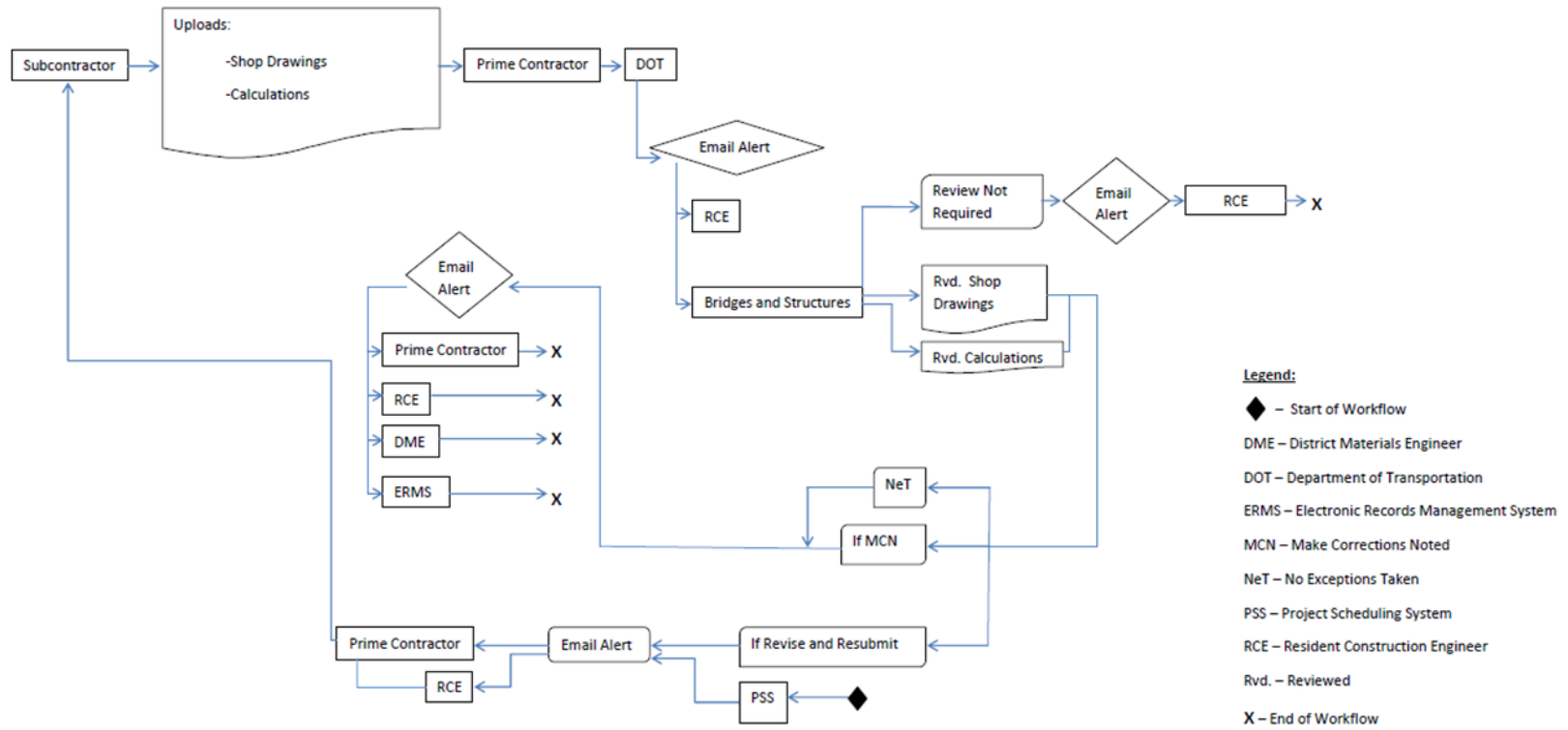
Figure 4. Structural erection manual workflow

Workflow: Steel and Aluminum Pedestrian Handrails
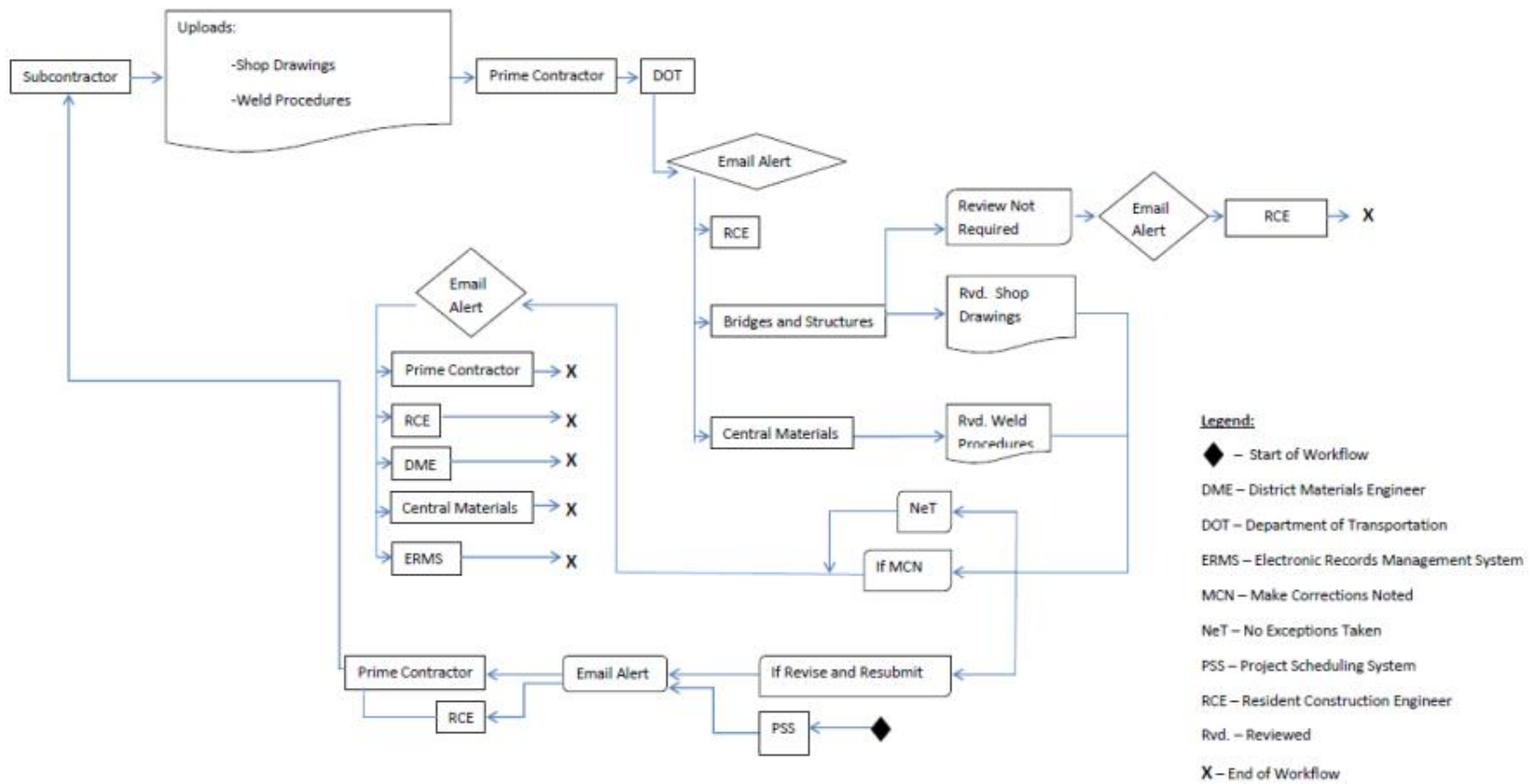
Figure 5. Workflow for the steel and aluminum pedestrian handrails
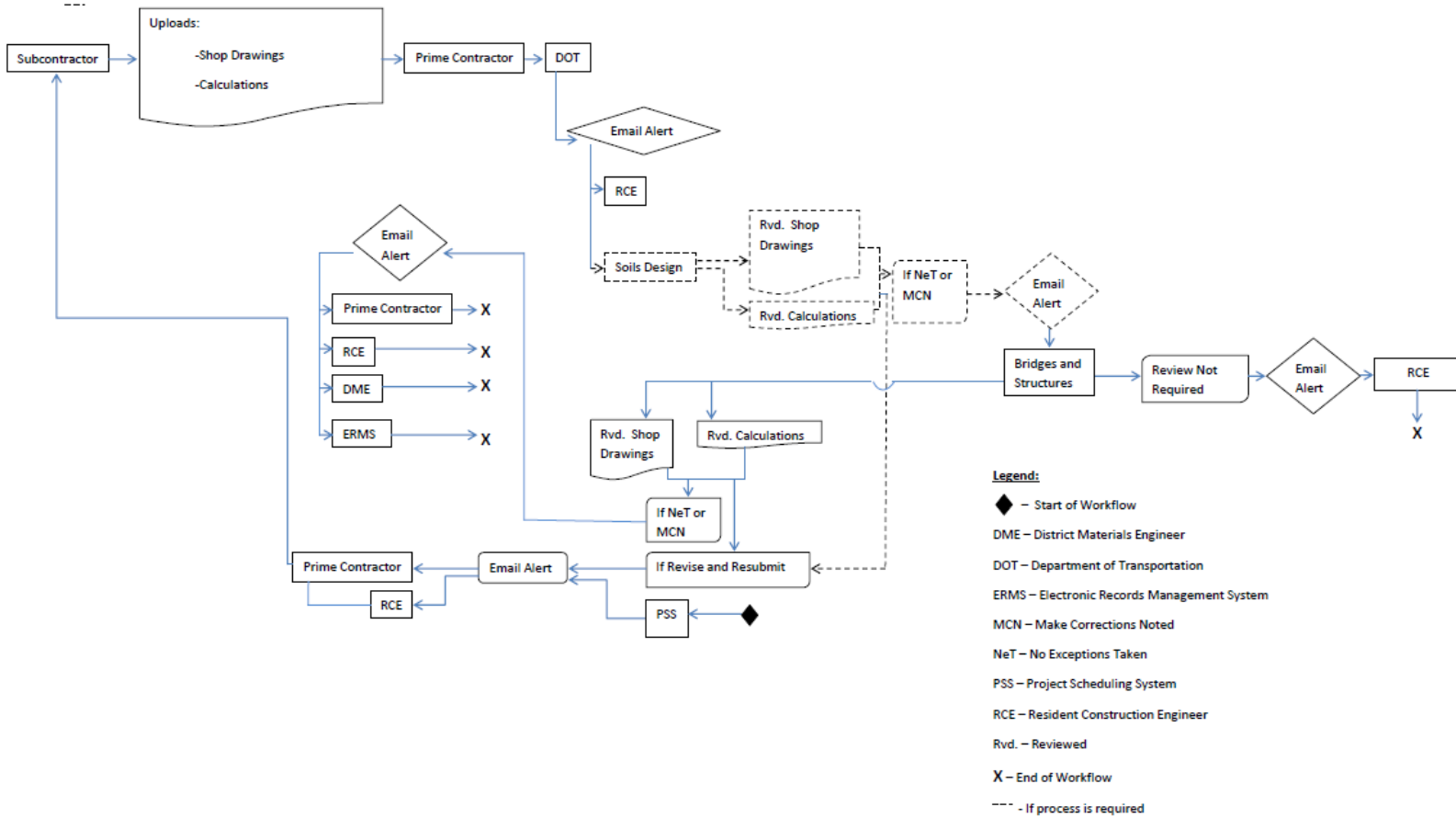
Figure 6. Cofferdam design workflow

Workflow: Safety Grates

Uploads:

    -Weld Procedures

    -Truss Shop Drawings

    -Signs Shop Drawings

    -Anchor Bolts

    -Hand Holes

Subcontractor → Prime Contractor → DOT → Email Alert

RCE

Traffic and Safety → Rvd. Signs Shop Drawings / Rvd. Hand Holes

Bridges and Structures → Rvd. Truss Shop Drawings / Rvd. Anchor Bolts

Central Materials → Rvd. Weld Procedures

Review Not Required → Email Alert → RCE → X

Email Alert →
- Prime Contractor → X
- RCE → X
- DME → X
- Central Materials → X
- ERMS → X

NeT

If MCN

If Revise and Resubmit → Email Alert → Prime Contractor → RCE

PSS ← ◆

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

Figure 7. Safety grates workflow

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Workflow: Temporary Sheet Pile Retaining Walls

Subcontractor → Uploads:
-Shop Drawings
-Calculations
→ Prime Contractor → DOT

Email Alert → RCE → Soils Design → Rvd. Shop Drawings / Rvd. Calculations → If NeT or MCN → Email Alert → Bridges and Structures → Review Not Required → Email Alert → RCE → X

Email Alert → Prime Contractor X / RCE X / DME X / ERMS X

Rvd. Shop Drawings / Rvd. Calculations → If NeT or MCN → If Revise and Resubmit → Email Alert → Prime Contractor / RCE

PSS ◆

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

Figure 8. Temporary sheet pile retaining walls workflow

Analysis

As it was seen in the results section, different work processes for the respective shop drawing approval process were able to be grouped together. At the beginning of the project, this situation was not expected to happen, but during the interviews it was found that a number of working drawings shared the same evaluation process and workflow. This put into perspective the importance of documenting and developing workflows for these processes. It gave the reviewing offices at the Iowa DOT and the research team the opportunity to graphically visualize the review process of these shop/working drawings and realize that most of their review processes share tasks and relationships. It also gave the review offices the opportunity to identify if there was a need for "re-engineering" components of these processes. Documenting the workflows helped the research team understand the requirements that the Iowa DOT needed in a WPMS. These workflows developed served as a model to identify and evaluate possible WPMS solutions. For the TAC, the workflows represented a guide to develop pages and solutions within the WPMS solution.

Lessons Learned

- Understanding the tasks and relationships involved in a process is vital for the development of workflows. The required information needed to developed can be gathered through interviews with the people involved in the process, for this project, the engineers involved in the shop/working drawings review process.

- Documenting the workflow for these processes allowed the research team and review offices to visualize the review process of the aforementioned drawings. It also provided an opportunity to evaluate if there was a need to re-engineer portions of the review process.

- After developing the workflows for different process, it was found that a number of these actually shared the same workflows. Having identified that processes shared the same workflow, makes the WPMS identification and

implementation easier.

- Documenting the workflow for the review process before identifying a WPMS solution, allowed the research team to understand and have all the requirements and specifications. This helped the research team identify a solution most suited for their needs.

- Documenting the workflow for these processes allows for the implementation team set the requirements and features for the selected WPMS solution.

Future Work

This paper is part of a larger research effort that endeavors to identify, select, and implement a Web-based project management system for highway projects under $10 million. This was the first stage of the iterative process to identify a WPMS solution. The workflows developed will be used to identify the solution that best meets the needs are requirements presented by the Iowa DOT. The workflows will also be used to set the actions and processes within the WPMS solution. Even though the scope of this project will not allow for the implementation of the WPMS solution for all of the processes described in this paper, the workflows developed will help the Iowa DOT continue with the implementation process after the research phase ends.

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CHAPTER 4. WPMS DEVELOPMENT AND IMPLEMENTATION: A COMMUNICATION PROCESS

Introduction

The Iowa Department of Transportation (Iowa DOT) was interested in implementing a web-based project management system (WPMS) for smaller highway projects that had a construction cost of less than $10 million. Their need to use a WPMS for these smaller projects, was based on previous WPMS implementation on large and complex bridge projects. It was found that the use of commercially available WPMS eased the document management of the shop drawings review and RFI response processes for the bigger projects. Having noticed the success of the WPMS's implementation, they sought to identify a less expensive system for the smaller highway projects. The needs of the Iowa DOT may be encountered in other State Transportation Authorities, so a similar process and solution can be applied in those satiations.

The research team and the technical advisory committee (TAC) studied several commercial web-based project management systems that could be implemented in smaller highway projects. The following requirements were established for the WPMS:

- Automation of the workflow
- Email notification
- Document tracking history
- Document versioning
- User interface
- Ease of use and access

A web-content management system (WCMS), such as Microsoft SharePoint, was selected for implementation with the smaller highway projects. The Microsoft SharePoint pages are developed in-house using SharePoint's established rules and settings. The server space and the storage capacity depend on the in-house server capacity. There are two licenses available when purchasing SharePoint: the internal and external licenses. With the internal license, only the people within the internal network

(usually employees of the contracting authority only) can access the SharePoint page and contribute to the document exchange process. With the external license, people outside of the network (such as contractors, subcontractors, suppliers, and consultants) can access the documents given permission of the SharePoint page developer.

SharePoint is a document management system that can be integrated and allowed to communicate with other software applications, such as email and personal content management systems (such as Microsoft Outlook), previously existing programs, and users. This paper reports on how various software, programs, data bases, and users communicate with Microsoft SharePoint. Understanding how the communication process takes place can help in future development of SharePoint or other WCMS pages. Another aspect that will be discussed is how the various people involved in the development process should interact to devise the communication and information transfer protocols for SharePoint and other software applications.

Project Team Role

An important aspect of developing and implementing a WCMS in construction projects, such as Microsoft SharePoint, is to develop a team that can understand the requirements needed for the site implementation. This team can be created by the client requiring the development of the SharePoint page. The client or the client's representative determines and selects the team members involved in the SharePoint page development based on their experiences and qualifications. Figure 9 depicts the various team members involved in the development of SharePoint. Even though the Iowa DOT WCMS implementation team had one person responsible for each role, other State Transportation Authorities might have one person fulfill more than one role, and conversely, it may be possible to split a role by more than one person.
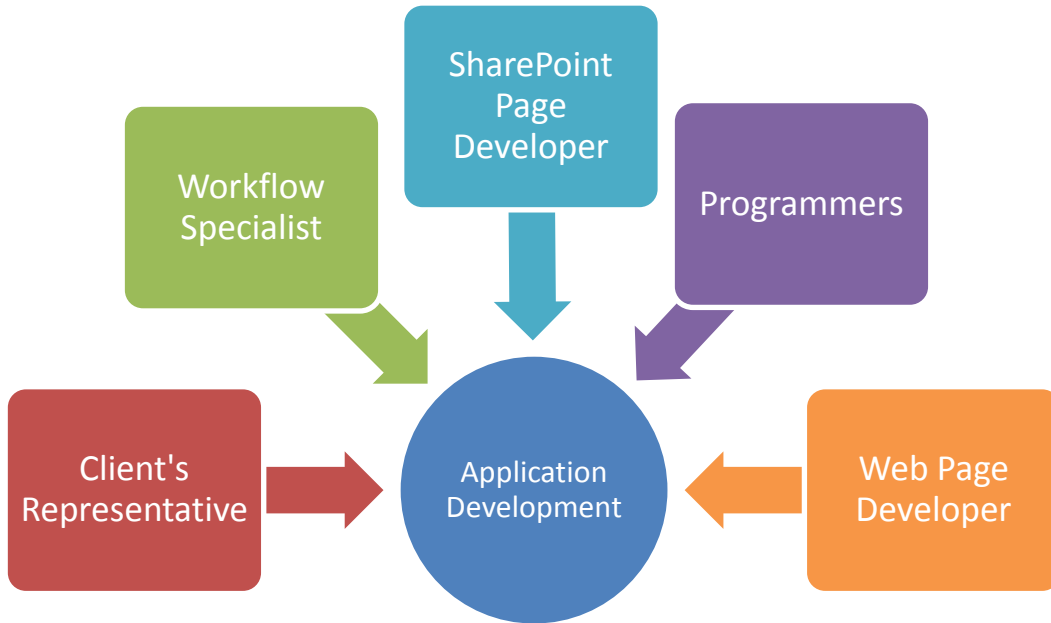
Figure 9. The SharePoint development team

The responsibility of the workflow specialist is to document the workflows of work processes that are going to be automated in Microsoft SharePoint. To document the workflows interviews have to be scheduled so the various tasks and their relationships involved in the work process can be identified. These workflows need to correctly depict the work processes since they will serve as the backbone for the SharePoint page development.

The SharePoint Page Developer is involved in the development of the various work processes taking place within the SharePoint page. The developer uses the workflows developed by the workflow specialist to create the document libraries within SharePoint as well as to set the restrictions to these. They set the required rules and specifications that meet the established workflows. The SharePoint Page developer may need to communicate with computer programmers to devise a way to initiate the SharePoint Page at the beginning of the project in such a way that it is preloaded with important project information known as metadata.

The programmer's responsibility is to help identify a way that the SharePoint page can initiate automatically at the beginning of the work process. The programmer is also

responsible on integrating the SharePoint page into any electronic systems or server spaces that the client may have already established.

The web page developer has the responsibility of developing the portal. The portal is the web page on which a user initially lands which includes branding for the contracting authority and important partners, as well as the authentication for application users, and other miscellaneous notices and web links that may be helpful to users.

Incorporating all these team members, and end users, at early stages of the development process can greatly benefit the outcome of the SharePoint page. By establishing a team that is able to work together starting with the workflow development stage opportunities can be provided to communicate and solve almost all challenges that the team might face.

SharePoint Interface and Users

An important feature of any software or website is the user interface. The user interface has to be sufficiently intuitive so the user can browse around and complete the tasks without any problems or minimal training. An interesting aspect about the SharePoint pages is that the SharePoint page developer or specialist has considerable control of its look and feel. It is customized to the requirements of the project and workflow, thus meeting the user requirements.

An important consideration for the SharePoint page interface is that it should be developed for specific purposes and workflows. To better develop the page and the interface, interviews and meetings should be scheduled with the end users to document their requirements and project workflow. For the small highway projects, the research team met with the various parties involved in the shop/working drawings process for these projects. These meetings consisted on interviews in which questions asked to potential users about their involvement in the approval process of the shop drawings and what requirements and actions were desired from the SharePoint page. Workflows were developed based on these interviews. An example of a workflow developed can be seen in Figure 10. This workflow corresponds to the Highway Lighting working drawings

approval process. Using these requirements, the SharePoint templates and available task options are used to develop the page. The interface and the page functionalities are established by the creation of document libraries and developing library folders within the libraries. These libraries and folders can be restricted and limited to certain users as set by the page developer.
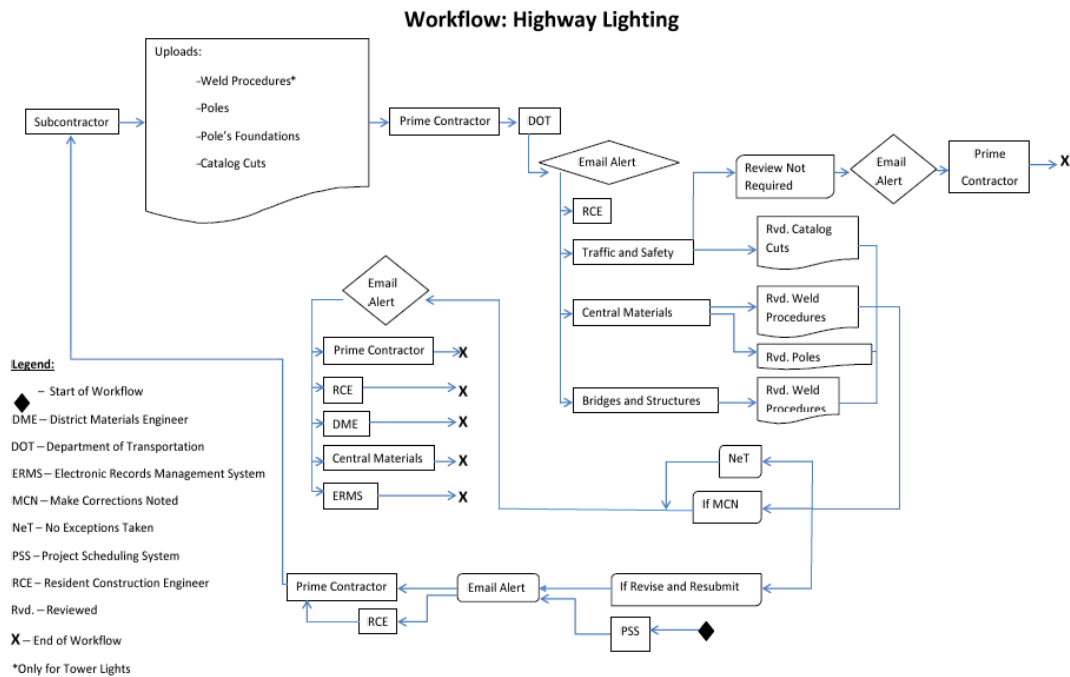
Figure 10. Example of workflow – highway lighting

Using these workflows, the SharePoint pages for the projects will be developed. The expectation is to have a test page for the sign truss projects ready for testing on early January 2012. Using that page as a pilot test, the user and interface communication can be evaluated so that future implementations can benefit from the lessons learned.

SharePoint and Personal Content Management Systems

A personal contentment management system (PCMS) that provides email management services, schedule and organizational tools such as Microsoft Outlook can be synchronized with Microsoft SharePoint. The 2010 version of both Microsoft SharePoint

Server and Microsoft Outlook provide synchronization of contacts and tasks lists (Microsoft 2010).

The research team and the TAC encountered a Microsoft SharePoint licensing problem: in order for the external users to access the Iowa DOT's SharePoint page, the Iowa DOT either had to acquire the external license or identify a different way for those users access the documents stored within the Microsoft SharePoint page. Since Microsoft Outlook can synchronize with SharePoint, the research team undertook the task of identifying a method for external users communicate to SharePoint through Microsoft Outlook.

It was proposed by a TAC member who is a specialist in Microsoft SharePoint to use SharePoint's and Outlook's synchronization capabilities to create various tasks in SharePoint from corresponding folders in Microsoft Outlook. Figure 11 presents this relationship. The process was proposed to be automated: the trigger for creating the folders in Outlook was the kick-off of the SharePoint page.

SharePoint Page is created ➡ Outlook creates task folders based on SharePoint Page
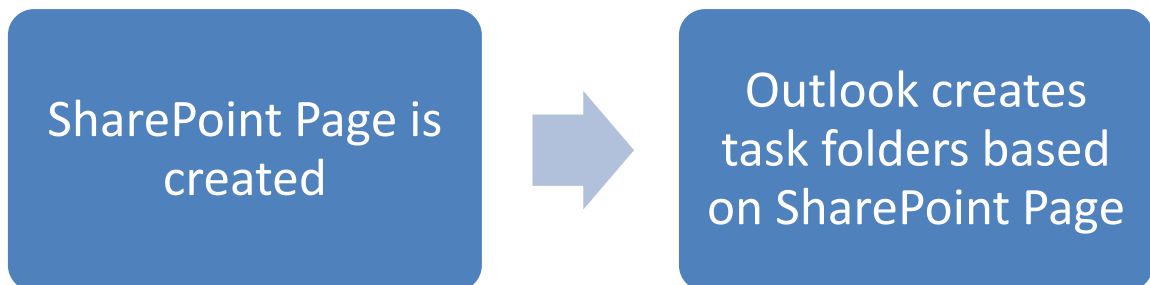
Figure 11. SharePoint-Outlook relation

The Iowa DOT would then develop email addresses to allow the external users send the documents to the Outlook folders. It was proposed that a common format would be followed on the email subject line. It would be required that the external user, or the submitter, write the work code for the document being sent. The Iowa DOT would create "rules" in Outlook to sort the incoming mail based on the email's subject line, i.e. work code. The rules will sort the incoming mail based on these codes which is unique for the project and submittal type. Then, Outlook will synchronize the documents to the

SharePoint page. Once there, the document can be accessed by the internal users. After the internal users have reviewed the documents and they are re-uploaded or updated in SharePoint, they will also be updated in Outlook. The Iowa DOT would also have to develop rules to forward the updated documents in Microsoft Outlook to the external user. Figure 12 presents the workflow for the previously explained process.
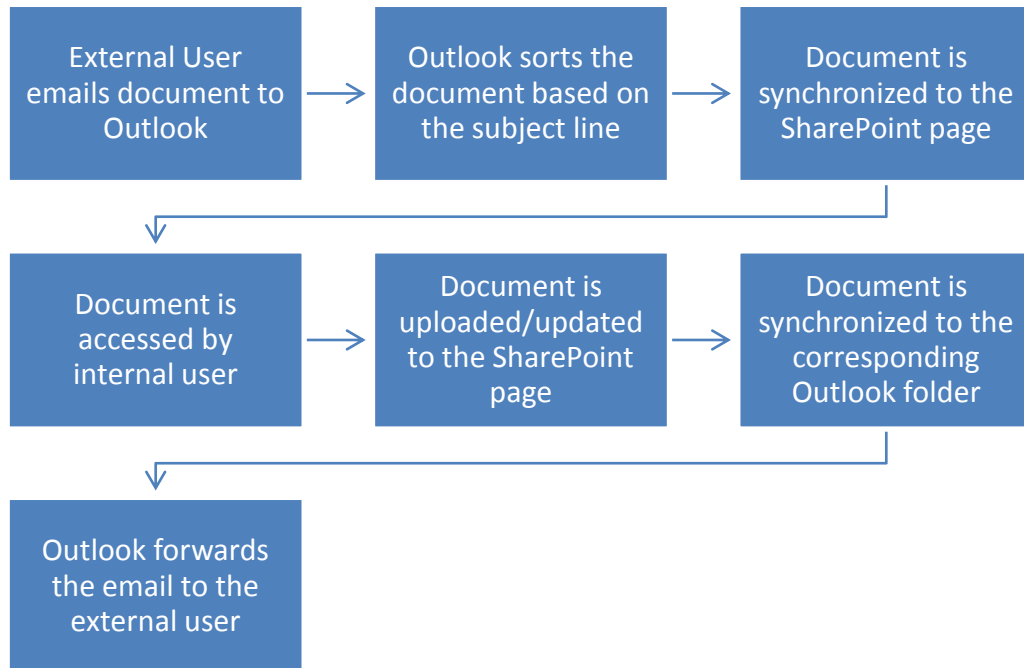
Figure 12. SharePoint – Outlook interaction workflow

Although this process was discussed and considered for the small highway projects, the Iowa DOT acquired an external SharePoint license before the scheme could be implemented. However, the author considers that scheme is worth sharing, since it would be an important step in the development of a SharePoint page when an external license is not available or worth purchasing.

Microsoft SharePoint and Project Initiation

The Iowa DOT was interested in developing a system to initialize the SharePoint page automatically after the contract for project was signed. The Iowa DOT seeks to have this process automated based on the project's metadata, types of shop drawing submittals required, and project letting date.

The Iowa DOT has developed an executable procedure that runs every night to identify the new projects that are newly under contract or have new project information that has been entered into the Iowa DOT Projects Letting Table. The procedure is able to re-distribute the information to other internal databases or servers and to initiate other programs associated with the project. The Iowa DOT is considering using this executable procedure to initiate the project's SharePoint page. A developmental specification number (DS), a number recorded with a specific project and metadata, will be added to the table by the Project Scheduling System (PSS) office after the project is let and the contract is executed. After this DS number is entered in the table, the executable procedure runs, and triggers the creation of a general SharePoint page. The workflow that summarizes this process is shown in Figure 13.
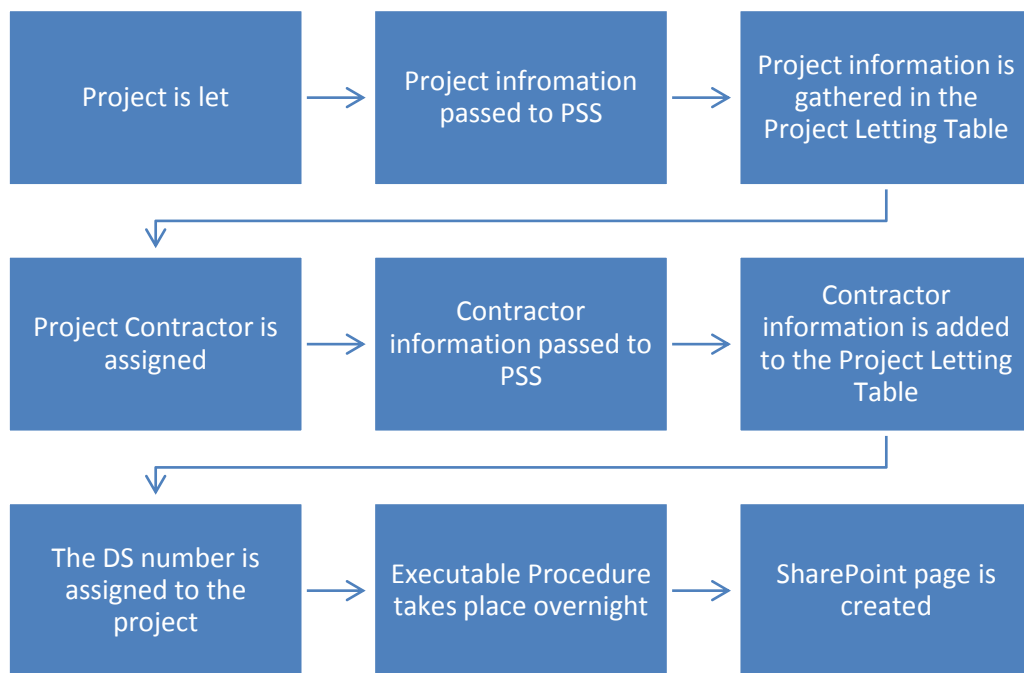
Figure 13. SharePoint page initiation workflow

Even though, this example procedure was developed for the Iowa DOT, it can provide template that other agencies can follow to initiate a SharePoint page using an executable procedure.

Microsoft SharePoint throughout the Project's Duration

After the SharePoint page is created, additional project metadata will be entered into the SharePoint page. This will allow for all the different workflows involved in the project execute properly. The workflow in Figure 14 that summarizes the process that would be executed after the SharePoint page is developed. The workflow depicts a process that is still in the development stage and it has not been tested. After implementation it will be evaluated to identify any possible opportunities for improvement. A note about this workflow is that the metadata provided by PSS at the initiation of the project SharePoint page will be updated as the project goes continues until completion.
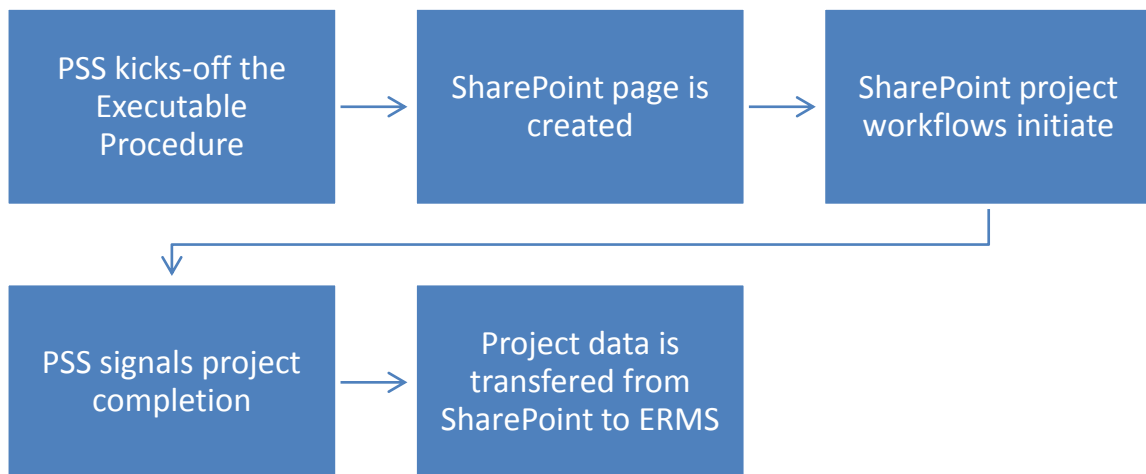
Figure 14. SharePoint project cycle

The activity in Figure 14 corresponding to the initiation of the SharePoint workflows includes several processes. The first process that SharePoint will go through is to identify that the SharePoint site has been created. It is through this process that the various "SharePoint Member Groups" will be created using the information provided by PSS. "SharePoint Member Groups" is an application that SharePoint offers, in which project members and participants that share the same responsibilities within the SharePoint site are grouped together so they receive the same notifications. The act of creating these groups will grant access permission to the various parties involved in the project and shop/working drawing submittal and review process. The various groups

created will also allow for the automatic SharePoint notifications to take place. The second and third processes that are involved within that SharePoint workflows activity are the shop drawing review workflow that was documented earlier in this paper, as well as the outcomes of the review. The review workflow will distribute the uploaded document to the corresponding Iowa DOT office so the review can take place. For this process refer to Figure 10 for an example. The Outcomes Workflow will be based on the result of the review process and the reviewer will categorize the document based on the result of the review. If a resubmission is required the contractor will be notified and the review and outcomes workflow will be launched again. If a resubmission is not required, that marks the end of the Outcomes Workflow.

The last two activities in Figure 14 go hand in hand. PSS signals the process for the completion of the project. At this stage, the Iowa DOT saves a record of the documents involved in the projects in and archival system named the Electronic Record Management System (ERMS). Also, the project's metadata will also be sent to ERMS if queried from PSS. Recall that the initial project metadata could be transferred from PSS to SharePoint. At the end of the project, the metadata could be transferred to ERMS from SharePoint and directly from PSS. At this writing, the Iowa DOT Information Technology team is still identifying a way that the document transmittal from SharePoint to ERMS can take place.

Conclusion

There are many communication processes that can take place during the development and implementation of SharePoint. This communication process begins with the development of a team that identifies the project needs and communication process that SharePoint has to address. This team is the key for developing the SharePoint page and into bringing a successful implementation.

An important communication process that takes place with SharePoint is the user interaction with the interface. In order for this communication to be successful, the development team must have captured the workflow for the various work processes. The

structure of these workflows can be documented by conducting interviews with the intended SharePoint page users and participants of the workflow process.

SharePoint can also interact with and be synchronized by using Microsoft Outlook. Documents sent to a Microsoft Outlook account folder can be synchronized corresponding SharePoint libraries. This communication and synchronization process can be useful when the document workflows involve project participants that are external to a contracting authority's network and an external license has not been acquired.

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    Office Webpage. < http://office.microsoft.com/en-us/sharepoint-foundation-
    help/synchronize-sharepoint-2010-content-with-outlook-2010-
    HA101881295.aspx > (Nov. 9, 2011).

CHAPTER 5. CONCLUSION

This thesis includes had three main components: the action research process of identifying a web-based project management system (WPMS) for small (under $10 million) highway projects; the development process of workflows for the identification and implementation of WPMSs; and the documentation of the communication involved in the development and implementation process of the Microsoft SharePoint (the selected WPMS) for small highway projects. Even though these topics were written in article format, they all relate to the entire process that was involved to identify, select, and implement a WPMS for the Iowa DOT's smaller projects. Although the research project's timeframe did not allow researchers to evaluate the Iowa DOT small projects SharePoint pages during actual use, conclusions can still be made based on the identification and development processes. Some of the conclusions are based on testing that was performed prior recommending that Iowa DOT use SharePoint as a solution and during the Iowa DOT SharePoint development stage.

Action Research Process to Identify the WPMS Solution

First of all, action research proved to be an efficient method to identify a web-based project management system. The iterative approach that this method offers, allows opportunities to identify and test WPMS alternatives that may be able to meet the end-user's needs, in this case a contracting authority such as the Iowa DOT or another state transportation authority. After a cycle finishes, lessons learned that have been gleaned from previous iteration, permits another iteration to take place with enhanced opportunities for improvement. This new cycle uses the lessons learned as a starting point to continue on with the process. As it was seen, this project underwent two iterations in order to identify a solution that met the needs of the shop drawing approval process for the smaller highway projects. Microsoft SharePoint, a web content management system, was selected for implementation on these projects because it met all of the Iowa DOT's requirements as well as being able to be customizable to the workflows and terminology established.

During the second iteration it was found that the license that was acquired by the Iowa DOT only served the internal users within their network. This situation marked the starting point of the third iteration, which consisted of identifying a way to allow the external users, such as the contractors and subcontractors, access the documents stored within the SharePoint page. For this, various options were considered, such as utilizing email communication, an FTP site, or acquiring the external Microsoft SharePoint license. The alternative selected was to acquire the external Microsoft SharePoint license; this simplified the SharePoint page implementation and allowed the document approval process to be a fluid, undisrupted workflow. The third iteration will be finished after this writing by the Iowa DOT since they will continue with the implementation and testing of the Microsoft SharePoint page in the smaller highway projects.

Workflow Documentation

The documentation of workflows proved to be a vital aspect in the process of identifying WPMS for the smaller highway projects, as well as for the development of the SharePoint pages. In order to document these workflows it was important to set meetings with personnel in the corresponding offices in charge of the shop drawing approval process. These meetings helped with the process of identifying the required tasks and their relationships in order to develop the shop drawing approval workflows. Once these were established, the needs and requirements that the final solution had to support were apparent. These workflows were then used as a model to identify and test the various WPMS solutions. The selected solution, Microsoft SharePoint, requires that a user or information technology specialist develop a web page user interface in order for SharePoint to perform the required tasks. The shop drawing approval workflows were used to develop the Microsoft SharePoint pages.

Even though for the Iowa DOT small project SharePoint pages were not tested by actual users before this thesis was written, the workflows established during this research were used to evaluate which software solutions would be capable of successfully implementing the WPMS application. If the SharePoint pages were able to perform all the tasks based on the established relationships, the likelihood of successful implementation can be rated

as high. If the SharePoint page does not appear to meet the requirements established in the original workflows, the SharePoint page implementation does not have to be classified as completely unsuccessful. The documented workflow allows re-engineering and the possibility to modify the SharePoint page to better meet the user's needs and requirements—or for the user to reconsider their needs. This was the basis of evaluation when the research team was initially testing Microsoft SharePoint and the other possible applications in order to select a platform for further development.

Communication and the Implementation of Microsoft SharePoint

Communication played an important role during the development and implementation of the Microsoft SharePoint pages. Communication was needed within the implementation team and between the various software applications or other electronic services that can be integrated with Microsoft SharePoint. Knowing and realizing the importance on how these various software applications interact during WPMS development, enabled the successful development of Microsoft SharePoint for the smaller highway projects.

An important conclusion that can be drawn by reviewing this thesis is that in order to have a successful WPMS development and implementation, a capable and integrated team has to be created. The project team should integrate various specializations. In the case of this research project, a team was formed included information technologists, engineers and academic researchers. To collect the information that was needed d to create the SharePoint pages, it was efficient for the Iowa State University research team to take responsibility of documenting and establishing the workflows for the various shop drawing approval processes. Requirements for information technology expertise included a webpage developer, a SharePoint page developer, and programmers to modify software applications that had been previously developed in house. The SharePoint page developer was responsible for using the workflows documented to develop the various project SharePoint pages. The webpage developer is in charge of developing the web portal where the different users will go to log-in into the system. The programmer is responsible of integrating the SharePoint pages with existing in-house programs. The key factor that brought success to this project was bringing all of these members early in

the development process. This allowed the team members to start the communication process and understand their roles and responsibilities during the early stages.

Microsoft SharePoint also has the capacity to communicate and interact with Microsoft Outlook. This feature was helpful when the development and implementation team was considering various alternatives to provide access for external users to submit documents to be uploaded to the SharePoint pages, when SharePoint is only licensed for internal users. It was found that emails sent to Outlook can be forwarded to the Microsoft SharePoint project page. Thanks to the Rules feature in Outlook, by examining keywords and phrases in the email's subject line, Outlook can send documents to Outlook folders that correspond to the appropriate library in SharePoint. The Outlook folders can be synchronized to corresponding Share Point libraries, thus providing and automated method whereby documents may be uploaded to SharePoint libraries, even in situations where some users cannot interface directly to SharePoint because of licensing restrictions. Even though, the SharePoint-Outlook interface was never implemented, this alternative was the one that was considered by the Technical Advisory Committee; it might well have been used if the external license would not have been purchased.

Lastly, SharePoint can be integrated with other programs, including executable processes that are developed in house. This was not tested by actual users by this writing; however, the TAC and researchers were able to develop and execute test programs to show that executable code developed in house could be used to trigger the imitation of SharePoint pages. It is expected that the Iowa DOT will employ such a process to create the SharePoint pages for each project automatically. A similar procedure can be implemented in other contracting authorities that are seeking a process to automatically initiate SharePoint pages.

Lessons Learned:

It can be concluded that the following are lessons learned from this research project:

- Action research is an effective research method for identifying a WPMS

solution. The iterative approach of action research allows the team to identify solutions based on the project's constraints and requirements. Further solutions can be found by referencing the lessons learned from past WPMS testing.

- Involving the implementation team early in the solution identification and development process can positively affect the outcome of the WPMS implementation. TAC member input at an early stage can accelerate the implementation process.

- Documenting the workflows aids during all stages of a WPMS implementation. It is an effective method to understand the client's needs and requirements and can be the basis of identifying various likely WPMS solutions. Whether or not it is possible for a solution to replicate the workflows, these workflows can serve as a selection criterion when various software applications are being considered. Also, if the WPMS solution allows for some customization, the workflows can be used to show hot to customize a solution.

- A WPMS solution can be integrated with existing program and software applications that a contracting authority may be already using. In order for this integration to occur, a programmer should be part of the implementation team various other integration opportunities can be identified.

APPENDIX 1. WEB-BASED PROJECT MANAGEMENT ACTION RESEARCH

Aaron Zutz, Charles T. Jahren, Jose A. Perez Reboredo

Abstract: This paper reports on action research conducted to find a web-based project management system (WPMS) for the Iowa Department of Transportation (DOT). WPMSs are often used in planning and control of building projects, but can also be used to manage highway and heavy construction projects. In 2008, the Iowa DOT initiated a five-year construction period of that includes several complex bridge projects (> \$10 million) and sought a WPMS that would facilitate the transmittal of requests for information (RFI) and shop drawings for these projects. Action research, an iterative process of continuous improvement, was used to identify a WPMS that met the Iowa DOT's needs. Through this process the research team with the help of a technical advisory committee (TAC) evaluated the effectiveness of WPMS solutions. The research team and the TAC also developed solutions that addressed immediate project needs and established ideas for subsequent implementation. This paper describes the special attention that was paid to the first and second iterations of action research that were vital for understanding the workflow and functions needed for the third iteration. As part of the third iteration, researchers reviewed 35 commercial WPMSs and concluded that most of the functionality that was required by the Iowa DOT already existed in these solutions. On-going research is pilot testing one of these WPMS for large projects and investigating whether a less elaborate WPMS can be identified and used for smaller Iowa DOT projects (<\$10 million).

Introduction

Construction projects incorporate complex details in their plans, operate on shorter schedules, and involve geographically diverse teams making communication more challenging. These and other factors mean that traditional methods of project management and information exchange are inefficient. Web-based project management

systems (WPMS) can alleviate some of the problems and unite project team members in any location to enhance their effectiveness. WPMS solutions can manage bids, schedules, budgets, documents, and construction administration resulting in accelerated transmittal of information, accountability and transparency between the team members, and easier access to information.

In 2008 the Iowa Department of Transportation, the research sponsor and contracting agent for the project, initiated a five-year construction period of several complex bridges. As the construction of the first bridge began, the sponsor realized that their current project management practices were ineffective for these larger projects. An investigation concluded that the review process of shop drawings and the transmittal and management processes of Requests for Information (RFI) were the problem areas. As a result, the team recommended that the sponsor implement a WPMS.

To evaluate and implement a WPMS for these larger bridge projects, researchers used an action research method, an iterative process of continuous improvement. The researchers evaluated the effectiveness of a WPMS as a solution and developed temporary solution. Action research also provided a test bed for developing subsequent WPMS implementation. Because the sponsor has considerable in-house information technology expertise, partial custom WPMS solutions were developed in early action research iterations. These iterations incorporated the Rapid Application Deployment (RAD) method, which not only helped the sponsor better manage these projects, but also gave the researchers initial feedback on the feasibility of WPMS as an improved management tool for bridge projects. So far researchers have worked through two full iterations and at this writing are executing the third and fourth iterations.

Theoretical Basis

As the technology of WPMS has developed and the costs relating to these systems have decreased, the use of WPMS in the construction industry has become more prevalent. Additionally, the improved communication associated with WPMS is increasingly viewed as a necessity to projects. A survey conducted in 2005 by Engineering News

Record showed that 80% of readers involved in information technology (IT) purchases agree 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, 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 et al. 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 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 (Nitithamyong et al. 2004). Furthermore, greater transparency, time saving and cost savings have also been associated with improved communication through WPMS (Nikas 2006).

Although WPMSs offer many possibilities, implementations do not benefit from them entirely because of 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 sound ultimately fail upon implementation (Erdogan 2008). The success of WPMS also may be hindered by the difficulty of quantifying cost and benefits of the WPMS, system reliability and security, ownership and legal issues, and Internet access (Nitithamyong 2004).

Because WPMS solutions sometimes fail to deliver 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 2008). Consideration of not only functionality of the system to the project, but also the functionality for the users is necessary for WPMS to be successful.

Research Method

The researchers met the immediate needs of the sponsor and started working towards the implementation of a long-term solution by using action research and RAD. Action research enabled the researchers to quickly implement partial solutions while using these as stepping stones for an ultimate solution to meet the project management needs.

This investigation was guided by a five-step action research method outlined by Susman and Evered:

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. (Susman et al. 1978)

Within the action research method, the custom development of solutions is driven by the RAD technique. RAD accelerates the design and deployment by actively involving the users in the design, ultimately decreasing the time for implementation (Whitten et al. 2000). Just as the action research method, RAD is also iterative allowing continual improvement of prototypes. RAD served as an excellent complement to the action research method used.

The literature includes several theoretical explanations and case study examples regarding action research and RAD. In particular Azhar, et al (2010) discusses the application of action research to construction. However, no references were found that address in detail how the first and second iterations are carried out, especially within a construction context. This paper offers a case study on the implementation of 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 helped with the development of the first two solutions, participated in the pilot projects, and served on the committee for the development and issuance of a Request for Proposals (RFP) for a more permanent solution.

Concurrently with the first and second iteration, the research team executed some of the diagnosing and action planning 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.

First Iteration

The first iteration began after the agreement between the research sponsor and the research team was established. The research sponsor assigned the team with the task of helping the sponsor select an appropriate WPMS tool. The anticipation for this WPMS was that it should have the ability for the project participants to upload and download documents, facilitate the workflow as such documents are reviewed, and track the status of each document in a fully automated fashion.

Diagnosing

The I-80 Bridge over the Missouri River was one of the larger bridges the research sponsor has constructed in the last decade. The large size of the bridge and complex design details related to its function as a border bridge in the interstate system generated a large number of correspondences that complicated its management. The project had a large number of contract documents and managing changes was difficult for all project participants. Revisions of documents needed 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. In some cases, the plans were given directly from the contracting agency to the subcontractors, leaving the prime contractor "out of the loop". Meetings with the full TAC were conducted to establish the needs of the different users. 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 for the TAC and limited anecdotal evidence. Although this was a modest and non-rigorous diagnostic effort, it was commensurate with the modest efforts that were contemplated for the remaining steps in the first iteration.

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 the researchers to act quickly for the solution's implementation within the limited timeframe that would benefit project participants. A concern that was raised by the researchers was of an increased user resistance to the system as the implemented WPMS represented a change in the middle of the project. Since the research sponsor had already the in-house capability to develop modest web based solutions, researchers planned to assist the sponsor in developing such a solution. Using the research sponsor's web development expertise also eliminated the need to go through a time consuming process of engaging additional outside expertise through a competitive process. While utilizing the existing research sponsor's website for development allowed for the most rapid development and deployment of the solution, limitation 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 research sponsor, and none of the other project participants.

Action Taking

The focus of this iteration shifted to the actual development of a solution that could manage contract documents. The research sponsor's staff developed a password protected webpage within their general website. Utilization of the existing webpage templates helped to decrease the amount of time required to get the project webpage to use. After the webpage was initially developed, the researchers and TAC members performed a review. After minor changes were applied, the password was given to other project participants and they started to utilize the webpage. The research sponsor monitored the use of the webpages while the research team and the TAC collected anecdotal evidence on the effectiveness of the new system. Figure 1 shows the workflow for a Contract Document on the I-80 Bridge Project.
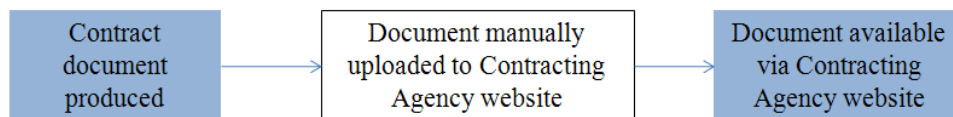
Figure A1.1. Workflow for a contract document on the I-80 Bridge Project. Manual transfers within the system are shown with outlined boxes.

Evaluation

As the project progressed, researchers interviewed a variety of project participants to understand what had worked and what had not with the project webpage. Post project interviews were conducted with system users including the contracting agency's personnel, consultants, and contractors. Based on the interviews, researchers made 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 required by project participants. Participants wanted the

features of a true collaborative WPMS, including the ability to upload documents to the webpage, post question, render decisions, and track progress.

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

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 web 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 sponsor's primary need. This would make these processes more efficient, but would also make them more transparent accountable.

Second Iteration

Diagnosing

Moving 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 RFI's than an average research sponsor's bridge project. Primarily this was due to its steel curved 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: its construction started shortly after the end of the first iteration, which allowed for the second iteration to be done shortly following the first. The bridge was identified by using the TAC chair's knowledge of bridge projects statewide.

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 first iteration: the need to fully manage both submittals and RFIs through a collaboration solution in a effective user-friendly manner.

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 RFIs 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 avoid a lengthy procurement process and provide a solution within two months, a custom solution was developed by the research sponsor's Information Technology Staff.

Action Taking

In a manner similar to that the first iteration, existing research sponsor's 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 research sponsor/contracting agency that would have otherwise been too large for email. Upon review of a shop drawing, the redlined versions would then be posted by the research sponsor/contracting agency 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 research sponsor's project webpage to the Groups application. This combination of applications allowed users to complete the whole submittal and RFI processes within the WPMS.
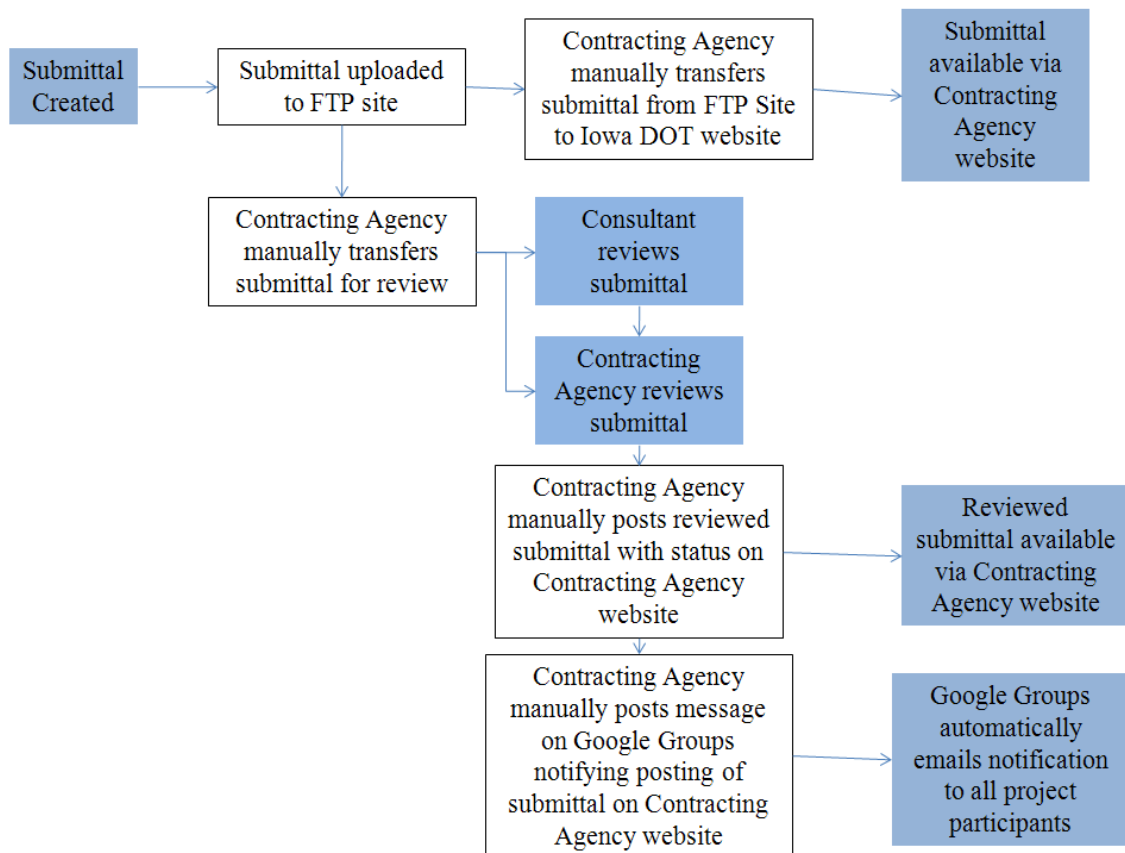
Figure A1.2. The lifecycle of a submittal on the second iteration. Manual transfers within the system are represented by outlined boxes.

Evaluation

As this second project was nearing completion a post project survey, utilizing open and closed ended questions, was given to twenty five 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 significant amount of administrative time spent transferring documents between the project website and the FTP site. A research sponsor engineer would need to spend approximately half an hour per document managing its workflow during its lifecycle. Figure 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 Groups project website were beneficial, some users received irrelevant emails which cluttered their inbox.

Specifying Learning

The second iteration of WPMS showed great improvement over the first, but also highlighted the need to refine much of the functionality. Notably, the introduction of applications allowing users to actually upload the submittal by 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 improvement desired was to ensure that future systems be more autonomous. It is not feasible for administrators to manually transfer documents behind the scenes. Figure 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. Additionally, while email notifications were

helpful, they needed 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.
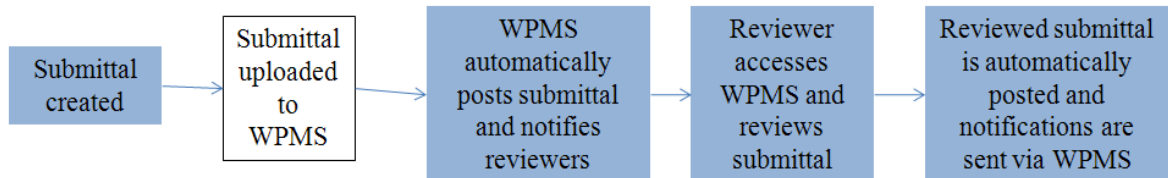
Figure A1.3. Lifecycle of a submittal in an automated solution. Manual transfers in system are outlined.

Application of specified learning for the third iteration

Diagnosing

Having completed two iterations, the research team and the TAC learned valuable lessons as to exactly what functionality project participants needed from a WPMS. With more complex bridges in the near future and a desire to implement WPMS within the research sponsor's agency and from contractors, consultants, and suppliers the research sponsor 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 research sponsor.

Action Planning

With a good idea of what the research sponsor needed based from the previous iterations, researchers sought out a more permanent solution to pilot test. Speaking with industry professionals and reviewing over thirty five commercially available WPMS, researchers concluded that most of the functionality required by the sponsor already existed in commercially available solutions. Furthermore, developing and deploying a custom solution to meet the sponsor'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 infeasible 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 research sponsor to develop and issue an RFP. Using knowledge gained from previous iterations and research an RFP was developed that specified the functionality that the sponsor needed. By publically issuing this RFP, the research sponsor will allow for a fair chance for any company to compete to have its solution selected for the pilot testing program.

Current work (Fourth iteration)

Alongside the third iteration, an iteration to find a WPMS for smaller highway projects (less than $10 million) is under development. Action research using the RAD approach is being used for the ongoing project phase. This is the first iteration for the smaller highway projects, but for simplicity in this paper, it is considered the fourth iteration.

Diagnosing

The researchers thought that finding a less elaborate and expensive WPMS for smaller highway projects would benefit the research sponsor. Upon contacting the sponsor, interest was shown to find a WPMS solution for sign truss projects. These projects have a

non-variable workflow for the shop drawing approval process. It involves a variable number of suppliers and departments within the agency that could benefit from a solution like this one.

Action Planning

Having a specific type of project to work with, a TAC was created to provide input about sign truss projects workflow and WPMS selections. Before meeting with the TAC, researchers decided to find less elaborate WPMS that focused on document exchange and management. The search entailed of finding commercial alternatives consisting of online project management collaboration tools. At the TAC meeting, it was agreed that this was a good starting point for the research.

Additional meetings were held with the sponsor's engineers to establish the workflow. The workflow consisted of a process beginning when the subcontractor uploads a shop drawing for the prime contractor, which then transmits it to the designated research sponsor's engineering division for review. The workflow ends when the drawings are approved by the engineers.

 Action Taking

Using the workflow that was generated in the Action Planning stage, researchers sought to find a WPMS that met the sponsor's requirements and workflow discussed. The initial online project management collaboration tools found before the TAC meeting were studied and compared to the workflow. Only one of these proved to have most of the sponsor's requirements. A negative aspect found in this already developed commercial solution was the lack of freedom to customize the website to better meet the workflow and the sponsor's needs. For this reason, finding a solution that allowed the creation and development of customized workflows was considered by researchers.

A commercial product, Microsoft SharePoint Server, that allows the development of workflows for the management of documents and projects, was selected for study. This product uses a web content management approach where it allows the user create the

libraries, calendars, notifications, and restrictions for the page. Using a platform that enables the creation of workflows, such as this one, is proving to be the most effective for situations where the desired workflow and tasks are already established.

No additional information regarding this iteration is available since it is still under investigation and further studies are being developed for the web content management solution.

Discussion

The results of pilot testing WPMS on the research sponsor's projects, in the first two iterations, showed that there was general interest in the concept of WMPS by project participants, even though the functionality of pilot tested systems were quite limited. Users appreciated many of the features provided by the systems, but indicated that for future implementations, more robust systems would be needed. Users also stated that there is a great potential for the use of WPMS on additional projects, but there is also a need to continue the improvement of the systems.

For the initial testing, the use of the iterative prototyping served as a good way to test WMPS. Since the research sponsor 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 Rapid Application Deployment to the process of developing the initial solutions, the research sponsor was able to develop 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 proved efficient 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 research sponsor agency allowed researchers to evaluate factors during the earlier iterations that would 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. One of the major concerns that arose during the first two iterations was 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 incorporate these concerns into the RFP and factor them into 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 able to explicitly and confidently state the needs of the research sponsor. 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.

Conclusions

Implementing WPMS using the action research method provided an effective way for the research sponsor to improve their project management. By beginning with small scale systems, researchers were able to meet immediate project management needs and refine understanding of the long term needs and challenges were with regard to WPMS. By refining the needs of the sponsor, researchers and the TAC were also better prepared to write an RFP for the procurement process that would help them 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 a WPMS.

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 the research sponsor's projects. By pilot testing WPMS in 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 research sponsor 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 iterations of action taking.

- 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.

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APPENDIX 2. RESULTS FROM COMPLEX BRIDGE WPMS IMPLEMENTAITON

Introduction

As part of this current phase, the researcher was responsible of continuing with the evaluation of the implementation of AEC Sync (formerly known as Attolist) on the complex bridge projects.

Broadway Viaduct Bridge Post-Project Survey Analysis

Survey Population

The survey was sent to 39 project team members. 14 project members responded, representing a 36% response percentage. From those 14 responses, three mentioned that they involvement with AEC Sync (Attolist) was not significant. These three members did not complete the survey questionnaire. The survey responses, then, corresponds to 11, representing 28%.

From the survey respondents 64% correspond to Iowa DOT staff and employees, 9% of the population were consultants to the project, 27% identified themselves as contractors (it is important to note that some subcontractors classified themselves as contractors). There were no responses from suppliers.

Survey Responses and Analysis

The post-project survey feedback turned out to be positive when it comes to making the project member's job easier, the overall cost of the document management, transparency of document management and project information. The results also portrayed that the WPMS made the RFI process much easier than anticipated as well as the submittal process. The project members also thought that the computer and internet requirements were reasonable.

An interesting aspect found when comparing the post-project surveys to the pre-project surveys was that the actual usage of AEC Sync per month was lower than anticipated. As it can be seen in Figure A2.1, the anticipated use for AEC Sync was from 10 to 20 times a month, when the actual usage of AEC Sync was of less than 10 times a month. None of the project members used the project's WPMS more than 20 times a month, compared to an anticipated member usage of 15% in the pre-project surveys.
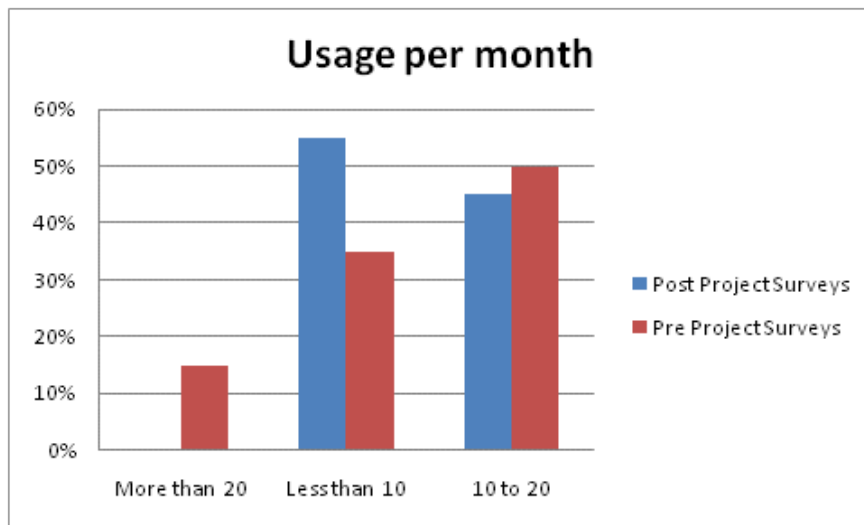
Figure A2.1. Survey results – usage per month

As it can be seen in Figure A2.2 the distribution of size for recommended future WPMS project implementation changed, compared to the pre-project surveys. The reason for this change can be due to the fact that having some knowledge about the system, additional implementation opportunities are easier to identify.
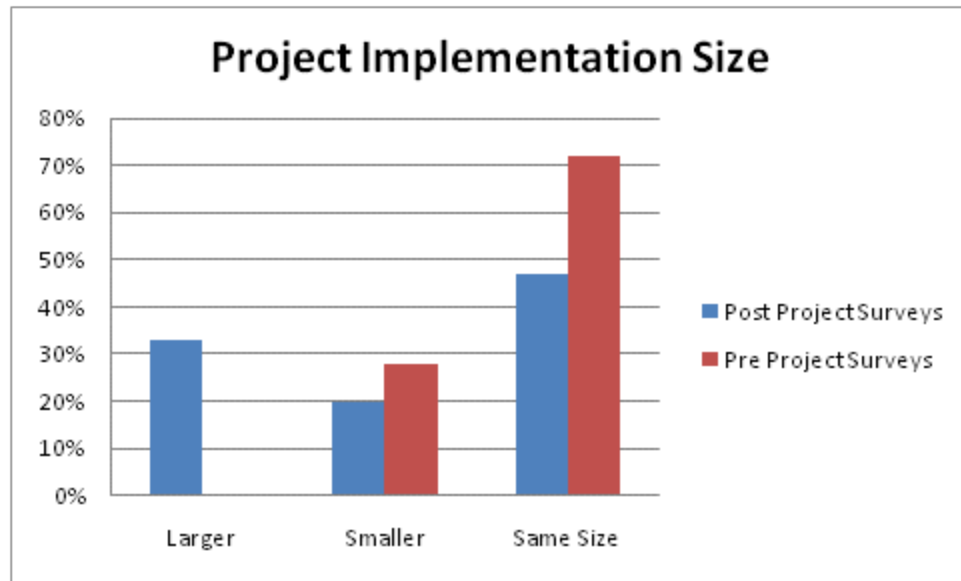
Figure A2.2. Survey results – project implementation size

One last observation found by the researchers is that around 10% of the respondents did not consider that learning how to operate and work with the system was not worth the benefits. Around 20% percent of the population felt neutral about learning the system. If combined, one third of the population does not feel that it was completely worth the benefits of learning the system. Figure A2.3 presents the post-project surveys with a comparison to the pre-project surveys. A similar result was found when the project team members where asked about the effect of AEC Sync to the bridge project management. It is recommended to the Iowa DOT to share with the other project members the benefits of WPMSs to bridge projects during the early stage in the preconstruction phase. The results of the surveys that pertain this topic can be seen in Figure A2.4.
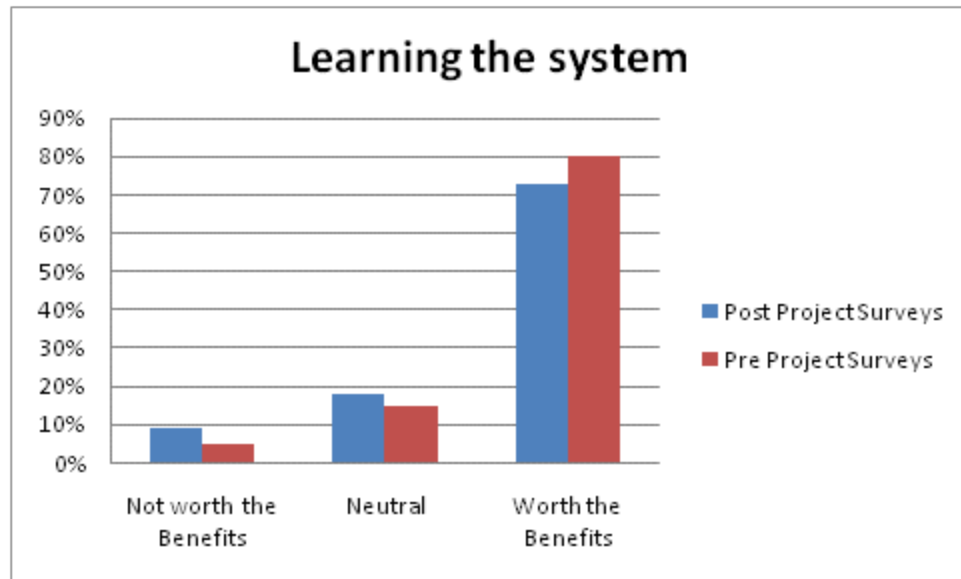
Figure A2.3. Survey results – learning the WPMS
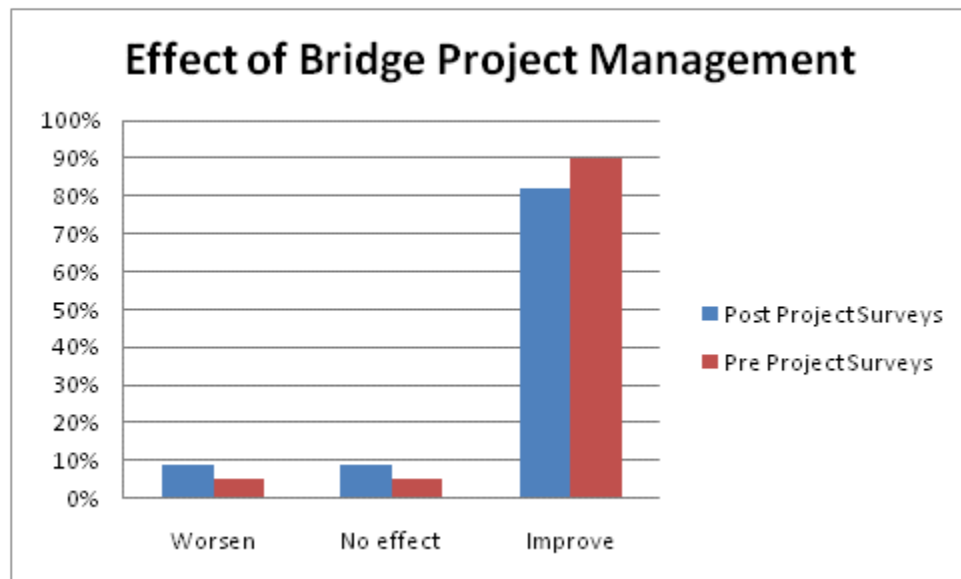
Figure A2.4. Survey results – effect of bridge project management

Iowa Falls Arch Bridge Post-Project Survey Analysis

Pre-Project Survey Respondent Population:

Since the researcher was responsible also of conducting the pre-project surveys for the Iowa Falls Arch Bridge Project, the pre-project survey information is deemed important.

The surveys were sent to 35 project team members. 18 project members responded, representing a 51.4% response percentage. From those 18 responses, two mentioned that their involvement with AEC Sync (Attolist) was not significant. These two members did not complete the survey questionnaire. The survey responses, then, corresponds to 16 respondents, that represents 45.7% of the initial population of people who were sent the surveys.

From the survey respondents 50% correspond to Iowa DOT staff and employees, 35% to subcontractors or suppliers, and 19% of the population were consultants to the project. There were no responses from the contracting agency (contractors).

Post-Project Survey Respondent Population:

The surveys were sent to 35 project team members. 9 project members responded, representing a 25.7% response percentage. From those 9 responses, one mentioned that its involvement with AEC Sync (Attolist) was not significant. This member did not complete the survey questionnaire. The survey responses, then, corresponds to 8 respondents, that represents 22.9% of the initial population of people who were sent the surveys.

From the survey respondents 62.5% correspond to Iowa DOT staff and employees, 25% to subcontractors or suppliers, and 12.5% of the population were consultants to the project. There were no responses from the contracting agency (contractors).

Survey Responses and Analysis

For the scope of this Appendix, several questions from the surveys were analyzed. An interesting result that was found was that more people found it worthwhile to learn the WPMS compared to the pre-project survey results.   The responses can be seen in Figure A2.5.

Learning the system
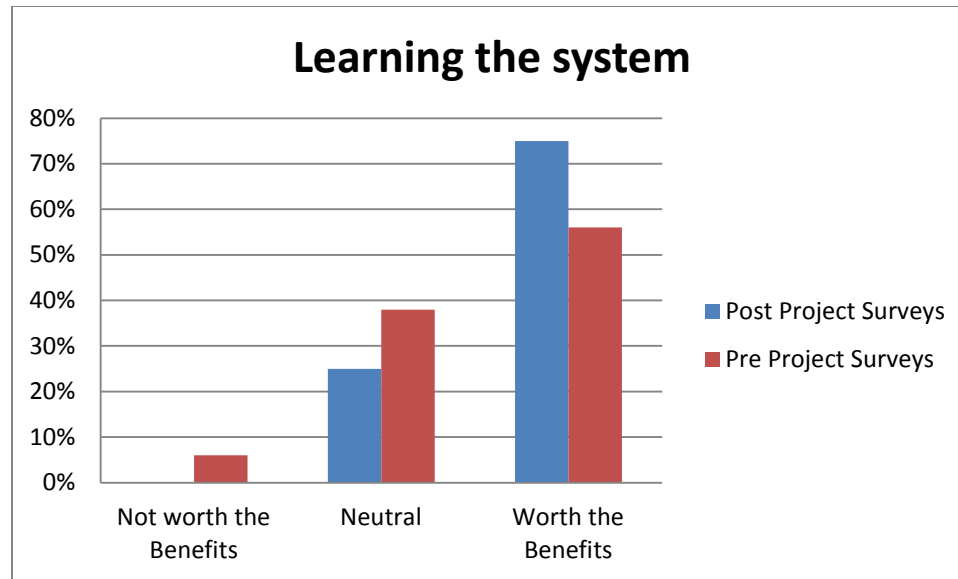
Figure A2.5. Survey results – learning the system

When asked about the effect of the WPMS on the transparency of document management, it was found that the people were expecting the WPMS, during the pre-project phase, to increase the transparency of the document management. When asked the same question in the post-project surveys, the results showed that the respondents found no change in the transparency of the document management. Even though the result was not the one that was expected, it is still a positive feedback related to the implementation of the WPMS. This represents that the WPMS did not affect negatively the document management within the Iowa DOT and that the current document management strategies within the Iowa DOT are transparent enough, compared to what the WPMS can offer. Figure A2.6 shows the results concerning this topic. A similar result was seen concerning the topic of the accountability of the project member participants. During the pre-project survey stage it was expected for the WPMS to increase the accountability of the project members by around 60%. After the post-project surveys were analyzed it was found that the half of the population believed that it positively affected the accountability on the project members, while the other half said that there was no effect. This can be seen in Figure A2.7.

Transparency of Document Management
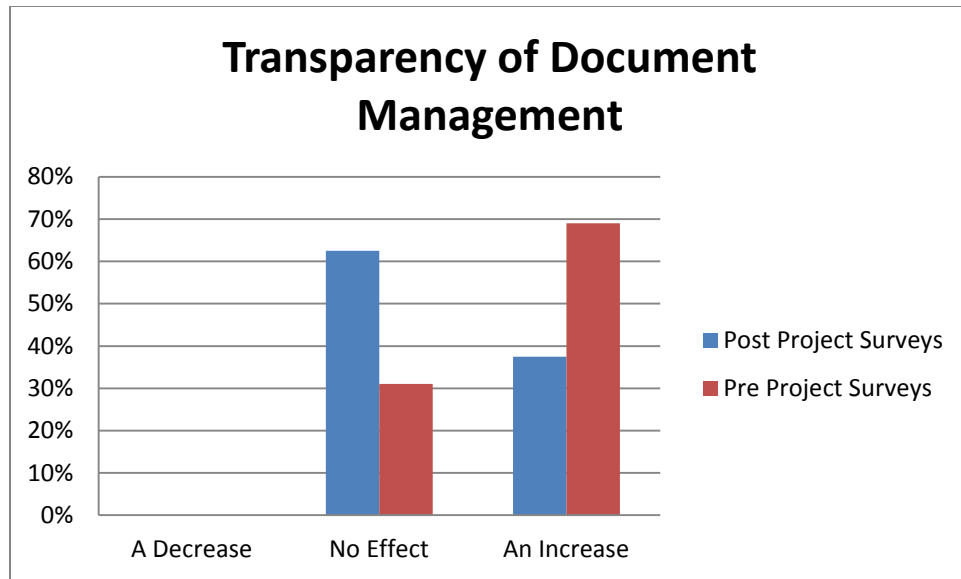
Figure A2.6. Survey results – transparency of document management

Accountability Project Participants
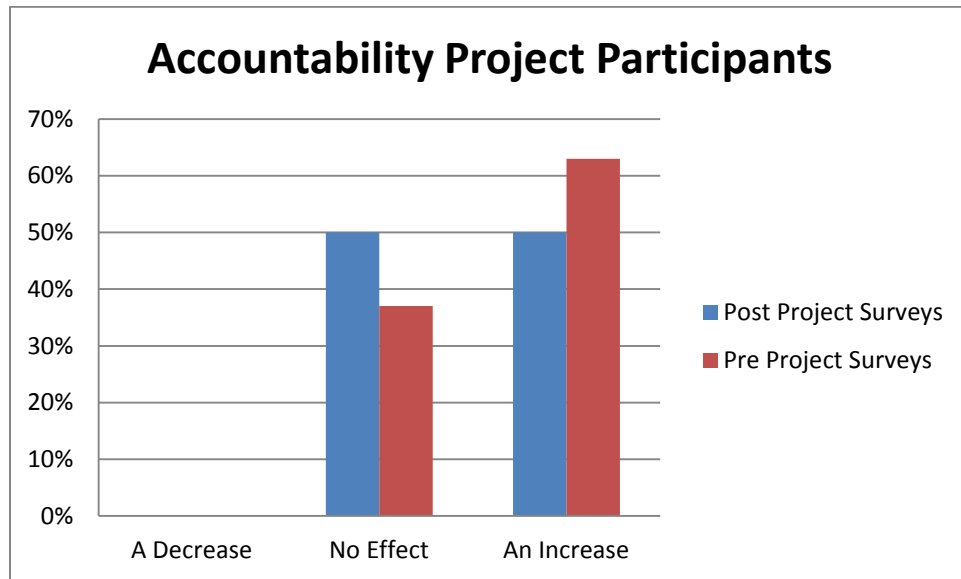
Figure A2.7. Survey results – accountability of project participants

When asked about the size of projects that they consider could benefit from a system like AEC Sync the answers from the pre-project surveys differed from the post-project survey results. During the pre-project phase the answers were almost evenly spread between smaller, larger, or same sized projects. During the post-project phase, around 75% of the respondents found that a WPMS like AEC Sync could benefit the most on a project that is around the same size of the Iowa Falls Arch bridge project. This answer represents

that maybe AEC Sync is too simple for larger projects, but too complex for smaller projects.
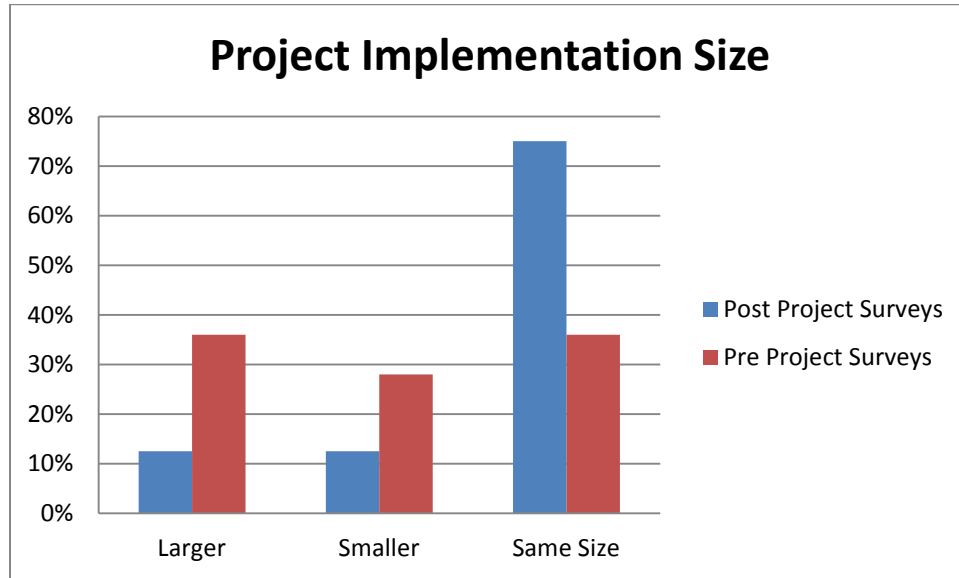
Figure A2.8. Survey results – project implementation size

Workflow: Falsework for Slab Bridges
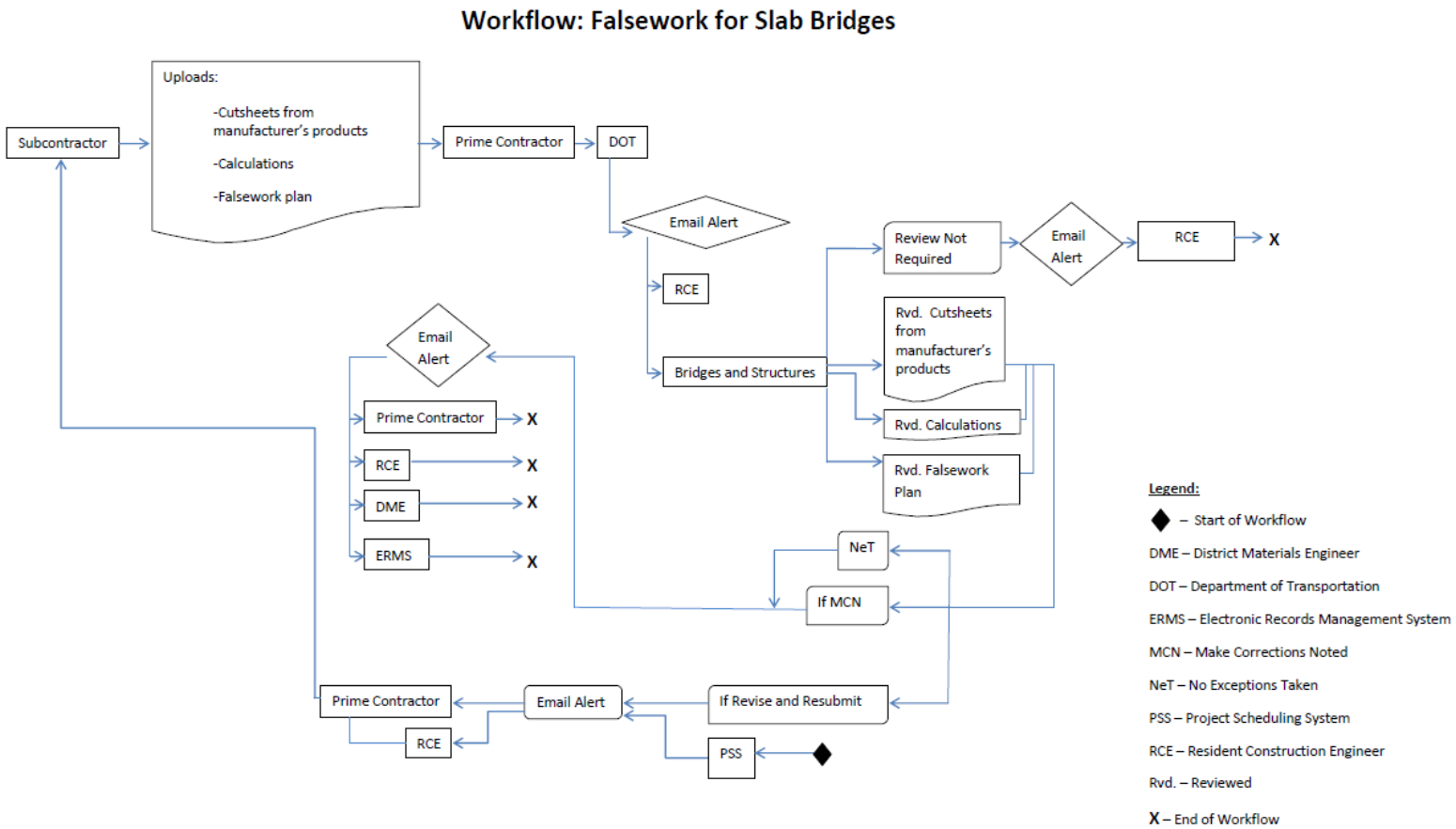
Figure A3.1. Falsework for slab bridges workflow

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

Workflow: Cofferdam Design
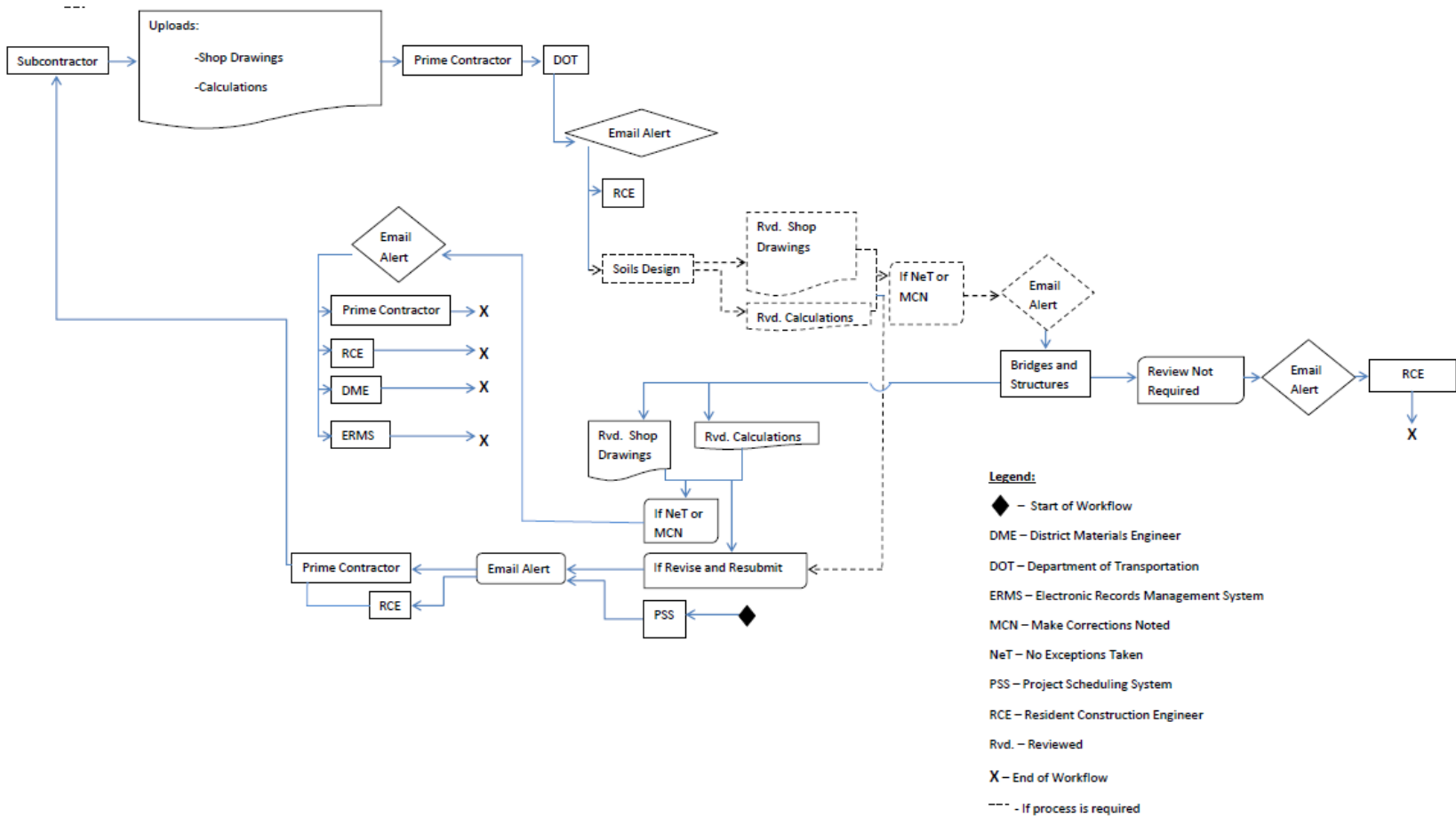
Figure A3.2. Cofferdam design workflow

Subcontractor → Uploads: -Shop Drawings -Calculations → Prime Contractor → DOT

Email Alert → RCE

Soils Design

Rvd. Shop Drawings

Rvd. Calculations

If NeT or MCN

Email Alert

Bridges and Structures → Review Not Required → Email Alert → RCE → X

Email Alert
Prime Contractor — X
RCE — X
DME — X
ERMS — X

Rvd. Shop Drawings
Rvd. Calculations

If NeT or MCN

If Revise and Resubmit

Prime Contractor ← Email Alert
RCE

PSS ◆

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

--- - If process is required

Workflow: Reconstruction of Substructure (detailed plans for supporting the superstructure)

Legend:
◆ – Start of Workflow
DME – District Materials Engineer
DOT – Department of Transportation
ERMS – Electronic Records Management System
MCN – Make Corrections Noted
NeT – No Exceptions Taken
PSS – Project Scheduling System
RCE – Resident Construction Engineer
Rvd. – Reviewed
X – End of Workflow
--- - If process is required
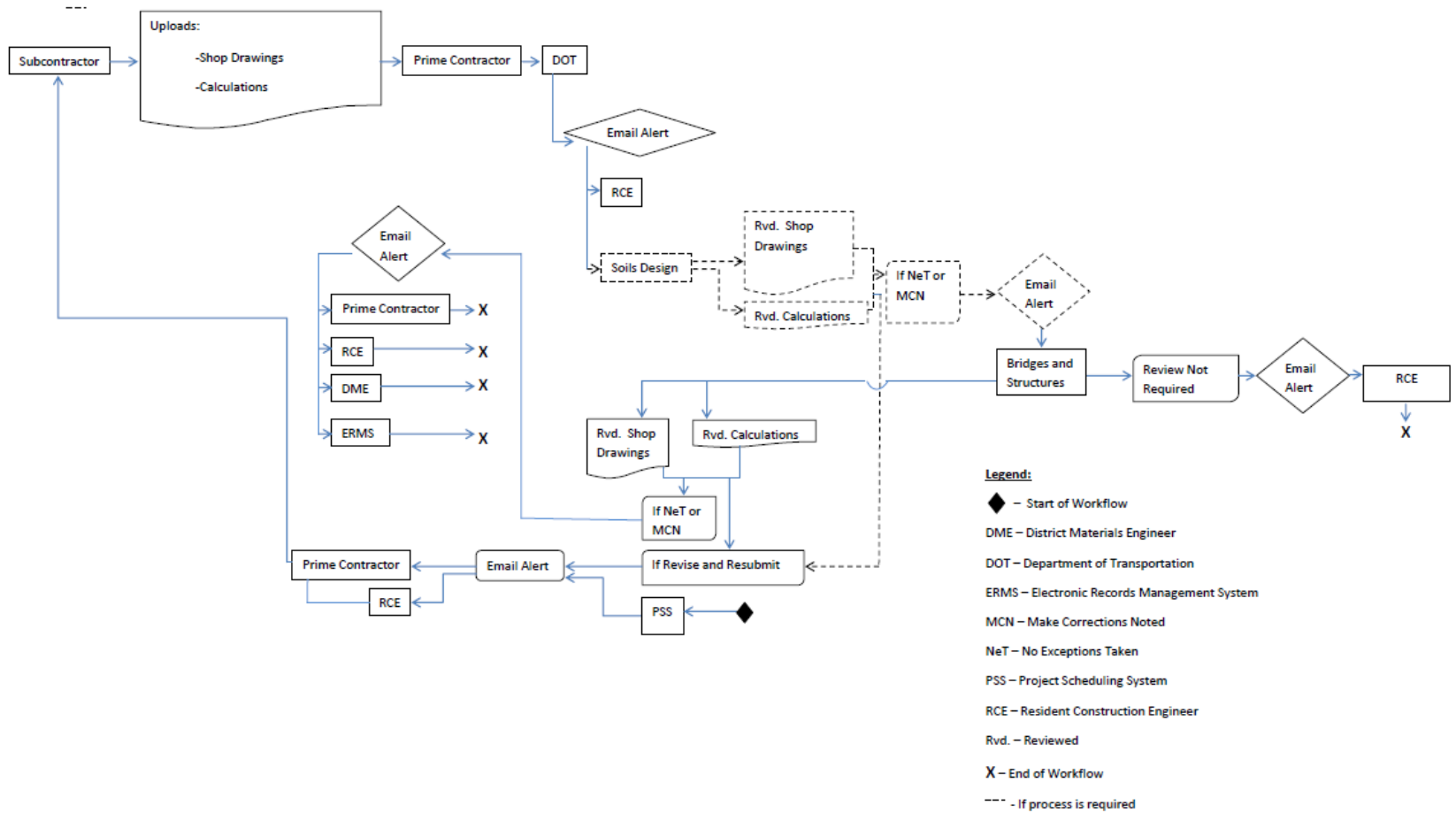
Figure A3.3. Reconstruction of substructure workflow

Workflow: Steel Structures

Subcontractor → Uploads:
- Structural Steel Details Shop Drawings
- Weld Procedures

→ Prime Contractor → DOT

Email Alert
- RCE
- Bridges and Structures → Rvd. Structural Steel Details Shop Drawings
- Central Materials → Rvd. Weld Procedures

Review Not Required → Email Alert → RCE → X

Email Alert
- Prime Contractor → X
- RCE → X
- DME → X
- Central Materials → X
- ERMS → X

NeT
If MCN

If Revise and Resubmit → Email Alert → Prime Contractor
RCE
PSS → ◆

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

80

Figure A3.4. Steel structures workflow

Figure A3.5. Detail Plans for falsework or centering support of steel structures workflow
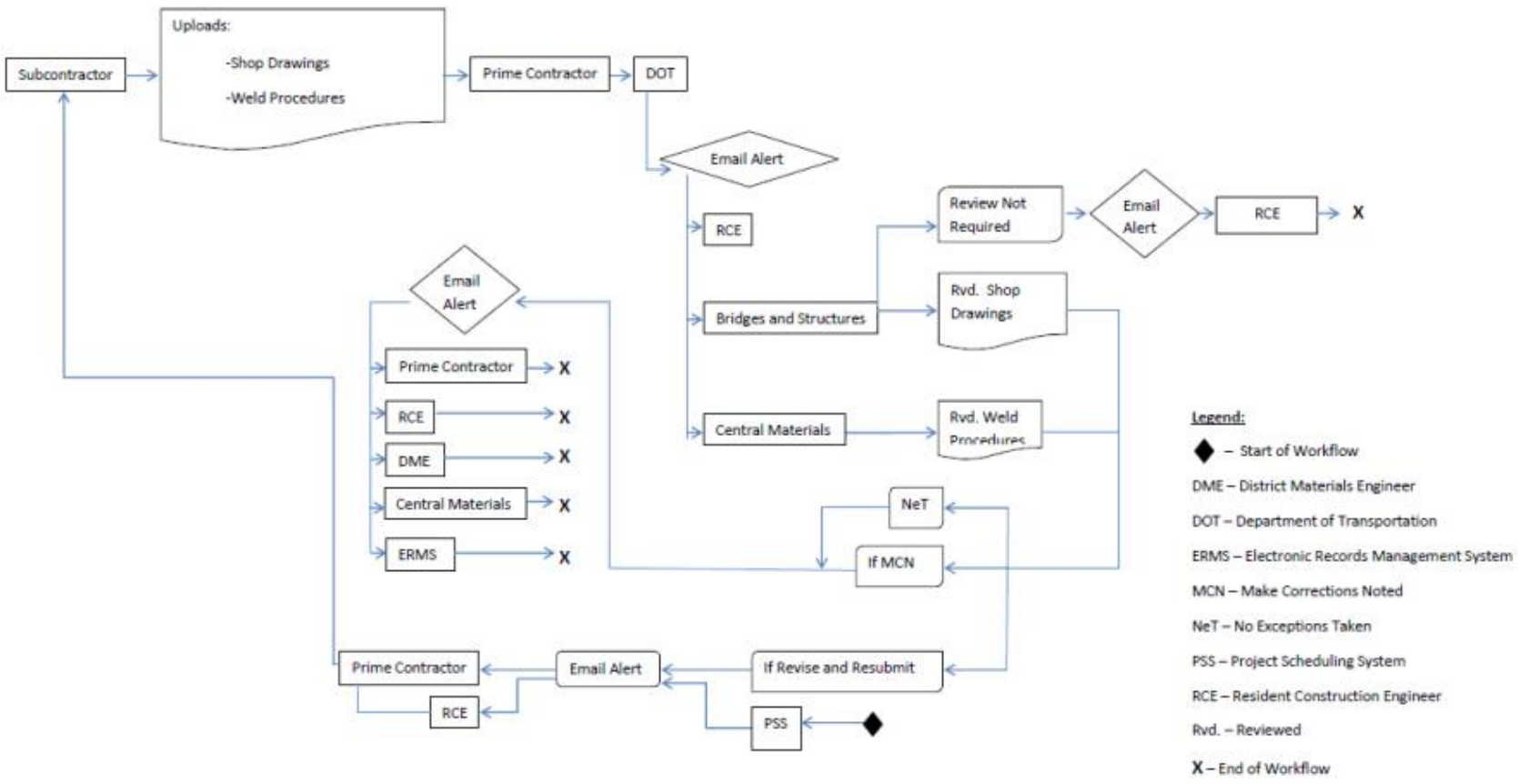
Figure A3.6. Steel and aluminum pedestrian handrails workflow

Workflow: Precast Concrete

Legend:
◆ – Start of Workflow
DME – District Materials Engineer
DOT – Department of Transportation
ERMS – Electronic Records Management System
MCN – Make Corrections Noted
NeT – No Exceptions Taken
PSS – Project Scheduling System
RCE – Resident Construction Engineer
Rvd. – Reviewed
X – End of Workflow
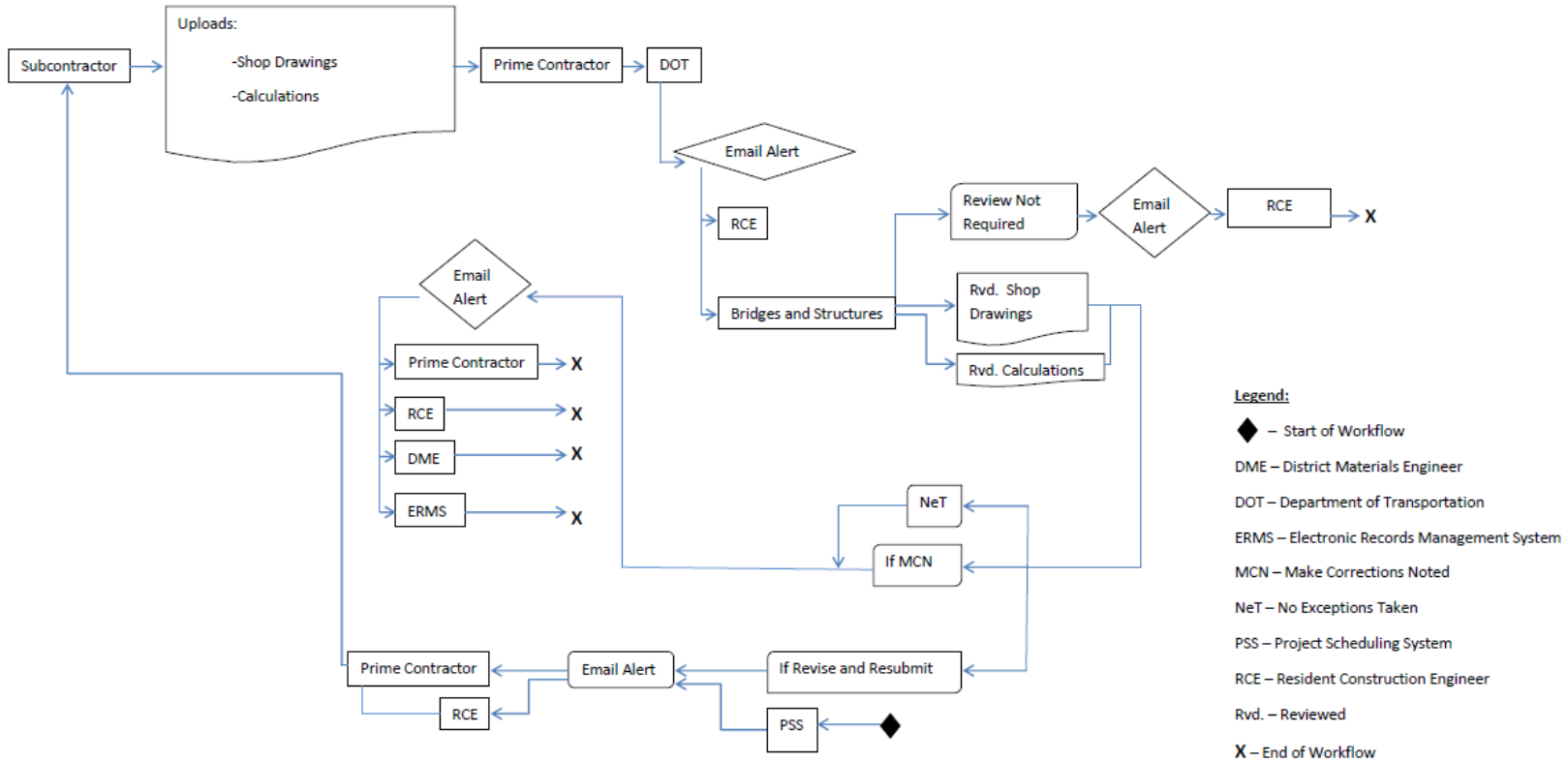
Figure A3.7. Precast concrete workflow
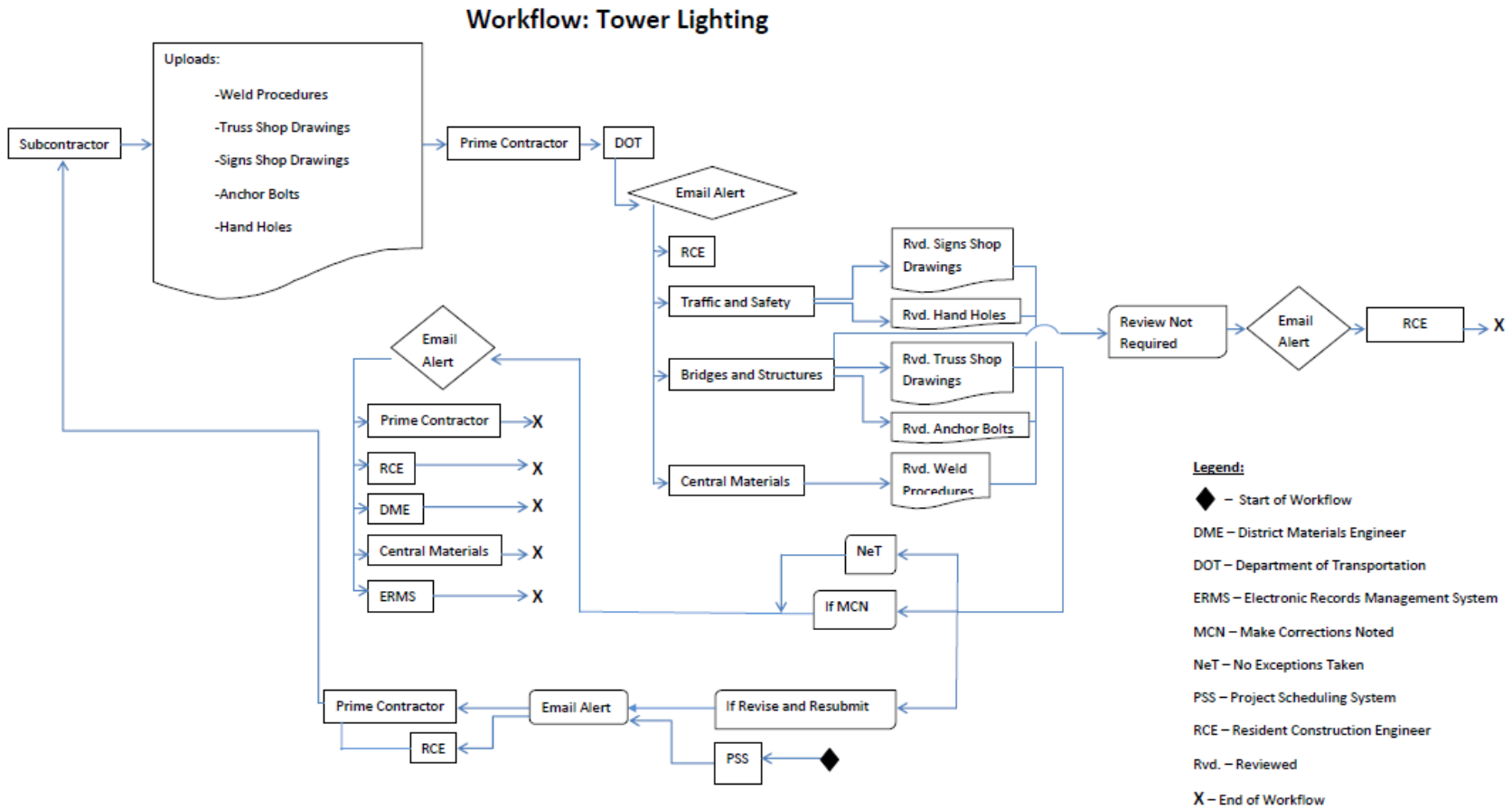
Figure A3.8. Tower lighting workflow

Workflow: Bridge Components

Legend:
- ◆ – Start of Workflow
- DME – District Materials Engineer
- DOT – Department of Transportation
- ERMS – Electronic Records Management System
- MCN – Make Corrections Noted
- NeT – No Exceptions Taken
- PSS – Project Scheduling System
- RCE – Resident Construction Engineer
- Rvd. – Reviewed
- X – End of Workflow
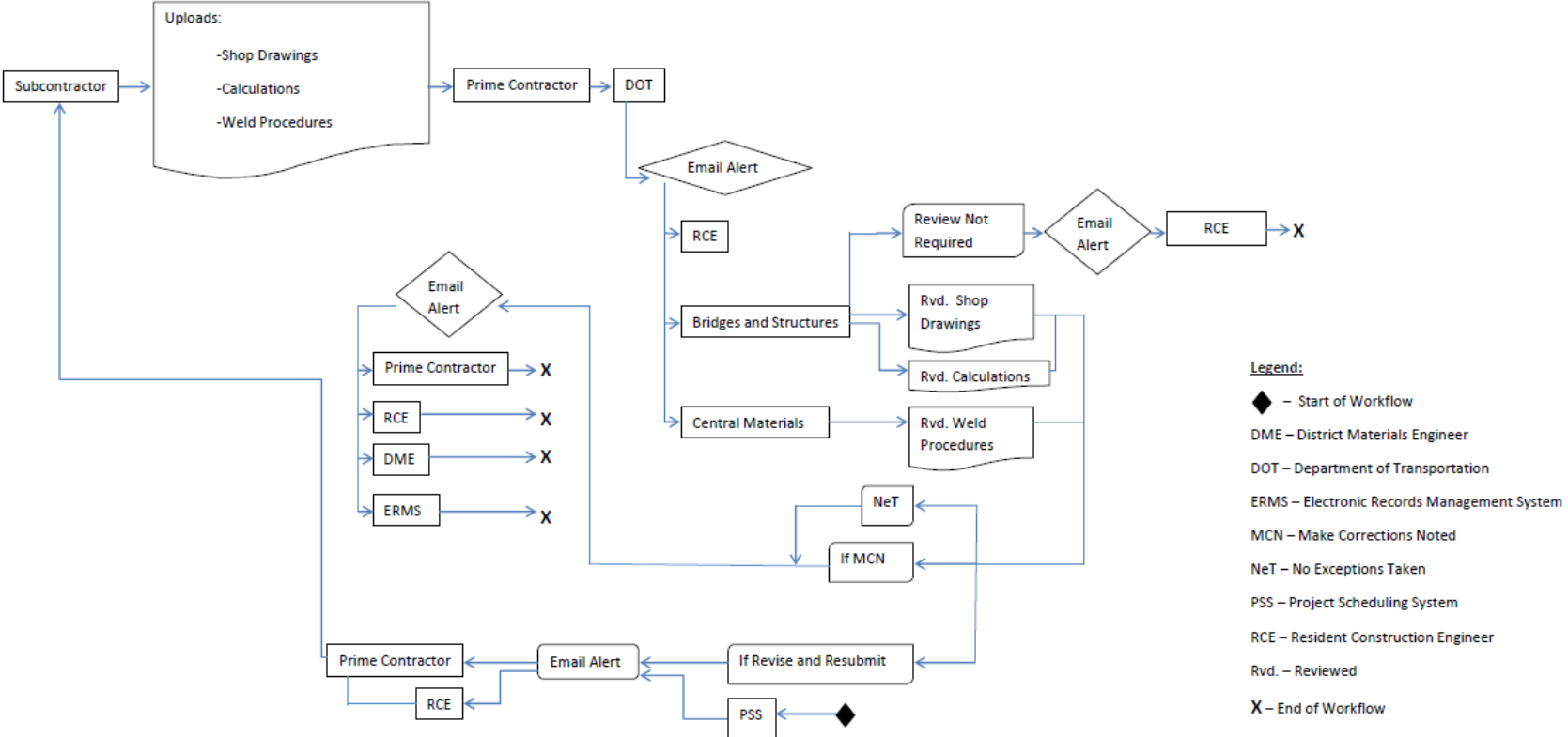
Figure A3.9. Bridge components workflow

Workflow: Pre-engineered Steel Truss Recreational Trail Bridge
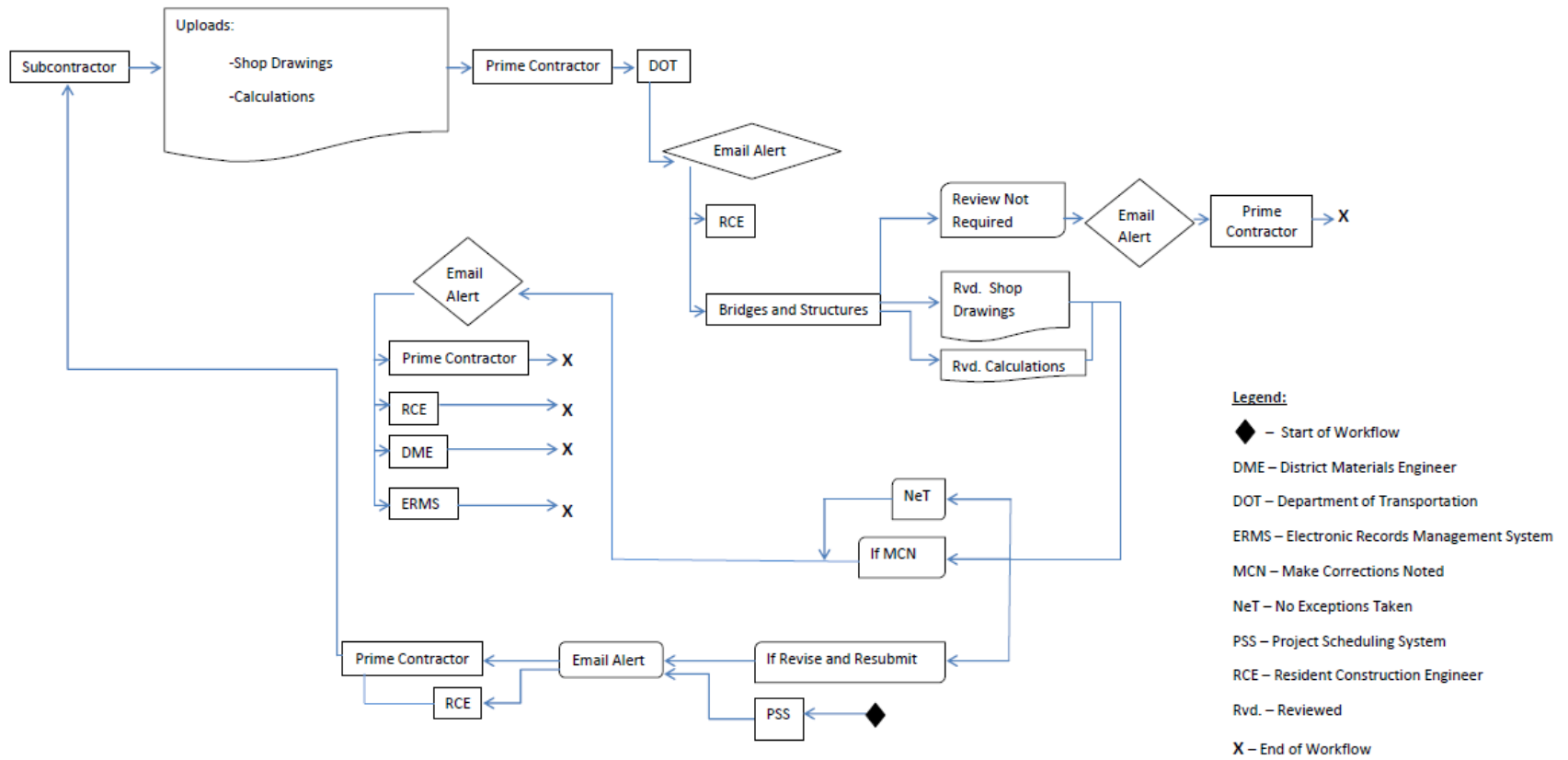
Figure A3.10. Pre-engineered steel truss recreational trail bridge workflow

Workflow: Removal of Box Girder Bridges
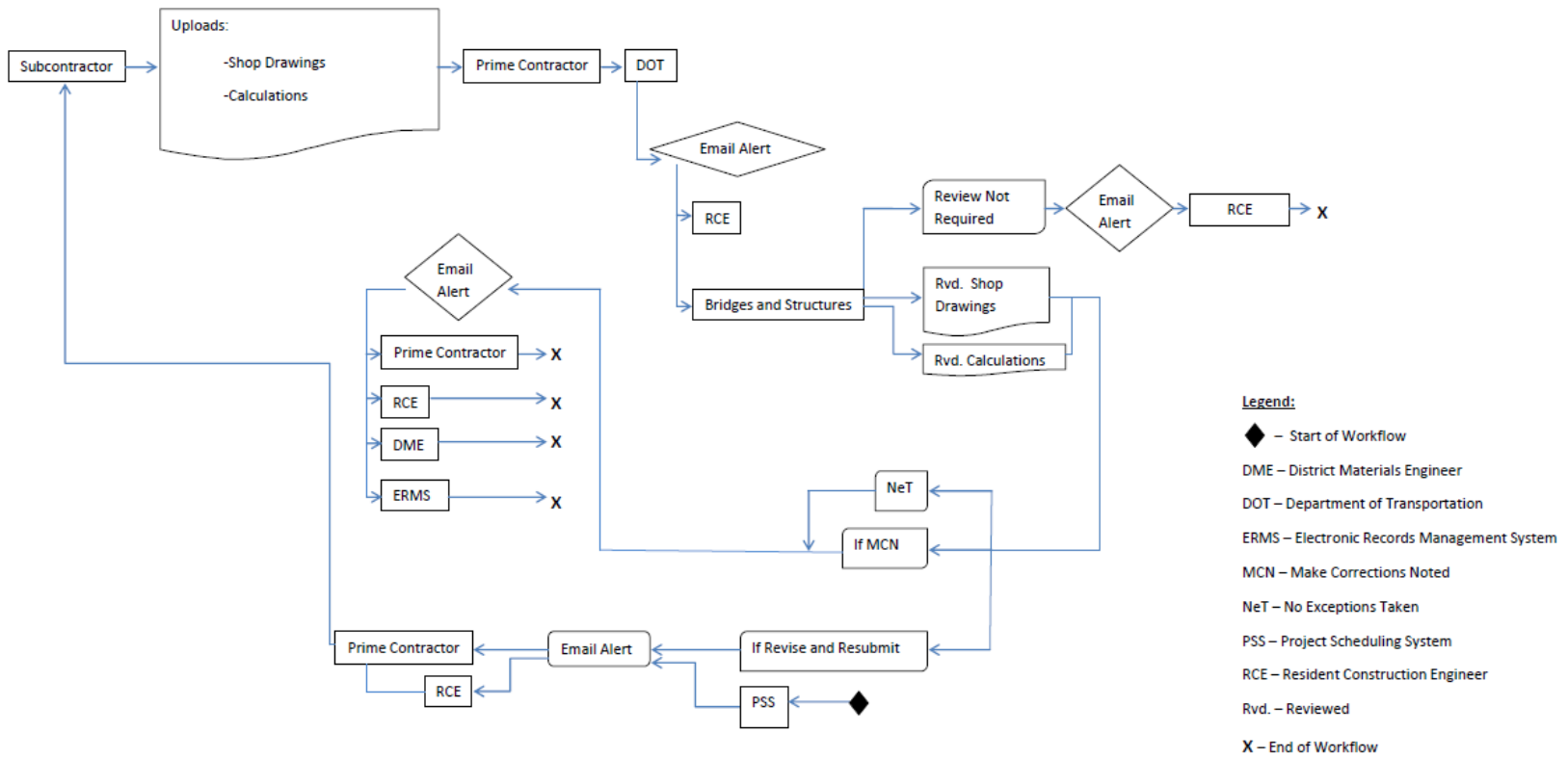
Figure A3.11. Removal of box girder bridges workflow
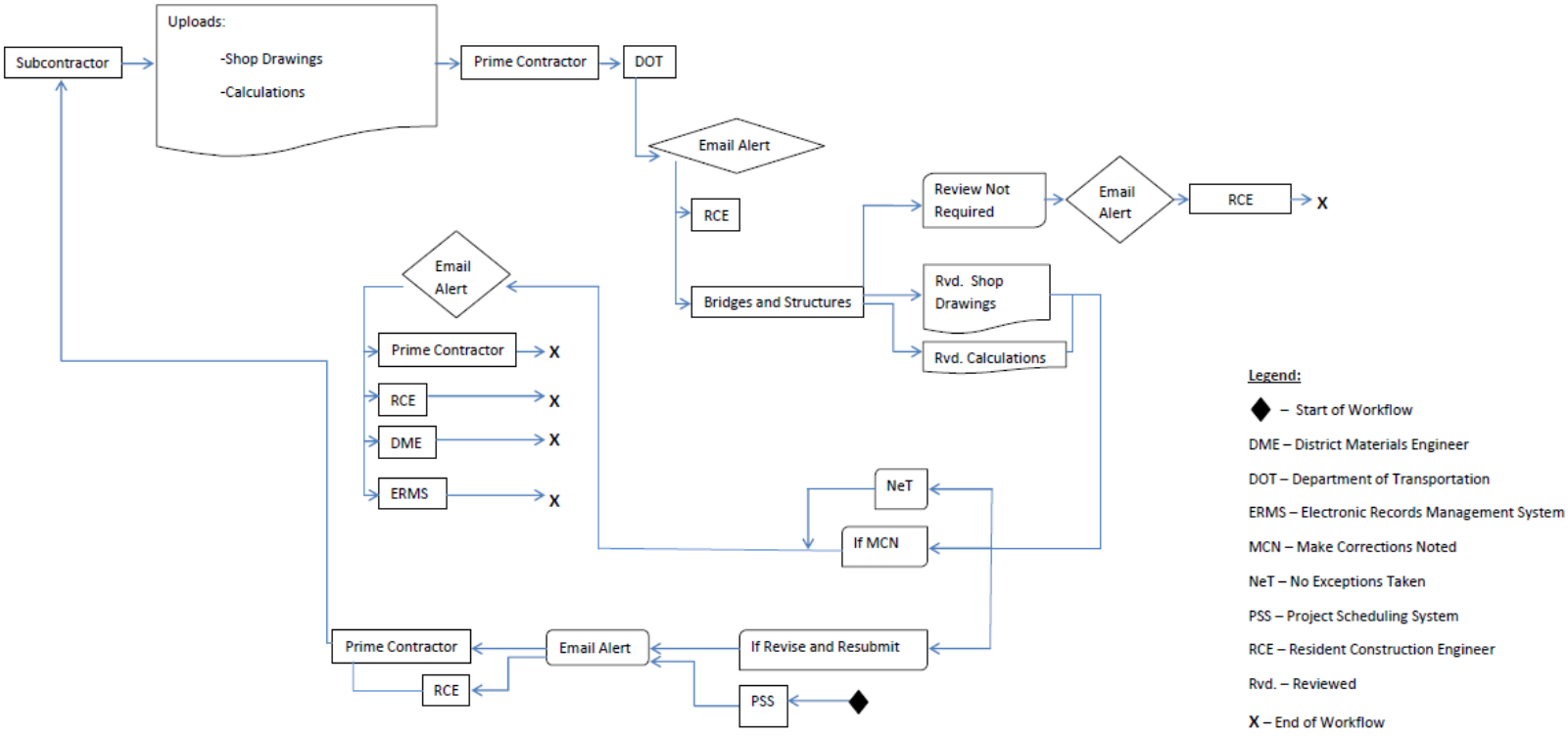
Figure A3.12. Structural erection manual workflow

Workflow: Temporary Shoring

Figure A3.13. Temporary shoring workflow

Workflow: Temporary Sheet Pile Retaining Walls

Figure A3.14. Temporary sheet pile retaining walls workflow

Uploads:
- Shop Drawings
- Calculations

Subcontractor → Prime Contractor → DOT → Email Alert → RCE → Soils Design → Rvd. Shop Drawings / Rvd. Calculations → If NeT or MCN → Email Alert → Bridges and Structures → Review Not Required → Email Alert → RCE → X

Email Alert → Prime Contractor X / RCE X / DME X / ERMS X

Rvd. Shop Drawings / Rvd. Calculations → If NeT or MCN → If Revise and Resubmit → Email Alert → Prime Contractor / RCE

PSS

Legend:
- ◆ – Start of Workflow
- DME – District Materials Engineer
- DOT – Department of Transportation
- ERMS – Electronic Records Management System
- MCN – Make Corrections Noted
- NeT – No Exceptions Taken
- PSS – Project Scheduling System
- RCE – Resident Construction Engineer
- Rvd. – Reviewed
- X – End of Workflow

Workflow: Safety Grates

Figure A3.15. Safety grates workflow

Workflow: Highway Lighting

Uploads:
- Weld Procedures*
- Poles
- Pole's Foundations
- Catalog Cuts

Subcontractor → [Uploads] → Prime Contractor → DOT

Email Alert

- RCE
- Traffic and Safety → Rvd. Catalog Cuts
- Central Materials → Rvd. Weld Procedures / Rvd. Poles
- Bridges and Structures → Rvd. Weld Procedures

Review Not Required → Email Alert → Prime Contractor → X

Email Alert
- Prime Contractor → X
- RCE → X
- DME → X
- Central Materials → X
- ERMS → X

NeT

If MCN

If Revise and Resubmit ← PSS ← ◆

Email Alert → Prime Contractor

RCE

Legend:

◆ — Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

*Only for Tower Lights

92

Figure A3.16. Highway lighting workflow

Workflow: Highway Signing Steel Breakaways Posts

Subcontractor → Uploads: -Working/Shop Drawings → Prime Contractor → DOT

Email Alert → RCE, Traffic and Safety

Review Not Required → Email Alert → Prime Contractor → X

Rvd. Shop/Working Drawings

Email Alert → Prime Contractor → X, RCE → X, ERMS → X

NeT, If MCN, If Revise and Resubmit

Email Alert → Prime Contractor → RCE, PSS

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

Figure A3.17. Highway signing steel breakaways posts workflow

Workflow: Traffic Signalization

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

Figure A3.18. Traffic signalization workflow

Workflow: Highway Signing – Type B Signs

Subcontractor → Uploads: -Working/Shop Drawings → Prime Contractor → DOT

Email Alert
- RCE
- Traffic and Safety

Review Not Required → Email Alert → Prime Contractor → X

Rvd. Shop/Working Drawings

Email Alert
- Prime Contractor → X
- RCE → X
- ERMS → X

NeT

If MCN

If Revise and Resubmit → Email Alert → Prime Contractor
- RCE

PSS → ◆

Legend:

◆ – Start of Workflow

DME – District Materials Engineer

DOT – Department of Transportation

ERMS – Electronic Records Management System

MCN – Make Corrections Noted

NeT – No Exceptions Taken

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

95

Figure A3.19. Highway signing-type B signs workflow

Workflow: MSE, segmental, & modular block retaining walls

Legend:
◆ – Start of Workflow
DOT – Department of Transportation
ERMS – Electronic Records Management System
PSS – Project Scheduling System
RCE – Resident Construction Engineer
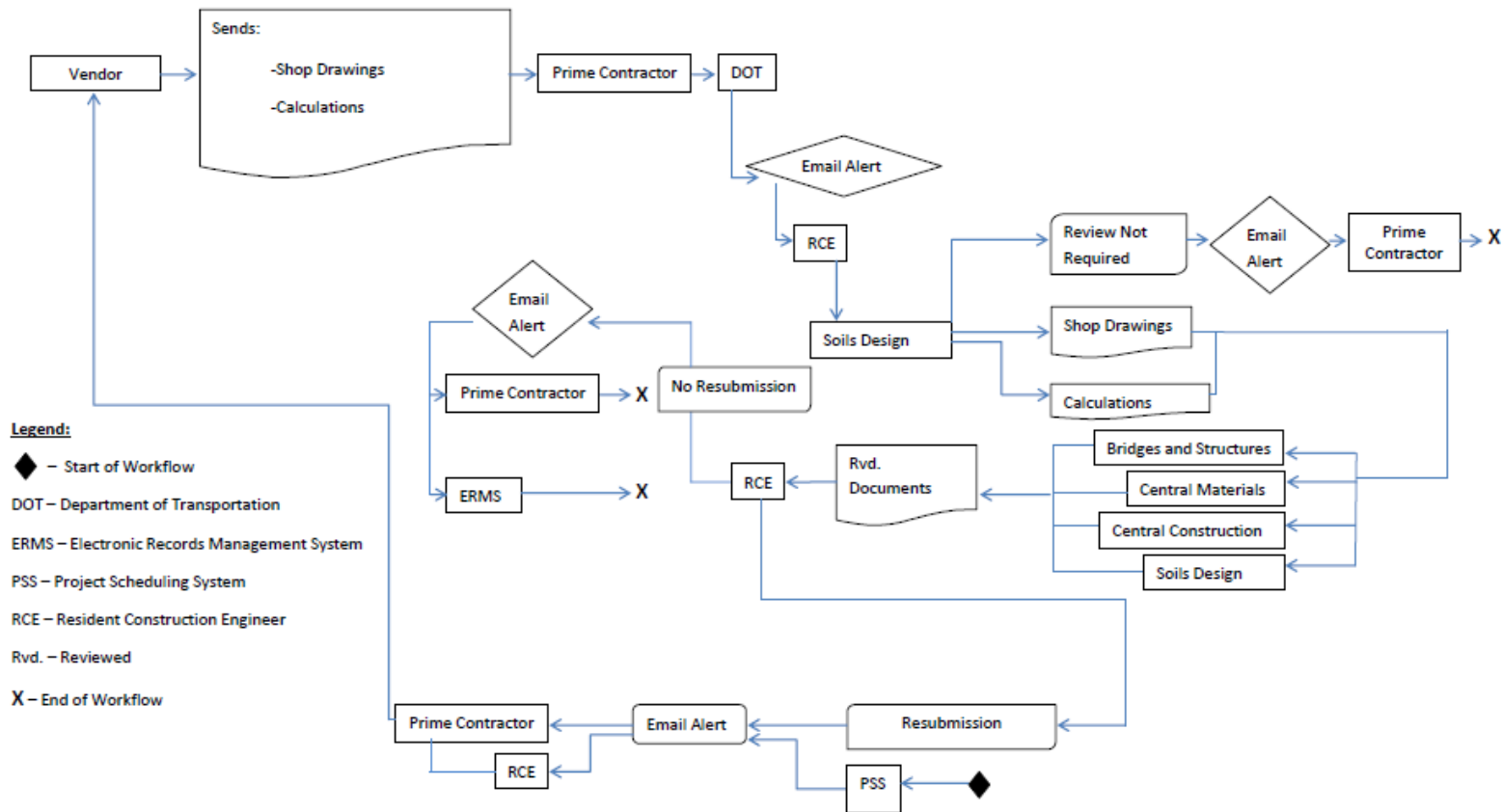Rvd. – Reviewed
X – End of Workflow

Figure A3.20. MSE, segmental and modular block retaining walls workflow
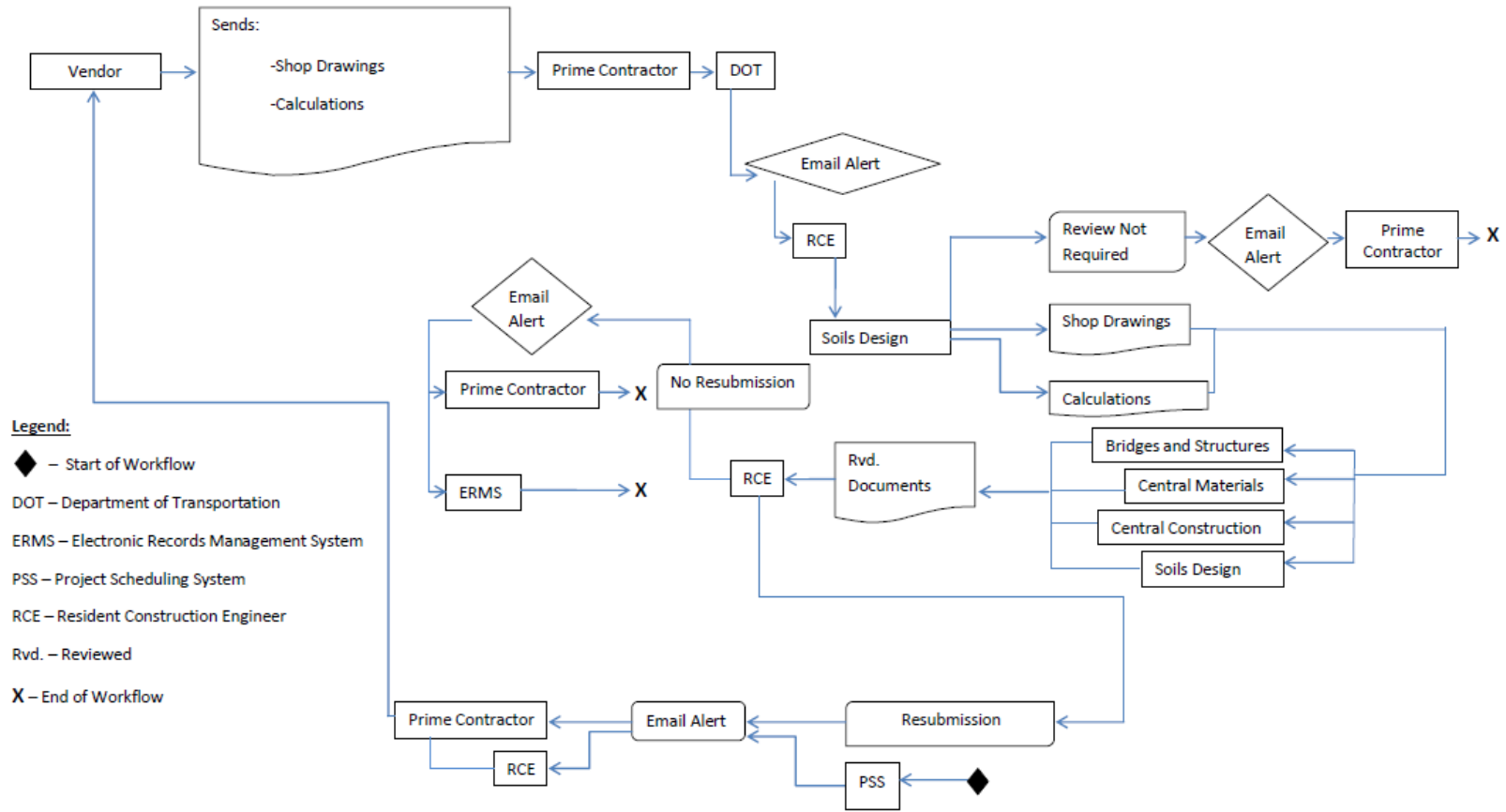
Workflow: Soil nail & tie-back retaining walls

Figure A3.21. Soil nail and tie-back retaining walls workflow

Legend:

◆ – Start of Workflow

DOT – Department of Transportation

ERMS – Electronic Records Management System

PSS – Project Scheduling System

RCE – Resident Construction Engineer

Rvd. – Reviewed

X – End of Workflow

Workflow: Intermediate Foundation Improvement
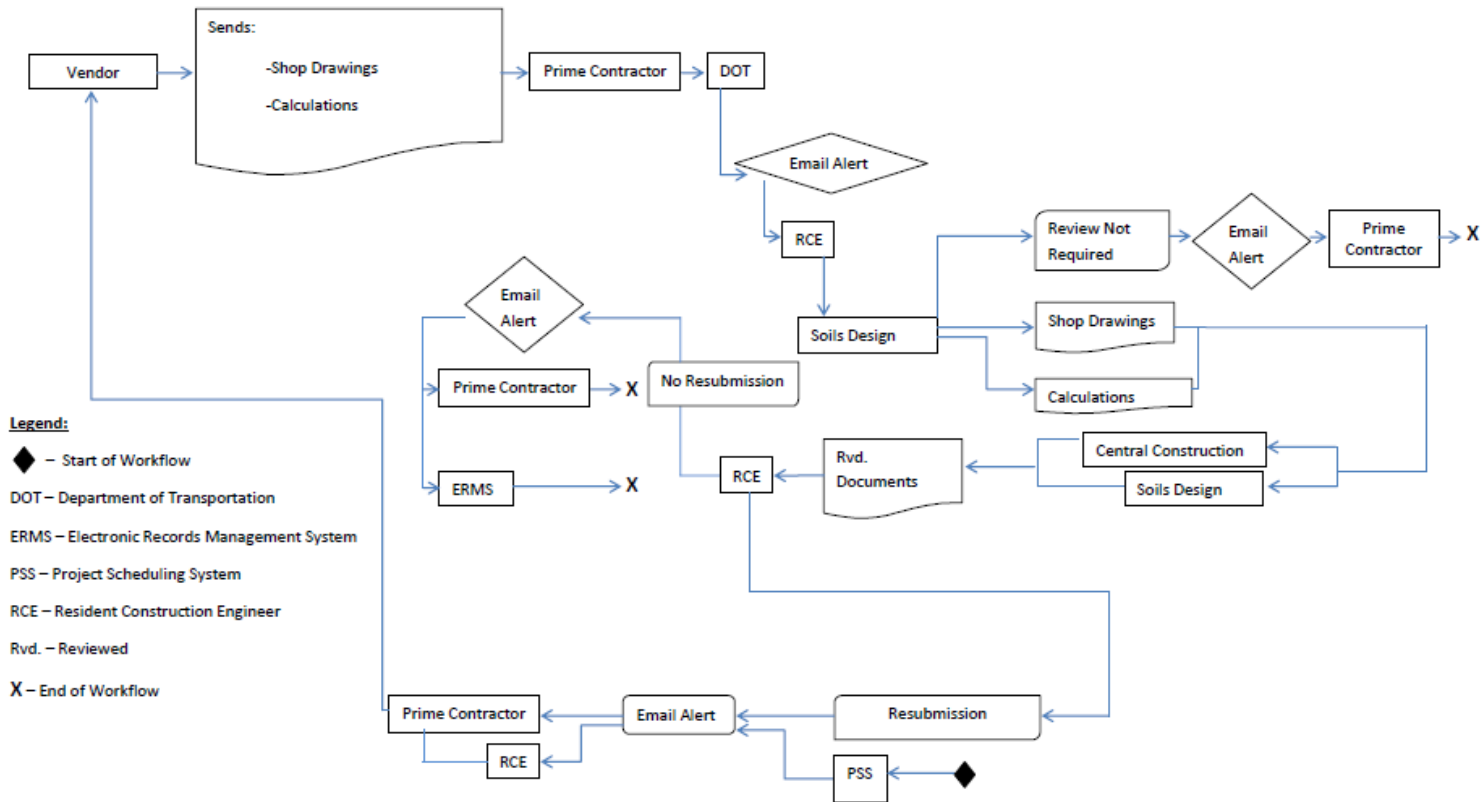
Figure A3.22. Intermediate foundation improvement workflow
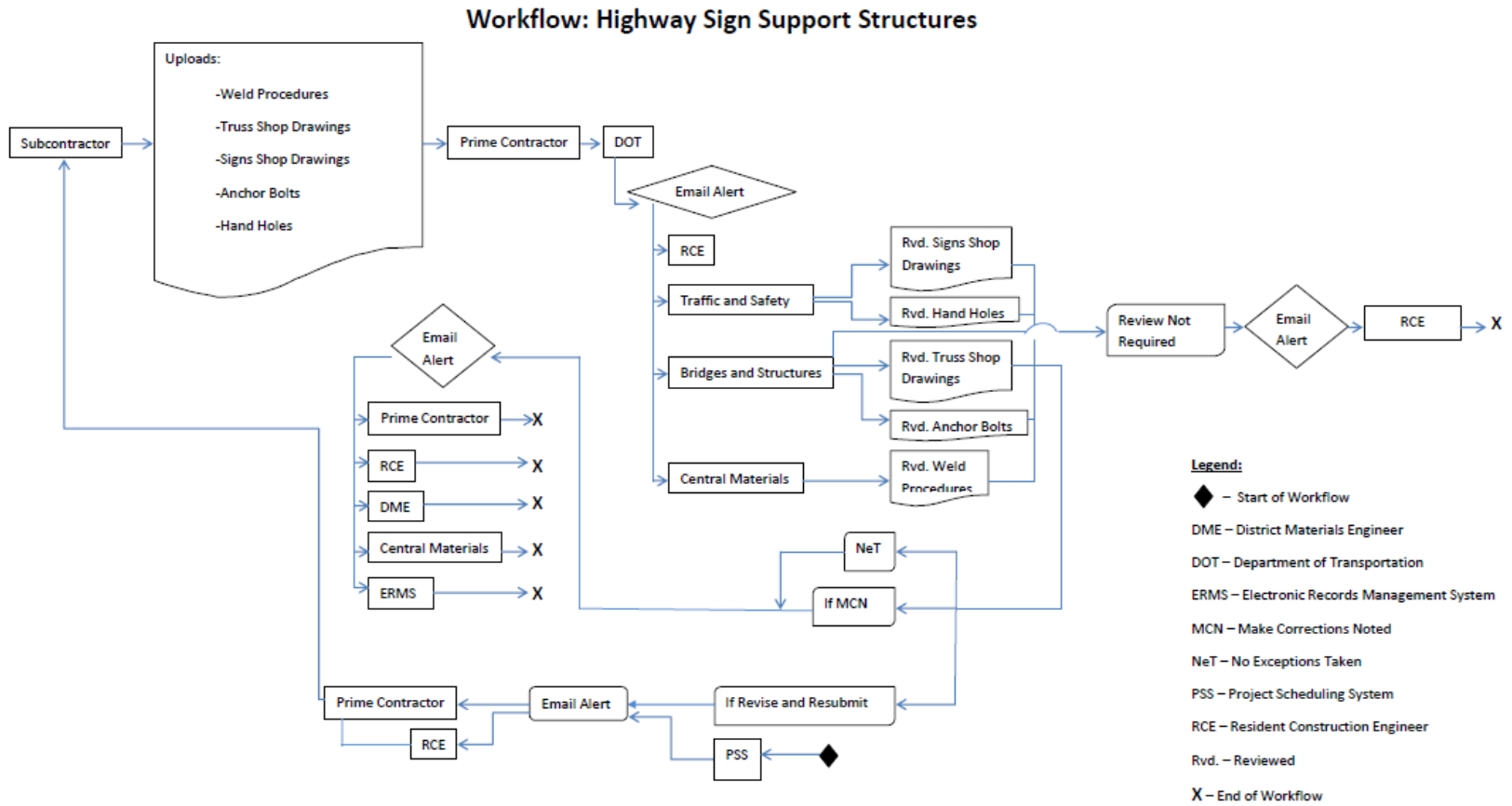
Workflow: Highway Sign Support Structures

Figure A3.23. Highway sign support structures workflow