Improvements in the Hypertext-based Electronic Reference Library for a Public Transportation Agency

by

Ozdemir Cetin

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Graduate College
Iowa State University

This is to certify that the Master's thesis of

Ozdemir Cetin

has met the thesis requirements of Iowa State University.

Signatures have been redacted for privacy

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ABSTRACT

The objective of this thesis is to find ways of enhancing the capability of the newly introduced Electronic Reference Library (ERL), which contains Iowa Department of Transportation specifications, standards, manuals, and drawings. The desired result is improvement in its functionality that will better meet the needs of transportation professionals. Specifically, this thesis discusses, in detail, Web-based questionnaire design, database applications, and search engine capabilities.

The Web-based questionnaire implemented in the ERL can be illustrated as a successful example of on-line surveys. Although the structure of on-line surveys is similar to mail surveys, the use of the Internet and computers makes the survey an effective way of collecting data when compared with other survey methods. The small amount of time and cost spent in the survey study showed that on-line surveys are good sources of observation and can provide valuable information.

Databases are necessary for storing large volumes of information and for making the data available for either developers or users. Although databases are mostly used for business purposes in the Web environment, the database application in the ERL was built for collecting the responses posted on the on-line survey. In order to create a database connection, a non-public server was established in the personal computer. Internet access then enabled developers to store information from the Web-based survey application in the ERL.

The growing size of the ERL forced developers to enhance capabilities of the existing search engine. The selection process of an adequate search engine software is

reviewed based on current examples and applied to the ERL. Furthermore, the search engine mechanism is explained in this study to provide a better understanding of its background.

CHAPTER 1. INTRODUCTION

Today, we are at the start of revolutionary change in the way knowledge is transferred and preserved. For five centuries, the medium most used for recording and transferring assembled knowledge has been the printed page; however, this is changing under the impact of information technology (IT). The storage and retrieval of documents in many industries has been changed from paper to electronic documentation. The construction industry has also been affected by this trend due to the wide usage of technology-enhanced project management techniques, such as use of the Internet, databases, and computer-assisted drawings and documentation.

The Electronic Reference Library contains several documents that are usually used by transportation professionals. These documents in hypertext format are published on compact disks (CD) and on the Internet in order to inform transportation professionals about new standards and specifications and to provide compact and efficient electronic access. These reference documents, however, are also published as books, pamphlets, and three-ring binders and are updated regularly in various ways.

Effective documentation is important in improving the quality of transportation projects, and electronic documentation provides an efficient means of disseminating information more quickly, easily, and reliably. The convenience of the ERL is likely to result in transportation professionals having higher expectations for such documents in the future.

A. Problem Statement

In a true hypertext system, users must be able to move freely through the system according to their needs without getting lost either spatially or cognitively, and navigation

techniques must be at least as effective as those available in books. When the initial excitement about hypertext wanes and systems become more common, better navigation techniques and more systematic evaluation measures will emerge from both developers and users. This will be based on the organizational setting, the targeted task domain, the typical user population, and the desired outcomes of navigation (Conklin, 1987).

During the designing and updating process, our main concerns were:

- Adequacy of the content and the interface
- Understanding and acceptance of readers
- Maintaining the ERL's integrity (i.e., whether it is up-to-date and accurate).

Our goal was to address these concerns maintaining ERL's intuitive and interactive utilities. Collecting feedback and comments from users has always played an important role in making improvements in the previous editions; therefore, it was fitting to implement a new utility in the ERL that could be used to collect the data from respondents completing the survey presented in a Web environment.

Basically, our ultimate goal is to continually improve the ERL effectiveness in satisfying user needs and wishes.

B. An Overview of Electronic Reference Library

Electronic Reference Library (ERL) was developed to help Iowa transportation professionals efficiently access information in critical and heavily used documents. These documents include Standard Specifications for Bridge and Highway Construction, General Supplemental Specifications, Standard Road Plans, Instructional Memorandums, and Construction Manuals. In addition to these materials, other useful documents have been

added to ERL, such as an Iowa DOT phonebook. All cross-references in the documents are hyperlinked, and a search engine is provided.

Upon completion of the master plan for ERL, it is recommended that the ERL be developed incrementally, beginning with Standard Specifications and Material IMs. A new, updated ERL should be issued every six months in concurrence with the issuing of Supplemental Specifications and revised Material IMs. Later, Standard Road Plans and Construction Manuals should be added to new ERL editions. Additional documents will then be added to the ERL as available effort allows. First, these additional documents will be added without hyperlinks to expedite their inclusion. Later, hyperlinks will be provided to facilitate cross-referencing.

C. Thesis Objective

It is the objective of this thesis to develop a system for improving usability and efficiency of ERL by collecting user feedback through a Web-based survey. On-line survey research provided developers with several advantages compared to other traditional market research, such as telephone or mail surveys. Faster distribution and return of the survey, cost savings, and interactivity are a few advantages of on-line surveys.

In this thesis, the history and current technology of electronic documentation design and Internet technologies will be reviewed. Based on this review, knowledge of web design, and Iowa DOT's requirements, guidelines for improving ERL's capabilities will be proposed.

One major goal of this study is to provide ERL users with access to needed information with greater efficiency when compared to hard copy users. To achieve this goal, the ERL must be consistent and intuitive.

The methodology followed in this study begins with a review of the pertinent literature to understand the factors behind electronic information storage techniques. After gaining a better understanding of design techniques, the second step will be applying such techniques for improvement. Also, this thesis discusses the technical background for each document that is added to ERL in order to provide assistance for developers with similar undertakings.

Reference libraries are tools for business success. There are both better and less effective tools, and, of course, the skill of the user is a major factor in any success. The ERL is nothing more than a set of tools designed with success in mind. Creating and maintaining an effective reference library system has always been problematic; that is, trying to strike an appropriate balance between users, writers, administrators, organizational needs, regulatory provisions, and customer needs has exhausted more than a few well-intended efforts. The development of ERL is taking its place among many new electronic tools as a pioneer in the construction industry.

CHAPTER 2. INFORMATION STORAGE

A. Database

The simple way to define database is "a collection of data organized especially for rapid search and retrieval." At the time of this writing, many Web sites have been set up to interact with databases, which enables visitors to query for current information, as well as contribute new information.

Between the high demand for databases and database applications within corporations and the increasing popularity of the Internet, there has been a phenomenal need for Internet-based database systems over the past several years. Being able to easily tie information from a database into a Web site, however, has typically required large amounts of special programming using a variety of tools. Development of complex Web sites on the Internet today requires several tools. For instance, one tool may be used to edit the HTML content for a site, while another application language is used to write scripts or programs on the Internet Web server, and yet additional software is required to manage data within the database on the system. Therefore, managing a Web site with database connectivity can be a daunting task.

Fortunately, because of ERL characteristics and its design requirements, the subject database was established with two popular software applications: FrontPage 2000 and Microsoft Access 2000.

B. Where to Use Databases

According to several references, databases are typically used in the following areas, among others:

1. Real-Time Systems

Every user in the Information Age expects to have the most up-to-date information at his fingertips. With real-time systems, users can connect to databases that house the most current information. Examples include an inventory system that keeps track of products and the stock on hand and a database of news content to be published on the Web.

2. Connections to Legacy Systems

Large corporations still use mainframes and other legacy systems that require special connectivity. In some cases, Web sites simply tie into the legacy data stores saving the effort of rewriting all of these older applications as new client/server systems.

3. Data Processing Systems

As people have used the Internet for more information gathering, users have decided that they want more interactive Web sites. Instead of simply viewing static Web site data, they want to control what information is displayed via accurate searches. In some cases, they are expecting to enter information into the Web-based system to accomplish a particular task, such as searching for a technical word.

With the database application in the ERL, our site's capabilities are enhanced, and more control is given to users by making these three systems available on-line. In addition, we are able to collect information about our users and their suggestions regarding ERL.

C. Advantages of Databases

As mentioned above, databases are important for holding large volumes of information and for making the data available to visitors of a site. In fact, this is their specialty, and database management software handles data better than any other type of

application. There are many advantages of having a database in the Web site, and some of them are as follows:

- Information stores: Databases allow developers to create a structure for database information quickly and invoke simple language commands to populate the database store and retrieve data from it.
- Large storage support: Database management software is designed to scale in order to handle large volumes of information, such as thousands--or even millions--of records.
- Quick indexing/searching: Most of the databases index the data within them in order to make the searching component faster. Thus, required information can be extracted quickly and easily from the system and displayed for the viewer.
- Concurrent user support: In order to receive users' feedback and suggestions, there are many databases on which information is stored and used for improving web site usability.

D. First Database Attempt in the ERL

Researchers used FrontPage 2000 to utilize the database and maintain information in the ERL. This software has enhanced database capabilities that were not found in previous versions.

FrontPage 2000 supports databases via many methods, including its database results wizard, data form entry, database creation utility, and Access 2000 data access pages.

We began the process by creating an HTML form for capturing key criteria for questions in the survey. Upon completion of the survey with the word processing software, we were ready to create HTML forms according to the desired type of button selection, of which there are three:

- One-Line Text Box: This selection provides a field one line high and up to 999 characters long. We used it for personal information such as name, position, etc., and for questions that require personal explanations. Researchers made some adjustments in order to require users to fill out certain sections of the form by specifying data validation parameters in the forms. For example, respondents could only enter numbers in the field for the phone number and had to respond to the personal information field.
- Radio Buttons: These are used instead of check boxes when the user must provide only one answer from a list. One button in a group of buttons is always selected; clicking another de-selects the initially chosen button. The buttons may be set to a default value. Although there is also a validation procedure that requires a respondent to select one of the radio buttons, this was not required for this survey form.
- Push Buttons: There are several types of push buttons for various purposes that may be integrated into the form template, including submit and re-set buttons that are automatically added when the form is created.

When a user fills out the information for a Web form, that information must go someplace for storage or review; therefore, after laying out the form with the appropriate types of buttons for the Web page, we attached the fields in the form to respective fields in a database table. This allows the developer to examine the database for collecting the responses.

Next, researchers had to choose the way in which results could be stored. Possible solutions include routing the information to a mailbox, storing it in a text file on the Web

server, passing it to another server-side application such as an Active Server Pages, or adding it directly to a database(Figure 1).

Text files were chosen to store the information because they can be easily created in the server. A text file is a file data consisting of characters that can be read with a text editor

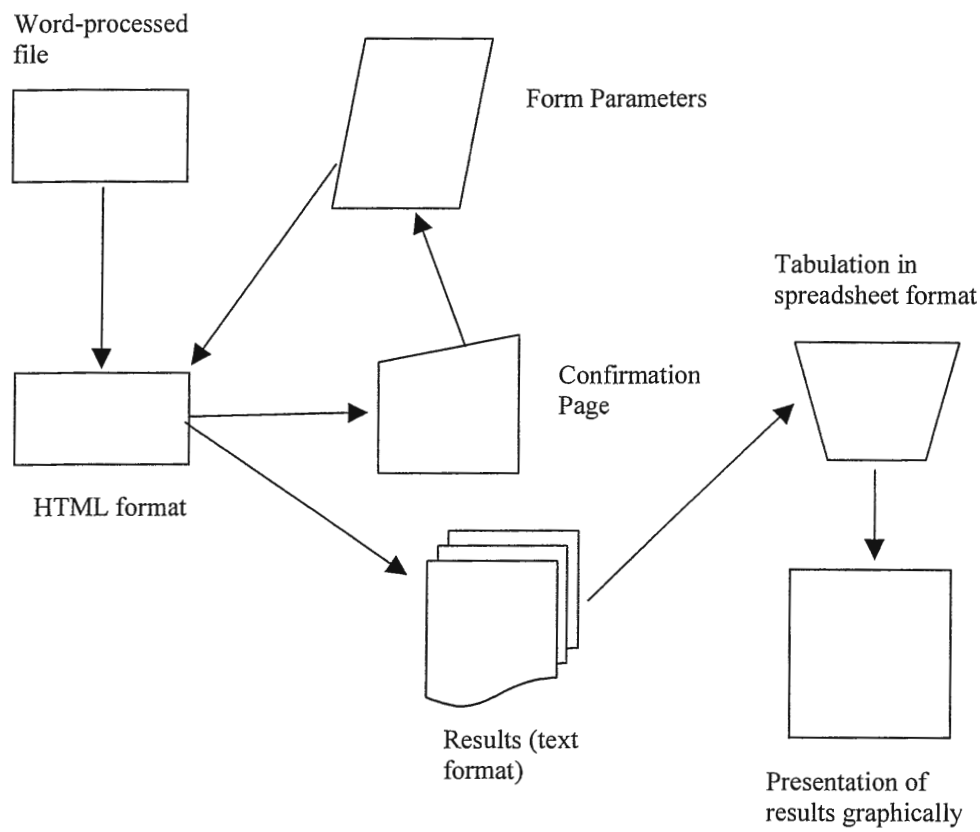

Figure 1. Database Mechanism in the ERL

such as Notepad or Dos Edit.com editor. This text file shows the data submitted from users in disorderly format so that it is almost impossible to read without converting it into a table or graphic format.

At that point, the text file imported by Microsoft Access, which parses the text between delimiters into separate fields. Microsoft Access accepts commas, tabs, and spaces

as standard field delimiters; commas were used for this project. Thus, Access converted the data to an organized, user-friendly table format.

After making some other regular adjustments with the some basic features of Access, the first database was integrated into the ERL.

CHAPTER 3. APPLICATION OF THE ON-LINE SURVEY

A. Introduction

On-line surveys have become increasingly popular for collecting personal information and data over the past several years as computer-readable storage systems for databases have developed. There are a number of questionnaire design considerations that are specific to Web-based surveys. Because the question in a Web-based environment is presented without interaction between the questioner and the respondent, the questions should be more structured and fully explained. In the case where the study is conducted by telephone or personal interview, less structure is required because the respondent can ask for clarification from the questioner.

Presentation techniques like bulleted lists or tables convey information very precisely in a visual environment but are confusing over the telephone or in an interview. Because visual communication is available, researchers can take advantage of such techniques when making on-line surveys.

Similarly, the choice of how to word questions in a telephone interview always requires a full explanation of each question in order to provide a better understanding of the responses. With the Web-based questionnaire, however, researchers can make more complete explanations using tables, checklists, and scaled questions. Respondents tend to answer open-ended questions with more detail on Web-based questionnaires since they can do the typing themselves. Their answers to these types of questions tend to be fully thought out and more structured. The provision of open-ended responses has also been stated by most users to be of great value in understanding the opinions of their respondent base.

B. Survey Methods

Questionnaires can be classified by the method that will be used to administer them (Figure 2). The main methods are by telephone interviews, personal interviews, mail questionnaires, and on-line questionnaires.

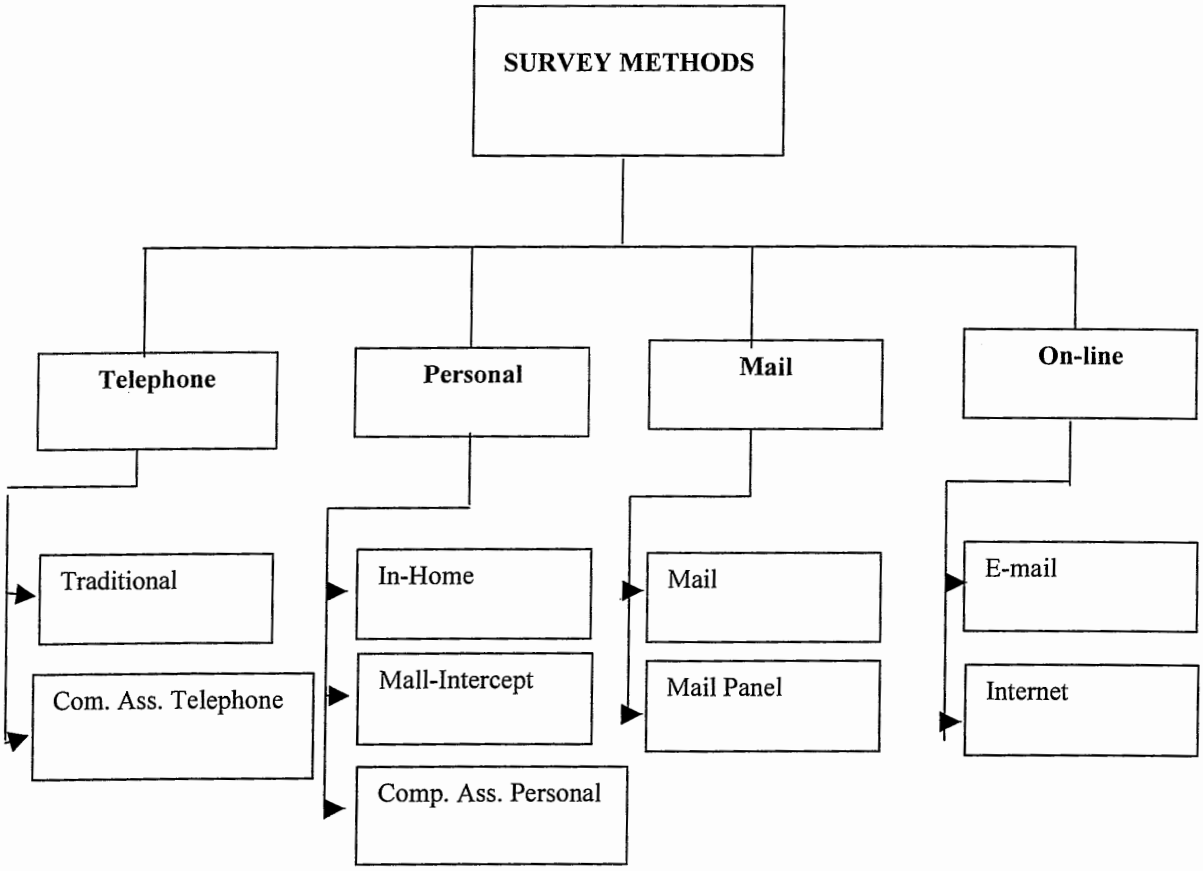

Figure 2. Survey Methods

A personal interview implies a direct face-to-face conversation between the interviewer and the respondent. The interview can take place in a home or office or at a central location, such as a mall where shoppers are asked to participate. In telephone interviews, conversation occurs over the telephone, and in both telephone and personal

interviews, the interviewer asks questions and records the respondent's answers either while the interview is in progress or immediately afterward. The mail questionnaire is sent to designated respondents with an accompanying cover letter. The respondents complete the questionnaire at their leisure and mail their replies back to the research organization. On-line surveys, which are gaining in popularity, can be completed at the respondent's convenience. One reason is the cost in most cases is less than telephone, mail, or personal surveys. Although it takes several weeks or months by conducting the research via phone, mail, or in person, by using the Internet, hundreds of potential candidates were found in only a few weeks at very little cost (Table 1).

Table 1. Comparison of Survey Methods

Criteria	Telephone	Personal	Mail	On-line
Difficulty in locating respondents	Low	High	Fair	Fair
Sample Control	High	High	Low	Fair
Cost	High	High	High	Low
Difficulty in analyzing the data	High	High	High	Low
Response time	High	High	High	Low
Collection and analyze time	High	High	High	Low
Popularity	High	Fair	High	Low
Updating Survey	Low	Low	Low	High
Administrative control	High	High	Low	Low

On-line surveys have several advantages over more traditional forms of market surveys, such as telephone and mail surveys:

- Least expensive survey methodology: For a given sample size, on-line surveys can be executed at a lower cost than any traditional form of survey.

- Surveys can interact with users without the expense of computer-assisted interviewing approaches.
- Faster turnaround possible: Instantaneous electronic distribution of survey materials and electronic return of completed surveys give the fastest possible opportunity for responses. By comparison, turnaround for telephone surveys takes days, and turnaround for mail surveys takes weeks.
- Availability of survey updates.

Every survey method has its weaknesses, as well, and on-line surveys are no exception.

- Uncertainty about who is answering the survey: Like mail studies, it is difficult to ensure the desired person answers the survey; however, this was not an issue for our survey because the survey was on a non-public server (personal computer). Therefore, it is unlikely that a non-targeted user would stumble upon the survey. Using another form of protection, we targeted users through sending an e-mail containing the private link to our survey form. Thus, we collected the responses from the people we had targeted. In addition, we were able to recognize unwanted or fake responses by seeing computer IP addresses.
- The research method being new: On-line surveys are new compared to other surveys, and their level of acceptance has not yet reached the same level.
- Difficulty administering survey: Some questions need more explanation in order to provide better understanding.

Despite the above listed disadvantages, on-line surveys should be seriously considered as an alternative. When surveying populations on a product that is marketed or presented through the Internet, such as the ERL, on-line surveys are an especially convenient method of information collection.

C. Questionnaire Design

Our first step in preparing the questionnaire was to decide what information would be of interest to us. As we were selecting questions, the most important information that we were looking for was users' hardware and software availability, Internet accessibility, and likes and dislikes related to the ERL design. We were also looking to collect our potential users' personal information, such as their names, positions, and companies, in the event that we needed to contact them in the future.

After the form of response and specific wording for each question was decided, the proper questionnaire sequence needed to be resolved, which is crucial to the success of the questionnaire design. The proper questionnaire sequence is to present questions securing basic information first and those seeking personal or classification information last. This is done so that the researcher does not risk alienating the respondent by asking a number of personal questions before capturing the basic information and feedback that are most desired.

Another issue of concern was the size of the questionnaire. Smaller questionnaires are better than the larger ones if they do not appear crowded. A crowded questionnaire has a formidable appearance, leads to errors in data collection, and results in shorter and less informative replies for both self-administrated and interview-administered questionnaires. On the other hand, smaller questionnaires seem easier to complete; they appear to take less

time and are more likely to attract respondents. Therefore, during questionnaire design, it was intended that it should be smaller, simpler, and easier.

D. Deciding on the target sample groups

A non-probability sampling technique was used, which includes personal judgement somewhere in the selection process. This technique applied to the ERL can be defined as a combination of convenience sampling and judgement sampling.

Convenience sampling is a non-probability sample that is sometimes called an accidental sample because those included in the sample enter by accident, in that they just happen to be where the study is being conducted at the time it is being conducted. Judgement samples are often called purposive samples; the sample elements are handpicked because it is expected that they can serve the research purpose better than anyone else.

Iowa DOT inspectors, Iowa Contractors/Designers, and other state DOT employers were our target population for the survey. Iowa DOT inspectors, the ERL's primary users, have the CD available for use in their laptops during the regular inspections on the field. ERL was developed specifically to benefit them; therefore, due to their experiences with the ERL, the Iowa DOT inspectors' responses are very important to the survey. Iowa Contractors/Designers were chosen to be another target population for feedback. This group's perspective is likely to be different from that of inspectors due to different work conditions and different project goals. However, since the Iowa Contractors/Designers are prospective users, their inputs and feedback will help developers in the future versions. The third option, the employers from other DOTs, were chosen as one of our target populations because most of them are interested in publishing their manuals and specifications electronically. Therefore, researchers supposed that they could provide feedback whether they actually have

electronic publications now or are planning to install one in the future. When considering this group as one of our target populations, we wanted to collect technical feedback rather than preferences, interests, or adequacy of content.

Almost half of the respondents came from a sample of people who were selected as researchers examined Web sites of other state DOTs and electronic publications. Basically, this population was targeted because its members are responsible for preparing such publications, and they are thought to be interested in the development of electronic publications whether they are currently being produced or plan to be produced in the near future. Therefore, this sampling can be defined as a convenience sampling because the names were easily available on the Internet and a judgement sample because people whose names appear on Web pages are more likely to be interested in improving an ERL.

The other half of the respondents were intentionally selected people because they were believed to be most representative of the population of interest, such as Iowa inspectors, contractors, and designers, which is a good example of judgement sampling technique. A few examples of how we selected respondents using judgment sampling are listed here:

- Mark Bortle, automation expert for the Office of Construction, helped us to contact Iowa DOT inpectors who use this medium on a daily basis.
- Ricke Welden, AGC of the Iowa Chapter, suggested contractors who receive the letting report with e-mail.
- Matt Love, Engineering Publications Washington DOT, contacted engineering publication professionals from other DOT employees.

After contacting many users by e-mail, we began to collect responses through the Internet and store them in our database.

E. Results

As mentioned earlier, three target populations were defined: Iowa DOT inspectors, Iowa Contractors/Designers, and other DOT employers. Survey responses, shown graphically in Figure 3, indicate that the respondents are equally distributed.

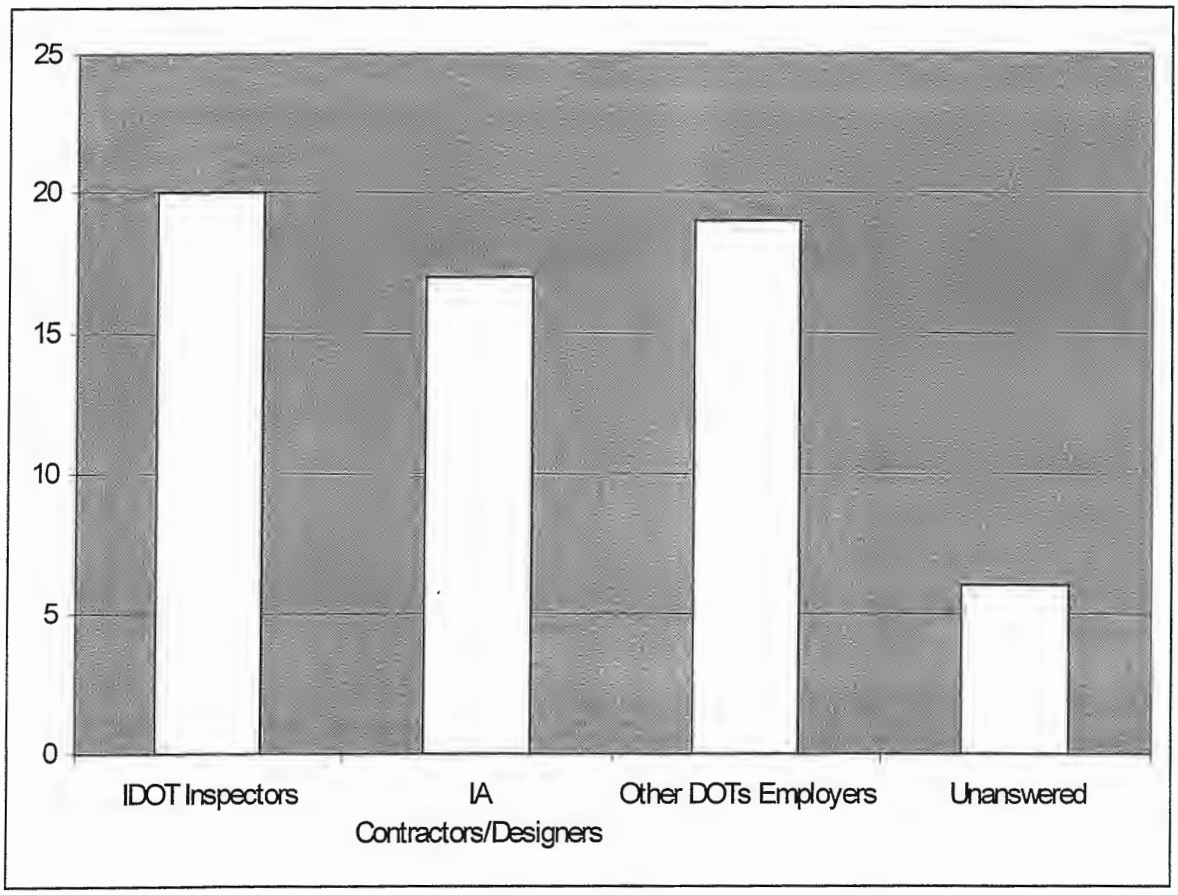

Figure 3. Distribution of Respondents

Survey participants were asked to rank seven publications on a scale ranging from most to least frequently used. Figure 4 shows rankings for all publications, as well as the numeric rating (7=highest, 0=lowest). The list of publications was based on the construction documents used in the newest ERL.

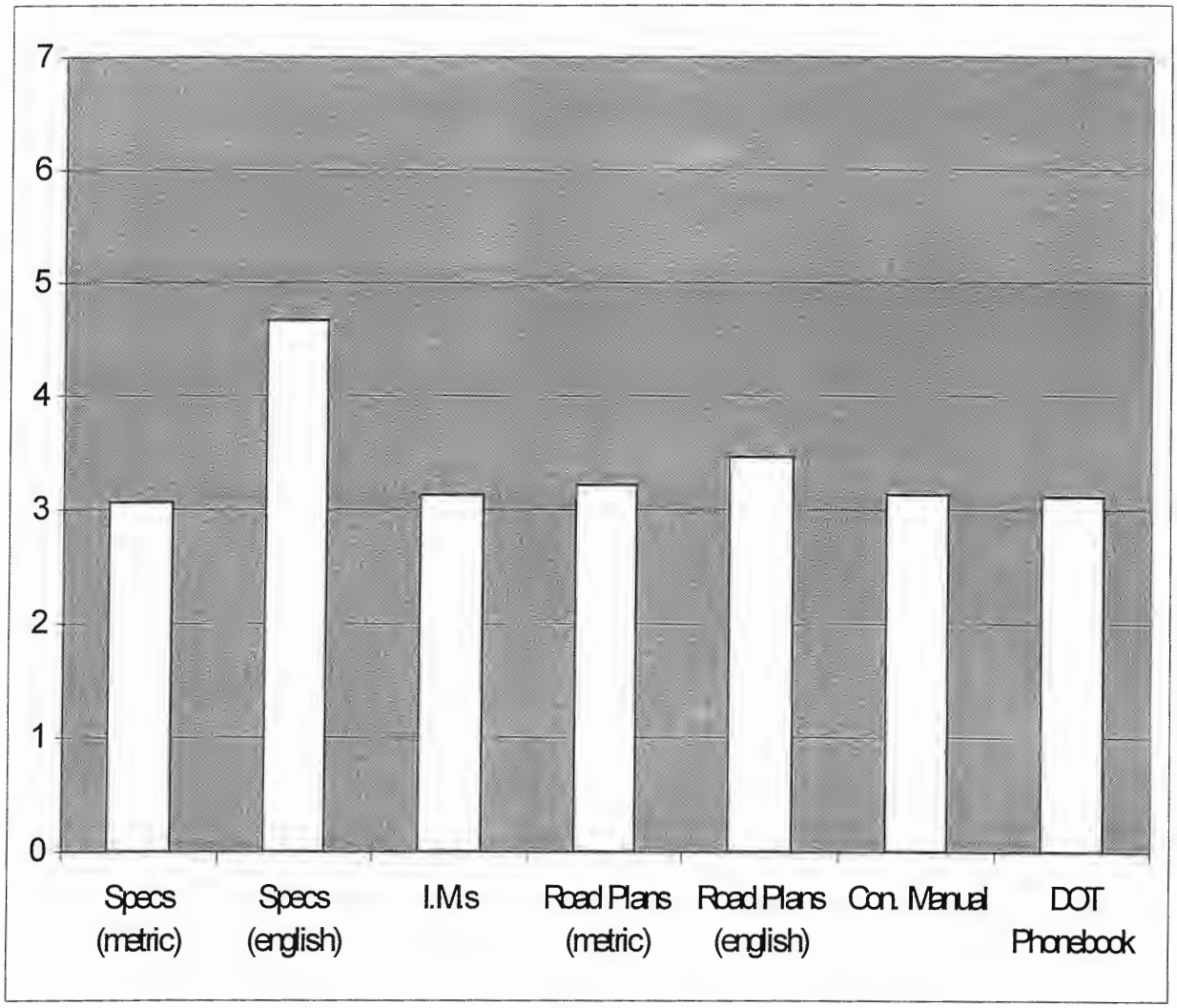

Figure 4. Frequency of Used Documents in the ERL

Also, in this survey, in order to learn the users' likes and dislikes regarding components of ERL, five scaled questions were asked of the respondents. Thus, it was thought that appropriate actions would be taken to maintain ERL's user-friendly characteristics according to Figure 5.

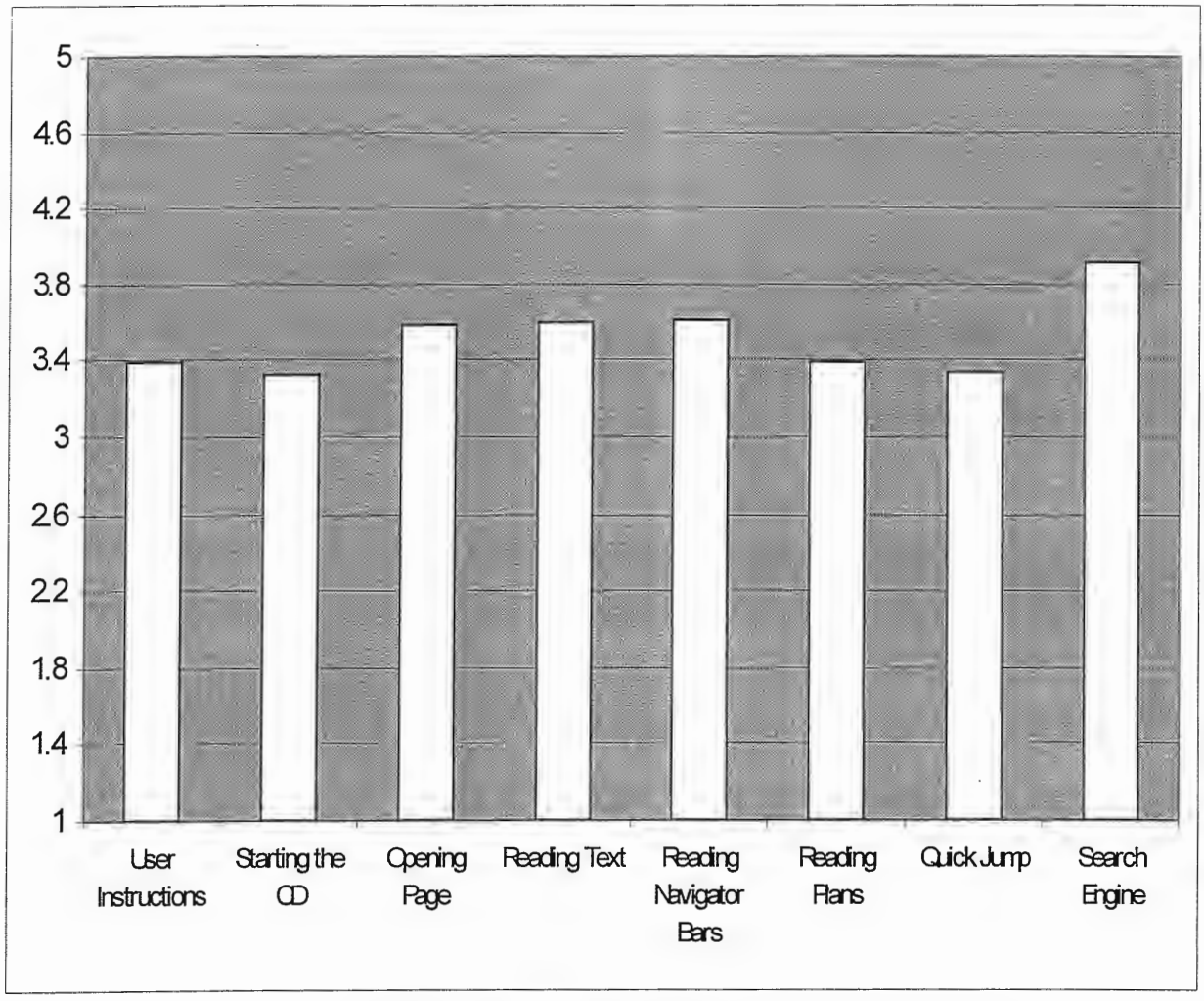

Figure 5. Users' Rankings on ERL Components

Respondents were asked which documents they would like to see in new editions of ERL. According to users' responses, Road Design Details and Iowa Maps are the construction documents most desired (Figure 6).

The results that are stored in the database and converted to the MS Access file format can be found in Appendix C.

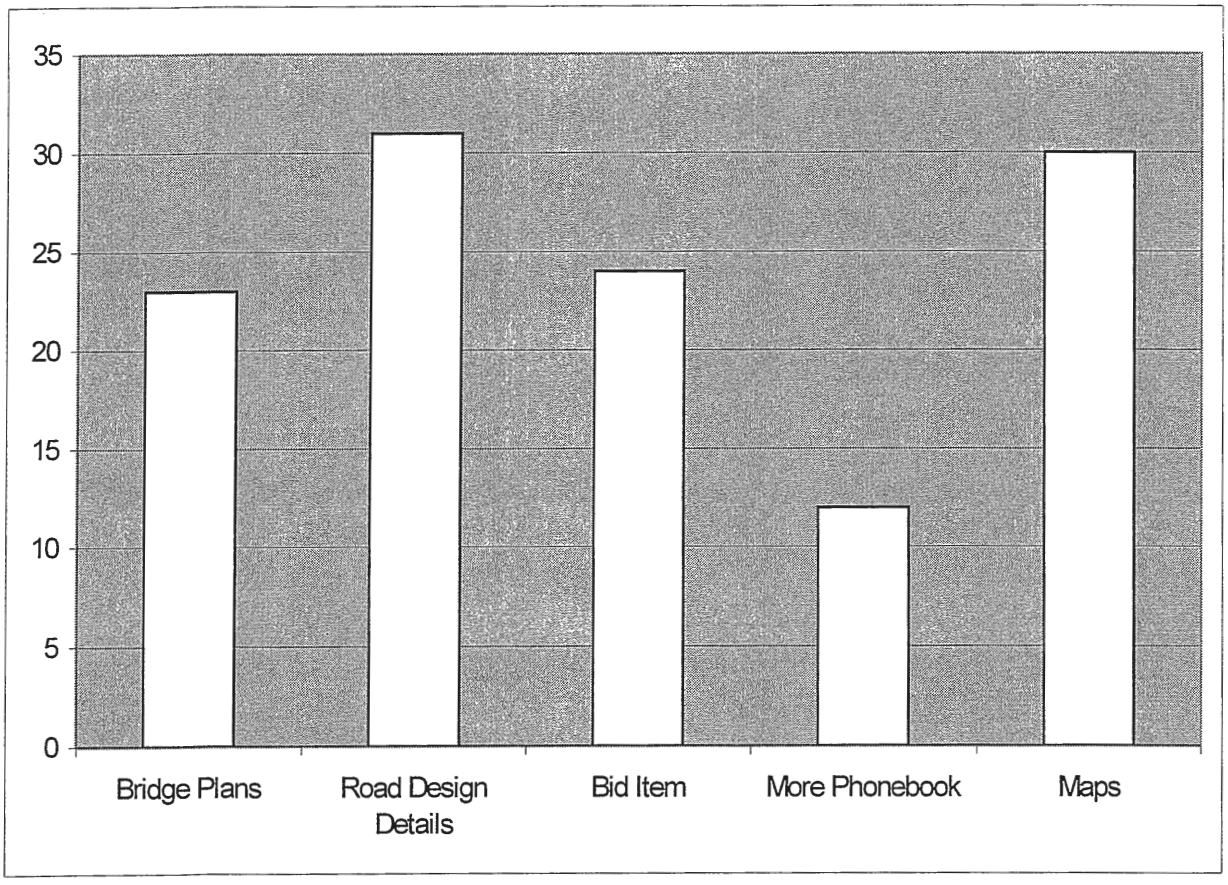

Figure 6. Desired Documents in New Editions

CHAPTER 4 – INFORMATION RETRIEVAL

A. Introduction

Two specific information retrieval systems were applied to the ERL: navigation control and search engine. Before beginning to explain the tools used in the development of ERL, we should take a look at the problems that we may encounter when designing Web-based applications.

As we know, the advantage of a hypertext system is its ability to create highly connected, complex, and cross-referenced types of information. Due to the complex body of hypertext, however, it may become confusing for both authors and users. Conklin (1987) states that disorientation and cognitive overhead are the two problems when using hypertext.

1. Disorientation

Disorientation can be defined as a "getting lost in space" that happens when the user needs to know where information is located in the network, where the user is in the network, and how the user got there. In order to avoid this problem, such tools as a table of contents, banners, navigation bars, quick jump, and search functions are added to ERL. Thus, with these helpful tools, users can predict their location in the ERL, and getting lost in thousands of nodes and links is unlikely.

2. Cognitive Overhead

High cognitive overhead comes from users having to make many decisions about which links to select and which to ignore when there is a large number of choices. When this occurs, the amount of time spent conducting a search time can be problematic for users. It can become a more serious problem if there are too many links and documents found in one place.

There are considerable numbers of studies underway in the computer industry to overcome or minimize the problems of disorientation and cognitive overhead. Our efforts to solve these problems include collecting users' feedback, maintain ERL's simplicity, and following the new developments in the computer industry.

Good navigation control can be explained as facilitating information flow without losing the user. For small hypertext systems, navigating with hyperlinks on Web pages is usually adequate. For large hypertext databases such as ERL, information retrieval through queries becomes crucial. Conklin suggests that search and query mechanisms could assist with navigation through a larger amount of information at a manageable level of complexity and detail. (Conklin, 1987). Many hypertext experts agree with this view (Fraternali, 1999) (Ransom, 1998). Search and query needs to be endorsed to help users access the information for which they are searching.

B. Search and Query Mechanism

Today, most search engines focus on keyword-based automatic searching, weighting of words based on their statistical properties, ranking of documents according to probability of relevance, automatic relevance feedback for query modification, and query languages. (Croft et al., 1990).

According to Halasz, query and search mechanisms can be classified into content search and structure search (Halasz, 1988). Content search is standard information retrieval technique extended to hypertext systems; that is, all nodes and links are treated independently and examined for a match to the given query. On the other hand, structure search will yield the hypertext sub-network that matches a given pattern. Query facilities that combine aspects of both content search and structure search will be capable of acting as filters. Based on the

user's query, the interface will display only those nodes and links that match the query, filtering out other parts of the network.

Figure 7, is a representation of how most search engines work, including the one implemented in the ERL.

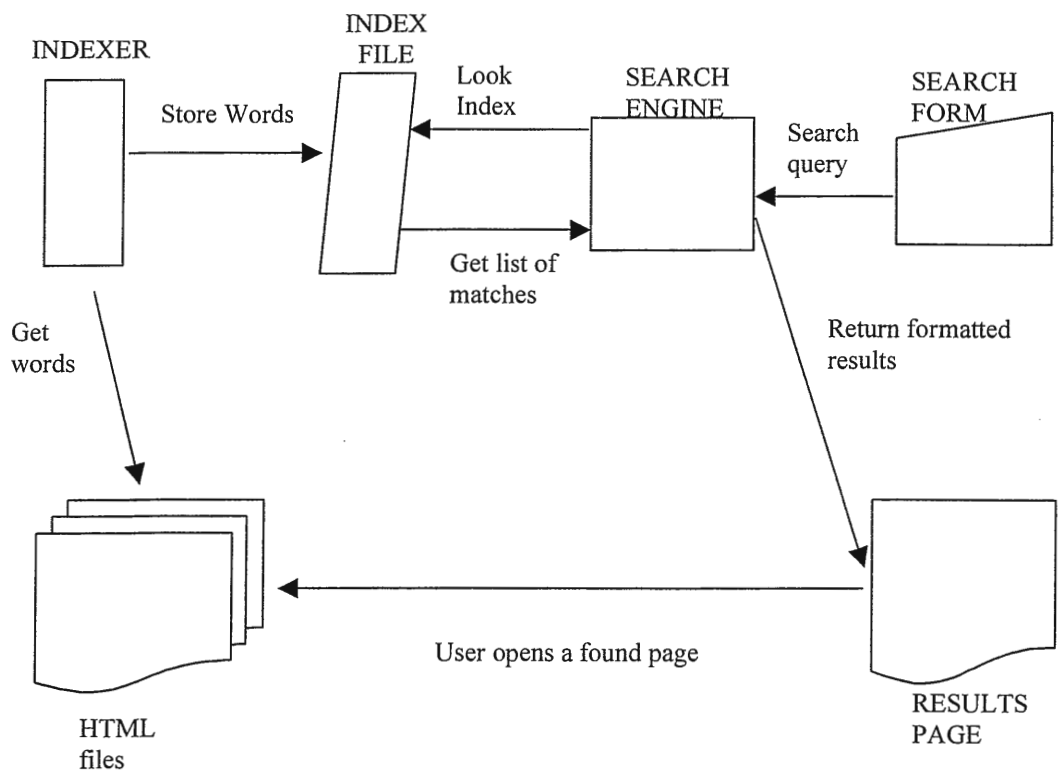

Figure 7. Search Mechanism in the ERL

The process starts with running the search indexer on the folder or folders to be searched. The search indexer is the application that reads the text of the documents to be searched and stores them in an efficient searchable form, usually called the Index (Index File).

This index file that the site search engine compiles and subsequently searches contains information about all the pages that make up the site. To account for changes to the site, the file must be updated regularly; depending on which site search software is used, re-indexing can occur either automatically or can be done manually by the developer at specified intervals or special occasions.

After running the indexer, the search engine looks for these index files based on the user's query. In the meantime, the search engine categorizes the results according to what the search form settings indicate. Afterward, the results will appear on the result page.

C. Selecting a Search Engine

Selecting the right search engine can make all the difference in a successful Web implementation. It can impose order and be a guide to helping users find the information they need from the site.

There are three options for adding search capabilities to a Web site. The first option is to delegate the search function to a public search engine. This is done by submitting the World Wide Web pages to the search engine owner and pasting their search form to the site. However, this approach has a couple of drawbacks: Public engines may allow only 10 or 20 of the site's pages to be searched, and the engine dictates how frequently it updates them. If the user's content changes more frequently than the engine visits the site, then users will be searching old data. This was never an option for the ERL since it was published on CD-ROMs, contains many more than 10 or 20 pages, and must be updated on particular dates.

The second option is to engage a service provider who has purchased a search engine to create a separate searchable index of the user's Web site. The service provider will create a search form to access this index and charge a fee for the service. It is easy to set up, but the

fees may eventually become more expensive than the cost of the user installing his own search engine, according to the reports published in journals.

The third option is applicable to large, volatile corporate Web sites in which content changes frequently. It involves installing a search engine directly on the Web site. This can be desirable because ultimate control is given to a webmaster.

An excellent example of site search requirements, analysis, selection, and installation process is available at the University of Pennsylvania's web team area (URL: http://www.upenn.edu/computing/web/webteam/rnd/search.html). They have kindly allowed others to view their information and notes, providing a model of the procedures they followed from late 1996 through the installation of new a search engine in 1997. These procedures are as follows:

- Create a plan and schedule.
- Screen available search tools based on compatibility and requirements.
    - Define preliminary end-user requirements.
    - Check existing listings of site search tools.
    - Choose the most appropriate options for additional research.
- Develop technical requirements document for end-user needs (Boolean searching, result listings, phrase search, etc.), administration, cost of ownership, vendor reliability, hardware, and OS compatibility.
    - Decide if the search engine should index only HTML files or if it should it index other file types as well.
    - Determine which platform to use. Obviously, the search engine must be compatible with the server's operating system.

- Evaluate options based on requirements in a table.
- Install test versions of the final candidate products.
- Perform automated and manual user tests, and evaluate results.
- Define and develop required local customization.
- Install and publicize the new search tools.
- Compare costs.

Behind the scenes, site search engines all work similarly. In fact, they work quite similarly to large Web-wide search engines that are commonly known. Large on-line search engines compile URLs for specific Web pages into a giant database along with other data describing the pages; then, the search engine searches this database. They do not actually go out and search the entire Web each time a user submits a query.

D. Search Engine in the ERL

The search engine that had been used in the ERL is named Jobjects QuestAgent 4.0®, which was provided by Jobjects Inc., Las Vegas (URL: www.jobjects.com). Recently, the Iowa DOT requested the addition of a phrase search function to the ERL. Iowa DOT believes that phrase search ability will enhance users' accessibility to information because many technical terms include two- to three-word phrases.

Upon completion of investigation of existing search engine software, researchers concluded that the new requirements of the Iowa DOT are not supported in Jobjects QuestAgent 4.0®; therefore, the researchers endeavored to find a new search engine using the University of Pennsylvania Web team's method.

First, researchers planned their investigation by preparing a real-needs assessment before beginning a software search. This assessment included several different

considerations, varying from technical requirements to financial limitation, in order to match with our project goals. The assessment is outlined below:

- Platform

  Examine the platforms supported. The search engine generally will only run on specific platforms with specific versions of the platform's operating system, with the exception of those that provide the source code and require compilation upon installation.

- Easy installation and low maintenance

  Identify search engines that are easy to install and maintain.

- Documents

  If the documents that are going to be included in the database are spread across file servers or directories, then the search engine chosen must have the ability to index documents wherever they are located. The search engine in the ERL can index different folders in different directories and save the index file as a whole in certain folders. The search engine must support the types of files that need to be searched. In the ERL, there are currently two different types of files, PDF and HTML, and our search engine software supports both.

- One or more database search

  If so, then the search engine has to have the capability of creating multiple databases, and the search interface must provide users with the option to select one or more databases. With QuestAgent 5.0, the user can choose more than one database (Figure 8).

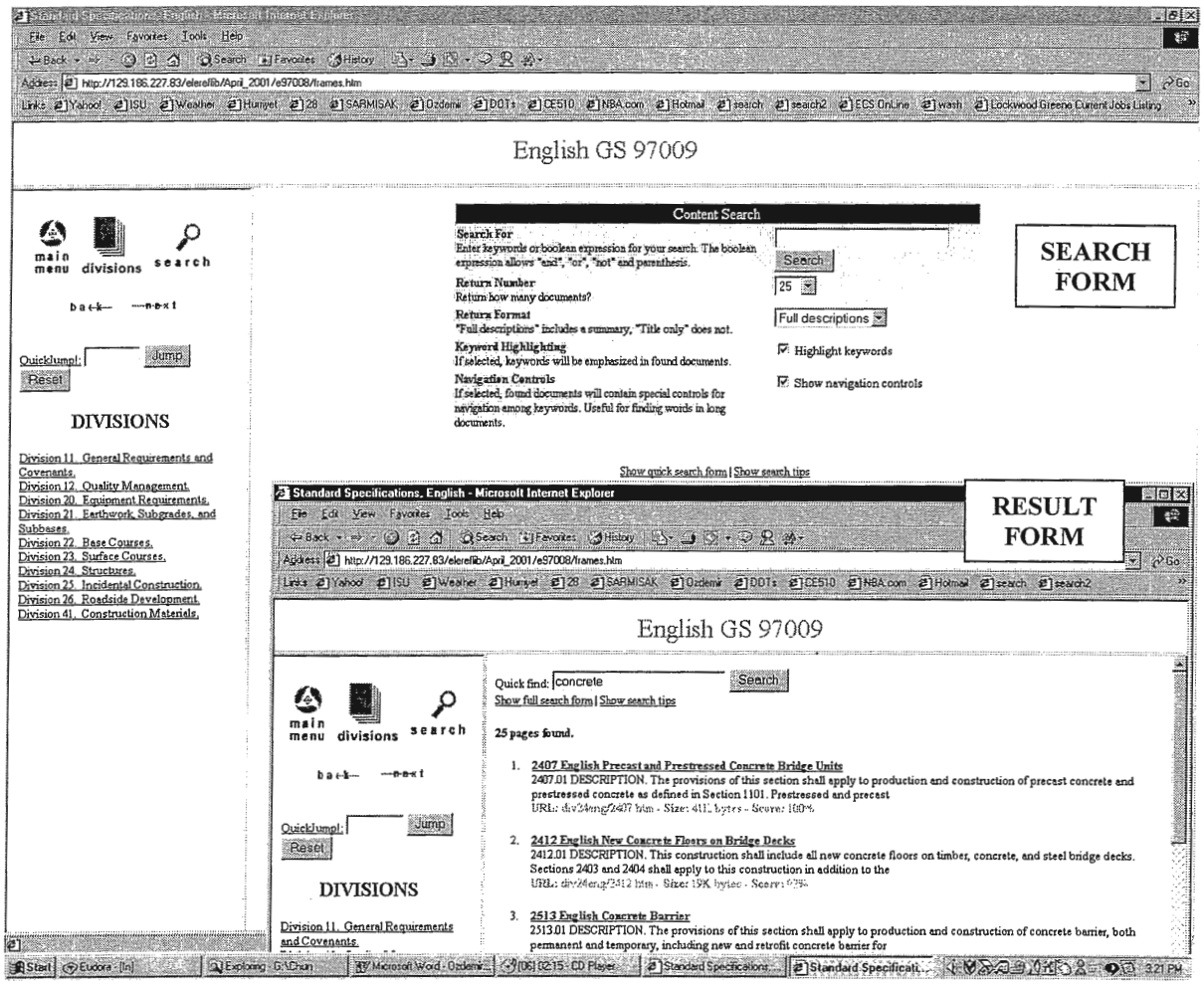

Figure 8. Search Engine Search and Result Form

- Special search functions

  The searching functions must be examined to ensure that they meet user needs, such as providing Boolean search, phrase search, and various other capabilities.

- Results

  Do we have the ability to modify the template that displays the results that are delivered with the search engine? As with the search functions, the result display function must be examined to see that it meets user needs. For example, in the

previous versions of the ERL, the highlighted word function in its search engine made it easier to find the desired words in the extensive text.

- Modification of Results

  Different users may need to display different components of the documents that they have retrieved or the total number of items returned.

- Cost

  The cost of a search engine can range anywhere from zero (pubic domain applications) to thousands of dollars. We have decided to use the most affordable one that matches our target budget.

After testing trial versions of three software applications (Table 2), QuestAgent 5.0 was found to perform in a satisfactory manner.

Table 2. Search Engine Comparisons

	QuestAgent 5.0	Site Surfer	Webrom
Platform	Java	Java	Java
Installation	Easy	Easy	Easy
Document (HTML and PDF)	HTML and PDF	HTML	HTML and PDF
Ability to choose one or more databases	Yes	No	Yes
Phrase Search	Yes	No	No
Modification of Results	Yes	No	Yes
Cost	$925 (3,000 CD)	$500 (2,000 CD)	$995 (3,000 CD)

CHAPTER 5 - IMPROVEMENTS IN THE ERL

This chapter discusses the actions taken in the ERL to improve its features and functions in order to offer a better product to transportation professionals. By utilizing various programming languages, software, and Internet tools, ERL has been changed into a primary reference media that has been getting a good reputation nationwide. The reputation of the ERL is affecting other state DOT decisions in converting their paper-based documents into the hypertext-based construction documents; therefore, the text-to-Web conversion required the authors to create a suitable new Web site design and several features.

A. New Construction Documents in the ERL

Due to the increasing popularity and demand for the ERL, both the Iowa DOT and researchers have been encouraged to add new features to new versions. After a few meetings and discussions, two different construction documents that are heavily used by contractors were selected for inclusion in the ERL. These construction documents are the Standard Road Plans and the Construction Manual.

The Standard Road Plans have been developed to show standardized design features, construction methods, and approved materials to be used in design plans for interstate, primary, and secondary road construction in the state of Iowa. These plans, however, are not intended to provide solutions to design problems.

The Construction Manual is intended primarily for use by field personnel as a compilation of policies for the administration and inspection of construction projects. In some cases, it also serves as a commentary for construction administrators on the specifications. It includes background information, required procedures, current instructions,

and descriptions of departmental policy. Although it does not answer all questions that may arise on construction projects, it does provide a general reference for common situations.

1. Standard Road Plans

Standard Road Plans are prepared by the Office of Design at Iowa DOT and distributed to users in three binders for both Metric and English construction projects. They are also presented in Iowa DOT's Web site for construction professionals who have Internet access. These plans can be downloaded from the Office of Design Web page in Portable Document Format (PDF) and Microstation file (DGN) format.

The first attempt to include the plans in the ERL was done using DGN format because it was believed that DGN offers more flexibility for users. Another requirement for ERL documents is that all references to other documents in the ERL should be hyperlinked. Since the Standard Road Plans contain such references, a method of providing hyperlinks was necessary. After several attempts to place hyperlinks and consulting with software support experts, it was concluded that Microstation does not have a hyperlink function; therefore, using an alternative file format was necessary.

As mentioned in several resources, Portable Document Format (PDF) quickly is becoming the standard for the publication and distribution of documents via CD-ROM and the Web. With PDF, it is possible to convert computer-aided designs, word processing files, spreadsheets, databases, and images into a single format. PDF gives users the ability to read, print, or plot the documents and images without being able to modify or change the files. The ability to add links to the documents played the most important role in our deciding on the software for Standard Road Plans.

One of the other advantages of PDF is that Adobe Acrobat Reader can be easily downloaded from the Internet at no cost and used for reading documents. Therefore, PDF has been widely accepted as the industry standard recently and has become one of the most popular document formats other than HTML on the Internet. There are a great deal of PDF documents today for all kinds of electronic publishing. Like printed books, PDF documents contain all layout formatting, fonts, and graphics of the original document (Table 3).

Table 3. Features of PDF and DGN Files

Type of File	PDF	DGN
Size	Small(if scanned in normal resolution)	Large
File opening	Easy	Difficult
Hyperlink Capability	Yes	No
Zoom	Good	Very Good
General Availability to Potential Users	High	Low
Cost for Read Only Software	None	$ 220
Print Quality	Good	Good

The file structure that is used for Standard Road Plans in the ERL allows developers to easily update and maintain folders because each specific type of plan or programming script is found in a single folder. This procedure has been followed since the inception of the ERL. Metric and English Road Plans were also saved in specific sub-folders in order to keep data safe and to provide relative links among files; this makes the updating process quicker and easier (Figure 9).

The expandable and collapsible tree view of the hierarchy on the left side, as it has been applied to General Standards and Supplemental Specifications, is used as a navigation frame for Standard Road Plans.

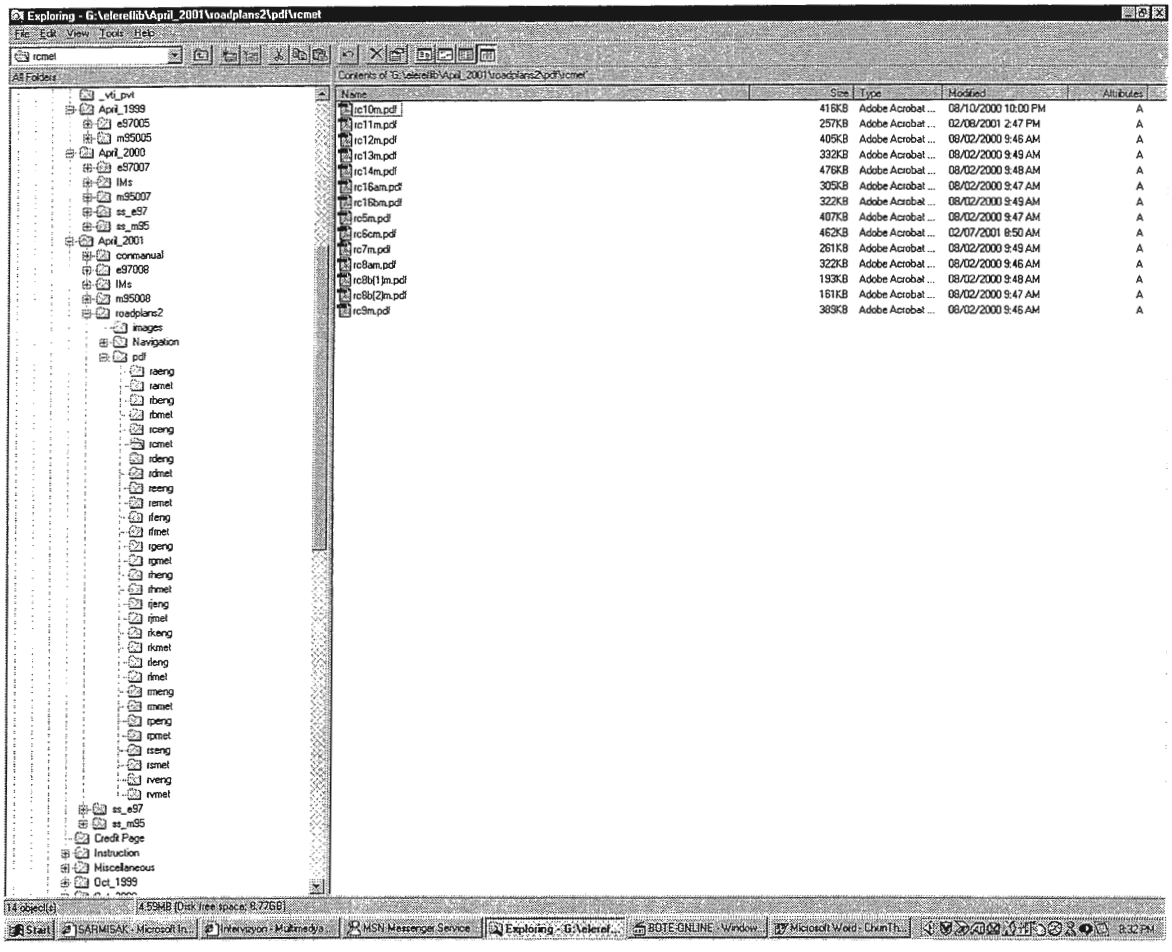

Figure 9. File Structure of Standard Road Plans

The most important advantage of this hierarchy system is that, when a new section is expanded, any other sections are collapsed, which allows much more space for the content.

The frame on the top that displays the title of the document (previously implemented in General Standards and Supplemental Specifications) is not used in Road Plans in order to provide more space for drawings. Index of plans with their assigned numbers is located in the navigation bar. On the opening page of Road Plans, however, the main index of the plans is given in the main frame in order to provide a better view to make the selection process easier (Figure 10).

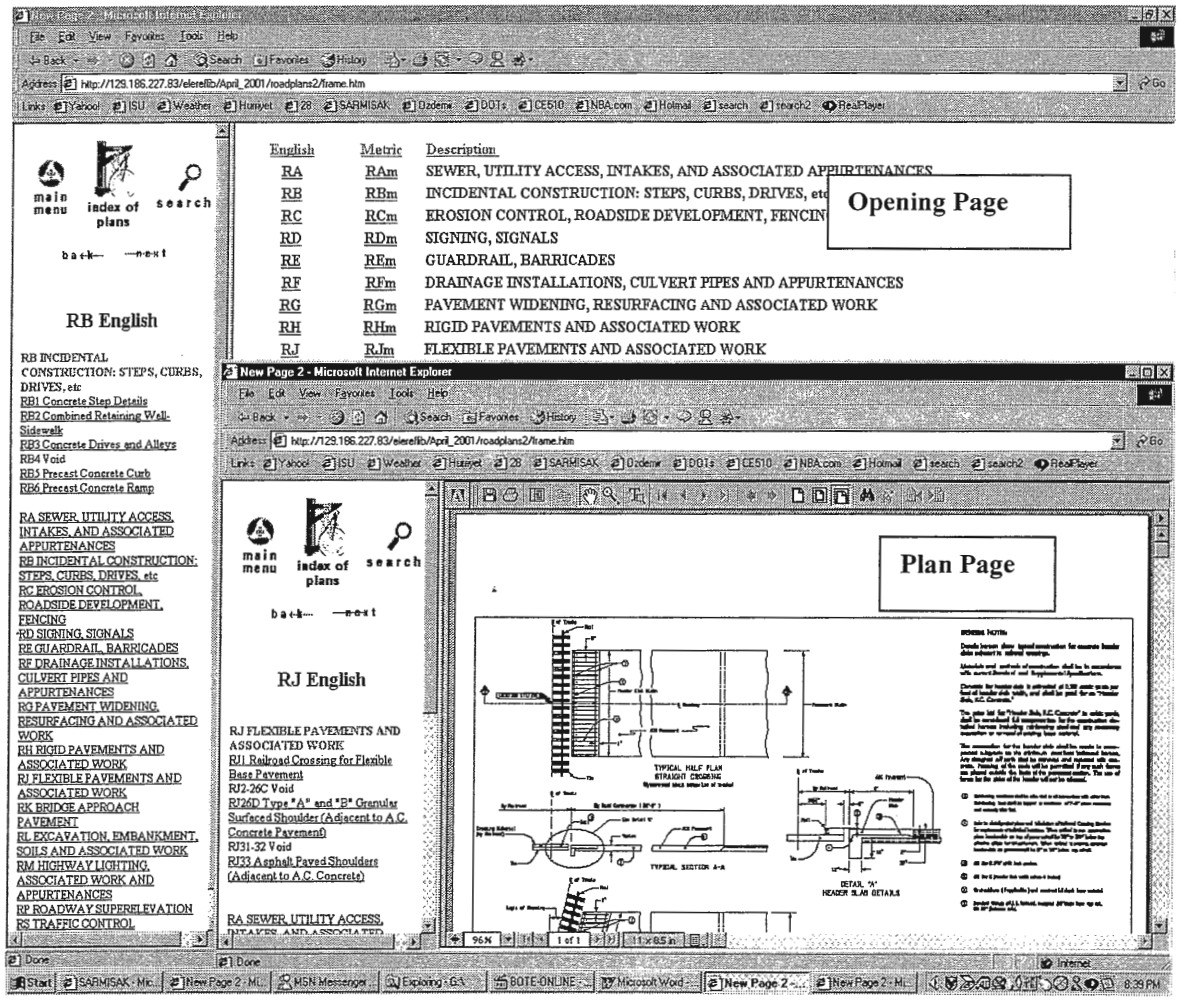

Figure 10. Layout of Standard Road Plans

As a result, the simplicity and consistency that are positive attributes of the ERL are sustained in the design of the Road Plans.

2. Construction Manual

Field personnel are expected to comply with construction standards for the typical work items that are included in this manual. They are covered in 12 chapters, which include safety, structure, grading, general survey, and others. The general format of these chapters is plain text and saved in a word processor document format. In addition, there are several

appendices linked to each specific chapter in the manual, most of which consist of forms and tables. Our first concern was deciding which file format should be used. Researchers agreed on converting chapters into HTML format and appendices into the PDF format. The reason for choosing HTML format for chapters is to facilitate use of a search engine. Additionally, HTML has other advantages, such as flexibility of design tools, familiarity of users, programmability (with CGI, Java, JavaScript), and extendibility (with plugging, add on media views).

PDF format was selected for appendices because they consist mostly of tables and forms rather than plain text (Figure 11). Converting tables and forms from the word

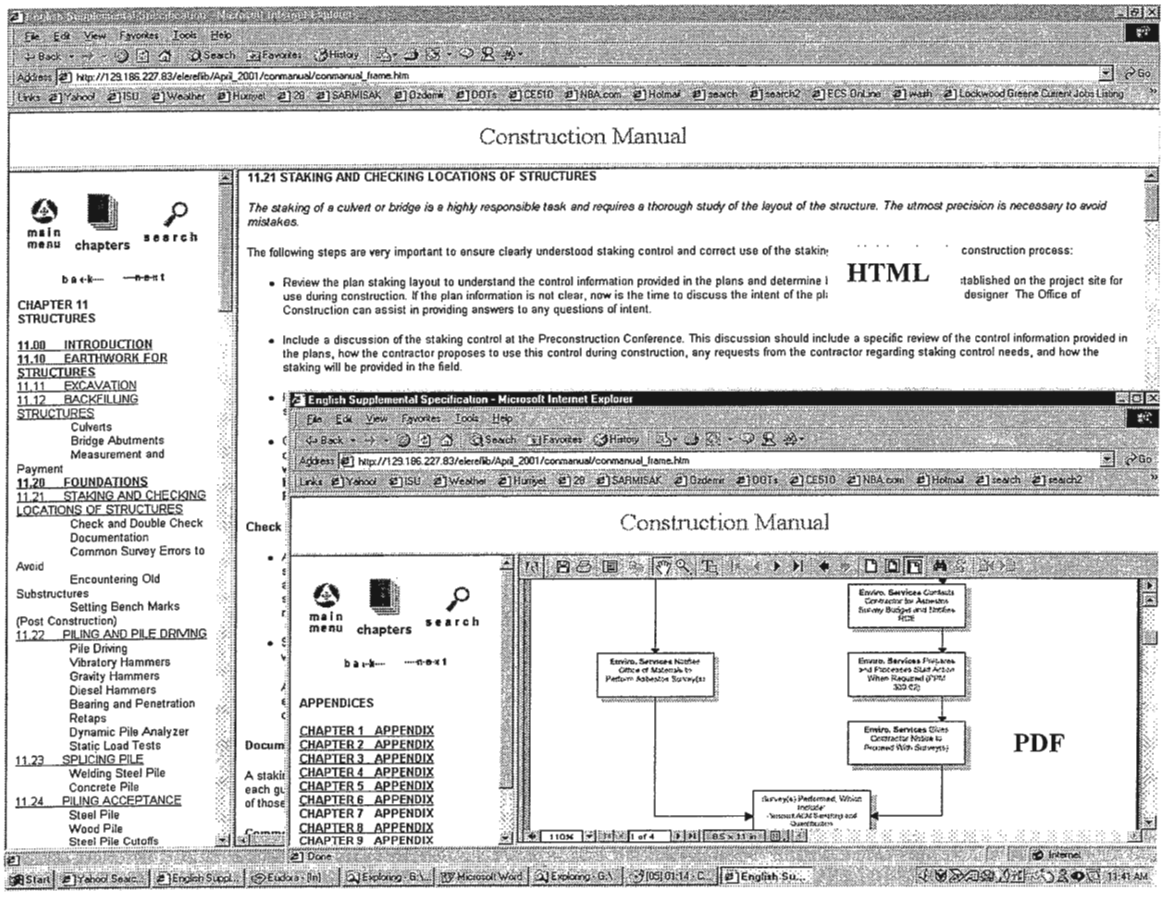

Figure 11. Layout of Construction Manual

processing format to the HTML format is labor intensive when compared to text conversions. Also, it is unlikely that the forms and tables would contain many references that would be found by search engines, and the search engines could still pick up the references to the appendices in the HTML text. It was decided that the benefits of HTML conversion did not outweigh the costs, so the decision was made to use the less labor-intensive PDF format.

The Construction Manual has not been included in the ERL at this writing. It has many cross-references and resources not yet available to have them hyperlinked. It is expected that a hyperlinked version of the construction manual will be included in the October 2001 edition of the ERL.

B. Review of Other State DOT ERL CDs

There are five other electronic reference libraries that have been reviewed in this thesis. They were obtained by exchanging CDs in order to provide information about our work and see if new improvements could be applicable to our ERL (Table 4).

Table 4. Review of Other ERL CDs

	Iowa	Illinois	Idaho	Pennsylvania	Indiana	Washington
File Format	HTML, PDF	PDF	PDF	PDF	PDF	PDF
Search Function	Yes	No	No	No	No	No
Navigation Control	Yes	No	Yes	Yes	Yes	Yes
Hyperlinks	Yes	No	Yes	Yes	No	No
Internet Access	Yes	Yes	No	No	No	Yes
Documents	Standard and Supp. Specs, Road Plans, Ins. Memo., Cons. Manual.	Environmental Manual, Bridge Manual and Plans, Cons. Manual	Design Manual, Standard Specs. Some Manuals and Tutorials	Standard Specs., Standard Provisions	Standard and Supp. Specs, Special Provision Standard Drawings Test Methods Unit Price Averages Pay Items List	Construction Manual, Standard Specs, Surveying Manual, Design Manual, Materials Manual

CHAPTER 6 - CONCLUSIONS

A construction project is a unique, complex, custom-built response to a client's needs. It involves the execution of a large number of diverse activities by many participants and evolves in both space and time, normally in a hostile and changing work environment. The growing complexity and magnitude of construction projects has resulted in an increase in the problems associated with manual document management and retrieval. Nowadays, several government and private agencies are making considerable progress in their ability to store and distribute contract documents electronically. Among these agencies, the Iowa DOT has also realized that use of personal computers, word processing software, and Web-based documentation technologies enhance the process of specification writing.

A primary task of the specification writer when using a computer-based specification system is to constantly upgrade and update the master specifications. The use of automated computer-based specifications makes continuous improvement of the quality of specifications a relatively easy task for the specification writer. This thesis described the best practice among transportation agency specification departments.

Also in this thesis, the improvement of automated computer-based specifications was discussed in more detail. The question that we asked ourselves during the study is how we could serve our users more efficiently and effectively by maintaining basic characteristics of ERL, which are simplicity and consistency.

The multi-party nature of the construction industry creates a challenging environment for successful project implementation. Project success relies heavily on the timely transfer of information among owners, project managers, general contractors, inspectors, and designers. This task is made difficult by the lack of technology-enhanced systems of data storage and

retrieval designed for project participants. Electronic Reference Library now provides a new paradigm on the concepts of technology-enhanced electronic documentation systems. A few suggestions for new developers are as follows:

- The advantage of using ERL should be introduced more effectively: Training activities, technical support, and advertisement opportunities should be further discussed.
- The increasing capacity of ERL: Since ERL has reached the maximum capacity that a CD-ROM can hold, reducing or compressing the size of some of the files should be reconsidered.
- Personal Digital Assistant: The growing popularity of PDA should be considered the new storage and retrieval device for the ERL in the near future.
- Frequently used construction forms and new documents should be added to ERL.
- The necessary time period for updating and checking the process should be brought to the table in order to avoid undesirable and costly results.

APPENDIX A. STATE DEVELOPMENT OF TRANSPORTATION'S ELECTRONIC REFERENCE LIBRARY REVIEW (as of April, 2001)

State DOT	Publications		Contents				File type	Organization
	WWW	CD	Specifications	Construction Documents (Manuals, Standard Drawings)	Phone Book	Other		
Alabama DOT	Yes		92/ 95 Construction Specification	Bride Standards Bridge Design Manual			*pdf	Categories
Alaska DOT	Yes		98/00 Specs. 99/00 Modifications	98/99/00 Construction Manuals(Highway, geotechnical, environmental, etc) , Drawings	Yes	Forms, Harbor Directory	*pdf *doc *zip	Categories
Arizona DOT	Yes		96m/00e Stored Specs.	Bridge Detail Drawings Roadway Drawings		Bid forms	*pdf *zip	Icons
Arkansas DOT	Yes		96 Std and Supplemental Spec.		Phone search	Bid Tabulations	*doc	Categories
California DOT	Yes		95/99 Std. Specifications	Bridge Standards Standard plans		Earthquake Design Support	ftp, *pdf *dxf, *dgn	Site index
Colorado DOT	Yes		99 Std. Specifications	Bridge Design Manuals; standard drawings Road plans, Pavement Manuals, Traffic Plans		Safety Guide Standard Structural Worksheets	*dwg *doc *xls *pdf, winzip files	Icons
Connecticut DOT	Yes EL		Std. and Supple. Specifications	Bridge & Highway standards and drawings	Yes	Bid Items Estimating documents	Zip files, *pdf *doc	Categories Navigation control
Delaware DOT	Yes			Utilities Design Manual	Some	Cost estimating forms, Bid Forms	*xls *html	Categories
Florida DOT	Yes EL		00/01 Specs and Std.	Road design; 97/98/00 std. drawings, structural guidelines, manuals and standards.	yes	Feedback collection	*pdf, *dgn *wpd	Categories
Georgia DOT	Yes			Electronic Bidding System	Yes		Self-extracting	Categories
Hawaii DOT	No							Categories
Idaho DOT	Yes	Ye	Specification w/	Unavailable so far	Yes			Table of

		s	Supplement					contents
Illinois DOT	Yes	Yes	Supplemental Specifications	Highway standards	Yes	Pre-qualification forms	Self-extracting, *doc *pdf *dgn	Categories
Indiana DOT	Yes		95/99 Std. Specification w/ Supplement	Standard drawings			*pdf *dwg *doc	categories
Iowa DOT	Yes	Yes	Specifications	Design manual; road design detail drawings, road plan	Yes		*pdf *doc *html	Site map
Kansas DOT	Yes		Specification w/ Supplement	Highway Plans		Miscellaneous publications	*pdf	Categories
Kentucky DOT	Yes			Standard drawings		Sampling manual	*dgn	Site index
Louisiana DOT	Yes			Bridge Design, standard plans		Material sampling manual	*html	List
Maine DOT	Yes EL		Specifications		Yes	Environmental assessment	*pdf	Site index
Maryland DOT	No		Supplemental	Construction Manual				Categories
Massachusetts DOT	Yes		Supplemental	Bridge manual drawings			Zip files	Categories
Michigan DOT	Yes EL		Std. Specifications w/ supplements	Road/bridge standard plans; road/bridge design manual			Zip files *pdf	Categories
Minnesota DOT	Yes		95 Standard. Specifications	Standard drawings		Technical Memo.	*pdf	Categories
Mississippi DOT	No				Yes			Site map
Missouri DOT	Yes		99/00/01 Standard Specifications	Construction manual, highway standard plans, bridge design, plans	Yes		*exe *pdf *dgn	Site map
Montana DOT	Yes		95 Specifications w/ supplemental			Bid forms	*pdf	Table of contents
Nebraska DOT	Yes		Highway Std. Specifications	Construction manual; design files	Yes		*pdf *exe	List
New Hampshire DOT	No							Categories
Nevada DOT	Yes		Have unavailable publications division	Standard Plans			*dgn	Categories
New Jersey DOT	Yes		96 Std. Specs. w/ 98 supplemental specs.	Design manual, roadway and bridge	Yes		*pdf zip files	Site map
New Mexico DOT	No				Yes			Categories

New York DOT	Yes		95 Standard w special	Design Manuals, standards		Design procedure manual	*pdf	Categories
North Carolina DOT	Yes		Std. Specs. for roads and structures	Design manual, standard structure drawings	Yes		*pdf *doc html	Outline
North Dakota DOT	Yes		Specifications and Supplemental specs.	CADD Standards	Yes		*pdf	Categories
Ohio DOT	Yes		Specifications and Supplemental specs.	Standard construction drawings, design manual	Yes		Micro-Station files	Table of contents
Oklahoma DOT	Yes		Traffic design standards	Construction manual, road/bridge design standards	Yes		*dgn *dwg	Table of contents
Oregon DOT	Yes		96 Std. Specs w/ Supplements	Standard drawings		Special Provisions	*pdf	Outline
Pennsylvania DOT	Yes	Yes	94/96/00 Std. Specs w/ supplements			CADD Files	*html *pdf	Categories
Rhode Island DOT	Yes		97 Std. Specs. Update Std. Specifications	Highway design manual information			*html *pdf	Categories
South Carolina DOT	Yes		Supplemental Specifications	Standard drawings for road construction	Yes		*pdf	Categories
South Dakota DOT	Yes		Supplemental Specifications	Road design manual, concrete pavement manual			*pdf *doc	Site index
Tennessee DOT	Yes		95 Standard Specifications w/ Supplemental			Various Forms	*pdf	List
Texas DOT	Yes		93/95/00 Std. Specifications	Standard plans for bridges/roads		Special provisions	*wp *pdf	Categories
Utah DOT	Yes		94/99/01 Std. Spec w/ Supplemental Specifications	Standard drawings, design manual, construction manual		Bid list document	*html *dwg *wp *pdf	Categories
Vermont DOT	Yes			AUTOCAD drawings			*dgn *cgm	Categories
Virginia DOT	No							Categories
Washington DOT	Yes	Yes	CD library, Std. Specifications	Construction manual, design manual, standard plans			*pdf	Site index
West Virginia DOT	Yes		2000 Std. Specifications	Standard details		Traffic-related publications (unavailable)	*pdf *html	Site map

Wisconsin DOT	Yes			Standard Road design, standard details	Yes		*dgn *exe zip files	Site index
Wyoming DOT	No			Bidding Document				Categories

APPENDIX B. ELECTRONIC REFERENCE LIBRARY USERS SURVEY FORM

What type of computer do you use?

☐ Dekstop

☐ Laptop

How do you access the electronic the Electronic Reference Library (ERL)?

☐ CD

☐ Internet

Which internet browser do you use?

☐ Netscape Navigator, version _____

☐ Internet Explorer ,version _____

How frequently do you use the documents in the ERL listed below?							
	Never						Very Frequently
Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Specifications (Metric)	O	O	O	O	O	O	O
Specifications (English)	O	O	O	O	O	O	O
Instructional Mem. IM	O	O	O	O	O	O	O
Road Plans (metric)	O	O	O	O	O	O	O
Road Plans (English)	O	O	O	O	O	O	O
Construction Manual	O	O	O	O	O	O	O
DOT Phonebook	O	O	O	O	O	O	O

Level of satisfaction with the ERL?					
	Unsatisfied				Satisfied
Items	**1**	**2**	**3**	**4**	**5**
User Instructions	O	O	O	O	O
Starting the CD	O	O	O	O	O
Opening Page	O	O	O	O	O
Reading Text	O	O	O	O	O
Reading Navigator Bars	O	O	O	O	O
Reading Plans	O	O	O	O	O
Quick Jump Function	O	O	O	O	O
Search Function	O	O	O	O	O

What documents do you want to be included in the next edition of ERL?

- ☐ Bridge Plans
- ☐ Road Design Details
- ☐ Bid Item Descriptions
- ☐ More Phonebook
- ☐ City and County Maps

Other (please specify): _____

How could the ERL be improved? please specify

_____

What do you like the most about ERL? please specify

_____

Name*	:	
Company/Organization*	:	
Address	:	
Email	:	
Phone	:	
Fax	:	

* Required

Years of your professional experience?

- O Less than 1 year
- O 1~5 years
- O 6~10 years
- O More than 10 years

Submit Reset

HOME

APPENDIX C. RESULTS OF ONLINE SURVEY

desired documents in next edition	how to improve ERL	like the most about ERL
	unsure	ease of moving about
Bridge & Culvert Standards		Able to use computer search
	havent used it yet	the fact this is available electronically
	I would like to see the Instructional I.M.'s be listed by their name & number.	How compact it is to take to the field on a CD.
	I'd use it more if it was faster	I don't need to store all that material in paper format
	Really just becoming familiar with it, no comments at this time.	Having so much information so readily available.
	EASIER to find on the D drive	Having it handy by being on the computer
	A program other than acrobatic reader used for the standards, using acrobatic reader makes the print time far slower than using other programs	
		Takes the place of all the books
	By Adding Bridge Plans	Easy to look up specf.
	latest version seems pretty complete	search function
	could be faster, and the computers we have are so very slow!	not sure just yet
		Easy access in the office on my computer
	This is my first time to view.	It seems to be quick.
	I didn't know about some of the things you said were on the cd. finding stuff is not very easy	Its a small cd to carry as apposed to all those large volumes of books.
	you could improve this form by enabling the name field to take spaces " " as a vaid charactor	
	[letting date] button on start page doesn't work - circular reference. Do even more cross referencing between various types of documents, for example hyperlink spec. references in the road standards to the specifications. Same with IMs. Search function	I like the compact size, the comprehensive reference aspect and cross-manual referencing. I also like the idea of it being compleatly updated every 6 months with new IMs, standards, Construction Manual, and GSs.
		Easy to use. Contains a lot of information
		The ease of navigating around.
	cross link documents sections, bookmarks and notes on HD copy, add a cross linked knowledge information system for tips and lessons	fast, date specific, logical, nice job! We have a portable training aid system called Lessons Learned Database for our construction field trailers that might interest you. Contact me if you if you would like a CD.

		IOWA is progressive to have an operational website.
		Have not used it.
Any information would be useful.	I have not used this much yet. But I can see where it is going to be very useful. Anything that can be done should help us out in the field.	Search Features.
NDOT recently formed a web team, which I head, and I want very much to include document management as part of our Intranet/Internet strategy. Would be interested in talking to your team about costs & development issues....		
		ease of access
	I have used this very little at this time, but plan on referencing it more in the future.	I like to have the information where I always know where it is. It can sometimes get misplaced around my office.
		Convenience
		That I now know it exists. Will use frequently in the future.
	?	Can carry all referances on a CD instead of 30lbs. of books.
	have a more diversified action page. Incorperate a link from the begining page to standard road plans and to specifications, rather than having to go through letting dates.	ability to contain the information in a small parcel, as well the ability to access various pages quickly and print out certain pieces of information that pertain only to certain jobs. Pretty flexible, and saves paper
		It's a compact library of the road spec's, easy to haul around with laptop.

dekstop	laptop	ERI_CD	internet	netscape	version	I.explorer	version	specs_met	specs_eng	IMs	r.plans_met	r.plans_eng	ConMan	phonebook	UserInstructions	starting_the_cd	opening_page	reading_text	readingnavigation	reading_plans	quick_jump	search_function	BridgePlans	read_design_Det	bid_item	more_phonebook	More maps	Organization
y			y			y	5.5	1	1	1	1	1	1	1	4		5	4	4	4	4	4	y	y	y	y	y	Other DOT
y			y			y	2001	2	4	4	2	6	4	5	4	3	4	4	4	4	5	4	y	y	y		y	
y		y				y	3.0	7	7	6	6	6	6	4	3	3	3	3	3	3	3	3	y	y			y	IDOT
y	y		y	y				1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	y	y	y			Contractors & Designers
y		y		y	6	y	3	4	6	6	3	6	1	4	3	2	1	3	4	3	1	4	y	y			y	IDOT
	y	y		y				1	1	4	1	2	4	2	1	4	3	4	3	2	2	4						IDOT
	y	y		y				2	2	1	1	1	3	2	3	4	4	4	4			3		y	y		y	IDOT
	y	y	y	y				1	1	5	1	2	2	1	4	4	4	4	4	4	4	4	y	y				IDOT
	y	y						2	2	2	2	2	2	2	3	1	3	4	4	2	3	2		y	y			IDOT
	y		y	y				5	5	5	5	5	6	7	4	4	5	3	4	4	3	4				y		
y			y			y	5.0	1	2	1	1	1	2	1	4	3	4	5	5			5		y				Contractors & Designers
y			y	y				1	4	4	2	4	4	4	3		3	3	3	3	3	3	y	y	y	y	y	IDOT
	y	y	y	y				2	5	3	2	4	4	3	3	3	4	3	3	3	4	4	y	y	y			IDOT
y			y	y				3	3	2	2	2	2	3	3	3	3	3	3	3	3	4		y			y	IDOT
y			y	y				7	7	3	3	3	3	1	3	3	3	3		3	3	3						
y		y		y				4	2	4	4	2	4	2	3	3	3	3	3	3	4	4	y	y				IDOT
	y	y				y		4	4	4	3	3	4	4	4	3	3	3	3	3	3	4	y	y	y	y	y	IDOT
	y	y				y	5.0	6	7	7	6	7	7	4	4	4	4	4	4	4	4	4	y	y			y	IDOT
y		y	y			y		5	5	5	5	5	6	6	4	4	4	5	4	5	4	4	y			y	y	IDOT
y			y			y	5.5	1	1	1	1	1	1	7	5		5	5	5	5	5	5						Other DOT
	y		y	y				4	4	3	3	3	4	4	3	3	3	3		3	2	5	y	y			y	IDOT
y		y				y	5	5	5	4	5	5	5	2	3	5	5	4	4	3	5	4						IDOT
y			y	y	4.73			2	2	2	2	2	2	2	3	3	3	3	3	3	3	3						
y	y	y	y			y		7	7	7	7	7	7	4	4	4	4	4	4	4	4	4		y	y		y	IDOT

y		y		y				3	3	3	3	3	3	1	4	4	4	4	4	3	4	4	y	y	y		y	IDOT
y			y					1	1		1	1	1	1	3	3	3	3		3	3	3						Other DOT
	y	y		y											1	3	2	3	2									
y			y			y	5.0	1	1	1	1	1	1	1	4	4	4	4	4	4	4	5						Other DOT
y		y				y	5																					Other DOT
y			y			y	5.0																					Contractors & Designers
y			y			y	5	2		2	2		1		5		5	5	5	5				y	y		y	Other DOT
y			y			y	5	1	1	1	1	1	1	1	3	2	4	2	3	4	2	3						Other DOT
y			y			y	5.0								5	5	5	5	5	5	5	5						Other DOT
y			y			y		1	2	2	1	2	3	1	3	3	3	3	3	3	3	3	y	y	y		y	Other DOT
y	y		y			y	5	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5					y	Other DOT
y			y			y	5.5 0	1	3	1	1	3	3	3														Other DOT
y			y			y			4	4	5		1	1	4			4	4				y	y				Other DOT
	y		y			y		1	1	1	1	1	1	1														Contractors & Designers
y			y	y	6.0	y	5.0	1	1	1	1	1	1	1													y	Other DOT
	y	y		y				3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	y	y	y	y	y	IDOT
y	y		y	y	4.7			1	2	2	1	3	3	1	3	3	3	3	3	3	3	4	y	y	y	y	y	Contractors & Designers
y		y		y				2	2	2	3	3	2	4	2	3	4	3	3	2	4	4			y		y	IDOT
y		y	y	y	4.6 .1																							Other DOT
y	y			y	var iou s	y	lat est																y	y	y	y	y	Other DOT
y			y	y				2	2	1	1	1	1	1	3		3	3	3									Other DOT
y			y			y																						Contractors & Designers
y		y	y	y				2	5	2	7	7	3	1	4	3	4	4	4	4	4	4		y	y			Contractors & Designers
y			y			y		3	5	5	3	4	6	4	4	3	3	4	3	4	3	4			y		y	Contractors & Designers
y			y			y	5.0	5	5	4	3	5	5	4	3		4	4	4	2	2	3	y					Contractors & Designers
y			y			y	4.0	4	4	1	4	4	2	2	4	4	4	4	4	3	4	4						Contractors & Designers
y			y			y	ex cit e	1	3	2	1	3	2	3	2	2	2	3	2	2	2	4		y	y	y	y	Contractors & Designers
y	y		y			y		3	4	5	3	3	3	4	3	3	4	3	3	3	3	4	y	y	y	y	y	Contractors & Designers

	y	y				y			2					2	4	4	4	4	4	4	4	4					y	Contractors & Designers
y			y			y	5.5	4	4	4	7	7	7	6	4	3	3	4	4	4	2	3	y	y			y	Contractors & Designers
y			y			y		1	1	1	1	1	1	1														Contractors & Designers
y	y	y				y	5.0	3	3	1	3	4	1	2	3	3	2	3	3	2	2	4		y	y		y	Contractors & Designers
y	y	y	y			y	5	5	5	4	6	6	3	6	4	4	4	2	4	4	4	4			y	y	y	Contractors & Designers
y	y	y	y			y	5	4	4	4	4	4	2	2	3	4	3	4	4	4	3	3		y	y		y	Contractors & Designers

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