

Development and Maintenance of the Electronic Reference Library

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ABSTRACT

This paper presents a case study of the Electronic Reference Library (ERL) that is produced biannually by the Iowa Department of Transportation. This project began with the goal of producing a CD that contains all of the information necessary for designers, inspectors, and contractors working on transportation projects. This paper details the progression of the ERL from concept to its current production status. Other issues discussed are the benefits of electronic documents, a development strategy based on lessons learned, and the challenge of maintaining a large, cross-referenced, electronic library.

Key words: electronic documents—specifications

INTRODUCTION

Successful construction projects depend on good communication, and for construction projects, drawings and specifications are critical for communicating the design intent. At the Iowa Department of Transportation (Iowa DOT), these documents include the Standard Specifications for Highway and Bridge Construction that contain non-project specific information, Construction Manual for field administration and inspection, Instructional Memoranda (IMs), Standard Road Plans, and the Standard Bridge Plans. These documents are updated twice a year through the General Supplemental Specifications for Highway and Bridge Construction, the Supplemental Specifications, and through updated and additional IMs. The Electronic Reference Library (1) began as a method to take these and other documents and make construction specifications better.

One of the characteristics of the ERL is that it has a well defined target user group consisting of engineers, inspectors and contractors. Understanding users' needs and establishing design requirements for the ERL was the first step in this project. Two focus group meetings and a number of interviews with potential users were conducted from August 1998 to January 1999 (2, 3). The results of these focus groups are listed in Tables 1 and 2. Table 1 lists the desired contents for the ERL, and Table 2 lists the desired attributes of the ERL.

DEVELOPMENT PLAN

The following documents were selected because they are frequently updated and commonly used for construction projects. These documents include:

- Standard specifications
- General Supplemental Specifications
- Materials Instructional Memoranda (IMs)
- Standard Road Plans
- Standard Bridge Plans
- Road Design Aids Manual
- Bridge Design Manual
- Construction Manual

Table 3 lists desired ERL contents that are not included in the current version of the ERL. These suggestions should be considered for future versions.

TABLE 1. Desired Contents of the ERL

Standard Specifications	General Supplemental Specifications
Design Manuals	Road Standards
Materials Instruction Memoranda	Construction Manual
Telephone books	Letting dates
Iowa DOT programs	Trade association manuals
Job site posting requirements and posters	Davis Bacon wage rates
List of who is under contract for which jobs	County IM's
Bid item list	Average unit prices
CFR sections that apply	Iowa Code section that apply
Forms (fill out and send electronically)	Standard proposal notes
Urban Standard Specifications for Public Improvements	ASTM, AASHTO, MUTCD manuals
	-- subject to copyright restrictions
DBE information as of issuance date	Equipments rental rates
Links to internet sites	-- subject to copyright restrictions

TABLE 2. Desired Attributes of the ERL

User-friendly	Good search engine
Easy to read	Printable
Hyperlinks between documents	Able to open multiple windows
Able to fill in and send form	Able to ensure authenticity
Will retrieve correct documents when letting date is input	Provide technical support
Electronic documents similar to paper documents	Make connections between ERL and SiteManager®

Three types of navigation structures were considered, hierarchical, non-linear, and mixed (4, 5, 6). In a strict Hierarchical text, nodes are linked to form a strict hierarchy, in which a node can only access those nodes directly above and below it. In non-linear text, nodes are connected to form a complex network based on a large number of referential links. Mixed text has a basic hierarchical structure with a number of referential links that allow users to jump across the branches of the hierarchy.

The mixed text approach is considered more suitable because of the organization and cross-references in the documents and is actually applied in the ERL.

TABLE 3. Suggested Content for Future Versions of the ERL

Telephone books: Iowa DOT Local jurisdiction officials Contractors Consultants	Links to other internet sites (users could link to the site directly to the CD if on-line) Requirements for job site posters and electronic version of posters that could be printed by user
Davis Bacon wage rates	Computer programs developed by Iowa DOT for use by contractors, consultants, and Iowa DOT employees
Historical units prices	Bid letting dates
Design aids published by trade associations	Iowa DOT web site
Standard proposal notes	Applicable CFR and Iowa Code sections

Hypertext links can be classified as two basic types: navigational and associative links (7). Navigational links connect main content with other sub-content and function as path-finding tools. They serve as backbone of a user interface. Associative links offer parenthetical material, footnotes, digressions, or parallel themes that the author believes will enrich the main content (8, 9).

To avoid or minimize disorientation of the users and other adverse side-effects of using hyperlinks, two approaches of making associative links are discussed:

- Open the referred content in a new browser window
- Use frames

Table 4 presents the status of use of electronic documents in other states. The table shows the states that provide electronic versions of their specifications. The WWW column marks the states that provide the documents through the web, the CD column marks the states that provide the documents on CD, File Format lists the electronic format that is used, Search Engine is marked if they provide the ability to do keyword searching, Internal Hyperlinks is marked if the document contains hyperlinks within the document (i.e. links within the Standard Specification), and External Hyperlinks is marked if links are provided between documents (i.e. links from the Standard Specifications to the Construction Manual).

TABLE 4. Comparison of ERL with other DOTs

State	WWW	CD	File Format	Search Engine	Internal Hyperlinks	External Hyperlinks
AL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
AK	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
AZ	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
AR	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CO	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CT	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	HTML	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
FL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GA	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HI	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ID	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PDF	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
IL	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PDF	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
IN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
IA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	HTML	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
KS	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
KY	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
LA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ME	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MD	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MI	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MN	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MS	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MO	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MT	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NV	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NH	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NJ	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NM	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NY	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NC	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ND	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
OH	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
OK	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
OR	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PDF	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
RI	<input checked="" type="checkbox"/>	<input type="checkbox"/>	HTML	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

State	WWW	CD	File Format	Search Engine	Internal Hyperlinks	External Hyperlinks
SC	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
SD	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TN	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TX	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
UT	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
VT	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
VA	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
WA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PDF	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
WV	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PDF	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
WI	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
WY	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

IMPLEMENTATION PLAN

Implementation of the ERL was divided into four stages: alpha version, beta version, pilot version, and the first mass published version. A hypertext application development process was adopted as a guideline for implementation of the ERL. Major tasks at this stage included:

1. Selection of document format. Two file formats are used in the ERL: Hypertext Markup Language (HTML) or Portable Document Format (PDF). Documents are converted into HTML files whenever possible. If the documents have complex forms, then they are converted to PDF format, which saves time and reduces translation errors.
2. Preparation of electronic document files. The contract documents were compiled in Microsoft Word, WordPerfect, and Bentley Microstation. Converting these documents to HTML or PDF format and inserting hyperlinks constituted a significant portion of the development work.
3. Implementation of the desired attributes. When designing the user interface for the ERL, the research team worked to achieve usability, consistency, portability, and flexibility.
4. Management of the development team. The project team includes the developers of the original documents plus the ERL team. All teams are working to produce updated specifications twice a year. Task assignment, specialization, communication, and coordination issues were critical to the performance of the project.

Using the information gained from focus meetings, the design team developed an alpha version of the ERL. For the alpha test, the ERL did not need to implement all desired features. The team decided that it would be better to quickly issue an early copy to test the design concept. Ten copies of the alpha version were distributed to experienced computer users who also were familiar with the hard copy of the specifications. This version yielded the following suggestions:

- Navigation must be quick and efficient
- A good search engine is mandatory

Experienced specification users memorize common specification section numbers, because knowing these numbers provides for quick navigation through the printed specification book. Much as a person reading the local newspaper knows where the weather forecast is printed, and experienced specification users know where to find concrete mix designs without checking the table of contents. The design team responded to this issue by creating a feature called quickjump. Quickjump allows the user to enter a specification number at any time, and the ERL responds by quickly displaying that section. If the section number is not known, then the user can navigate through the ERL using the table of contents, or can use the search function.

One overwhelming comment from all surveys is that a good search engine is critical to the success of the ERL. If the user does not know the location of the desired material in the specification book, then it is often quicker to search for the desired terms than it is to locate the material using the table of contents. The search function also helps when the user remembers some keywords from a section they wish to locate, but does not remember the specification number.

MAINTENANCE

Update and maintenance of ERL is a continuous effort. Every six months, a new revision of ERL, which contains new documents or changes to existing construction documents, will be released by Iowa DOT. Constrained by the limited resources, the process of updating and maintaining the ERL is always a challenge to the project team. After carefully reviewing the ERL development and maintenance process and available technologies, the following improvements were proposed and implemented (10). These included:

- Automating the document conversion process;
- Documenting the ERL update and maintenance process;
- Understanding users' changing needs.

Automating the HTML File Preparation and Modification Process

HTML File Development Process. For a normal document like the Construction Manual or Standard Specifications, a person requires about 10 - 15 working days to finish the task of inserting hyperlinks for all cross references in the documents. If the updater is involved in other works, the job could take more than a month to finish. Also, because reading page after page of specifications for weeks at a time can be tedious work, conversion errors are inevitable.

Typical errors found in the past include:

- Unlinked cross references;
- Broken links;
- Links refer to a wrong document.

Thus, another one or two weeks is required to fix errors in these files.

Fortunately, the documents used for this project are methodically arranged, and cross references can be easily recognized by a computer. Two convenient scripting utilities were identified and introduced into ERL development and maintenance for their capability of manipulating contents of text and binary files using common scripting languages (11, 12). Due to the large size of construction documents and the time required to manually classify these documents, there is an interest in automatically processing these documents (13).

Documenting the Development and Maintenance Procedure

One of the issues that come along with the long time span of the ERL life cycle is capturing the knowledge of the developers and writing a procedure manual. Although most skills needed for ERL maintenance and update are not very complicated, they are not typical skills for those unfamiliar with website development. Each time a new member joins the team, it takes about half a year for these new members to master the skills and get acquainted with the update procedure due to the large size of the specifications, and they are very likely to make mistakes on their first update task. To reduce the time of learning and cost of errors, an instruction manual was compiled to assist successive updaters.

Before the instruction manual was compiled, the only documentation that recorded ERL development and maintenance procedures were the theses written by earlier graduate students. While these theses can provide helpful information for later project members, they cannot take the place of a good instruction manual. Unlike a thesis, which normally focuses on the particular tasks of a graduate student, an instruction manual should document all procedures involved in the development and maintenance process completely and in sufficient detail to allow new employees to learn quickly. Moreover, an instruction manual focuses on how a certain task is accomplished without regard to why this solution is selected.

Once a solution is written in an instruction manual, it becomes the standard solution to be followed by later maintainers. Thus, the solution must be carefully tested and must be proven effective and efficient before being included in the ERL update process.

The instruction manual records the best practices of ERL development and maintenance available to the compilers. As time goes by, new tools and methods may be found by successive updaters. Thus revision to the instruction manual will be an ongoing effort as long as new versions of ERL are to be published.

CONCLUSIONS

The ERL project at Iowa DOT and Iowa State University aims to develop and maintain a hypertext electronic publication that contains Iowa DOT standard contract documents. Currently, a new ERL is released every six months, and comments have been good. Key factors responsible for the success of the ERL project include:

- Conducting focus group sessions
- Developing the rapid prototype
- Minimizing the ongoing task of maintenance
- Development of a good procedure manual

While the ERL brings convenience and efficiency to the target users, implementation and maintenance of the ERL had been a challenging experience for the project members. Based on reviews and the experience from implementing and maintaining the ERL, a few tools and methods were created to address the various challenges faced by the ERL project team including automatic hyperlink creation for cross references and improved PDF file link verification.

Preparation (formatting, adding bookmarks and hyperlinks) of HTML files and checking errors in the PDF files are two of the most time consuming works in the ERL maintenance. To improve the work efficiency, scripts are used to automate the preparation and error checking. Documentation of the working procedures was used in the ERL project to share the knowledge. The methods proposed in this report have been used in the ERL project. These methods have been found to significantly help in improving work efficiency and quality.

The ERL project will continue for the foreseeable future. Because of the changes in users' needs, available tools, etc, searching for improvements in the ERL and its development methods will be a continuous work. Possibilities for future improvements include:

- Continue the effort of including more documents and links in the ERL to meet users' needs.
- Collect feedbacks from users.
- Search for the necessity and possibility of using new forms of storage and distribution method.
- Develop the ERL for handheld devices.
- Incorporate video and audio files to illustrate testing methods, and other concepts in the ERL.

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REFERENCES

1. *Electronic Reference Library*, <http://erl.cce.iastate.edu/erl/>. Accessed Jul. 1, 2002.
2. Li, C. Developing a Hypertext-Based Electronic Reference Library for a Public Transportation Agency. Thesis for M.S. degree, Iowa State University, 2000.
3. Cetin, O. Improvements in the Hypertext-based Electronic Reference Library for a Public Transportation Agency. Thesis for M.S. degree, Iowa State University, 2001.
4. Yabuki, N., and K. Law, HyperDocument Model for Design Standards Documentation. *Journal of Computing in Civil Engineering*, Vol. 7, No. 2, April 1993, pp. 218-237.
5. Mohageg, M.F. The Influence of Hypertext Linking Structures on Efficiency of Information Retrieval. *Human Factors*. Vol. 34, No. 5, 1992, pp. 351-367.
6. Kellogg, W. A., and J. T. Richards, The Human Factors of Information on the Internet. *Advances in Human-Computer Interface*. J. Nielsen (ed.), Vol. 5, Ablex, 1995.
7. Kim, H. and S. C. Hirtle, Spatial Metaphors and Disorientation in Hypertext Browsing. *Behavior and Information Technology*. Vol. 14, 1995, pp. 239-250.
8. Komer, P., A. Ferreira, and A. Kwak, *Document Management for Hypermedia*. Springer, Berlin, 1998.
9. McDonald, S. and R. J. Stevenson, Effects of Text Structure and Prior Knowledge of the Learner on Navigation in Hypertext. *Human Factors*. Vol. 40, 1998, pp. 18-27.
10. Li, L. Maintenance of a hypertext-based electronic reference library for a public transportation agency. Thesis for M.S. degree, Iowa State University, 2002.
11. Caldas, C., L. Soibelman, and J Han, Automated Classification of Construction Project Documents. *Journal of Computing in Civil Engineering*, Vol. 16, No. 4, 2002, pp. 234-243.
12. Robbins, A., and M. Brennan, *Effective awk Programming*. O'Reilly & Associates, New York, 2001.
13. Wall, L., T. Christiansen, J. Orwant, *Programming Perl*, O'Reilly & Associates, New York, 2000.