Final Report

The Development of Improved Information Management Processes for FDOT Dispute Review Board System

FDOT Contract No.: BDK80 977-01

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16. Abstract

Often disputes may arise between owners and contractors during the execution of a construction project. Construction disputes typically cause monetary and time losses. Disagreements often result in litigation that is both time-consuming and expensive. A dispute review board (DRB) provides a valuable and proven alternative method of dispute resolution. Currently, the Florida Department of Transportation (FDOT) stores DRB reports in portable document format (PDF) with limited search capability. Improving information retrieval of DRB documents and providing a certain level of integration of DRB reports with relevant but heterogeneous data and documents are key to enhancing the current FDOT DRB system. Therefore, an improved DRB information management system is desirable to satisfy the needs of FDOT engineers.

The objective of this study is to develop a software system and set a foundation for future improvements of DRB report management. Improvements to the existing Web-based DRB report listing include using data and metadata models that share lessons learned, implementing advanced text-based search mechanisms, and integrating DRB reports with member data and other relevant documents. The objective of this study is achieved by implementing a system that uses Oracle-based Web technologies and provides key features including metadata generation, an integrated review process, a simple issue description, member information management, and versatile information retrieval.

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EXECUTIVE SUMMARY

Background

Often disputes may arise between owners and contractors during the execution of a construction project. Construction disputes typically cause monetary and time losses. Disagreements often result in litigation that is both time-consuming and expensive. A Dispute Review Board (DRB) provides a valuable and proven alternative method of dispute resolution.

The Florida Department of Transportation (FDOT) began using DRBs in 1994. The current website has limited functions to classify and display DRB reports. Due to the lack of elaborative information, the DRB reports are not effectively used to guide construction engineers in resolving similar problems in other projects. An analysis of FDOT DRB reports listed on the FDOT website reveals major needs for having an improved system. These needs can be summarized as 1) a better representation of the structure of DRB reports, 2) links to external documents, 3) enhanced accessibility to associated data to support better decision-making.

Currently, DRB reports are stored in portable document format (PDF) with limited search capability. Those DRB reports are different in content, structure and description methods. For example, weather-related delay dispute cases can be expressed in the contractor's position paragraph of DRB reports using various descriptions and different attack points.

Meanwhile lengthy DRB documents often make information retrieval extremely difficult and time consuming. However, even though details are different from case to case, most dispute reports bear some resemblance in their document structures. For example, some types of data or sections always appear in most of the DRB reports. If such structures are captured and modeled (e.g., developing data and metadata models), an implementation using these models can potentially improve information retrieval and review of DRB reports.

The root cause of the problem is the data format of existing DRB reports. The reports are accessible as PDF documents in a format that is called unstructured data because it is not designed for computerized applications such as linking to different "sections" of standard specifications that are also in the PDF format. In addition, searching unstructured data for relevant information is more troublesome than searches that are based on structured data such as databases. Improving information retrieval of DRB documents and providing a certain level of integration of DRB reports with relevant but heterogeneous data and documents are key to enhancing the current FDOT DRB system.

Therefore, an improved DRB information management system is desirable to satisfy the needs of FDOT engineers.

Objectives

The objective of this study is to develop a software system and set a foundation for future improvements of DRB report management. Improvements to the existing Web-based

DRB report listing include using data and metadata models that share lessons learned, implementing advanced text-based search mechanisms, and integrating DRB reports with member data and other relevant documents.

Significance

This study is significant because 1) the existing Web-based system is inefficient, 2) the existing Web-based system is not effective, and 3) the proliferation of DRB cases online will further decrease the efficiency and effectiveness of the existing system.

First, the existing system is primarily a replicate of the paper-based DRB reports. These reports have limited classification capability, e.g., by district, subject and results. The system was designed for people to manually store, classify, search, and organize the DRB reports. Consequently, using the system is very time-consuming and it is error prone. Due to the fact that most of the reports are created and stored as PDF files, searching and grouping related DRB reports for further analysis is very difficult. As a result, users have trouble finding helpful information related to handling disputes or claims. As the number of FDOT construction projects using DRBs increases, the number of DRB reports will also increase. Due to the hundreds of reports that are stored online, finding specific DRB cases that address a similar issue is a difficult task.

The new system not only allows DRB members and FDOT construction engineers to store and retrieve DRB reports, but also provides more functionality to process those reports. New functionalities include a structured search based on the metadata of DRB reports, an unstructured search using advanced computer technology, and the integration of DRB reports with other related information for analysis. This type of functionality can improve the efficiency and effectiveness of the DRB system.

Benefits

The benefits of having such an improved system are reflected by the following key features:

- Simple data input yet useful results: with limited data input to capture information about a DRB report, the system provides FDOT engineers with capabilities to effectively and efficiently retrieve important information, review DRB cases, select DRB members with appropriate experience and expertise, and learn from lessons learned.
- Integrated review processes: the system provides a capability to identify external documents that are associated with a DRB report. This makes DRB review processes, which typically use cited materials, much easier, compared to manually searching through specification sections or the construction project administration manual (CPAM) for specific information.
- Simple issue description: Having a consistent description of issues can help sort DRB reports in useful ways to support future decision-making. With the metadata of issues, this system provides a way to describe unstructured content and allow a user to directly search for a specific type of issue or sort issues according to their metadata. This is a very powerful feature, which can significantly improve handling DRB reports.

- DRB member information management: DRB members play a significant role in handling disputes. Selecting appropriate members to a review board is very important. The system provides a mechanism to manage DRB member information in the context of dispute review activities. Such information can assist FDOT in many decision-making processes.
- Versatile data analysis: the system provides two methods for data analysis. A user can use text search by entering keywords as search criteria to retrieve desired DRB documents. Or, the user can use a structured search by selecting one or several types of DRB data, such as FIN number, district, and member involved, to retrieve DRB reports. The versatility provides FDOT engineers many different ways to examine DRB reports.

Conclusions and Future Studies

The objective of this study is achieved by implementing a system that uses Oracle-based Web technologies and provides key features including simple data input for results, an integrated review process, a simple issue description, member information management, and versatile information retrieval.

The system can help FDOT engineers query DRB reports and perform analysis based on metadata stored in the system. The development of this system is motivated by the fact that there is no information system that assists FDOT to process a large amount of dispute data. Without an improved system, the processing task can be time consuming and costly because engineers must manually manage and search DRB reports.

Even though the new system can improve the existing process of handling DRB reports, the system can be further enhanced in numerous areas. Currently, DRB data such as FIN number, contract number, and creation date are manually entered. This process may be completed automatically with text mining techniques. An automatic process can save FDOT engineer time. However, more studies are needed to investigate the feasibility of this approach.

Additionally, the system treats lessons learned as text. For example, a user can only retrieve the lessons learned by first searching for issues in DRB reports. A direct search for different types of lessons learned and reference DRB cases may be more helpful than the current system. A metadata model of lessons learned needs to be developed in order to perform a direct search.

Finally, more types of external documents should be integrated in the review process. First, FDOT should perform an evaluation of its internal computer systems and data format because not all desired features are easily supported by the capability of the existing systems at FDOT. It would be helpful to develop a strategy before beginning implementation because many technical issues have not been identified. Lack of proper strategies for resolving these problems may be costly and may hinder the implementation process.

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1 INTRODUCTION

This chapter provides an overview of this project and the report. Contents include the problem statement, the objective, the significance and methodology of the study, and the organization of the report.

1.1 Problem Statement

Often disputes may arise between owners and contractors during the execution of a construction project. Construction disputes typically cause monetary and time losses. Disagreements often result in litigation that is both time-consuming and expensive. A dispute review board (DRB) provides a valuable and proven alternative method of dispute resolution. According to the Dispute Review Board Foundation, there were 1,338 projects with DRBs in the year 2005, worth a total contract value of $95 billion (http://www.drb.org/index.htm).

The Florida Department of Transportation (FDOT) began using DRBs in 1994. The practice was expanded to include the use of regional boards in 2002 and statewide boards in 2004. Currently, the FDOT either uses DRBs or makes them available on every construction project. The FDOT maintains a website that stores all DRB decisions and recommendations (Figure 1-1). However, the current website listing of DRB decisions and recommendations does not provide illustrative information. The website displays flat statements of the board decisions that are not typically linked to relevant documents such as specifications or other project administrative documents. Due to the lack of elaborative information, the DRB reports are not effectively used to guide construction engineers in resolving similar problems in other projects.

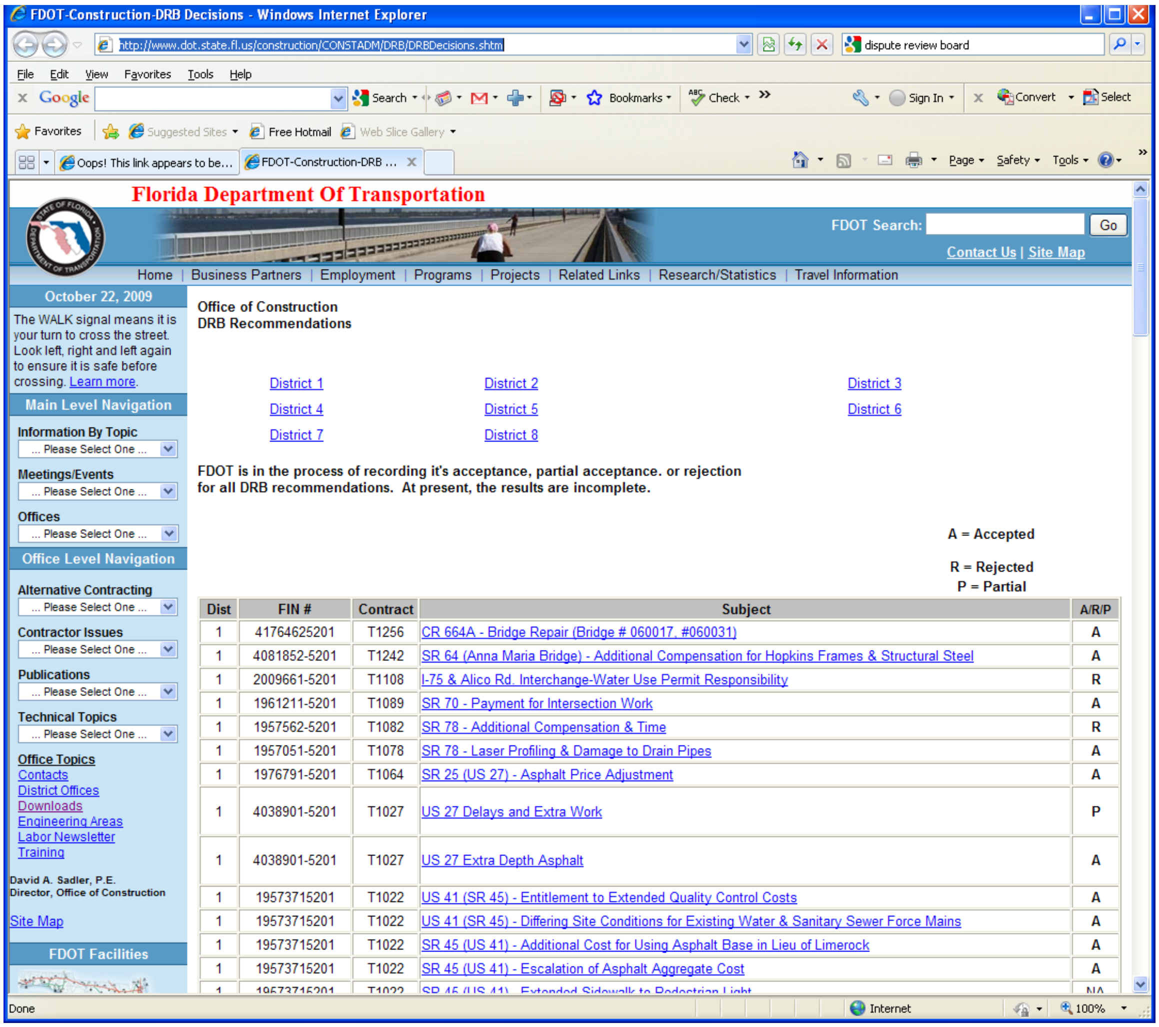


Figure 1-1 Existing FDOT Website for DRB Reports

The root cause of the problem is the data format of existing DRB reports. The reports are accessible as portable document format (PDF) documents in a format that is called unstructured data because it is not designed for computerized applications such as linking to different "sections" of standard specifications that are also in the PDF format. In addition, searching unstructured data for relevant information is more troublesome than searches that are based on structured data such as databases. Improving information retrieval of DRB documents and providing a certain level of integration of DRB reports with relevant but heterogeneous data and documents are key to enhancing the current FDOT DRB system.

1.2 Objectives

The objective of this study is to develop a software system and set a foundation for future improvements of the FDOT DRB system. Improvements to the existing Web-based DRB report listing include using data and metadata models that share lessons learned, implementing advanced text-based search mechanisms, and integrating DRB reports with member data and other relevant documents.

- The DRB reports are primarily written as unstructured text documents. Processing unstructured text is more challenging for computers than processing structured data. Thus, converting unstructured text into structured data can improve information retrieval and knowledge discovery. One proven approach is to apply metadata. A DRB report contains a specific type of information, which provides a foundation for metadata model development.
- In addition to metadata application, a text-based search engine is another common method for organizing unstructured data. Advancement in computer science has resulted in powerful text-based search algorithms and search engines that support advanced searches of structured and unstructured documents. These searches

utilize Boolean operators (e.g., AND, OR, NOT, NEAR, and so forth) as well as more sophisticated features.

- The metadata model provides a mechanism to integrate DRB reports with other reports through a predefined document structure. Construction engineers can use this feature to quickly locate reference documents when reviewing a DRB report. Other related data, such as the DRB member data and lessons learned, might be integrated in the same environment to facilitate DRB-related tasks.

1.3 Significance

This study is significant because 1) the existing Web-based system is inefficient, 2) the existing Web-based system is not effective, and 3) the proliferation of DRB cases online will further decrease the efficiency and effectiveness of the existing system. First, the existing system is primarily a replicate of the paper-based DRB reports. These reported have limited classification capability, e.g., by district, subject and results. The system was designed for people to manually store, classify, search, and organize the DRB reports. Consequently, using the system is very time-consuming and it is error prone. Due to the fact that most of the reports are created and stored as PDF files, searching and grouping related DRB reports for further analysis is very difficult. As a result, users have trouble finding helpful information related to handling disputes or claims. As the number of FDOT construction projects using DRBs increases, the number of DRB reports will also increase. Due to the hundreds of reports that are stored online, finding specific DRB cases that address a similar issue is a difficult task.

The new system not only allows DRB members and FDOT construction engineers to create DRB reports, but also provides more functionality to process those reports. New functionalities include a structured search based on the metadata of DRB reports, an unstructured search using advanced computer technology, and the integration of DRB reports with other related information for analysis. This type of functionality can improve the efficiency and effectiveness of the DRB system. The extensiveness of the system will improve because it is based on database technology.

1.4 Methodology

The development of the new DRB system is based on Oracle database technologies. The development process follows a typical software development procedure, including requirements engineering, design, implementation, testing, and release.

Conventional techniques such as surveys and text analysis are used to perform requirements engineering. In this study, requirements engineering focuses on deriving information that supports the design of the following key components of the system: 1) a workflow model, 2) a DBR data model, 3) metadata models, and 4) preset terminology. A workflow model captures the process of inputting metadata and other relevant data associated with a DRB report. A DRB data model studies the structure of DRB reports and is carried out to determine whether a stable data structure exists and whether the data structure can be used as the basis for developing a DRB data model. Metadata models effectively handle important unstructured text such as issues, positions, and recommendations in a DRB report. Metadata models for such text need to be developed for capturing the key information elements of the text. The metadata are a part of the DRB data model. However, since the development of metadata models needs different requirements from developing other parts of the DRB data model, this topic is discussed separately. Preset terminology defines terms that are used by the system as predefined keywords will be identified and defined. Index tables are a type of tree structure that models documents to be integrated with DRB reports. The structure includes section numbers and titles extracted from the documents to create links in DRB reports.

The DRB data, including metadata, developed for this system should be logically interpretable and clearly defined. In order to achieve this objective, an analysis on the structure of DRB reports and selected text contents will be performed. A random sample of the DRB reports listed on the FDOT website will be collected and analyzed. The results of the analysis allow researchers to determine a common structure for DRB reports. DRB reports are business documents that contain a specific structure. Therefore, the identification of particular types of information such as title, sections, subsections, and contents in specific sections (e.g., identification number used in references) can help develop DRB data and metadata. A similar analysis is performed to select unstructured contents in the DRB reports and to extract key data types that will achieve the purpose of the study.

In order to integrate DRB documents with related external documents, index tables for the construction project administration manual (CPAM) and the FDOT standard specifications are developed. The CPAM and FDOT specifications are two examples of documents that are constantly referenced when processing or reviewing a DRB report. A citation to external documents is often located in the position or recommendation section of a DRB report. Computers can use the index table to connect sections in a DRB report and related documents.

The system is designed through the development of a prototype. The prototype is web-based so that FDOT engineers can review and comment on the prototype. Feedback is collected and implemented through prototype revisions.

A classic, three-tiered system is designed using Oracle technologies. Implementation of the system is first completed in a test environment provided by FDOT and accessed via a virtual private network (VPN). After testing, the system is transferred to the FDOT production environment and released to FDOT engineers and DRB members.

1.5 Organization of Report

The report is organized in six chapters. Chapter 1 introduces the research project, including the research problem, the objective, the methodology of the study, and the organization of this report.

Chapter 2 presents a review of the state of knowledge in areas of software requirements engineering, an overview of claims and disputes, a discussion on claim sources and types, topics related to information modeling and metadata, and techniques of text-based search and information retrieval.

Chapter 3 discusses requirements elicitation in detail, including the workflow requirements of the DRB system, the structure of DRB reports, the DRB data model, the index structure of target documents, and the member database.

Chapter 4 is devoted to the design and development of different modules of the DRB system based on the requirements discussed in Chapter 3. These modules include the input module, analysis module, and maintenance module. The input module includes a set of templates that allow users to generate DRB data including the metadata of unstructured content, establish links to related documents and their sections, and store DRB reports in a relational database. The analysis module provides two means for users to search DRB reports, structured and unstructured searches. The maintenance module is designed for managing access to the DRB system and the maintenance of member data, index tables, preset terminology, and DRB data.

Chapter 5 briefly introduces the improved DRB system. Chapter 6 provides conclusions and recommendations for future research studies.

2 LITERATURE REVIEW

This chapter reviews literature that is related to the project, including software requirements engineering, disputes and dispute review boards, dispute sources and types, construction document and metadata modeling, and full text search.

2.1 Overview of Software Requirements Engineering

Requirements engineering is a process of systematic requirements analysis (Wiegers 2003). The goal of requirements engineering is to determine the goals, functions, and constraints of software systems. Requirements elicitation, requirements analysis, requirements specification, and requirements validation are major steps of a requirements engineering process (Figure 2-1). The success of a software development project largely depends on the quality of the requirements engineering process (Abran et al. 2005).

Requirements elicitation deals with collecting software requirements from proper sources by using appropriate techniques such as surveys, interviews, prototyping, and observations (Davis 1993, Kotonya and Sommerville 2000, Pfleeger 2001).

Requirements analysis involves a process for collected requirements that eliminates potential conflicts between requirements, identifies the boundary of software system and interaction with its environment, and elaborates on system requirements (Sommerville 2005).

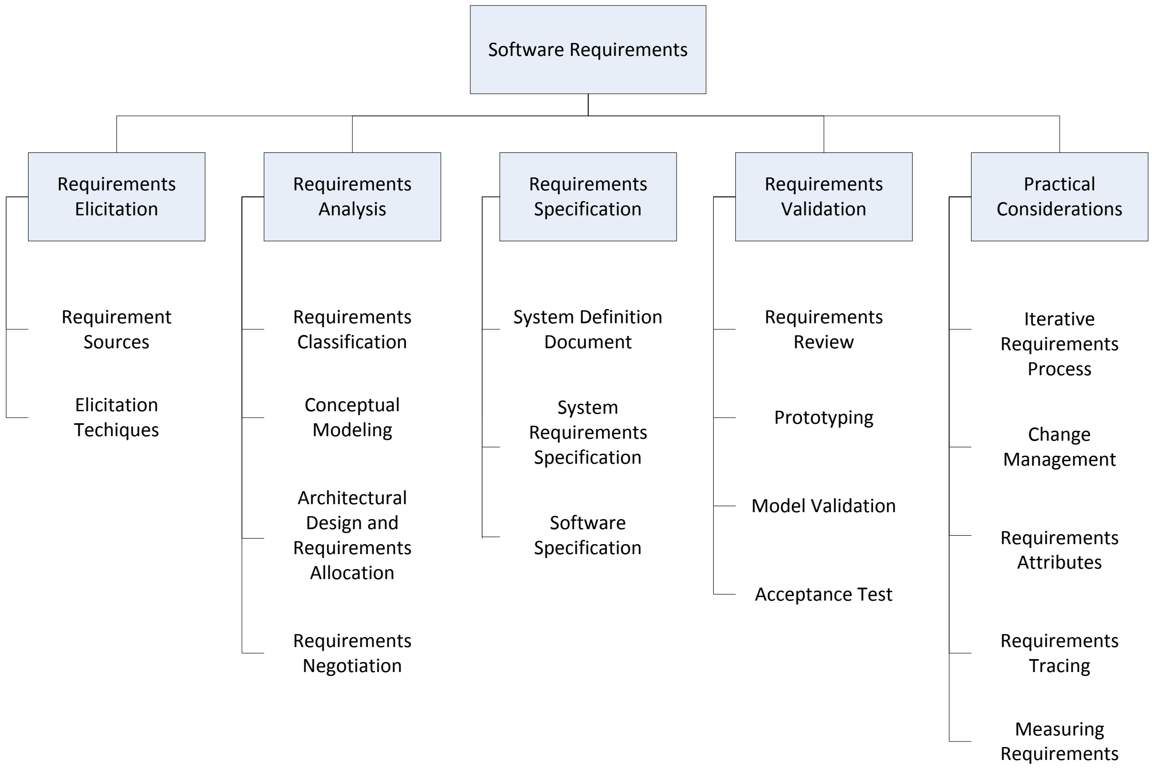


Figure 2-1 Requirements Engineering (Abran et al. 2005)

The major tasks for requirements analysis include the following: 1) requirements classification, 2) conceptual modeling, 3) architectural design and requirements allocation, and 4) requirements negotiation. Requirements classification categorizes requirements according to different criteria, such as functional requirements versus non-functional requirements, product versus process, the scope of a project, and the priority of the requirements (Davis 1993, Kotonya and Sommerville 2000). Conceptual modeling is a process for developing an abstraction of real world problems or observations. Several types of models can be used in a software project including data models, process models, object models, and user interaction models (Sommerville 2005). Architectural design is focused on a design system or the required relationships between software components. Requirements allocation assigns requirements to different components so that these components have states and behaviors (Sommerville 2005). Requirements negotiation deals with resolving conflicts in requirements that arise from the conflicting needs of stakeholders (Kotonya and Sommerville 2000, Sommerville and Sawyer 1997).

Requirements specification typically refers to the development of a document that is systematically reviewed, evaluated, and approved regarding the requirements of a software system. Generally, there are three different types of documents that are developed: system definitions, system requirements, and software requirements. Software products only require software requirements. System definitions provide a high-level specification of system requirements from the domain perspective. These definitions may also include background information about the overall objectives for the system, its target environment and a statement of constraints, assumptions, and non-functional requirements (Robertson and Robertson 1999). System requirements provide a foundation for developing software requirement specifications. On the other hand, software requirements specifications are used to establish an agreement between clients and software developers for the expected capabilities of a software product (Robertson and Robertson 1999, Kotonya and Sommerville 2000).

Requirements validation involves a set of procedures to validate and verify software requirements. It may include requirements review (Sommerville 2005), prototyping (Kotonya and Sommerville 2000), model validation (Kotonya and Sommerville 2000), and acceptance testing (Davis 1993).

Practical considerations address requirement evolutions (You 2001), change management (Kotonya and Sommerville 2000), requirements tracing (Kotonya and Sommerville 2000), and other aspects for improved requirements management.

2.2 Disputes and Dispute Review Boards

Disputes refer to controversies or disagreements between different stakeholders. Generally, disputes arise from different perceptions of the legitimacy and/or the quantum of claims. If previous conflicts cannot be properly settled, construction disputes normally evolve from initial conflicts and claims (Figure 2.2) (Kumaraswamy 1997). A conflict is defined as a "serious disagreement and argument about something important" or "a serious difference between two or more beliefs, ideas or interests" (Sinclair 2001). Conflicts represent the sources of a disagreement between construction participants. Claims result from conflicts and are an assertion of the right to remedy, relief or property (Semple et al. 1994). Construction claims aim to gain extra monetary or time compensation.

A DRB process is a popular form of alternative dispute resolution (ADR). A DRB panel includes experienced industry professionals who are jointly selected by the owner and contractor of a project under contract. The panel reviews and recommends strategies for solving disputes that arise on a project (Matyas et al. 1996).

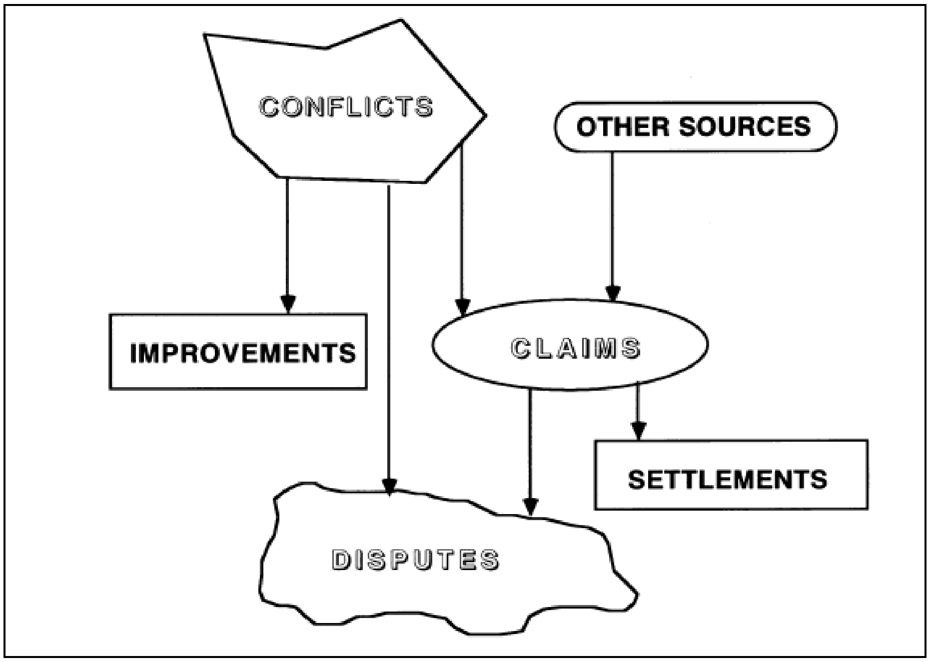


Figure 2-2 Dispute Evolution Process (Kumaraswamy 1997).

The selection of board members is mainly based on the knowledge of claim issues and industrial experiences. According to a previous study, 89% of responders believed that the recommendations contained in DRB reports were equitable and well reasoned, 92% agreed that the results were logical and timely, and 98% considered the results useful in resolving the financial quarrel (Harmon 2003). The DRB method does not reduce the problems or recognize the deficiencies in documents. This method also does not mitigate potential claims on a project (Yates and Duran 2006).

2.3 Dispute Sources and Types

In order to better classify disputes, reduce disputes, and retrieve dispute cases, a significant amount of research has been performed to determine dispute sources and types over the past few decades. According to Kumaraswamy (1997) (Figure 2-2), dispute sources can be traced back to claim and conflict sources. Williamson (1979) argued that project uncertainty, contractual problems, and opportunistic behaviors were the basic factors that led to disputes. Based on studies of highway projects, O'Connor et al. (1993) suggested that the fundamental causes of disputes were related to 1) site investigation, 2) plans and specification, 3) contract performance, 4) owner performance, 5) bidding practice, 6) change justification, and 7) weather. Diekmann et al. (1994) provided a more high-level observation and summarized that people, project, and processes were the three basic factors that may cause disputes. Sykes (1996) identified contract-related and unpredictable events as the major sources of disputes. More recently, Cheung and Yiu (2006) concluded that contract provisions, trigger events, and conflicts were the basic structure and necessary factors to cause a dispute.

Previous research has developed many different schemes for classifying disputes (e.g., Kumaraswamy 1997). Charles et al. (1990) identified changed conditions, payment issues, time and delay, errors in bid, and a lack of communication as the five major categories of disputes. Totterdill (1991) provided a method to classify disputes based on technical, legal, and managerial aspects. This observation was mainly based on the nature and origin of a dispute. Based on claim characteristics, Hewit (1991) identified six types of construction disputes: 1) change of scope, 2) change conditions, 3) delay, 4) disruption, 5) acceleration, and 6) payment, and protection of persons and property. Splitter (1992) showed that ambiguous contract documents, competitive/adverse attitude, and dissimilar perceptions of fairness by participants are the main source of construction disputes. O'Connor et al. (1993) classified disputes according to damage type, highway element, and fundamental causes based on highway industrial experiences (Table 2-2). Watts and Scrivener (1993) identified six generic types from a review of court cases: 1) determination of agreement, 2) payment related, 3) site and execution of work, 4) time-related, 5) final certificate, and 6) tort-related. Jones (1994) classified disputes into the categories of management, culture, communication, design, economics, tender pressure, law, unrealistic expectations, contracts, and workmanship. Based on contractual documents, Yates (1998) pinpointed seven categories: 1) variation, 2) ambiguity in contract documents, 3) inclement weather, 4) late issue of design information/drawings, 5) delay possession of site, and 6) delay by other contractor employed by client, and postponement of project. Amir et al. (2005) classified Canadian construction court cases into contract administration, allowance, default notice, dispute resolution, execution of work, general provisions, governing regulations, insurance or bond, payment, and protection of persons and property.

On the other hand, FDOT uses the following categories to classify disputes:

- Design errors
- Rework
- Different site conditions
- General contract interpretation
- Pay items and quantities
- Other issues

Damage Type	Highway Elements	Fundamental Causes
Defective contract documents	Earthworks	Site investigation
Different site conditions	Pavement	Plans and specifications
Compensable delays	Structure	Contractor performance
Excusable delays	Others	Owner performance
Hindered productivity		Bidding practices
Maladministration		Change justification
Implied warranty		Weather
Constructive change		Miscellaneous
Direct change		
Economic impossibility to perform		

Table 2-1 Dispute Classification of Highway Projects (O'Connor et al. 1993)

2.4 Construction Document and Metadata Modeling

There are many different types of documents associated with the management of a construction project (Zhu et al. 2001). DRB reports are one type of document. One barrier to processing construction documents is that almost all of these documents, including the DRB reports, are semi-structured or even unstructured. This format replicates their paper-based counterpart. For example, DRB reports can be regarded as semi-structured because they contain structured data such as the project FIN number, the project contract number, and the report creation date. DRB reports also include unstructured text such as issues. In many cases, some information contained in the unstructured text is critical for processing the DRB. The retrieval of DRB reports based on a certain type of issues requires unstructured text. However, this information is hidden in unstructured document text and is hard for computers to retrieve or analyze. An improved method is required for modeling the documents and the unstructured content of the documents (Zhu and Issa 2003).

Markup languages such as Structured General Markup Language (SGML) and eXtensible Markup Language (XML) are used to add semantics to documents (e.g., Decker et al. 2000). Many applications were based on this strategy. For example, Zhu and Issa (2003) discussed the application of XML to structure construction documents, e.g., RFIs and change orders. They also discussed the use of tags that are defined by the markup language as a foundation for integrating data and information from other structured or unstructured sources.

The text content of those documents can be handled by using metadata. Metadata are described as the data describing data (NISO 2004). Metadata are used to describe unstructured text and to provide a mechanism for integrating the unstructured text with other relevant, yet heterogeneous data. In addition, metadata associated with the text of documents can help retrieve the text. The three types of metadata are descriptive, structural, and administrative (NISO 2004). Descriptive metadata mainly describe a resource and provide semantics for the identification and discovery of the resource. Structural metadata indicate the inherent structure of an object such as the document structure of a DRB report. Administrative metadata provide administrative support of an object such as the location of the object and the time when the object is created or accessed. Metadata can be created by human authors or by automatic machine generation (Duval 2001). NISO (2004) and provides detailed information on the tools that can be used to create metadata. These tools include templates, mark-up tools, extraction tools, and conversion tools.

Many applications in the architecture engineering and construction (AEC) industry have used metadata for different purposes such as information retrieval and interoperability. Leung et al. (2003) proposed a metadata-based construction information system for data exchange among web-based documents. This system retrieved data from original documents, which was commonly called customized searching function. Then, the system reorganized the unstructured information according to specific tasks or users and displayed information in an integrated web page. Chan et al. (2004) used metadata to develop a web-based document management system facilitating construction document management and information exchange. More recently, Mao et al. (2007) demonstrated the use of a metadata model for RFI documents to integrate heterogeneous data that includes doors, the construction process, and project management information. Integration of this data can facilitate construction document processing.

In addition to using metadata, text mining-based approaches that handle unstructured or semi-structured construction documents are useful for data integration. For example, Caldas et al. (2005) proposed an unstructured construction data management methodology named Text Information Integration Methodology (TIIM). This method enables document classification, ranking and retrieval, and data analysis.

2.5 Full Text Search and Information Retrieval

Full text search offers a different capability of information retrieval than a model-based search as discussed in Section 2.4. A search engine is required to use this method because a target document can be scanned and searched for matching words that are supplied by a user (e.g., Brown 1995).

There are two steps involved in search, indexing, and searching. Indexing is typically applied by text search engines to improve the performance of search when a large set of documents are involved (e.g., Clarke and Cormack 1995). During the indexing step, the search engine will scan the text of the target documents. An index, or a list of search terms, will be developed. During the search step, the search engine will refer to the index rather than to the entire documents to create the best matching of queries. Certainly, this approach will generate a false positive problem, i.e., retrieving many documents that are not relevant.

Today, many search engines are capable of performing a full text search with satisfactory results. For example, Oracle Text provides a platform to index, search, and analyze text and documents stored in the Oracle database using standard structured query language (http://www.oracle.com/technology/products/text/index.html).

3 REQUIREMENTS ELICITATION

This chapter discusses the requirements gathered from existing documentation that are related to DRB reports, DRB processes, and FDOT engineers, for the design and implementation of the DRB system. Requirements related to the following aspects are discussed in detail: 1) the workflow of the DRB system, 2) the DRB document structure, 3) DRB data modeling, 4) index tables, and 5) the member database.

3.1 Workflow of the DRB System

The arrangement of different components of the DRB system is critical to the unhindered flow of data among different system modules. This structure is an important requirement for supporting the purpose of the system. Figure 3-1 illustrates the major components and data flows of the system.

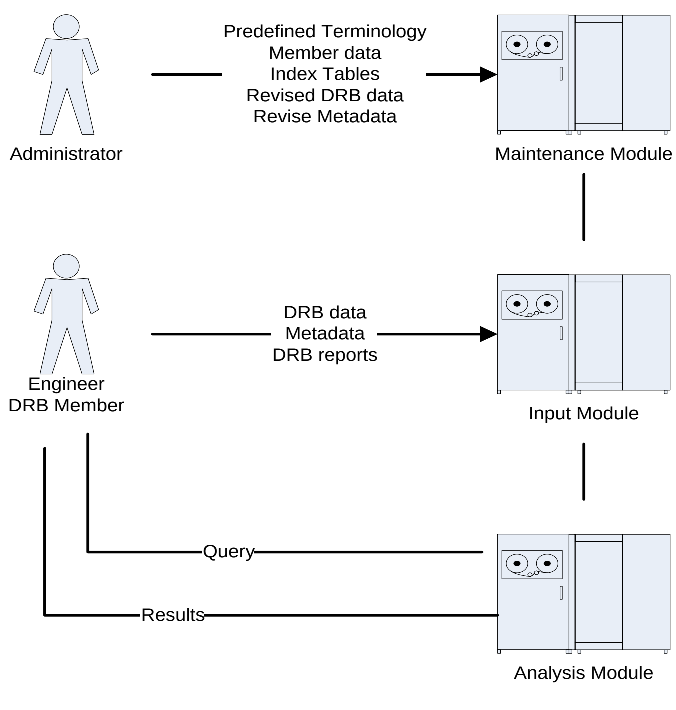


Figure 3-1 Workflow of the DRB System

The system has three components: 1) a maintenance module, 2) an input module, and 3) an analysis module. The system supports three roles including an administrator, an engineer, and a DRB member. The maintenance module needs to provide the following functions:

1) Managing access rights. It should be possible to differentiate between FDOT engineers and DRB members. A system administrator will have full rights to the system and will manage the system.
2) Updating member data. The database is not comprehensive for DRB members and only contains necessary data for managing and processing DRB reports. Member data may change. This function provides a mechanism for managing the member data.
3) Managing index tables. The structure of documents that are integrated with DRB reports needs to be captured in a format that can be interpreted by a computer. The maintenance module should be able to create, revise, and delete the index table associated with a target document without incurring a negative impact on the operation of the system.
4) Managing preset terminology. Some terminologies used by the system must be preset and defined to provide clarity to users. These terminologies may change over time by deleting existing terms or adding new ones. This function allows a system administrator to manage changes and maintain the consistency of the system.
5) Updating DRB data. The DRB data, including metadata, can be input by DRB members and/or FDOT engineers. Occasionally, the data may need

adjustment, such as correcting an error or better describing an issue. In those cases, this function provides a tool for a system administrator or an FDOT engineer to update DRB data.

The input module allows users to input DRB data and DRB reports. The DRB data includes metadata and allows users to search DRB reports for a particular purpose. Users can use Microsoft Word to prepare their DRB reports and convert them to PDF format. This system allows users to store DRB reports with their DRB data, including metadata. The details of DRB data and metadata will be discussed in the following sections of this chapter.

The analysis module allows the user to search for specific DRB reports once the necessary data in the maintenance module are set and DRB data and DRB reports are uploaded to the system. In addition to the search, this module should also provide a display function allowing users to review documents that are related to a DRB report.

3.2 Structure of DRB Reports

The structure of DRB reports is determined by performing a text analysis on a collection of them. In this study, seventy one DRB reports from District One were selected and studied. Each report was read manually. Major types of data and section titles were identified and recorded using Microsoft Excel. The number of times that repeating section titles occur was calculated and presented in Figure 3-2.

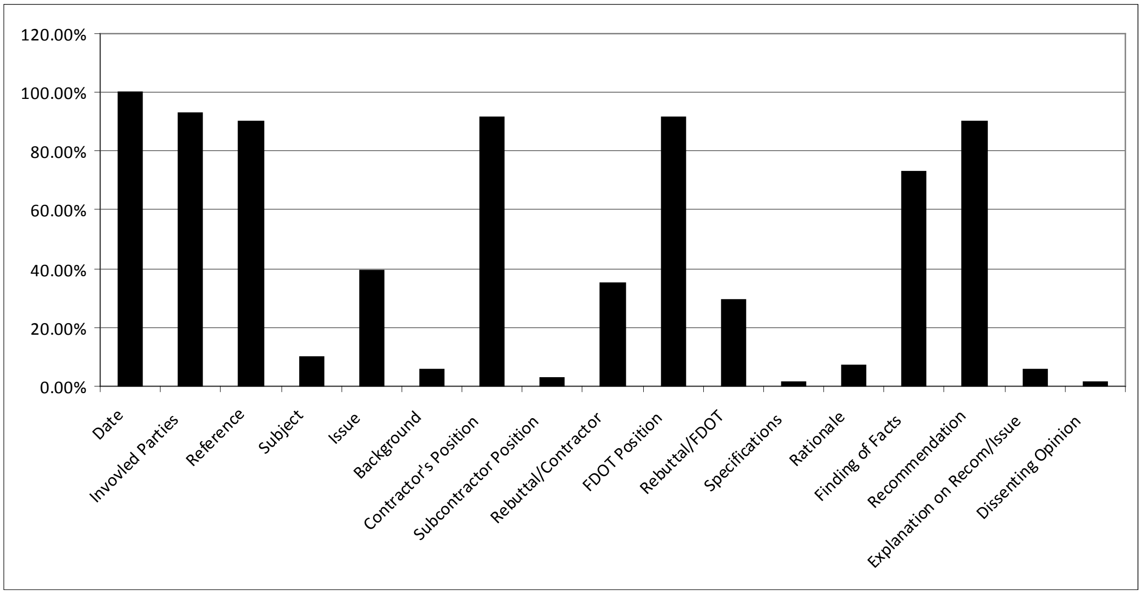


Figure 3-2 Results of Text Analysis on Sample DRB Reports

Major data types and section titles include:

- Date – the calendar date (e.g., June 25, 2009) when a DRB report is created. Every report has the date information.
- Involved Parties – refers to the participant information, including the contractor and FDOT. The information includes the contact person's name, title, company name, and business address (e.g., John Morgan, Senior Project Manager, KCCS, 8220 State Road 84 Suite 300, Davie, FL 33324).
- Reference – contains several types of information associated with a dispute case. Commonly, only one or several types of following data are used in a DRB report.
  - ❖ FIN (or FPID): This number uniquely identifies a FDOT project. The data format of a FIN number is an 11 digit number with "-" separators (e.g., 194093-1-52-01).

- ❖ Contract Number: The contract number of a FDOT project. Normally, the format of a contract number has one letter with four numbers (e.g. T1009). This number is not as widely used by DRB reports as the FIN number.
- ❖ WPI State Job Number: The third most frequently used identification number following the FIN and the contract number. It is a seven digit number (e.g., 1114707). Sometimes, this number is expressed as WPI in a DRB report.
- ❖ Federal Job Number: This number only appears in a few DRB reports.
- ❖ ACCI Number: This number is not frequently used.
- ❖ Short Description of Cases: A very brief description of the dispute case, often in one sentence, used to express the entitlement of a claim.

- Subject/Issue/Background: Typically, a DRB report contains a text section that describes the disputes involved in the report. There are many different ways to provide this description. Some reports use a subject line to briefly state a case; others use the issue or background section to provide a more elaborate description. Theoretically, these statements serve a similar purpose in the DRB report. A subject usually includes information regarding location, highway section number, related materials, equipment or man-hours, etc. Similar types of information may be found in an issue or in background descriptions.
- Contractor’s Positions and Rebuttals: After the dispute case is presented, a DRB report usually begins by discussing the contractor’s position and the rebuttals, which is a major part of a report. The position statement includes evidence and

supporting materials to help contractors make their points. Normally, in a position statement, contractors begin their arguments with perceived issues. These issues are supported by reference documents such as specification sections, CPAM, a project schedule, and contract provisions regarding specific facts or issues. In some reports, after the contractor's position, an additional rebuttal against FDOT's arguments may be presented. Compared to the position section, the rebuttal section contains the contractor's statements that are targeted at some FDOT statements. In the position section, contractors attempt to prove their entitlement and quantum of a claim. In some reports, a subcontractor's position may be included.

- FDOT Position and Rebuttals: After the contractor's position and rebuttals, the FDOT's position and rebuttal sections follow. The purpose of this section is similar to the contractor's position and rebuttals, but it is used by FDOT to present the Department's arguments, facts, and perspectives. Similarly, reference documents such as FDOT standard specifications are used and rationale is often provided for justification.
- Findings of Fact: After both party's alleged positions and rebuttals, a dispute review board will provide its findings that are related to a dispute. These findings are used to support commendations that are provided by the DRB.
- Recommendations: This part is the last section of the report. In this section, DRB members will state their final decisions on a dispute. These decisions include whether the contractor or FDOT is entitled or not, and if entitled, the amount of entitlement. Often, members provide signatures at the end of the report.

- Explanation: Occasionally, DRB members provide a separate section that offers a more elaborated explanation of their recommendations.
- Dissenting Opinion: In a few cases, a separate text records any dissenting opinion.

Although each document differs, the DRB report structure bears some level of consistency. This analysis indicates that some items do not appear frequently; while many others do. If less-frequently-appeared items are logically merged with frequently-appeared items, a stable document structure would emerge. If constructed, this structure could establish a DRB data model.

3.3 DRB Data Model

Previous discussions show that DRB data contain both structured and unstructured data. The date, parties, and references are structured data. On the other hand, positions, rebuttals, and recommendations are mostly unstructured text. In order to effectively manage DRB reports, both structured and unstructured data need to be captured and modeled. The structured data can be modeled relatively easily. For unstructured data, important metadata of the text will be elicited and captured. The resulting model is called a DRB data model.

In order to develop the DRB data model, reports from different districts have been carefully reviewed. Data types have been identified according to the document structure analysis, user requirements, and system objectives. The requirements used for developing a DRB data model are presented below.

3.3.1 Basic information

The DRB data model must capture basic information in a DRB report. Some types of models are shown in the sample report (Figure 3-3).

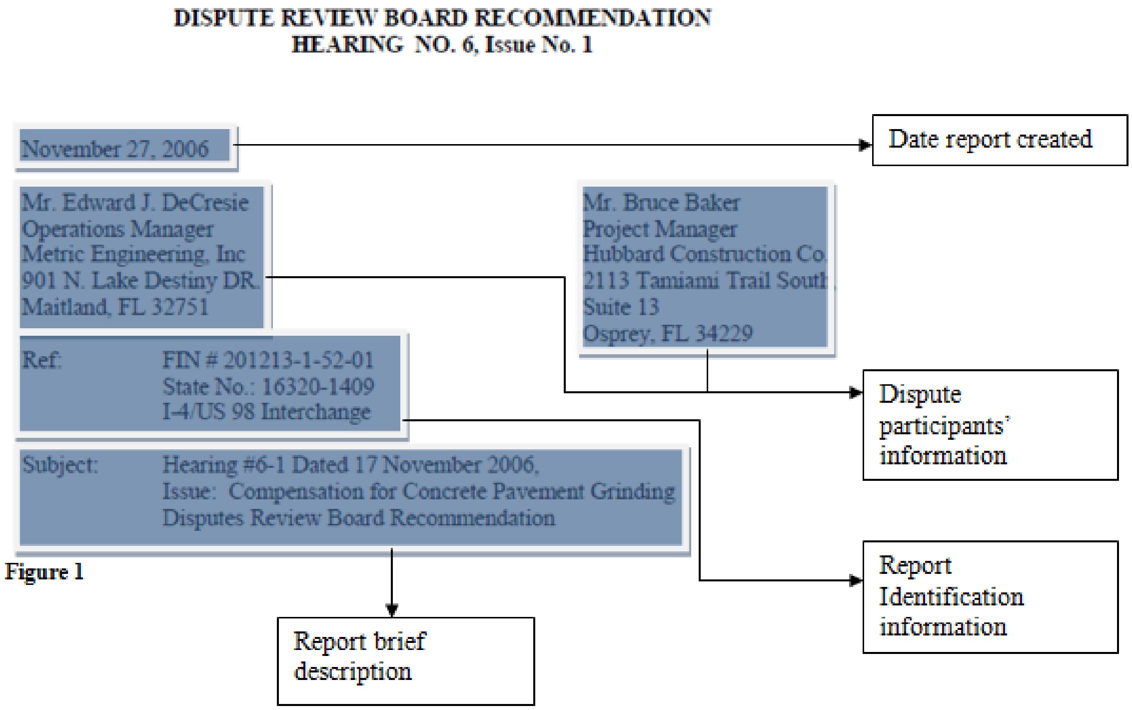


Figure 3-3 Sample Basic Information of a DRB Report

Major types of data include:

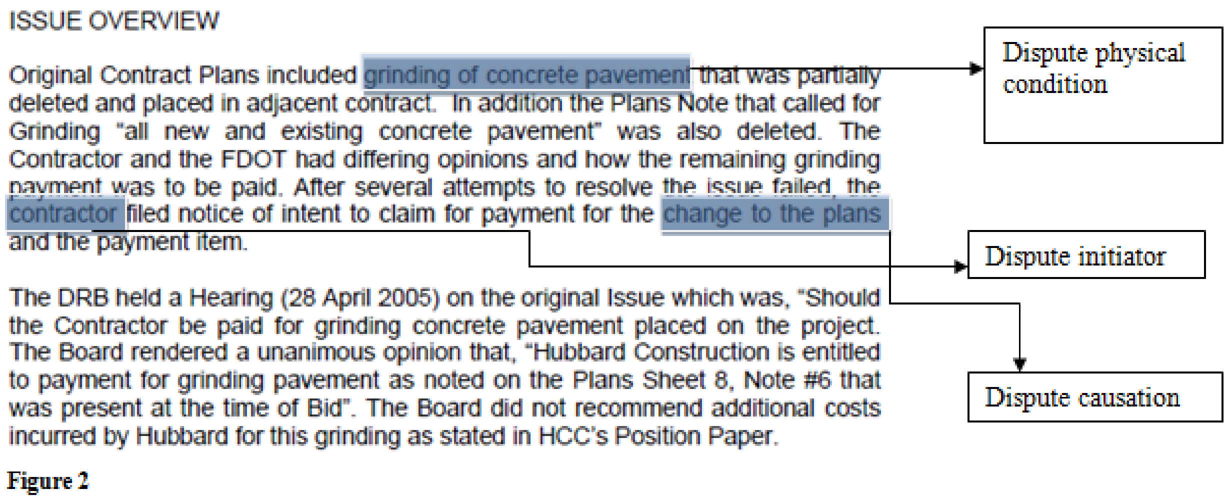
- Date when a DRB report is created.
- District that is involved in the dispute.
- Participant information, e.g., contact information of the contractor or subcontractor.

- Report reference information, e.g., the FIN or the contractor number.
- Construction project reference.
- Subject of a DRB report.
- Involved DRB members.

3.3.2 Issue metadata

A dispute issue is a short paragraph that provides detailed information about a dispute. It includes the initiator of a claim, the request from the claimer, such as the requested compensation of time (days) or money (dollars) or both (Figure 3-4). The paragraph describes the rationale of a claim by describing causes such as weather, materials, equipment, additional work, or different site conditions. For example, an issue can be stated as, “the contractor requests entitlement to additional contract time and recovery of costs for the water use permit delay”. In this example, the initiator (the contractor), the request (additional time and cost), and the cause of the dispute (water use permit delay) are clearly spelled out.

According to such observations, the issue metadata should capture four types of information: 1) the claim initiator, 2) the related physical condition, 3) the claim source (cause), and 4) the claim type. According to a telephone meeting with FDOT staff, the initiators of a claim are the contractor and the department. Claim-related physical conditions include pavement, structure, site work as well as others. This information is obtained from a study by O’Connor et al. (1993). Claim type is a set of widely-accepted and used types such as excusable delay, compensable delay, breach of contract, and request of equitable adjustment. The claim source was discussed in the previous chapter.


ISSUE OVERVIEW

Original Contract Plans included grinding of concrete pavement that was partially deleted and placed in adjacent contract. In addition the Plans Note that called for Grinding "all new and existing concrete pavement" was also deleted. The Contractor and the FDOT had differing opinions and how the remaining grinding payment was to be paid. After several attempts to resolve the issue failed, the contractor filed notice of intent to claim for payment for the change to the plans and the payment item.

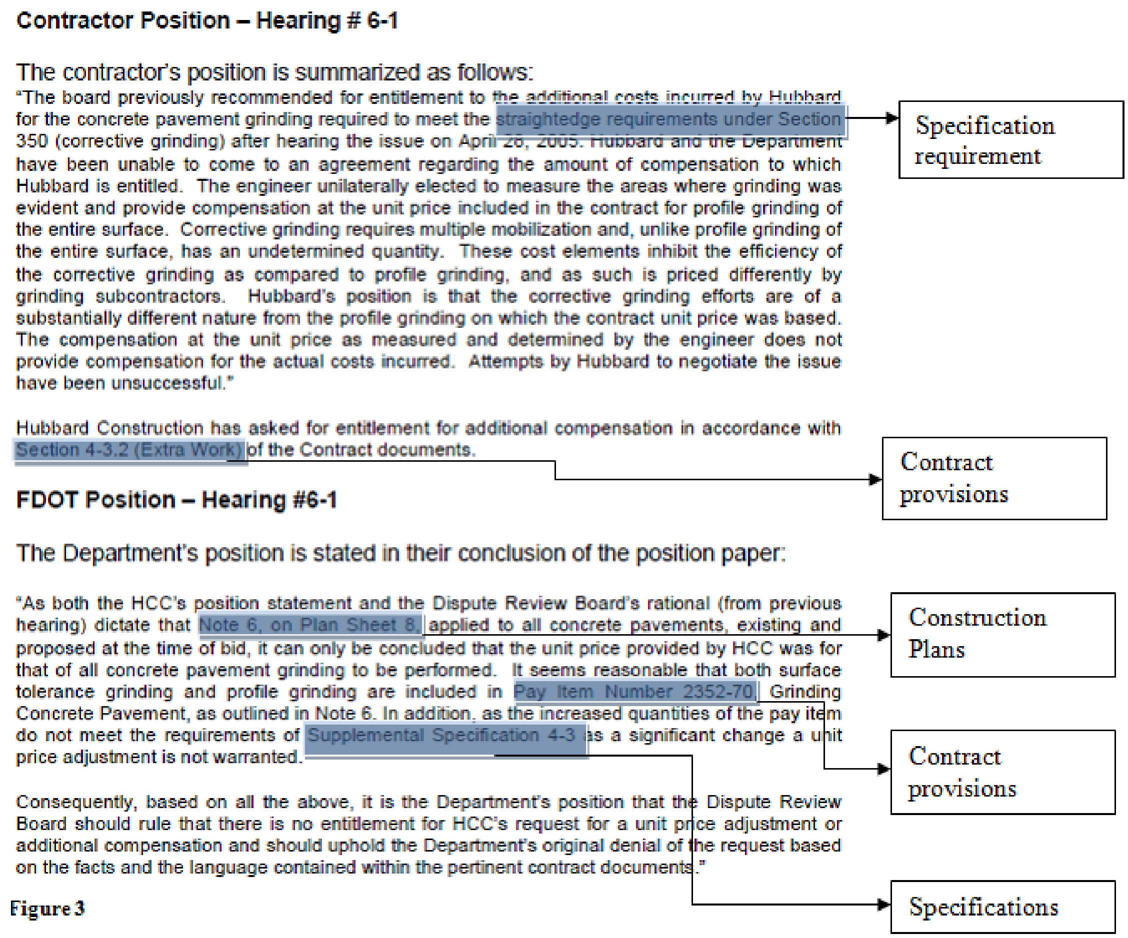
The DRB held a Hearing (28 April 2005) on the original Issue which was, "Should the Contractor be paid for grinding concrete pavement placed on the project. The Board rendered a unanimous opinion that, "Hubbard Construction is entitled to payment for grinding pavement as noted on the Plans Sheet 8, Note #6 that was present at the time of Bid". The Board did not recommend additional costs incurred by Hubbard for this grinding as stated in HCC's Position Paper.

Figure 2

Figure 3-4 Sample Issue

3.3.3 Position Metadata

The position refers to either the contractor or the FDOT position. In order to fulfill the FDOT requirement, the metadata of a position focuses on establishing connections between a position section and the referenced external documents by the position section. Thus, the metadata of position sections capture the type of referenced documents (Figure 3-5) such as the FDOT standard specifications or CPAM, and the actual link to the referenced documents.


Contractor Position – Hearing # 6-1

The contractor's position is summarized as follows:

"The board previously recommended for entitlement to the additional costs incurred by Hubbard for the concrete pavement grinding required to meet the straightedge requirements under Section 350 (corrective grinding) after hearing the issue on April 26, 2005. Hubbard and the Department have been unable to come to an agreement regarding the amount of compensation to which Hubbard is entitled. The engineer unilaterally elected to measure the areas where grinding was evident and provide compensation at the unit price included in the contract for profile grinding of the entire surface. Corrective grinding requires multiple mobilization and, unlike profile grinding of the entire surface, has an undetermined quantity. These cost elements inhibit the efficiency of the corrective grinding as compared to profile grinding, and as such is priced differently by grinding subcontractors. Hubbard's position is that the corrective grinding efforts are of a substantially different nature from the profile grinding on which the contract unit price was based. The compensation at the unit price as measured and determined by the engineer does not provide compensation for the actual costs incurred. Attempts by Hubbard to negotiate the issue have been unsuccessful."

Hubbard Construction has asked for entitlement for additional compensation in accordance with Section 4-3.2 (Extra Work) of the Contract documents.

FDOT Position – Hearing #6-1

The Department's position is stated in their conclusion of the position paper:

"As both the HCC's position statement and the Dispute Review Board's rational (from previous hearing) dictate that Note 6, on Plan Sheet 8, applied to all concrete pavements, existing and proposed at the time of bid, it can only be concluded that the unit price provided by HCC was for that of all concrete pavement grinding to be performed. It seems reasonable that both surface tolerance grinding and profile grinding are included in Pay Item Number 2352-70, Grinding Concrete Pavement, as outlined in Note 6. In addition, as the increased quantities of the pay item do not meet the requirements of Supplemental Specification 4-3 as a significant change a unit price adjustment is not warranted.

Consequently, based on all the above, it is the Department's position that the Dispute Review Board should rule that there is no entitlement for HCC's request for a unit price adjustment or additional compensation and should uphold the Department's original denial of the request based on the facts and the language contained within the pertinent contract documents."

Figure 3-5 Sample Positions of a DRB Report

Due to time and resource limitations, this study will only look into the specifications and CPAM. However, the system can expand to include other types of documents and data.

3.3.4 Recommendation Metadata

The recommendation metadata contains reference document numbers as well as the acceptance to the recommendations by both parties. When a DRB makes a recommendation for a dispute, some references will be listed to facilitate the review of recommendations for both the contractors and the FDOT. Ordinarily, the board references the same types of documents that are quoted by the contractors or the FDOT in the contractor or the FDOT position section.

In addition to references, the metadata should also include either party's acceptance of a dispute recommendation and an explanation about the acceptance.

3.4 Structure of Index Tables

3.4.1 FDOT Standard Specifications

The FDOT standard specifications have three divisions. Each division has several chapters and each chapter consists of several sections. A section number ranges from 1 to 995, but it is not continuous. For example, Division One has one chapter, and the section numbers of the chapter range from one to nine. Division Two includes nine chapters, and the section numbers of the chapters range from 100 to 786. Division Three has ten chapters, and the section numbers of the chapters range from 901 to 995.

There are up to seven levels in the FDOT standard specifications (Figure 3-6). Each level has a number. For example, a division has a division number and a section has a section number. Each level has a title as well. For example, one of the Level 4 titles is "Acceptance Program." The text of the specifications is associated with Levels 4 to 7. Levels 1 to 3 are used for classification purposes.

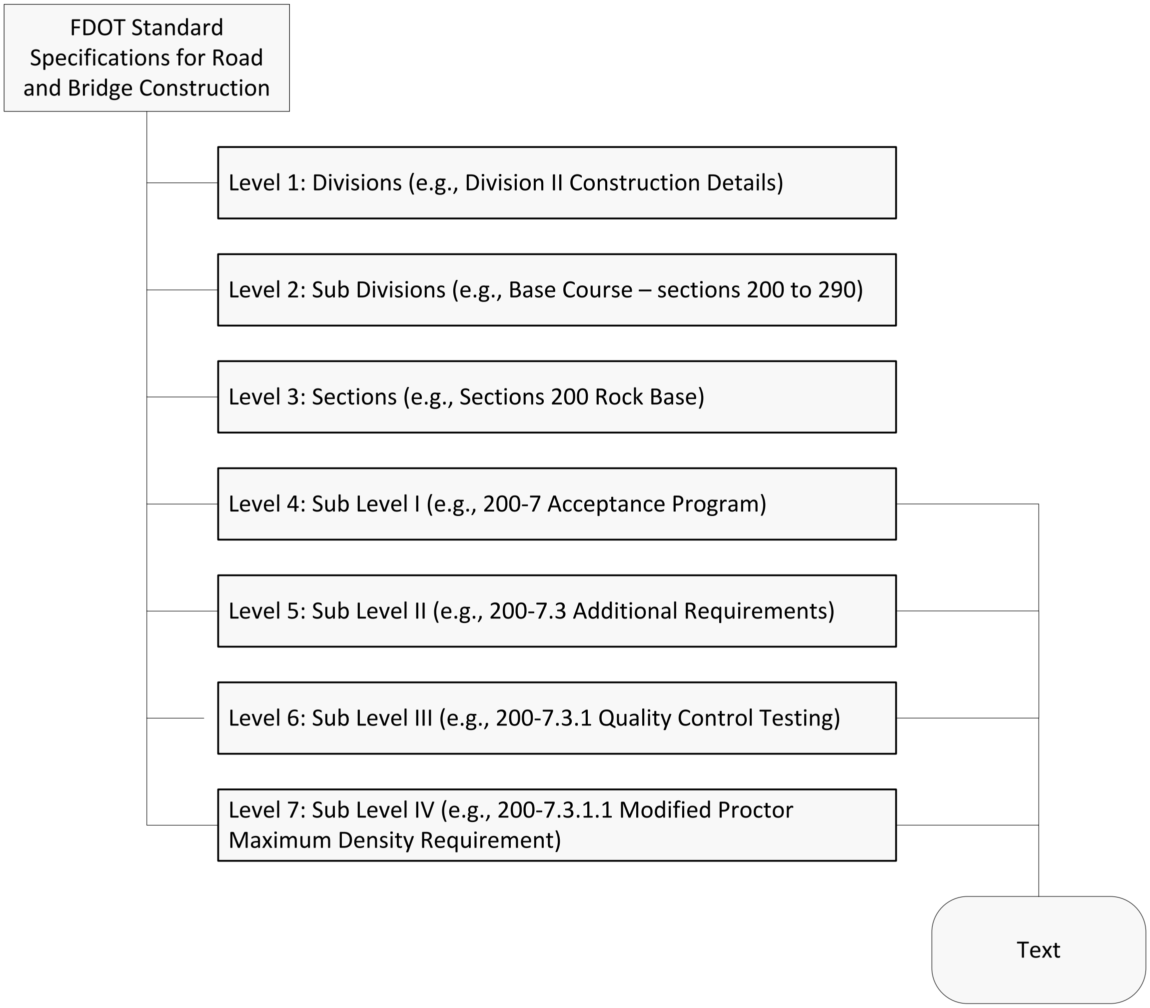


Figure 3-6 The Document Structure of FDOT Standard Specifications

The number of each level and the level title uniquely identify a particular portion of text. For example, “200-7.3.1 Quality Control Testing” is a unique string in the standard specifications. Duplicates of a string in the specifications are rare. This characteristic provides a way to develop an index table for FDOT standard specifications and allows a computer system to use the index table to search for specific text.

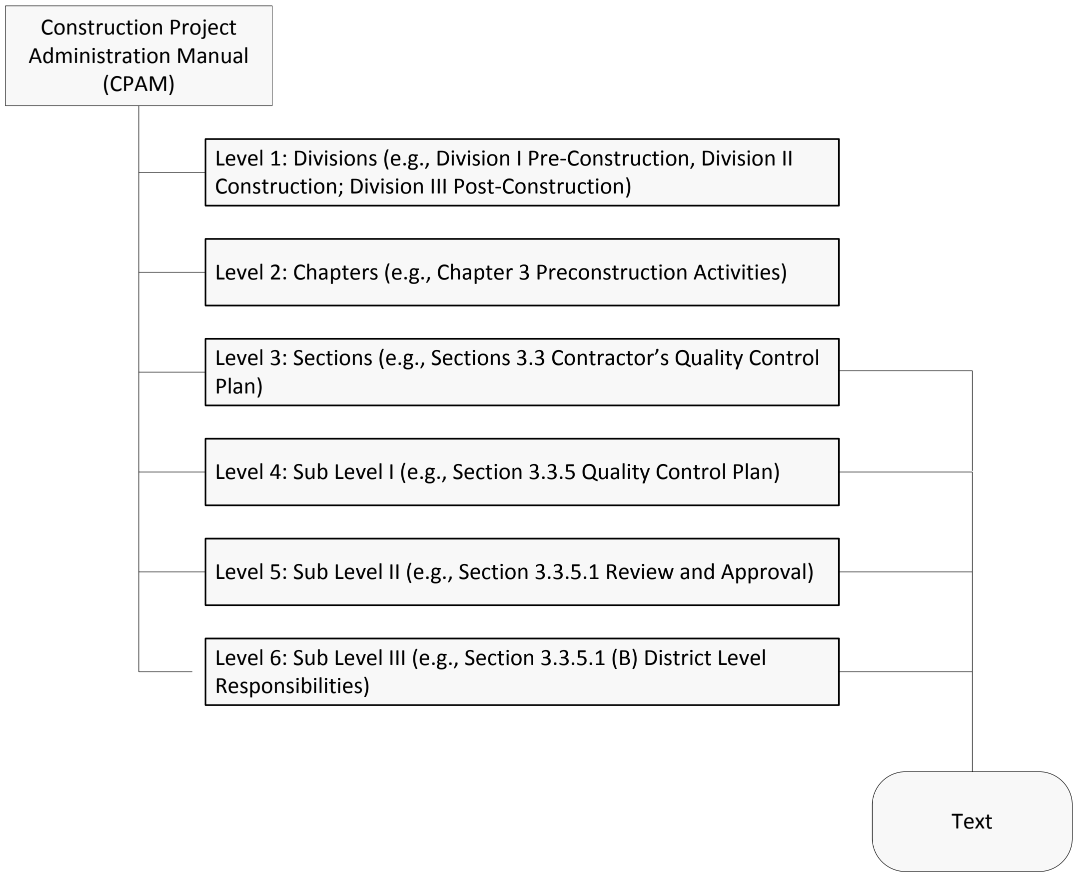


Figure 3-7 The Document Structure of FDOT CPAM

3.4.2 Construction Project Administration Manual (CPAM)

The CPAM consists of thirteen chapters, which are conceptually grouped into three divisions. Division One deals with pre-construction issues. Division Two discusses construction-related project administration requirements. Division Three deals with post-construction issues. Chapters 1 to 5 are in division one. Chapters 5 to 11 are in division two. Chapters 12 and 13 are in division three. Each chapter has sections and subsections. The document structure includes up to six levels (Figure 3-7).

Similar to the standard specifications, the combination of the level number and the level title of the CPAM can be used to uniquely determine a specific portion of text. The index table of CPAM can also be designed using this characteristic of the document structure.

3.5 Member Database

Currently, a paper-based DRB report only records the name of the DRB members. The association of a DRB member with dispute case is very difficult to retrieve. With the proliferation of DRB cases, valuable information can be derived based on the study of associations. However, it is time-consuming and ineffective to perform this task using paper-based DRB documents. Thus, an integrated database is needed.

This database only needs to store basic member information such as names and the expertise of the member. This information allows a user to determine whether a member is properly assigned to a dispute case. In addition, a resume of the member may be stored in the database for further reference regarding the qualification of the member.

Figure 3-5 Association between Member Data and DRB Data

As mentioned before, important knowledge about the member in the context of handling dispute cases is derived by the association of the member and the dispute cases (Figure3-5). For example, the DRB data mentioned above includes the district, the issue, and the results. Using these data, the system can help district engineers to determine who has been working on a certain type of issue or what expertise is needed to handle a specific issue or what the recommendation results are when a particular member serves on the board.

Therefore, the system can enable engineers to better select DRB members with proper expertise by adding a minimal amount of additional information about the DRB member to the new DRB system.

4 DESIGN AND DEVELOPMENT OF THE DRB SYSTEM

This chapter discusses the design and development of the indented DRB system, including the process and data models of the DRB report input template, the integration of target documents, the management of preset terminology, the DRB member data, the report retrieval and analysis function, and the maintenance of the DRB system.

4.1 Report Input Templates

The captured requirements related to workflow, report structure and metadata are presented in the form of process models and data models for implementation. The process models define the process of tasks and the data flow of each task. The process models are developed using the data flow diagram (DFD) (Kendall and Kendall 2004). Data models specify the data required by the system. UML static structure diagrams are applied in this study for defining data models (Fowler and Scott 2003).

4.1.1 Process Modeling

Figure 4-1 shows a process model of DRB data input. There are five steps including login, obtaining data, validating data, storing data, and storing a DRB report. In order to access the functions of the system, a user needs to login into the system. The username and password will be stored in a database for verification and matching with a predefined user profile. The user profile specifies the access rights of the user. Once logged in, the user can start to input relevant DRB data. There are many types of DRB data including a FIN number, the creation date, a contract number, a project description, the issue description, the contractor's position, the FDOT's position, and DRB recommendations. The DRB data are specified in a data structure model. The format of input data is validated before the data are stored in the DRB database, i.e., DRB DB in Figure 4-1. Once the DRB data are entered and stored, a user can upload a DRB report to the DRB report database specified as the DRB report DB in Figure 4-1.

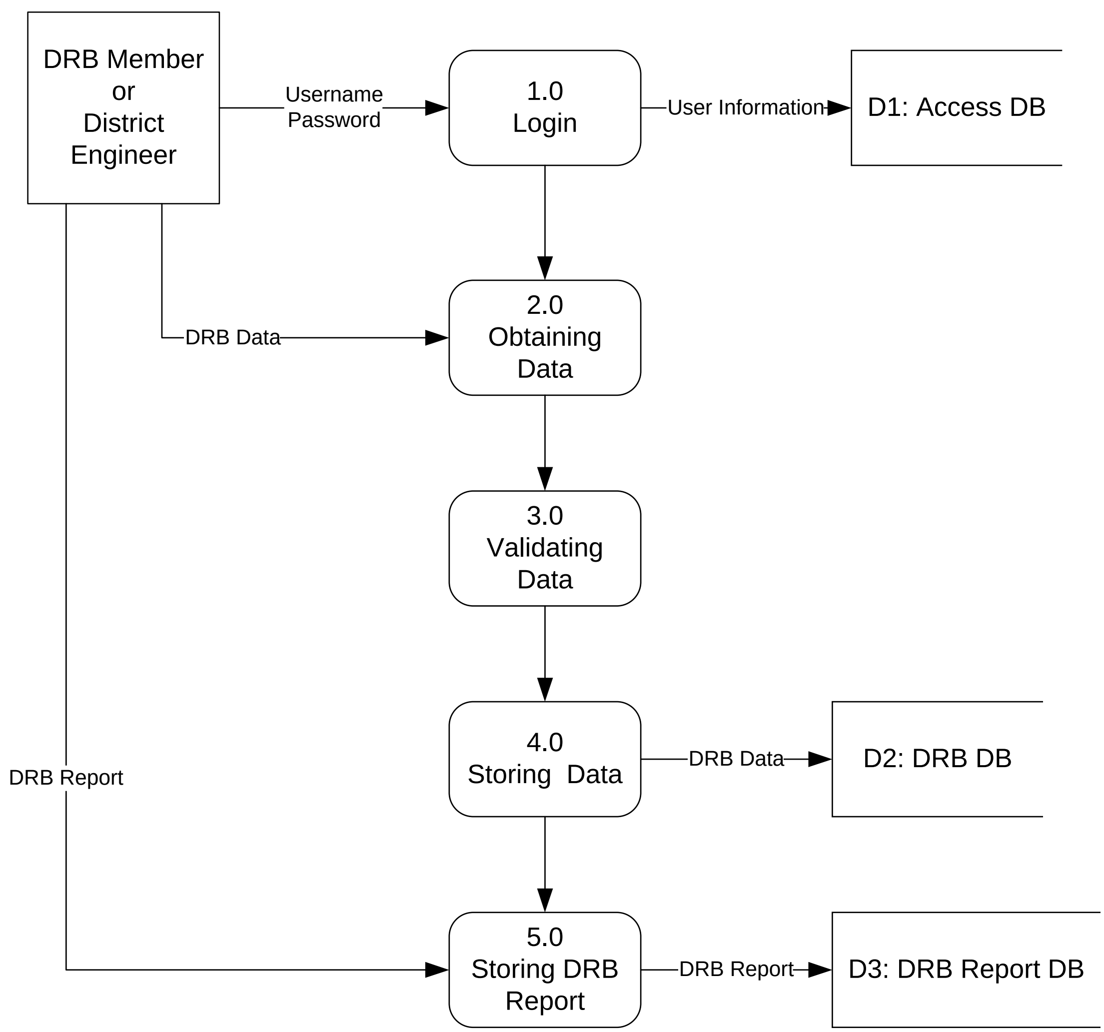


Figure 4-1 a DRB Data Input Process Model

After the completion of the process shown in Figure 4-1, a DRB report is stored in a database. The DRB data, including metadata associated with textual content such as issues, positions, and recommendations, are created and stored to facilitate document search and retrieval. Links between the DRB report and related documents, such as the construction project administration manual (CPAM) and specification sections, are created as well.

4.1.2 Data Modeling

The data model presents an integrated view of DRB reports with metadata (Figure 4-2).

The data model contains six entities including DRBReport, DRBMemebr, IssueMetaData, FDOTReference, ContractorReference, and RecommendationMetadata. The DRBReport captures structured data in a DRB report, links it to metadata with unstructured content (i.e., issues, positions, and recommendations) and to required data stored in other data sources (e.g., DRB member data). Table 4-1 provides a specification of the data associated with the six aforementioned entities.

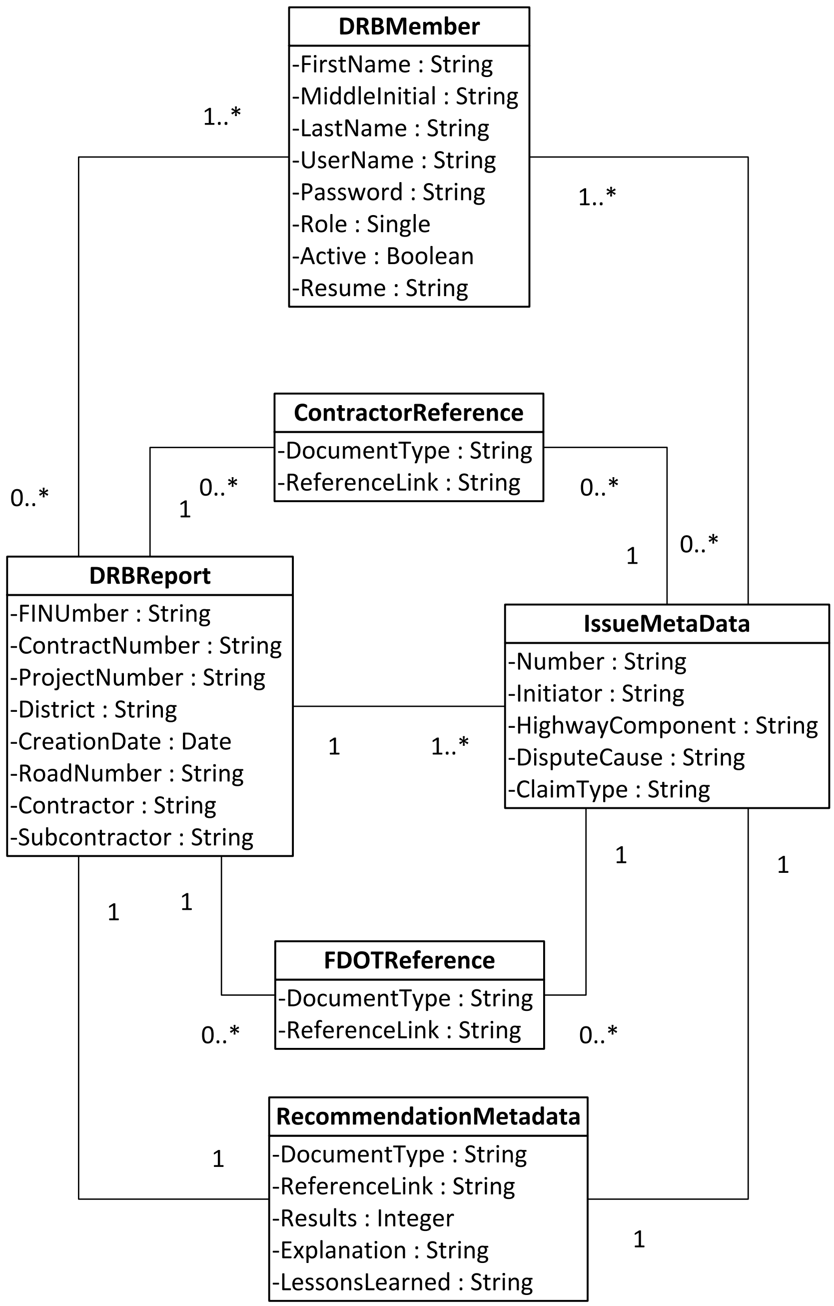


Figure 4-2 DRB Data Structure

Table 4-1 Data Specification of the DRB Data Model

Data Term	Data Type	Description
Entity: DRBReport		
FIUNumber	String with mask	This is the project FIN number.
ContractNumber	String	This is the project contract number.
Project Number	String	This is the project number.
District	Enumeration	This is the eight districts of FDOT
CreationDate	Date	This is the date when the DRB report is created.
Road Number	String	This is an identification of a section of road.
Contractor	String	This is the name of a contractor.
Subcontractor	String	This is the name of a subcontractor.
Entity: IssueMetaData		
Number	GUID	This is a unique string to identify each issue.
Initiator	Enumeration	There are two types, either FDOT or contractor.
HighwayComponent	Enumeration	This includes site work, bridge, pavement and others.
DisputeCause	Enumeration	This includes
ClaimType		
Entity: DRBMember		
FirstName	String	This represents the first name of a DRB member.
MiddleInitial	String	This represents the middle initial of a DRB member.
LastName	String	This represents the last name of a DRB member.
UserName	String	This is the user name of a member who has access to the DRB system.
Password	String	This is the password of the member.
Role	Enumeration	This is the role of a member, which can be Administrator, Engineer or DRB member.
Active	Enumeration	This is the status of a member, which can be yes, or no.
Resume	String	This stores a link to the resume file of a member.

Table 4-1 Data Specification of the DRB Data Model (Continued)

Data Term	Data Type	Description
Entity: ContractorReference		
DocumentType	String	This refers to the type of a target document, either specifications or CPAM.
ReferenceLink	String	This is the link to a section of the referenced target document by the contractor.
Entity: FDOTReference		
DocumentType	String	This refers to the type of a target document, either specifications or CPAM.
ReferenceLink	String	This is the link to a section of the referenced target document by the FDOT engineers.
Entity: RecommendationMetadata		
DocumentType	String	This refers to the type of a target document, either specifications or CPAM.
ReferenceLink	String	This is the link to a section of the referenced target document by the DRB members.
Results	String	This refers to FDOT and contractor’s opinion to recommendation.
Explanation	String	This records the reasons behind the opinion of FDOT or the contractor.
LessonsLearned	String	This datum records lessons-learned from FDOT perspective.

4.2 Integration of Target Documents

Previous discussions indicate that there are two types of data associated with the development of links between a DRB report and certain target documents, such as the CPAM and the FDOT standard specifications. The first, DocumentType, specifies the document type and the second, ReferenceLink, specifies the links to a particular section in the referenced document. This section discusses the process and data requirements to establish links.

4.2.1 Process modeling

There are two steps needed to integrate a DRB report with its target document. Figure 4-3 shows the first step, which is creating and maintaining a document index table.

There are five key processes in the process model (Figure 4-3). These processes include login, creating index table, saving index table, retrieving index table and updating index table. The process of login is the same as the one discussed before. The login process checks the authorization of a user for creating and accessing index tables based on the username and password. Most target documents have a structure, reflected by the level numbers and titles, or can be structured in this way. For example, the structure of the pre-construction division of the CPAM is shown in Figure 4-4.

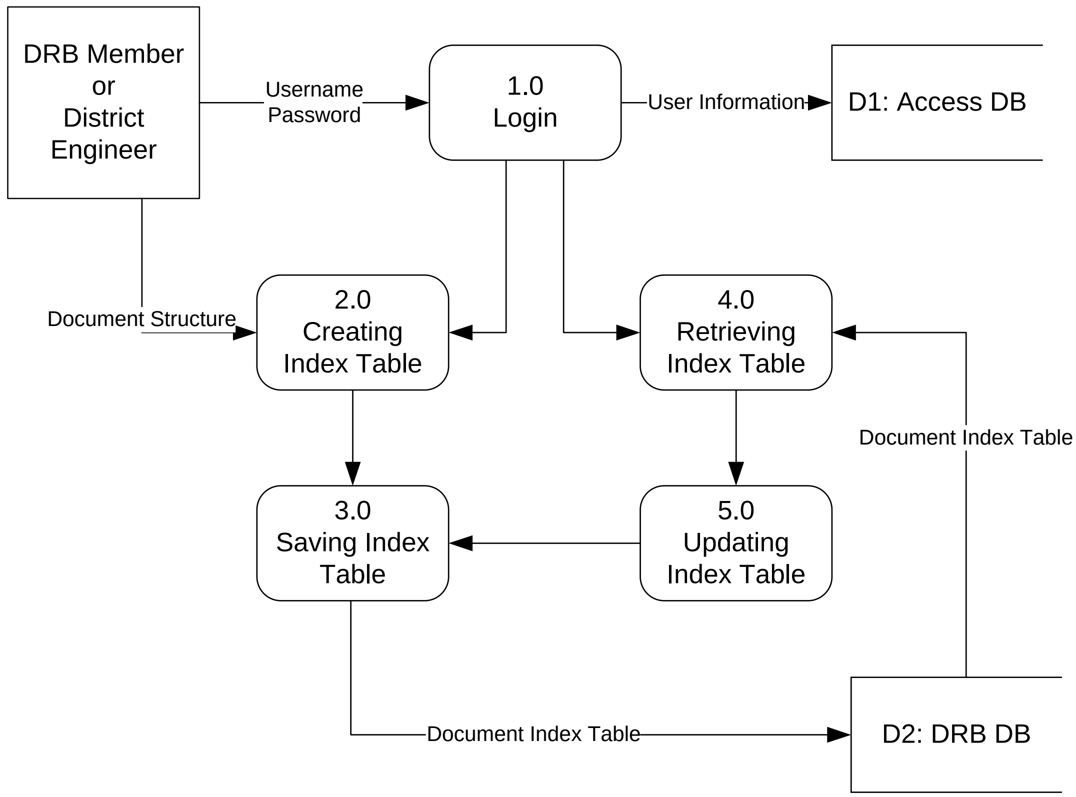


Figure 4-3 Process Model for Creating and Maintaining a Document Index Table

PRE-CONSTRUCTION

Chapter-1 PRE-LETTING ACTIVITIES

1.1 Plans Review and Comments 1-1-1

1.2 Contract Duration and Alternative Contracting Techniques 1-2-1

Chapter-2 OFFICE PREPARATION

2.1 Project Scheduling 2-1-1

Chapter-3 PRE-CONSTRUCTION ACTIVITIES

3.1 Pre-Construction Conference 3-1-1

3.2 Quality Control 3-2-1

Figure 4-4 Sample Document Structure

A tree structure, called an index table, is created in the maintenance module of the system. This structure stores each level number and title so that they can be used to link a DRB report with the particular section of a target document. Due to limitations in the current implementation environment at FDOT, the creation of index tables is a manual process (i.e., sever-side PDF processing is needed to improve this process).

The system administrator or a designated FDOT engineer will create the index table manually and save the index table in a database. If there is any change to the document structure, a new index table will be created by updating the old one or generating a completely new table. In either case, the old index table will be saved. In this way, previously established links will not be broken.

Once the index tables are created, they will be available for use during the "Obtaining Data" step (See Figure 4-1). The process of integrating a DRB report and specific sections of a target document is shown in Figure 4-5.

This process model includes four major steps. The login process is the same as previously discussed. The retrieval of an index table allows a user to obtain the index table of a target document. Once the index table becomes available, a user can select a proper entry in the index table. Finally, the selected entry will be saved together with other DRB data. The entry is the link between terms used in a DRB report and the section of a target document.

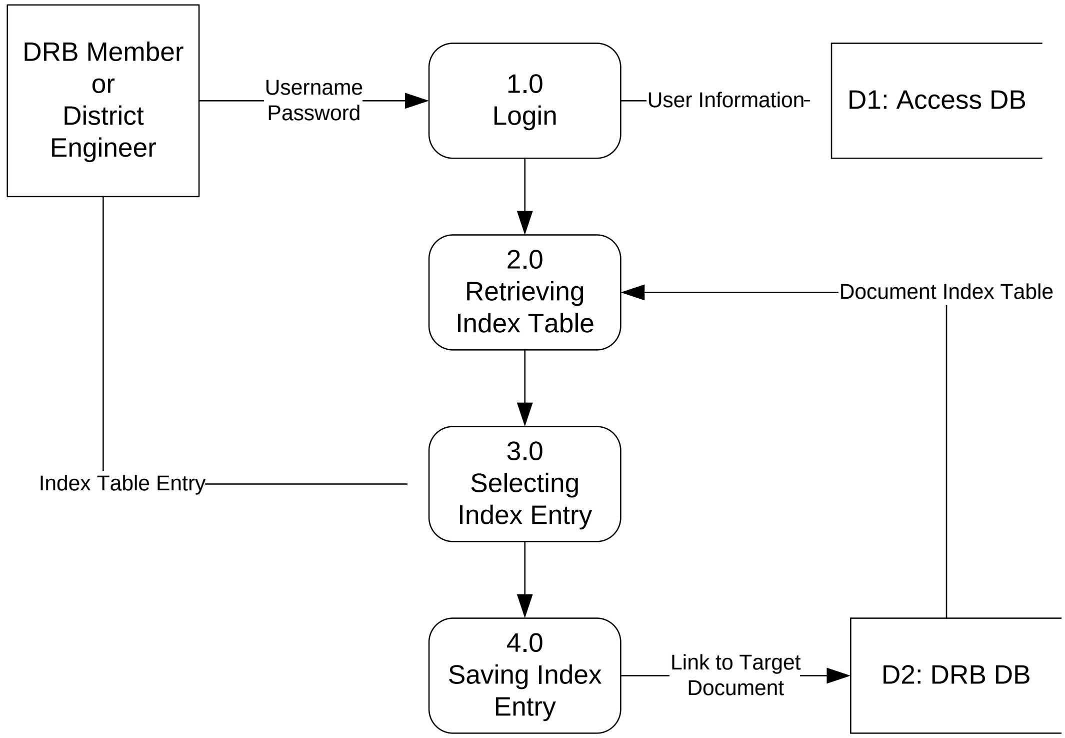


Figure 4-5 Process Model of Integrating a DRB Report and Target Documents

4.2.2 Data Modeling

The data model of the index table is shown in Figure 4-6. The data model contains two entities, IndexTable and IndexEntry. The IndexTable entity holds general information about an index table. The IndexEntry entity contains specific information regarding each entry of the index table. The IndexEntry entity is a self-contained structure that reflects the hierarchical structure of any document.

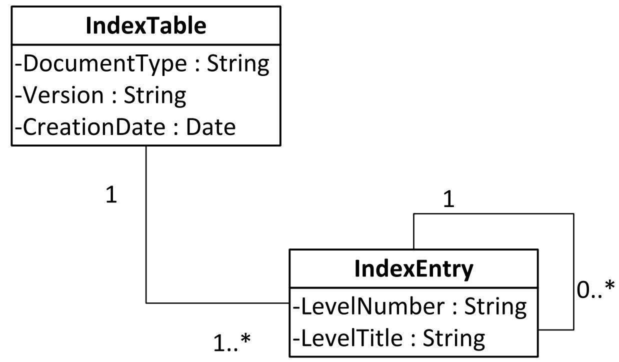


Figure 4-6 Data Model of Index Tables

The IndexTable entity contains three types of data: DocumentType, Version, and Creation Date. DocumentType refers to the type of target document, such as CPAM or specifications. Version refers to the version of the index table for the same type of document. If there are changes to the CPAM, the system will need to maintain a new version so that a DRB report may be linked to multiple versions of the CPAM. The Version data is used for this purpose. CreationDate records the date on which an index table is created. The IndexEntry entity contains two types of data, LevelNumber and LevelTitle. LevelNumber records the level number of a title. For example, the level number for “Project Scheduling” in Figure 4-4 is “2.1.” LevelTitle refers to the title at a certain level, e.g., Project Scheduling. Each IndexTable may contain multiple IndexEntrys and each IndexEntry may have multiple sub-entries. Using this method, a hierarchical tree structure is modeled.

Figure 4-2 shows that the entities, ContractReference, FDOTReference and RecommendationMetaData, have an attribute called ReferenceLink. During implementation, the ReferenceLink is assigned values for LevelNumber and LevelTitle of a target document. The references in the contractor's position (i.e., ContractReference), FDOT's position (i.e., FDOTReference), and the DRB recommendations (i.e., RecommendationMetaData) are connected with sections of a target document.

4.3 Preset Terminology

The system contains many data enumeration types (Table 4-1). The enumeration data type relies on predefined terms, which need to be carefully maintained. The maintenance module of the system allows users to manage the terms. Figure 4-7 shows the process for creating and maintaining the terms.

In addition to login, the process model has four more major steps, creating terms, saving terms, retrieving terms, and updating terms. The terms currently implemented by the system are shown in the following list:

1. **Expertise**: Construction Manager, Civil Engineer, Design Engineer, Estimator, Project Engineer, Researcher, and Residential Engineer.
2. **Cause**: Defective Designs/Specs/Plan, Different Site Condition, General Contract Interpretation, Hindrance, Impossibility to Perform, Pay Items and Quantity, Rework, and Termination.
3. **Claim**: Breach of Contract, Cardinal Change, Compensation, Constructive Acceleration, Constructive Change, Excusable Delay, Others, and Request for Equitable Adjustment.
4. **Highway Component:** Bridge Structure, Others, Pavement, and Site Work.
5. **Districts**: 1, 2, 3, 4, 5, 6, 7 and Turnpike.

6. **Access Role**: Administrator,

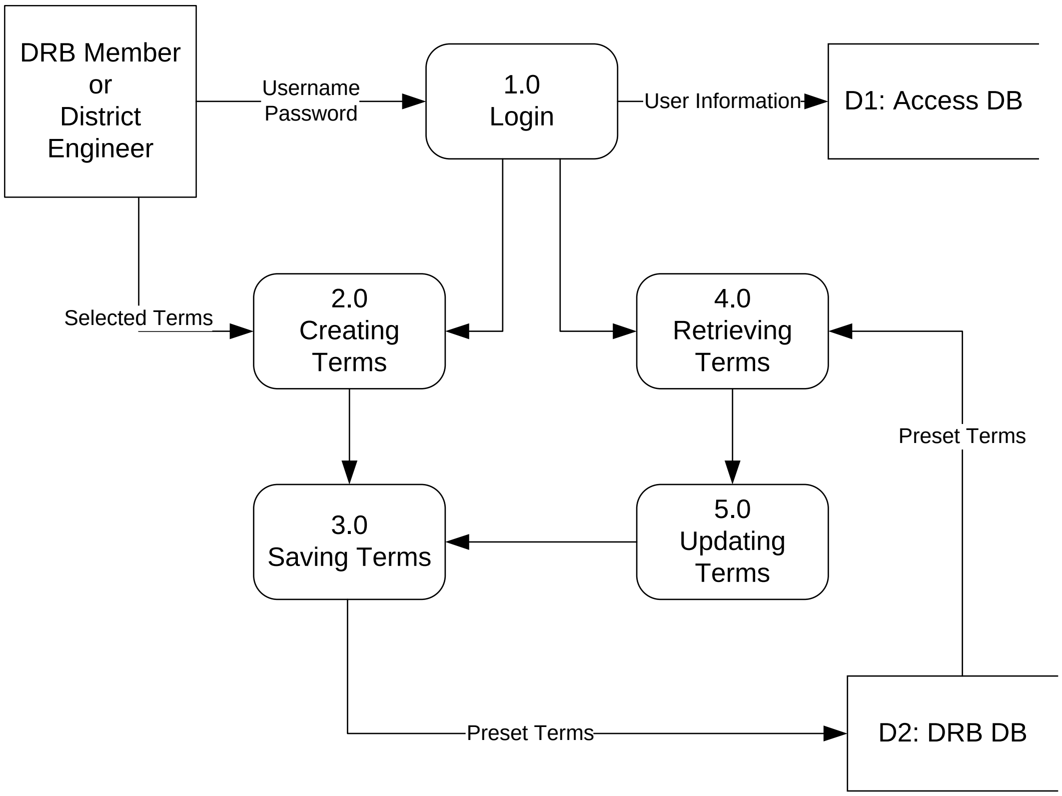


Figure 4-7 Process of Creating and Updating Preset Terminology

4.4 DRB Member Data

This system tracks a list of data that are associated with DRB members, including:

1. **First Name**: Mandatory.
2. **Middle Initial**: Optional.
3. **Last Name**: Mandatory.
4. **Expertise**: Mandatory; a value can be selected from a list in the keywords (See Section 4.3).

5. **Resume**: Optional; a resume of members may be stored in PDF format.
6. **Username**: Mandatory; each member will have a user name that is automatically assigned for login.
7. **Password**: Mandatory; each member will have a password that is set by the system administrator for login.
8. **Active**: Mandatory; this datum determines if a username is active. If not, the member cannot log in to the system.
9. **Access Role**: Mandatory; it defines the role of a member assigned by the system administrator. There are three types of roles: Administrator, Engineer, and DRB Member.

The above data are stored in a member database and used for member analysis. The access control data and the status data (e.g., active) provide an administrative control method for better management of DRB members. The personal data (e.g., name, expertise and resume) provide some basic information about a member. Once a member is assigned to a DRB case, the database can track the history of a member's service on different dispute review boards over time.

4.5 Report Retrieval and Analysis Function

The system provides two complementary mechanisms to support information retrieval and analysis, structured and unstructured information retrieval and analysis. The structured approach relies on DRB data that are associated with each report; the unstructured approach allows a user to search the DRB database based on any chosen keywords. The full text search, an unstructured search, is also supported by Boolean logics. Both approaches display search results in a very similar way.

4.5.1 Structured Information Retrieval

The structured information retrieval is based on the DRB data model. The types of data that can be searched using this model are those shown in Table 4-1. There are two types of searches. The first one, called the basic search, conducts searches that are associated with basic facts of a DRB report, including:

1. FIN number.
2. Contract number.
3. Districts.
4. Creation date.
5. Issue (including claim type, dispute causation, and related highway components).

A user can construct a search from any combination of the above data. For example, the user may search for DRB reports that are related to a certain district on a particular type of claim. A user can also use FIN numbers and contractor numbers to narrow a search.

The second type of search, an advanced search, expands the basic search by allowing a user to set search criteria other than the basic fact of a report. Search criteria can include external documents referenced by the DRB reports or the results of a DRB recommendation (either in favor of contractor or FDOT, etc.).

4.5.2 Unstructured Information Retrieval

The unstructured information retrieval is designed based on the capability of existing text search engines. A user simply needs to input the keywords to conduct the search. In addition, a user can define the logical relationship between the keywords to refine a search.

4.5.3 Search Result Display

Once a document is found based on a set of criteria, the DRB data (See Table 4-1) will be shown with the matching DRB reports. The reference links are connected with the related documents. A user can review the documents that are associated with a DRB report.

4.5.4 Lessons Learned

FDOT district engineers can input lessons learned as text while creating DRB data (See Figure 4-1 and Table 4-1). The lessons learned can be retrieved by searching for DRB reports using procedures discussed in sections 4.5.1 and 4.5.2.

4.6 Maintenance

The maintenance model is designed to satisfy the requirements for managing the system, which includes access maintenance, member data maintenance, and report maintenance. The report maintenance covers preset data maintenance, index table maintenance, and DRB data maintenance.

4.6.1 Access Maintenance

Each member will be assigned a username and a password for access control purpose. There are three types of access roles: Administrator, Engineer and DRB Member. The access rights are defined in Table 4-2.

4.6.2 Member Maintenance

The member maintenance module provides three functions, creating a new member, updating a member, and deleting a member. Data types are defined in Section 4.4. Creating a new member adds the data of a new member to the member database and creates a user profile based on the assigned role of the member. Updating a member modifies information related to a particular member. Deleting a member deactivates a member so that the member cannot access the system. However, the member data are still stored. If a member becomes active again, his/her access rights can be restored via the updating member procedure.

Table 4-2 Access Rights of Different Roles

Type	Access Rights
Administrator	Has full access to all three modules of the website (Input, Analysis, and Maintenance). Can input reports and search through reports (via Text Search or Structural Search). Can also create, edit, and delete member accounts for the website.

	Can edit report metadata as well.
Engineer	Has full access to the Input and Analysis module, but limited access to the maintenance section. Can input reports, search reports, or edit reports. Edit DRB data using the maintenance module. Does not have access to member maintenance.
DRB Member	Has full access to the Input and Analysis module. Can input reports or search through the reports. Has no access to the Maintenance section.

4.6.3 Report Maintenance

The report maintenance module includes preset term maintenance, index table maintenance, and DRB data maintenance. The preset term maintenance involves with adding, revising, and deleting a term. Adding a new term has minimal impact on existing terms because this process simply adds a new term to an existing list. Revising a term has an impact on existing documents that use the old term. After revision, the change will be broadcasted to those documents that have already used the term as part of its DRB data. A new term needs to be selected to replace the deleted term in those affected documents. New documents will use the revised terms. In this way, consistency is maintained. When deleting a term, the system will identify the documents that use the deleted term and require a user to replace the deleted term with a new one.

There is one function supported by the system to maintain index tables, i.e., creating an index table. The types of data captured in this process are shown by the data model (Figure 4-6). If there is any change to a document, a new version is created. The old version will support documents that use the old index table.

The DRB data maintenance updates any errors that are introduced during the DRB data input process.

4.7 Implementation Environment

The DRB system is built using Microsoft ASP.NET (2.0 Framework) along with Microsoft VB.NET. All pages and code are developed using Microsoft Visual Studio 2008. All active server pages (ASP) use Microsoft VB.NET for their server-side code. JavaScript are used in several pages as well. The AJAX Control Toolkit has been used in the implementation of several ASP pages. All database tables are created and managed using SQL Plus and SQL Developer. Oracle Text has been used to create and maintain the indices used for the text search.

The application is designed following a three-tiered architecture. The first tier is the Interface Level and includes all the pages with which users interact. The second tier is the Logic Level. This tier contains all the code that processes the data that is retrieved from the Interface level. Several data structures are created to make the manipulation of this information easier. Most information that is processed at this level is passed into the third tier for storage in the database. The third tier is the Storage Level. It receives data from the Logic level and stores the necessary information in the database. Many functions were developed at this level to make the access and storage of information in the database simple.

5 THE DRB SYSTEM

This chapter discusses the major features of the system that demonstrate the fulfillment of the requirements discussed in the previous chapters. For the details and use of this system, please refer to a separate system user manual.

5.1 Access Control

If a user needs to input data or maintain the system, the user needs to provide a valid username and password (Figure 5-1). The username and the password are assigned by the system administrator.

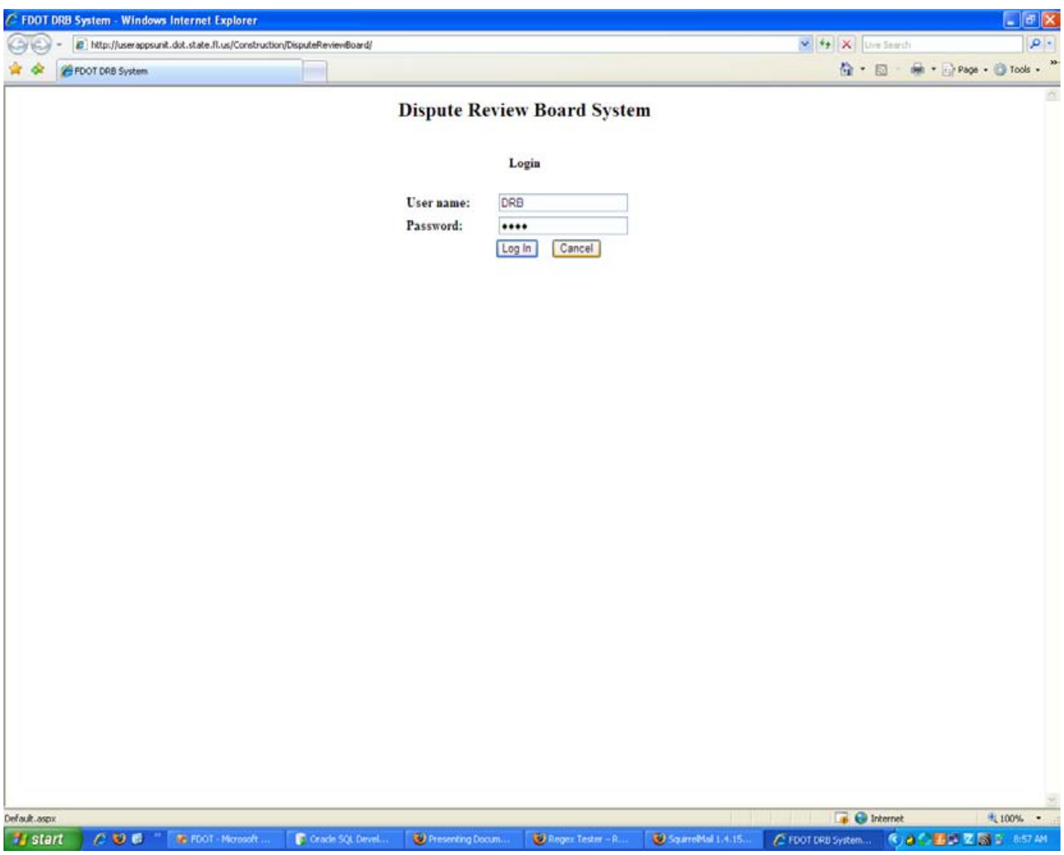


Figure 5-1 System Access

To view the reports and associated metadata, a user does not need a username or a password.

5.2 Information Input Module

The information input module provides a template for users to input DRB data and upload DRB reports to a database. The user can input basic information related to a DRB report such as the report creation date, the district, the project FIN number, the contract number, the contractor and sub-contractor, the project description, the road number, and review board members (Figure 5-2).

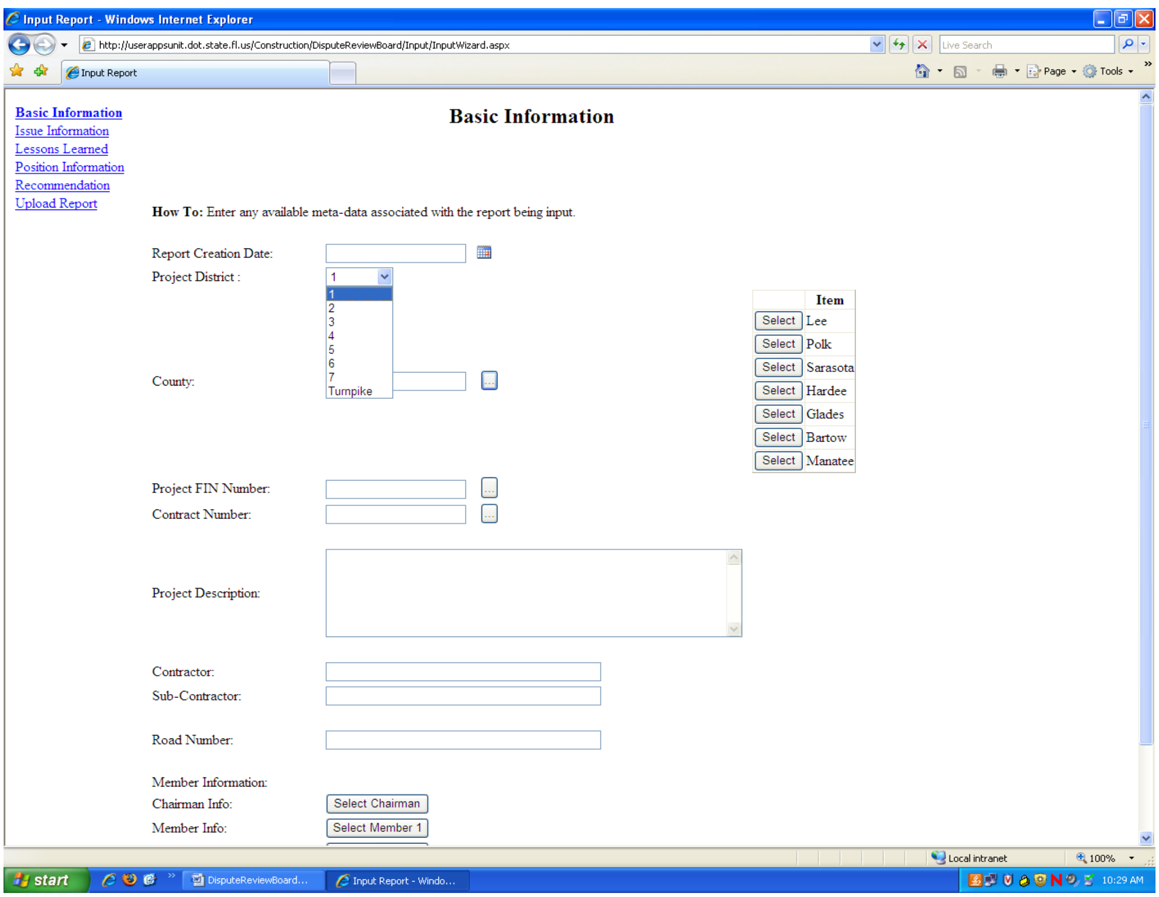


Figure 5-2 Basic Information Input

In addition, templates are created to capture issue metadata (Figure 5-3). A report may be involved with multiple issues. For each issue, the claim type, the cause, the related highway component, and the issue description are captured by the system.

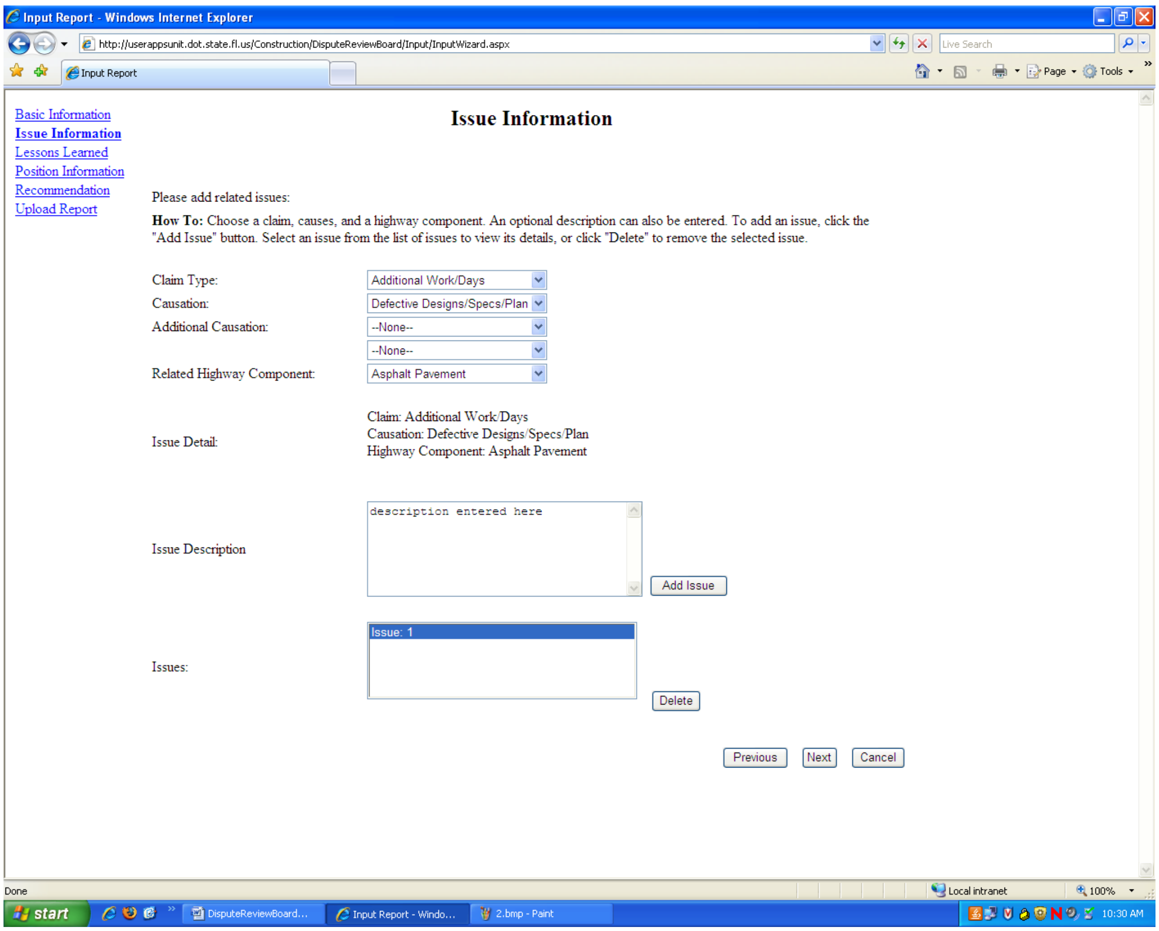


Figure 5-3 Issue Metadata

Then, the system will capture metadata related to the contractor's and the FDOT's positions (Figure 5-4).

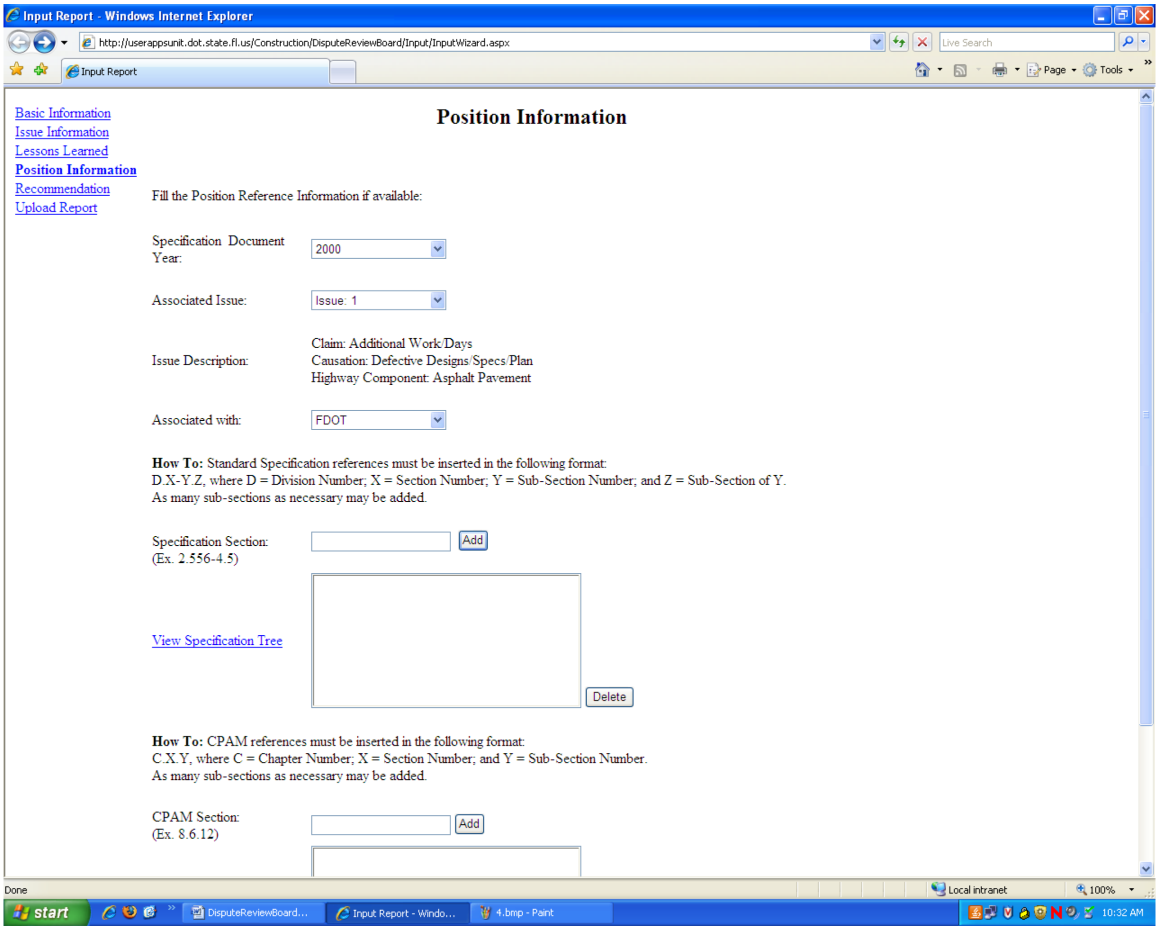


Figure 5-4 Position Metadata

In this case, each position is related to an issue. Links are created because related specification and CPAM sections can be inserted. A user may view the specification or the CPAM document structure from this page. When the user types in a section number, the system will prompt the section title if the number correct. For example, Figure 5-4 shows that a user inputs "2.100-2" for "Specification Section," and the system prompts "Equipment Condition and Approval." By using this system, a user can ensure that the position is linked to the correct section of a target document.

For each issue, a user may also describe the lessons learned that are associated with handling an issue (Figure 5-5). Currently, the lessons learned are processed as text.

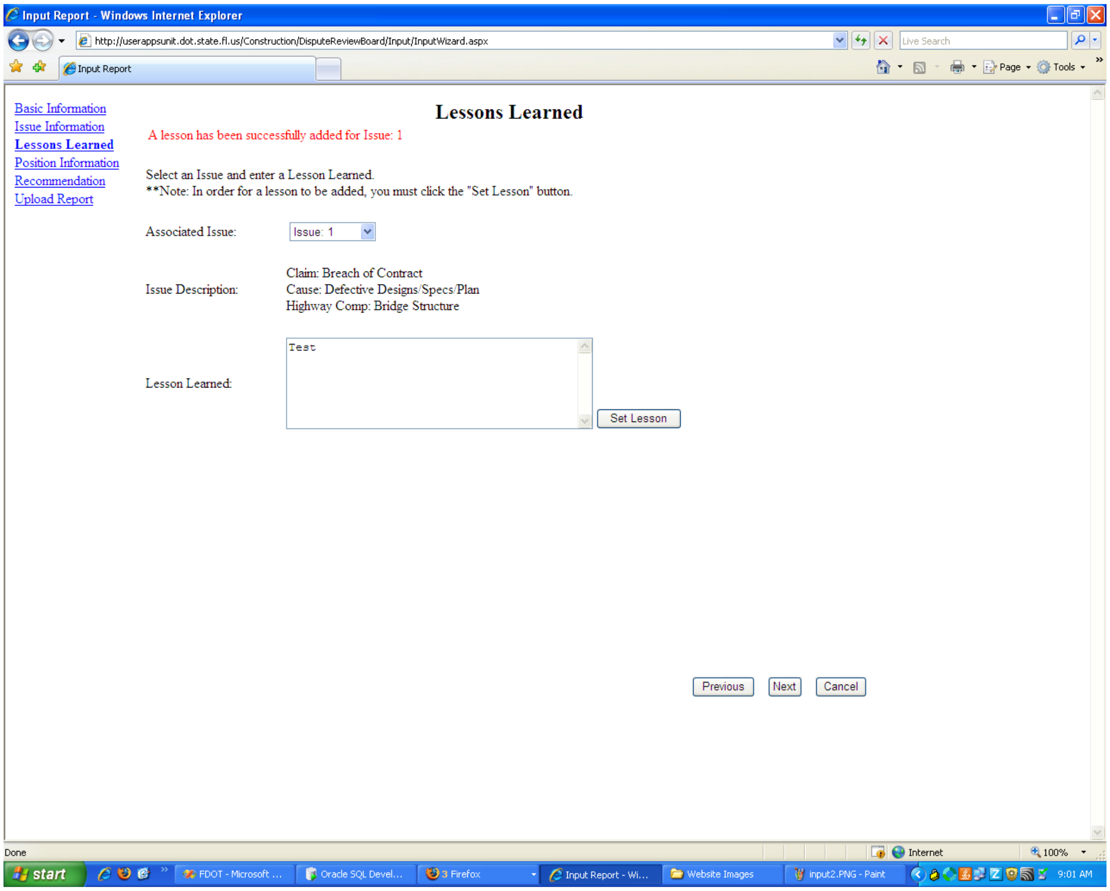


Figure 5-5 Lessons Learned

Finally, a user may capture metadata that is related to DRB recommendations (Figure 5-6). A recommendation is associated with an issue. It contains results and explanations for the acceptance of the FDOT and the contractor.

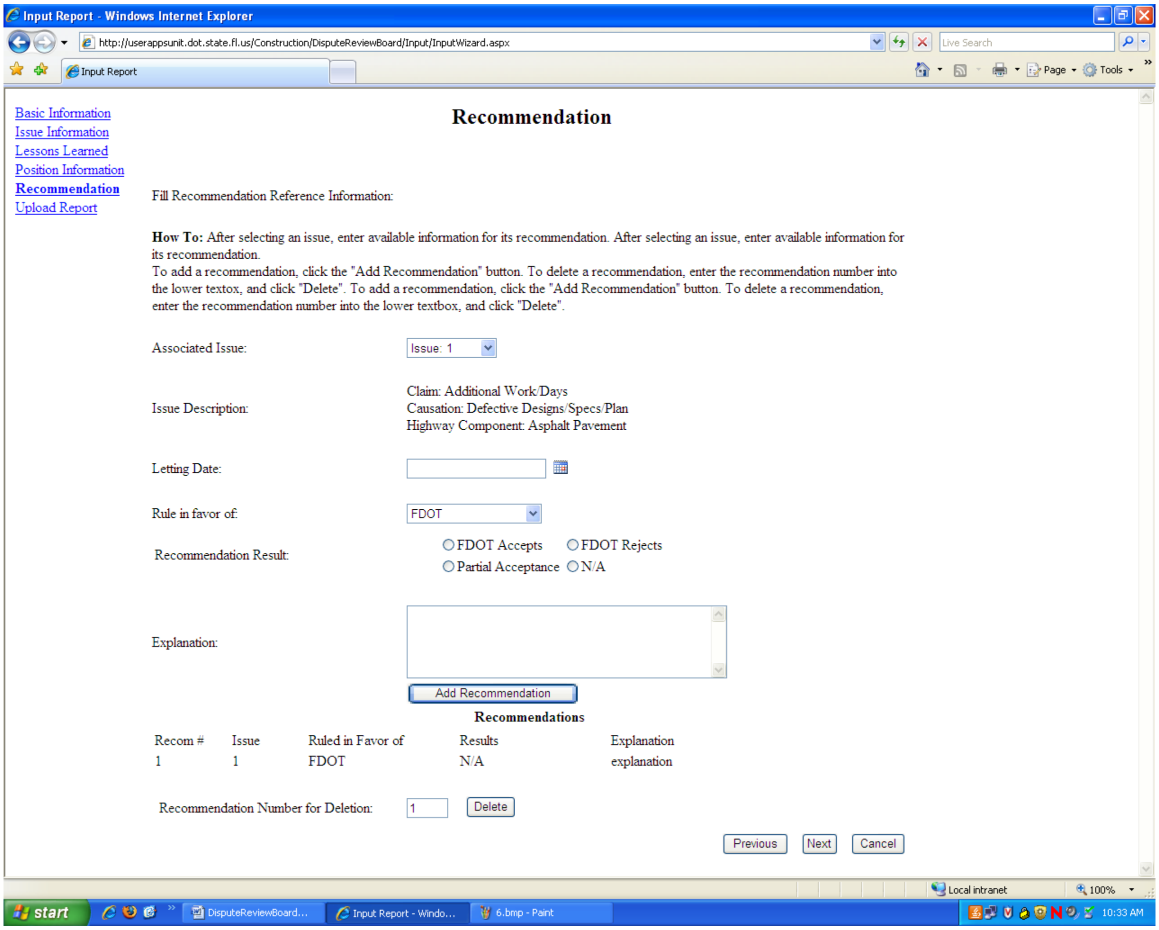


Figure 5-6 Uploading Metadata

Once all DRB data are captured in the system, a user can upload the corresponding DRB report to the system. The DRB reports and their associated data are stored together for future use.

5.3 Report & Member Analysis Module

The report & member analysis module provides both a structured and a full text search of DRB data and reports. These two methods are complementary to each other. The structured search uses the captured DRB data during the information input process discussed in Section 5.2; the full text search only uses the DRB reports that are related to selected user keywords.

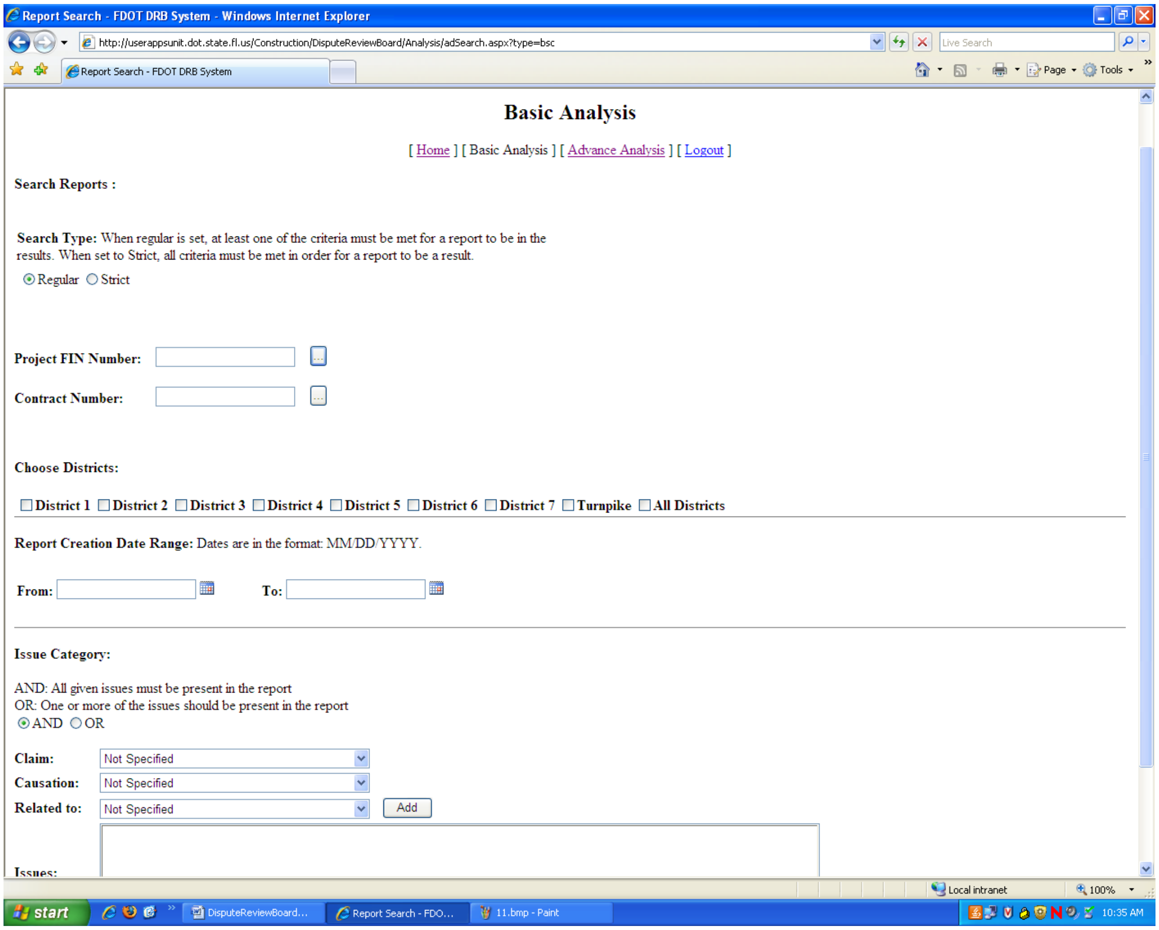


Figure 5-7 Basic Analysis

The basic analysis allows a user to search for DRB reports and other relevant information using a set of pre-defined criteria. The user may define a search with any combination of the data types shown in Figure 5-7. The basic analysis is mostly limited to data types that are directly contained in DRB reports.

In addition to a basic analysis, the system allows a user to search for DRB reports based on data that are not directly contained in the reports. These data include links to the FDOT standard specifications or results of recommendations. This process is considered an advanced analysis in the system (Figure 5-8). In the future, more search capabilities of this type may be added, such as the ability to search by lessons learned.

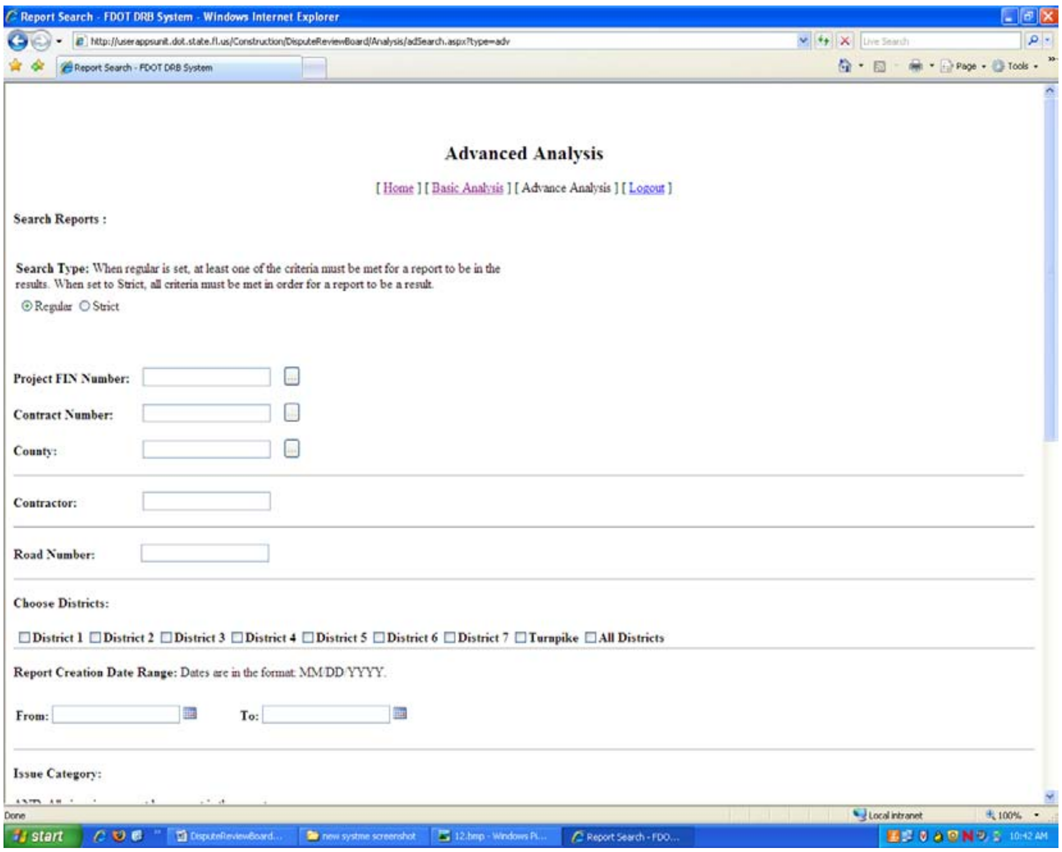


Figure 5-8 Advanced Analysis

The results of a search are shown in Figure 5-9.

Figure 5-9 Search Results

The results contain the following: 1) matching DRB reports, 2) issues and links to other documents, and 2) links to other metadata. The links to other documents can help users identify the sections that are associated with the issue. For example, in Figure 5-9, the sample report “101 PDE” has a link to CPAM Section 100-2. If the user clicks on the link, it will open the CPAM section 100-2 (Figure 5-10).

Due to the limitation of implementable technologies, when a user inputs a high-level section number such as “1” for Chapter One, the search results will not be ideal. The more detailed a section number, the better the search results. In many cases, this mechanism will work because references target documents that are specifically related to a text section and are not general.

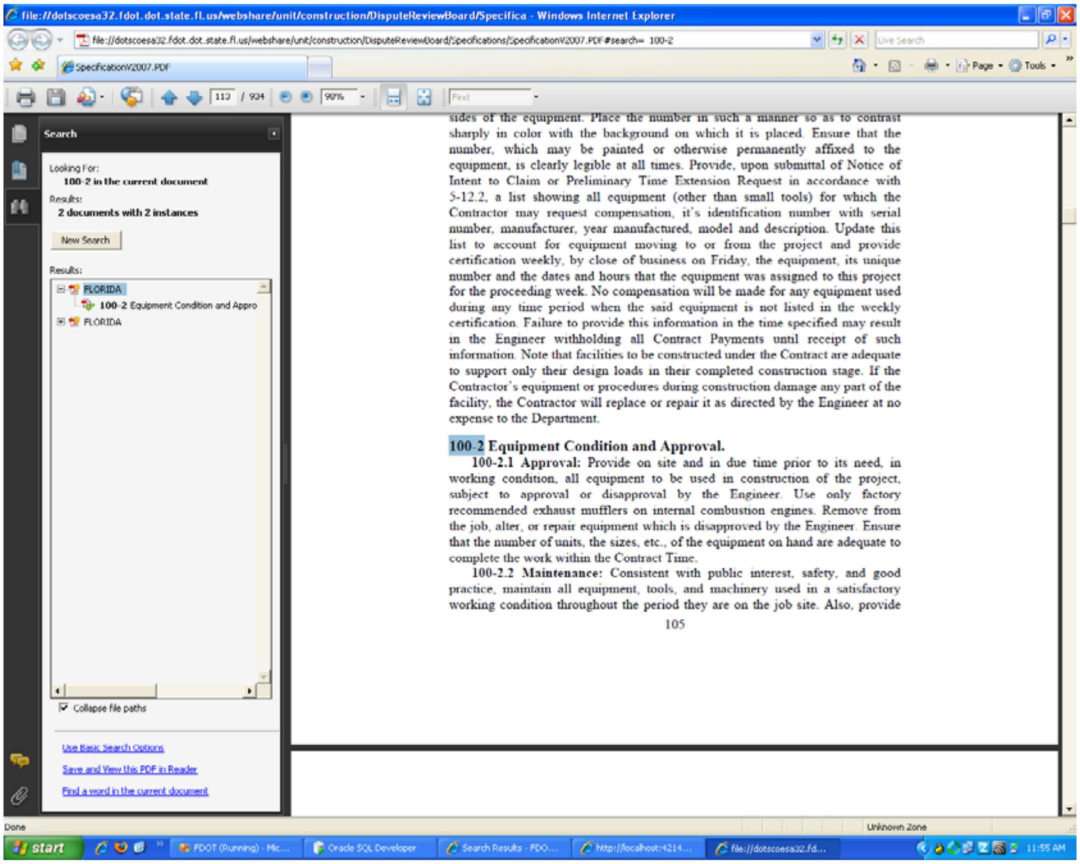


Figure 5-10 Sample Linked CPAM Section

5.4 Maintenance Module

The maintenance module supports member and report information. The member information maintenance allows a system manager to create (Figure 5-11), edit (Figure 5-12), and delete a member (Figure 5-13)

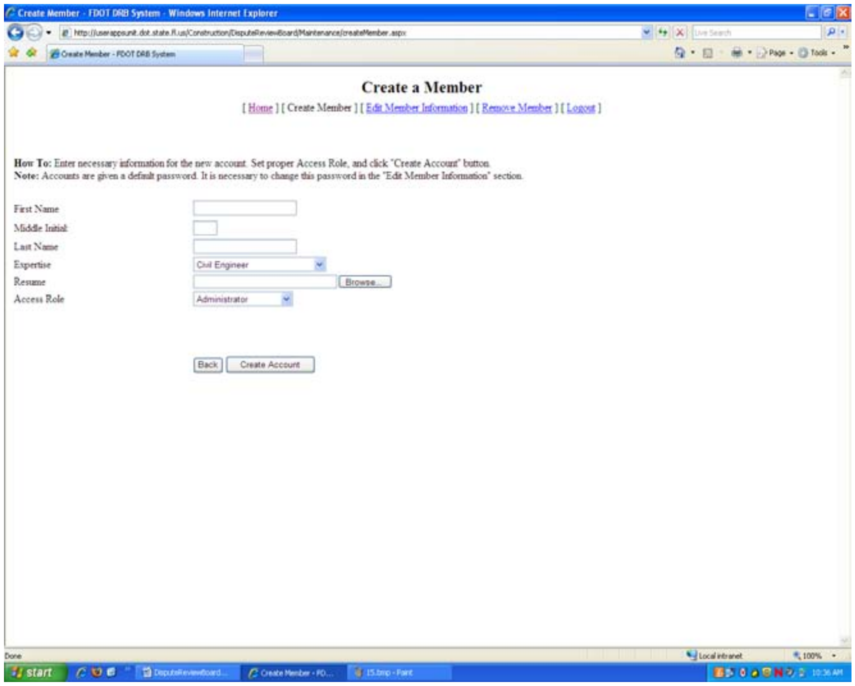


Figure 5-11 Creating a Member

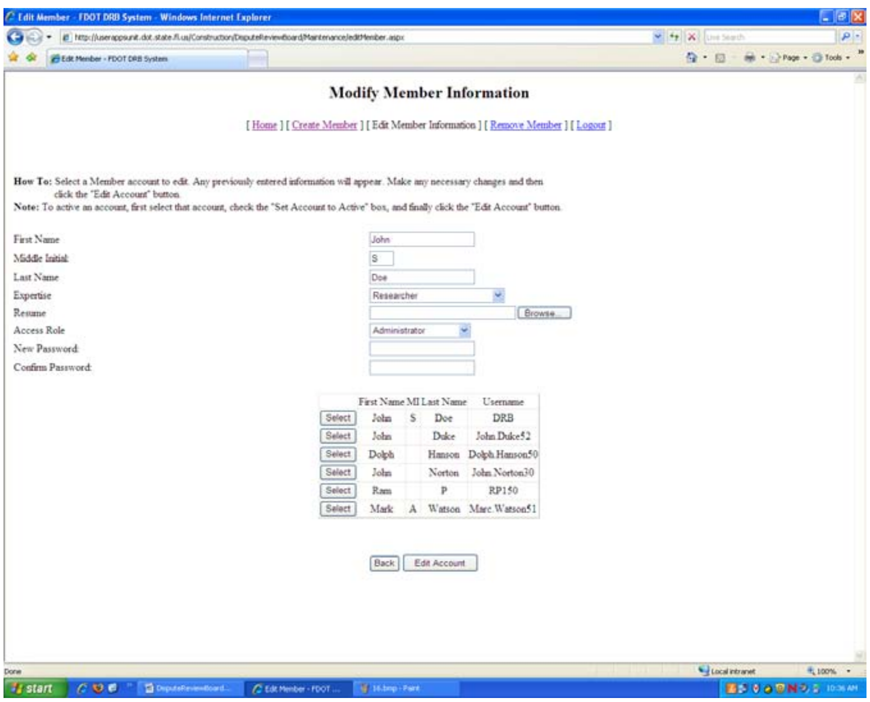


Figure 5-12 Editing a Member

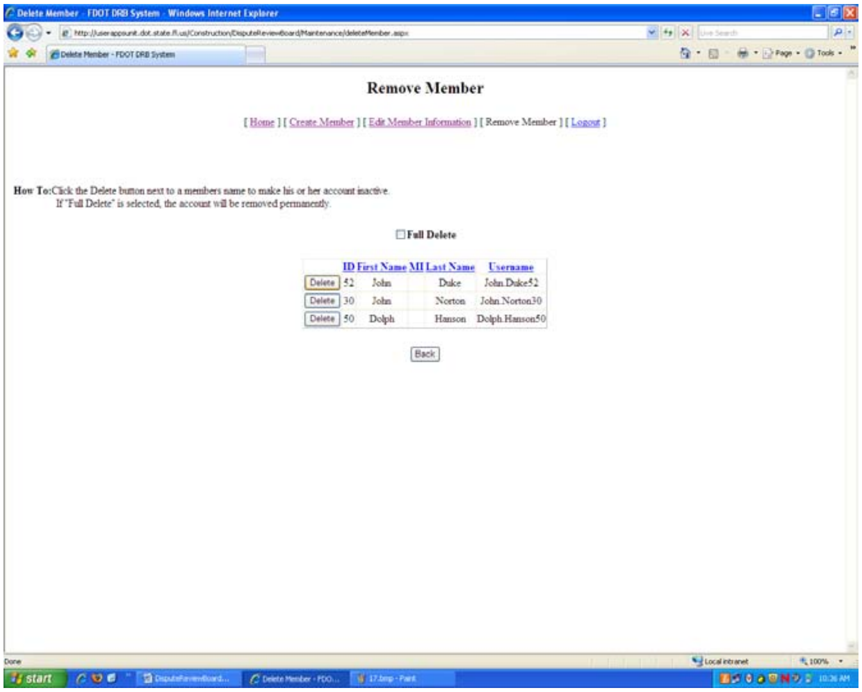


Figure 5-13 Deleting a Member

Report maintenance provides a way to manage the preset terminology, the index tables, the DRB data, and the synchronization of newly input DRB reports. In the system, the function, “Keywords”, refers to the maintenance of preset terms (Figure 5-14). The system allows a user to add, revise or delete a term. The index tree maintenance allows a user to create a new tree or update an existing one (Figure 5-15). The report maintenance allows a user to correct any errors in the previously entered DRB data (Figure 5-16). The user first retrieves a report and then goes through a process that is similar to the information input module (Section 5.2) to update the DRB data. If a new PDF file is uploaded to the system, the system will prompt the system administrator to synchronize. The PDF file then becomes searchable by a text-based search.

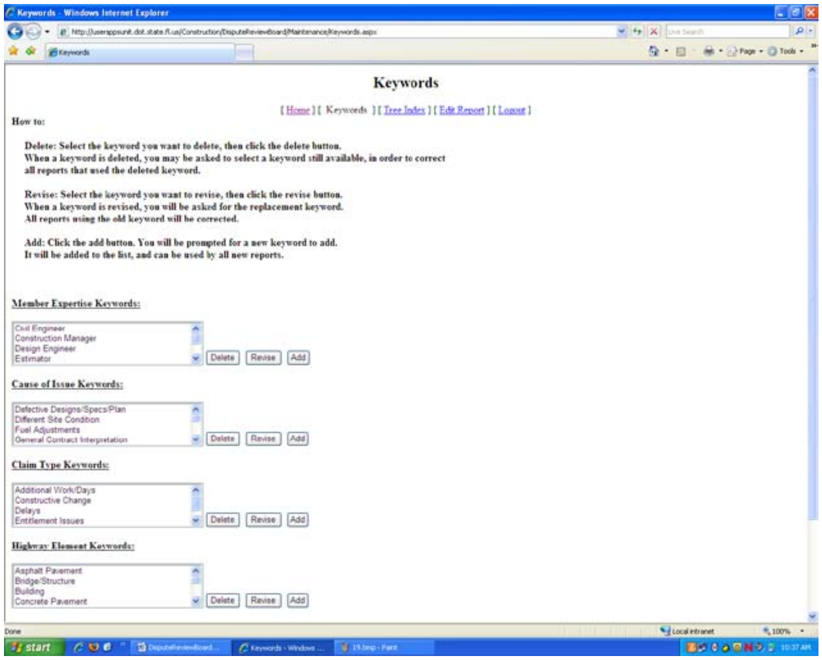


Figure 5-14 Keyword Maintenance

Figure 5-15 Index Tree Maintenance

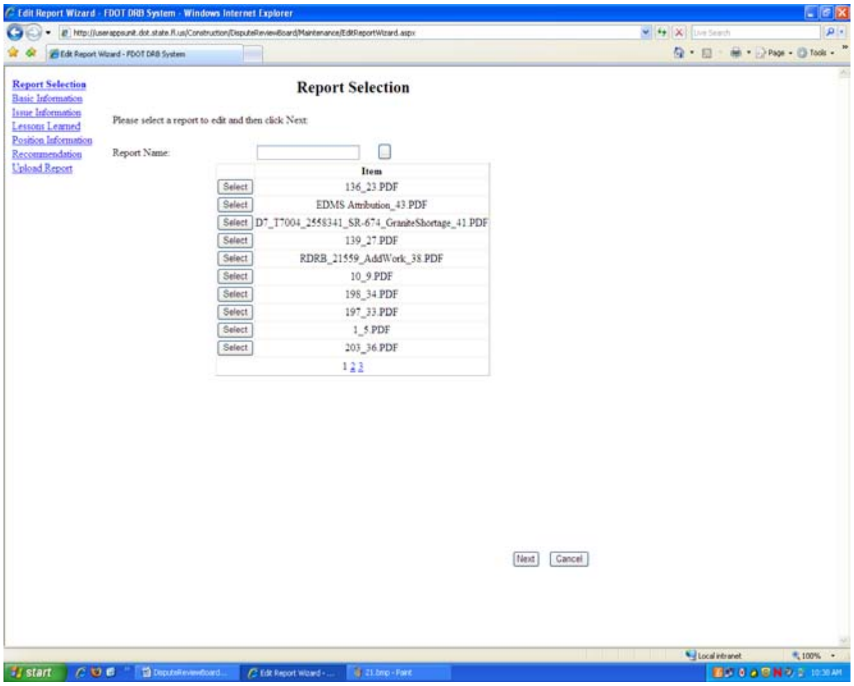


Figure 5-16 DRB Data Maintenance

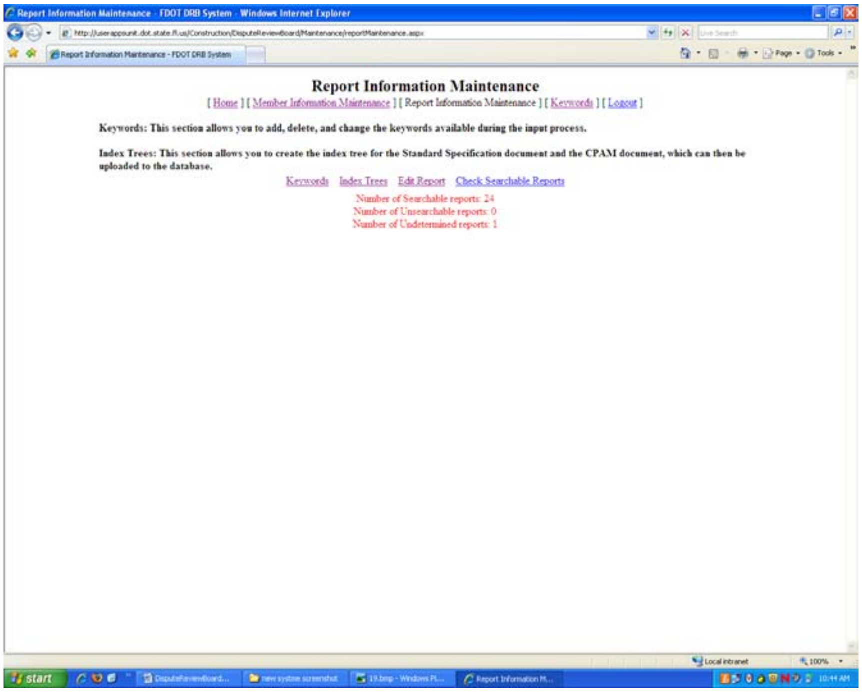


Figure 5-17 Synchronizing DRB Reports to Support Full Text Search

6 CONCLUSIONS AND FUTURE STUDIES

The objective of this study is achieved by implementing a system that uses Oracle-based Web technologies and provides key features including metadata generation, an integrated review process, a simple issue description, member information management, and versatile information retrieval.

The system can help FDOT engineers query DRB reports and perform analysis based on metadata stored in the system. The development of this system is motivated by the fact that there is no information system that assists FDOT to process a large amount of dispute data. Without an improved system, the processing task can be time consuming and costly because engineers must manually manage and search DRB reports.

Even though the new system can improve the existing process of handling DRB reports, the system can be further enhanced in numerous areas. Currently, DRB data such as FIN number, contract number, and creation date are manually entered. This process may be completed automatically with text mining techniques. An automatic process can save FDOT engineer time. However, more studies are needed to investigate the feasibility of this approach.

Additionally, the system treats lessons learned as text. For example, a user can only retrieve the lessons learned by first searching for issues in DRB reports. A direct search for different types of lessons learned and reference DRB cases may be more helpful than the current system. A metadata model of lessons learned needs to be developed in order to perform a direct search.

Finally, more types of external documents should be integrated in the review process. First, FDOT should perform an evaluation of its internal computer systems and data format because not all desired features are easily supported by the capability of the existing systems at FDOT. It would be helpful to develop a strategy before beginning implementation because many technical issues have not been identified. Lack of proper strategies for resolving these problems may be costly and may hinder the implementation process.

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