Development of an Electronic Appraisal System for

Right-of-Way Acquisition

By

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Dedicated to my Father

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The acquisition of Right-of-Way is one of the major tasks involved in most of the highway projects. It is a highly complicated process requiring multiple stages, various participants, and large amount of data and information.

It is the duty of the state Departments of Transportation to ensure that the property owner is fully compensated for the loss of land and resulting damages incurred due to the acquisition of his/her land. This involves valuation of the property being acquired. Normally, an independent fee appraiser is hired by a state Department of Transportation to determine the compensation that has to be paid to the property owner. There is a substantial divergence in values of the appraised properties that are similar in nature by two different fee appraisers. A variety of factors are responsible for these inconsistencies. In spite of the recent technological advances made by the states, the problems still persist.

The objective of this thesis is to develop an Electronic Appraisal System (EAS) that is capable of capturing the appraisal data, transmitting, storing, managing and analyzing the appraisal data, thereby improving the appraisal process and reducing the likelihood of inconsistent appraisal values. A prototype of the proposed EAS has been developed to demonstrate the applicability and features of the new system.

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Glossary

Term	Definition
Appraisal	A written statement independently and impartially prepared by a qualified appraiser setting forth an opinion of defined value of a adequately described property as of a specific date, supported by the presentation and analysis of relevant market information. (FHWA)
Acquisition	The process of acquiring property or some interest therein. (FHWA)
Eminent Domain	The right of the Government to take private property for public use. (FHWA)
Condemnation	The legal process of acquiring private property for public use or purpose through the acquiring agency's power of eminent domain (FHWA)
Parcel	For the purposes of this thesis, the term means any plot of land.
Partial Taking	An acquisition wherein only a part of the property is acquired leaving behind a remainder
Whole Taking	An acquisition wherein the entire property is acquired
Highest and Best Use	The legal use of a property which makes it most valuable to a buyer or the market. (FHWA)
Damages	In some instances, the acquisition, planned use, or the construction may cause a loss in value of the remaining property. Normally, the value of the damage is based on the before and after appraisal or cost to cure. (FHWA)
Just Compensation	The price the Agency must pay to acquire real property. The price offered by the Agency is considered to be fair and equitable to both the property owner and the public. The Agency's offer to the owner is just compensation and may not be less than the amount established in the approved appraisal report as the fair market value of the property. If it becomes necessary for the Agency to use a condemnation process, the amount paid through court will be the just compensation of the property. (FHWA)

CHAPTER 1 Introduction

One of the primary functions of the state Departments of Transportation (DOTs) is to provide safe and reliable transportation facilities to the public. To meet this demand for transportation, construction of new infrastructure facilities such as highways is imperative. The construction effort usually requires a significant amount of right-of-way (R/W) acquisition.

Acquisition of R/W for highways and other transportation improvements can be a complicated process involving multiple stages. The process is further convoluted due to the involvement of various participants with diverse and differing interests. Therefore, it is not surprising that the acquisition of R/W has become a significant part of the total project costs and duration.

One significant component of the R/W acquisition process is the determination of the monetary value to be paid to the property owner by a state DOT to completely compensate the loss suffered by the owner in terms of the value of the land acquired, the improvements acquired and any other financial damages resulting from the acquisition of the property. This process can be extremely complex depending on the type and the location of the property being acquired. In addition, there are a host of different issues that can have an enormous impact of the valuation.

Variations in the valuation of similar or same properties appraised by different individuals or bodies are quite common. According to NCHRP Report 126 [71], "the most important basic reason for divergences in estimates of value is the nature of the value itself. Value is a subjective phenomenon…Real estate valuation is an art that calls for the exercise of experienced judgment based on a logical and justifiable approach; it is an observational process–by no means an exact science." The occurrence of this problem is primarily because of varying degrees of experience,

knowledge and background of the individuals employed to perform the valuation of the property being acquired. Although the severity and magnitude of this problem has been reduced due to the technological advances and institutional experience, the problem still exists.

1.1 MOTIVATION

The motivations for this research are many. First, the problem of property valuation is complex in nature. Generally, this task is contracted to an independent fee appraiser. The value recommended by the fee appraiser is evaluated by the appraisal reviewer at the local district office. The process used for property valuation differs significantly among different fee appraisers. This results in dissimilar price valuations for properties that are alike in nature. The primary factor that causes these differences is the lack of proper data. In fact, according to a NCHRP Report [71], approximately 21% of the R/W valuation divergences occur as an outcome of the lack of proper or insufficient data. Also, many incongruities result from misguided information on the part of the appraiser. Thus, this variation in valuation of similar properties leads to higher appraisal values reducing the purchasing power of tax payer's dollar. Hence, it is essential to determine the data that is required to arrive at the 'just compensation' for the property. Second, the inconsistencies in the appraised values are extremely difficult to detect and can often go unnoticed by the reviewer. It is necessary to develop a mechanism to identify these abnormalities in the property values in order to make the process more efficient. Third, the traditional R/W acquisition system is a paper based system. With the developments in the field of information technology, there is a substantial scope to employ the emerging as well as the established technologies in the field of R/W acquisition to make the system more proficient and organized. Fourth, according to a study conducted by Adkins and Buffington [67], poor documentation of appraisals was a leading cause of discrepancies in more than half of the districts in Texas. Thus, there is a need to accurately store and manage the data effectively. Fifth, there is a substantial delay

experienced in the transfer of appraisals from the appraisers to the reviewers and from the reviewers to the R/W administrators. Additionally, lack of prompt communication between the above mentioned individuals is also an issue. A system that reduces the time required for the entire appraisal submission and evaluation is warranted.

1.2 THESIS OBJECTIVES

The following are the objectives of this thesis. First, to establish the list of data required by the appraiser so as to arrive at the 'just compensation' for a property. Second, to develop a statistical mechanism to reduce the likelihood of inconsistent appraisals by warning the reviewer of variations deemed conflicting with the expected values. Third, to explore emerging technologies for use in the R/W acquisition process. Fourth, to build a system that can efficiently organize, manage and store the appraisal data. Fifth, to develop an effective communication mechanism that would minimize the idle time spent during an appraisal acquisition process.

Thus, the ultimate objectives of this thesis are to develop the conceptual framework and technical requirements of a new Electronic Appraisal System (EAS) that could effectively support the transmission, analysis and storage of the appraisal information, and to construct a prototype of the proposed EAS to demonstrate its capabilities.

1.3 THESIS ORGANIZATION

The organization of this thesis which presents the development of a new EAS is as follows:

Chapter 1 provides the introduction to this thesis, illustrating the motivation and objectives of this research and the organization of the chapters of this thesis.

Chapter 2 focuses on the overview of the current practices followed in R/W acquisition. It starts with the discussion of the traditional practices of R/W acquisition

explaining the various stages in the acquisition process. It presents the commonly used data elements during the valuation process. The chapter then focuses on the recent advances made in R/W acquisition. It presents a discussion on the few electronic appraisal systems and databases that been developed for use by state DOTs and other agencies. Finally, a description of popular commercial software applications for R/W management is provided.

Chapter 3 presents the various components of the EAS. It provides the Conceptual Framework of the EAS describing the data flow structure in the EAS. This chapter also includes the User Functional Needs of the EAS which enumerates the various functionalities required by different types of users employing the system. The chapter then presents the Data Requirement of the EAS listing the data that needs to be included in order to produce a competent and a prudent appraisal report. Technical Requirements of the EAS are also discussed in this chapter. These include the various technical options available to meet the User Functional Needs of the EAS.

Chapter 4 provides the Statistical Process Control (SPC) mechanism of the EAS. The chapter starts by proving a brief overview of the SPC mechanism concentrating on the different implementation strategies. The chapter then presents the generalized SPC mechanism explaining the use of data clustering, a statistical approach of classifying data into homogenous groups, and the selection of a suitable data clustering technique for incorporation in the EAS. The implementation scheme of the SPC mechanism and the sample results from the process are also presented.

Chapter 5 details the design and the development of the prototype of the EAS. It starts by providing a description of the plan that was followed for the development of the prototype of the EAS. It consists of a description of the general architecture, the key functionalities, and the process flow diagram. Then, the chapter explains the design specifications for the EAS. It gives a narrative portrayal of the system architecture and components, as well as other relevant technical information. Finally, the chapter presents a discussion of the scheme followed for testing and validating the

prototype. It lists the various tests and procedures carried out to ascertain the proper functioning of the EAS.

Chapter 6 features the implementation strategies and recommendations for the future production system of the EAS. The chapter provides the various steps that should be followed while developing the implementation version of the EAS. It presents a discussion on the system fine-tuning, system customization for individual state DOTs, and populating the system with real appraisals for testing purposes. Next, the chapter suggests the use of a pilot study to evaluate the new EAS. Finally, the system details the tasks that need to be undertaken in transferring the developed technology to the respective state agency.

Chapter 7 concludes this thesis by summarizing the research and making recommendations for future advancements.

CHAPTER 2 Literature Review and Current Practices

This chapter presents the results of the literature review conducted to develop an effective understanding of the principles and practices followed in the appraisal community. It explains the traditional R/W acquisition procedure followed by the various state DOTs as well as the recent advances made in this field by public and private bodies.

2.1 TRADITIONAL RIGHT-OF-WAY ACQUISITION PROCEDURE

Under the constitution, a State has the right to acquire privately owned properties necessary to provide the public with the transportation facilities. The entire property (whole-taking) or a part of the property (partial-taking) may be acquired depending upon the needs of the transportation project. As has been mentioned earlier, every State has to ensure that property owner is properly compensated for his/her losses. It is the practice of the States to enlist the services of an independent fee appraiser to determine the appropriate value of the property being acquired. The fee appraiser follows the framework specified by the respective state transportation agency to prepare an appraisal report for the subject property.

Conventionally, the appraisal process consists of the following fundamental features: The process begins with an evaluation of the physical land, improvements and the area and neighborhood characteristics that might increase the value of the property. The various data elements that are generally collected as part of the property valuation process are listed in Table 2.1.

Table 2.1: Examples of Data Elements Collected During Valuation Process

Land Characteristics	Improvements	Local Services	Property Use
Size	Structures	Educational facilities	Arts and entertainment
Shape	Paving	Health care facilities	Retail and shopping centers
Topography	Landscaping	Religious facilities	Amount of business and industry
Soil type	Curbs and sidewalks	Public services	
Geographical location	Signage	Utilities	
Land-use type	Transportation facilities		
Access to property	Improvements to surrounding property		
Surrounding land characteristics	Fencing		

Once this information is collected, the subject property, comparable sales and the neighboring area is inspected by the appraiser. The appraiser analyzes this data and the data listed in Table 2.1 in a systematic procedure known as the valuation process, from which the 'best use' of the land is determined. Based on this best use, a monetary value is assigned to the property. In states like Texas, both a narrative appraisal report and a vital information form are drafted by the contracted appraiser and submitted to the DOT for review.

The State makes an offer to the property owner based on this recommendation of the fee appraiser. If the land owner declines the offer, he/she may make a counter-offer to the State. If the terms of the counteroffer are not acceptable to both the parties, the State will institute the authority granted to it under eminent domain as a last resort. Eminent domain is the power given to a State by the constitution to confiscate private

property without the owner's consent, either for its own use or on behalf of a third party. The term condemnation is used to express the act of a government applying the authority of eminent domain. Condemnation proceedings are held at the appropriate State or Federal court, and jury decides the final value for the subject property.

2.2 RECENT ADVANCES IN RIGHT-OF-WAY ACQUISITION TECHNIQUES

In the appraisal process, an enormous amount of data and information is collected. This information is mostly recorded by hand and stored in a hard-copy format. This system of data recording, storage and analysis is not only time consuming, but is also open to error, miscalculation, and misplaced information. A reliable computer-based system that can be used to store, transmit and analyze this appraisal information would prevent the above mentioned problems and improve the appraisal process significantly.

A few electronic R/W appraisal systems have been developed for use at the state DOTs and other institutions. These database systems, such as "Right-of-Way Information System (ROWIS)" in the state of Texas, the "Right-of-Way and Utility Management System (RUMS)" in the state of Virginia, and Bentley's "Projectwise" in the state of Massachusetts have been implemented to help organize appraisal and R/W information so that it may be analyzed, queried and retrieved to aid in decision making. Efforts have also been made by the state of Florida to develop an R/W management system and an appraisal storage system.

Virginia's RUMS tool was developed to help the upper-level managers track construction projects, R/W acquisitions, displaced/relocated persons and the installation of utilities within R/W land. This system provides the managers with an excellent tool to monitor key project dates to ensure that resources can be shifted for on-time completion. RUMS allows a multitude of information, including that from

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appraisals to be entered into a database. It also permits detailed querying and reporting of database information via Cizer reporting software, a Microsoft server-based query reporting tool which utilizes Report Definition Language (RDL). Minnesota DOT has purchased the rights to the RUMS software. A few other DOTs are also considering purchasing the rights.

Florida DOT has also ventured into the development of electronic R/W management tools. They have developed two systems; an appraisal document storage database which stores the R/W appraisal reports, and an R/W management system. The storage document can only store the information from the appraisals. Statistical analysis cannot be performed using the database. Attempts have been made by Florida DOT to implement a Statistical Process Control (SPC) mechanism. The system was created using MS Excel and Visual Basic. These efforts met with little success. They seemed to work well with vacant lands, but they failed to give the desired results for complicated properties.

Bentley's flagship server, Projectwise, organizes the information for each piece of the property into a single electronic folder. It offers the professionals from various stages of the R/W process an option to retrieve information from the folder using a standard web-browser to create summary reports such as the R/W costs associated with the highway projects. Component indexing allows the users to search, query, and navigate all data-base entries. Thus, project-wide reports and statistics can be generated by the users providing them with timely information. Projectwise has been incorporated into the Massachusetts Highway R/W management system.

Another advanced R/W management system is the Right-of-Way Suite designed and developed by Quorum. It integrates the R/W management obligations, such as the payment, with alignment sheet technology. It comprises of various technologies like web viewing, Geographical Information System (GIS), query and

reporting, and site assessment. Web viewing allows the personnel to access the information online and also generate reports using the query and reporting tools. GIS produces integrated maps and the site assessment captures and manages field data surveys and associated documents. It also validates the data and ensures accuracy and consistency.

Microsolve developed a suite of software applications to manage appraisals. They are collectively referred to as Computer Assisted Mass Appraisal (CAMA) Solutions. The system helps in the actual valuation process by offering three types of valuation approaches; the cost approach, market approach and the income approach. The software package includes SPSS which is used for carrying out linear and non-linear regression required for the market approach. The software also has a data storage system to securely save the appraisals.

CHAPTER 3 Framework and Requirements of the Electronic Appraisal System

This research study on developing an Electronic Appraisal System (EAS) for R/W acquisition was a pool-funded project. Thus, the proposed EAS is based on the needs and the requirements of the state DOTs participating in this research project. This chapter deals with the various components and requirements of the proposed appraisal system. It discusses the determination of the functional, operational, data and the technical requirements of the proposed EAS.

In formulating the various requirements of the EAS, the research team worked extensively with the consultants from the appraisal industry. Also, because of the pool-fund nature of this project, the participating state DOTs were requested to provide information and advice on critical issues concerning the entire development of the EAS. Various technical memorandum were prepared and these documents were sent to the participating state DOTs, as a survey, for their ratings and comments. These documents dealt with the conceptual framework of the proposed system, the user functional needs and the data requirements of the EAS.

The sections that follow provide a summary of the survey and illustrate the Conceptual Framework, User Functional Needs, Data Requirements and Technical Requirements of the EAS.

3.1 SUMMARY OF THE SURVEY RESULTS

This section gives an overview of the survey conducted, results obtained, and actions taken. The survey was sent to the participating state DOTs to gather their input on the Conceptual Framework, the User Functional Needs and the Data Requirements for the Electronic Appraisal System (EAS). The research team with the

help of TxDOT's Right-of-Way Division as the contact point sent the survey documents to the thirteen participating state Departments of Transportation (DOTs) for their ratings and comments. The reviewers and the appraisers from the respective states were requested to assign a score on a scale of 1 to 5, with 5 being the highest, about the usefulness and applicability of the various components of the conceptual framework, functional needs, and the data requirements. Responses were received from ten DOTs, as summarized in Table 3.1 that follows.

Table 3.1: Survey Responses from DOTs

State	Conceptual Framework	User Needs	Data Requirements
Alabama	No	No	No
Alaska	No	No	No
Florida	R	R and A	R and A
Idaho	R	R	R
Illinois	R and A	R and A	R or A
Louisiana	R and A	R and A	R and A
Mississippi	R	R	R
Montana	R	R	R
New York	No	No	No
North Carolina	A	No	No
Texas	R	R	R
Washington	R or A	R or A	R or A
Wisconsin	R	R	R
Note: R = the Reviewer; A = the Appraiser			

The responses received from the participating state DOTs were now analyzed using Delphi Technique. This technique intends to reach a consensus about a particular opinion using surveys, questionnaires etc. It replaces direct debate and

committee activity with a carefully designed program thereby reducing the influence of certain psychological factors such as bandwagon effect.

The responses in general were very encouraging. In fact, the rankings received for the User Needs and Data Requirements were very high for almost all the sections. Most of the comments were positive and were in agreement with the philosophy of the research team. Some suggestions were made that helped the research team better understand the appraisal process being carried out in other participating states. There were some apprehensions about a few aspects of the process. These concerns were given careful attention and incorporated while revising the Conceptual Framework, User Functional Needs and Data Requirements of the Electronic Appraisal System (EAS). No significant comments were received for the EAS Data Requirements. Some of the important comments and conclusions of the survey process are highlighted as follows.

1. Based on the comments from the DOTs, it was decided to develop a web-based system as opposed to a File Transfer Protocol (FTP) system. Also, the survey helped make a decision that an appraisal can be changed only by the appraiser who has originally prepared the appraisal.

2. One of the most important outcomes of the survey was to clear the misunderstanding surrounding the use of the Statistical Process Control (SPC). Many participating DOTs had suspicions about the SPC and the part it would play in the appraisal process. It was explained to the DOTs that the SPC mechanism was only for guidance to support the reviewer during the review process. The reviewer would be the final judge regarding the acceptability of an appraisal report submitted by the appraiser.

3. Another important finding of the survey was the idea that the history of an appraisal report should be kept in the records in some manner. These appraisals, as part of the history, would not be mixed with the approved appraisals to protect the sanctity of the database. They would be stored in a different folder in the permanent database.

4. There was some confusion about the summary reports that would be generated at the end. Clarifications were given to the DOTs informing them that the summary reports pertained to the various analyses performed on the appraisals stored in the permanent database by the R/W staff.

5. The DOTs requested for clarifications and provided their suggestions about allowing flexibility in the appraisal form to cater to complicated situations that could not be predicted. The researchers agreed with the DOTs and decided to provide comment boxes where ever possible to accommodate that situation.

6. The DOTs were in agreement that the entire report should be in electronic format with the option to print the report.

7. The DOTs were very positive about the provision to automatically send the reviewer's comments to the appraiser and the appraiser's response to the reviewer electronically. They felt that it would go a long way in speeding up the appraisal process.

8. There was some confusion about the range of values that would determine the consistency of the input data. The research team clarified that the range was only in key values for the reference of the reviewer and that the data entry outside this range was not necessarily wrong. The reviewer would make the final decision about its acceptability as was the case with any other data input.

9. To reduce the confusion surrounding the SPC, the research team rephrased the appraisal approval process sections to make it known to the DOTs that the appraisal would only be approved by the reviewer, not by the SPC.

10. There was some confusion about the permanent database with different states having their own requirements and access issues. It was decided to leave the issue of accessibility to the permanent database to the individual state DOT.

To summarize, the participating state DOTs were in agreement with the majority of the work that was done by the research team. Some clarifications were sought and useful information and suggestions were provided by the DOTs. The researchers then made an earnest effort for integrating the necessary changes by suitably incorporating the recommendations made by the DOTs. The final versions of the Conceptual Framework, the User Functional Needs and the Data Requirements are presented in the sections as follows.

3.2 CONCEPTUAL FRAMEWORK

This section lies at the core of the EAS. It lists and explains the various components of the system. It elucidates the entire process envisioned in the proposed EAS. The framework for the EAS was prepared by the research team based on the performed literature review and fine-tuned with comments provided by the participating state DOTs. Figure 3.1 gives a schematic representation of the Conceptual Framework of the EAS. The following is a brief description of the various components of the Electronic Appraisal System as shown in Figure 3.1.

A) Field Data Acquisition

The first step in performing a Right-of-Way property appraisal is field data acquisition. This stage involves gathering basic information vital to making a value estimate. Data pertaining to site characteristics, such as physical features and

Field Data Acquisition

Electronic Appraisal Form

File Transmission

Queue Database (Temporary)

Statistical Process Control (SPC)

Flagged

Alert Appraisal Reviewer of Need for In-Depth Review

Appraisal Review

Notify Appraiser of Need for In-Depth Review and Adjustment

No

Appraisal Acceptable?

Yes

Update Database and Notify R/W Personnel

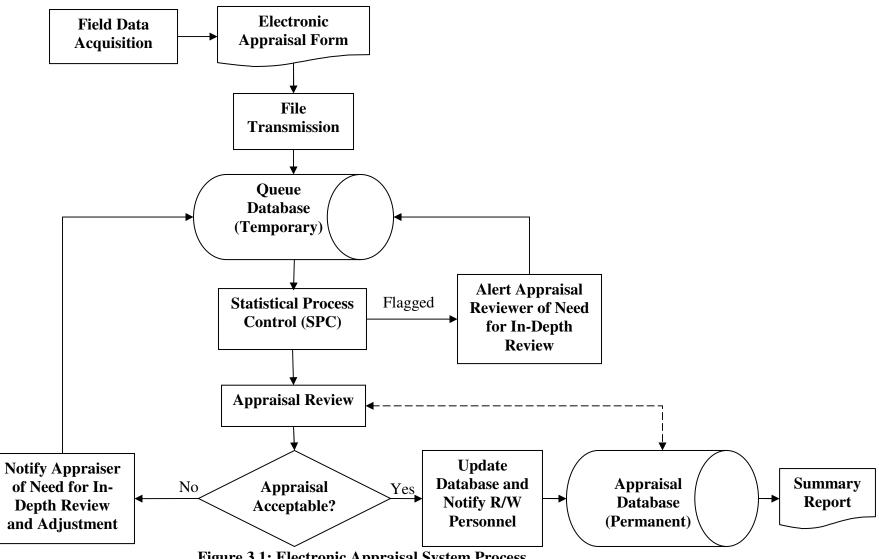**Appraisal Database (Permanent)**

Summary Report

Figure 3.1: Electronic Appraisal System Process

dimensions, is collected on-site by the appraiser and recorded in either paper or electronic format. The key data elements to be collected during field data acquisition are identified under the section 3.4 of this thesis. Defining a unique acquisition procedure and recording mechanism to be used during field data acquisition is outside the scope of the thesis and therefore, is not covered.

B) Electronic Appraisal Form

After the property data has been gathered in the field and sufficiently developed with other data to make a conclusion of value, it is converted into an electronic format compatible with the Electronic Appraisal System (EAS). All data, along with background information pertaining to the appraiser, the property owner, and other interested parties, is loaded onto the standardized electronic appraisal form. This process is accomplished by uploading the necessary information into the appropriate data fields through a web-based user interface accessible with a personal computer. This process is completed by the appraiser.

The standardized electronic appraisal form contains data fields for narrative, pictorial and numerical information. The form is stored and transmitted electronically, reducing the need for a hard copy of the appraisal. Once all the data has been uploaded, the standardized electronic appraisal form may be printed.

C) File Transmission

Once the appraiser has gathered the required property data and converted it to the standardized electronic form, the electronic appraisal form is transmitted from the office of the appraiser to a centrally located, temporary queue database via a secured electronic interface. This transmission is performed by a web-based interface. Upon file transmission, the electronic appraisal form will receive an electronic signature, verifying its authenticity.

D) Queue Database for Review

Upon successful transmission of a completed electronic appraisal form to the centrally located temporary queue database, it should be protected from tampering by unauthorized persons. Queued appraisals should be accessible only by those authorized parties that need to view, modify or suspend the appraisal as necessary. Authorized parties include the appraiser, appraisal reviewers (including contract reviewers) and a limited number of DOT right-of-way personnel. An appraisal can only be modified by the appraiser who prepared the appraisal. The function of the temporary queue database is short-term storage of the appraisal while it is being reviewed by appraisal reviewers. The short-term storage will last until the report has been approved by the reviewer and/or DOT.

E) Statistical Process Control

Initiated by DOT right-of-way personnel, the statistical process control examines and checks all critical values on the electronic appraisal form against historical appraisal information currently stored in the permanent electronic appraisal database. The purpose of the statistical process control is to identify and flag any information contained within an appraisal that falls outside of historical and/or known levels of acceptability. The reviewer will be the final judge about the acceptability of an appraisal. SPC will only serve as guidance for the reviewer.

F) DOT Approval Process

The appraisal reviewer performs the review at this stage and considers if any of the flagged data needs correction, verification or analysis by the appraiser. If the information contained in the appraisal in its current form is deemed acceptable and approved by the appraisal review process, the appraisal is transmitted to the permanent electronic appraisal database for storage. Any appraisal that is found to contain inconsistent information by the reviewer is not loaded to the permanent storage and notification is sent to the appraiser with details outlining those elements

that were deemed inconsistent. Appraisals containing information outside of acceptable limits require a more detailed review by the appraisal reviewer; based on the review outcome, revisions by the appraiser may be required in order for that appraisal to be deemed acceptable.

G) Appraisal Database

Only those appraisals accepted by the appraisal review process are uploaded to the permanent electronic appraisal database. Appraisals stored in the database may be accessed only by personnel authorized by DOT for later use.

H) Summary Information

All appraisals stored in the permanent database are available to authorized Right-of-Way personnel to perform various analyses and to generate summary information. This summary information may be viewed on personal computers and printed.

3.3 USER FUNCTIONAL NEEDS

After the conception of the framework for the EAS, in order to allow the various tasks and processes envisioned for the EAS, it was necessary to generate the functional needs and capabilities that are required by the users of the proposed EAS. The users of the system comprise of the appraisers, the reviewers and the R/W administrators. As can be imagined, each user type has a specific requirement and performs various functions using the EAS.

The EAS consists of the six major components and processes namely, Appraisal Form, Data/File Transmission, Queue Database for Review, Statistical Process Control, Approval Process, and Permanent Appraisal Database. The User Functional Needs determined as part of this research aim at simplifying the entire process of appraisal generation, transmission, review and storage. The following is a

list of the User Functional Needs broken down into six categories representing each of the major components and processes of the System: Appraisal Form, Data/File Transmission, Queue Database for Review, Statistical Process Control, Approval Process, and Permanent Appraisal Database.

3.3.1 Appraisal Form

A) One electronic appraisal form with the option of being expandable. Expandability removes the need for multiple forms (i.e. "complex" and "non-complex" forms). The level of expandability should be determined by the valuation approach used during the appraisal process.

B) All of the primary sections, such as the neighborhood analysis and the value of property, should be included in the electronic appraisal form.

C) Numerical values, check boxes and drop-down lists should be used as much as possible to help standardize input data and reduce the likelihood of misinterpretation of the information included in the appraisal.

D) For security purposes, the electronic appraisal form should contain a mechanism for authenticating the user.

E) The electronic appraisal form should contain a provision for including visuals such as plats and pictures. The visuals required are function of the type of appraisal being completed.

F) The electronic appraisal form should include a cover page with essential information such as the certification of the appraiser and executive summary. The specific page can be altered by the individual states.

G) The electronic appraisal form should require the identification and justification of the valuation approaches used during the appraisal process.

H) Navigation and control mechanisms should be provided to ensure that all of the required data fields are completely filled with valid data.

I) A mechanism should be included to allow the appraiser to "save" input information on a personal computer and/or temporary database location so that the appraisal form can be completed in stages.

J) A mechanism should be provided to use existing standard information and/or appraisals for the creation of templates.

K) The finished report (complete or abbreviated format) should be in electronic format such that it can be easily available in printable versions. Hard copies can be generated as needed.

L) The electronic appraisal form should include a summary page with statistical information that can be transmitted directly into the permanent database.

M) A printable version of the complete report, including both the form and attachments, should be available.

3.3.2 Data/File Transmission

A) The system should have a mechanism to retain a copy of the original acceptable appraisal in the database. States have the option to archive earlier versions.

B) A provision for automatically sending reviewers' comments back to the appraiser and corresponding district R/W office/ Central R/W office should be included in the system.

C) A quality control mechanism for the appraiser to review the submittals to ensure that all data fields are completely and accurately filled must be provided.

D) The system should have a mechanism to review the appraisal history for the property (i.e. multiple appraisals for a single piece of property).

E) E-mail confirmation/notification of the successful submission of an appraisal should be sent to all parties involved in the process.

3.3.3 Queue Database for Review

A) The database should be accessible to the appraisers, the reviewer, and corresponding R/W personnel with controlled privileges.

B) The database must maintain the option to overwrite the previous version of the appraisal until it is finalized. This feature will be given only to the appraiser until he officially submits the report.

C) The system should provide access to the R/W appraisal review form to the reviewer to carry out the appraisal review.

D) E-mail notification of a completed appraisal review should be sent to the appraiser and R/W personnel.

3.3.4 Statistical Process Control (SPC)

A) The goal of implementing such a system is to ultimately reduce the time needed to complete the appraisal process. The intention of the SPC is to flag inconsistencies in an appraisal to alert the reviewer. For example, when the land value from one appraisal significantly differs from the land value of similar appraisals, the reviewer should be alerted. In this manner, the SPC helps ensure consistency among similar appraisals. SPC should only serve as guidance for the reviewer; it is the reviewer who will make the final judgment.

B) The SPC should support the development of the summary information on appraisals for DOT's internal use.

C) Ranges in key values must be used to help determine the consistency of the input appraisal data.

3.3.5 Approval Process

A) The system must have the capability to approve the appraisal online with the support of the electronic appraisal review form.

B) E-mail notification of the approval should be sent to the appraiser, reviewer, and R/W acquisition consultant(s).

C) Upon approval and after any necessary final adjustments are made, the finalized appraisal should automatically be uploaded and stored in the permanent appraisal database.

3.3.6 Permanent Appraisal Database

A) Access to the permanent appraisal database should be restricted to only the personnel authorized by DOT.

B) The permanent database should provide a mechanism to conduct various queries based on attribute information.

C) Appraisals in the permanent database must be organized in a format that is compatible with the State DOT's administrative structure and policies in terms of the data access and management.

3.4 DATA REQUIREMENTS

The User Functional Needs as discussed in the previous section cannot be fulfilled without the appropriate support of adequate data. Hence it was necessary to produce a list of data requirements that were necessary to be collected by the

appraiser, in order to use the proposed EAS in support of making a sound and a judicious decision about the value for the property.

To meet the above objective, a detailed list of the data requirements was prepared. The list also contained the format in which the data would be provided in the appraisal (ex. Categorical, Text, etc.). The primary reason for this fixed format of data collection was to standardize the entire process. By standardizing the data, it was now possible to use the data for statistical analysis. This could not be possible in the case of non-standardized data. As has been mentioned earlier, this list of data requirements was sent to the DOTs as a part of the survey for their ratings. Only the data elements which received an average rating of 3 or more were retained in the final version of the list of data requirements. An excerpt from the final version of the Data Requirements is provided is Figure 3.2.

3.5 TECHNICAL REQUIREMENTS

After gathering the various functional needs and requirements that were essential for providing the users with a comprehensive system, it was now necessary to investigate the various means and mechanisms to realize those needs. Various technologies and techniques were investigated, keeping the User Functional Needs in mind, in order to compile a list of different alternatives to execute the functional needs.

A list of the Technical Requirements for the EAS are discussed in the following sections. The bulleted statements describe the basic features and technical options to meet the User Functional Needs previously described.

Table 3.2: An Excerpt from the Data Requirements of the EAS

5.7 Adjustment Explanation					
5.7.1	Financing Terms		Text		4.66
5.7.2	Conditions of Sale		Text		4.77
5.7.3	Date of Sale (Market Conditions)		Text		4.77
5.7.4	Location		Text		4.77
5.7.5	Physical Characteristics		Text	Text Box	4.77
5.7.6	Size		Text		4.77
5.7.7	Utilities		Text		4.77
5.7.8	Zoning		Text		4.77
5.7.9	Others		Text		4.77
5.7.10	Concluding Remarks		Text	Comment Box	4.88
5.7.11	Maps		Map	Box	4.55
5.8: Income Approach					
5.8.1	Potential Gross Income		Number	Text Box	4.33
5.8.2	Market Rent		Number		4.77
5.8.3	Other Income		Number		4.77
5.8.3	Percentage Vacancy		Number		4.77
5.8.4	Vacancy in Dollars		Number		4.77
5.8.5	Effective Gross Income		Number		4.77
5.8.6 Fixed Expenses	5.8.5.1	Taxes	Number		4.66
	5.8.5.2	Insurance	Number		4.77
	5.8.5.3	Others (Expandable)	Number		4.66
5.8.7 Variable Expenses	5.8.6.1	Management	Number		4.55
	5.8.6.2	Other (Expandable)	Number		4.55
5.8.8	Repairs		Number		4.77
5.8.9	Reserves		Number		4.77
5.8.10	Total Expenses		Number		4.77
5.8.11	NOI		Number		4.88
5.8.12	Capitalization Rate		Number (%)	Text Box	4.77
5.8.13	Capitalized Value		Number		4.77
5.8.14	Value of Excess Land		Number		4.66
5.8.15	Estimated Value by Income Approach		Number		4.77

3.5.1 Appraisal Form

A) One electronic appraisal form with the option of being expandable. Expandability removes the need for multiple forms (i.e. "complex" and "non-

complex" forms). The level of expandability should be determined by the valuation approach used during the appraisal process.

- There are two options to accomplish this user need. The first option is to ask the appraiser to specify the type of appraisal, before he/she starts filling the appraisal form. Based on the type of the appraisal, the form would be generated. For example, if the appraiser specifies that the appraisal under consideration is a whole land acquisition, sections of the form dealing with partial acquisition will not be generated.

- The other option is to have a completely adaptable 'intelligent' system where the form is generated on the basis of the inputs made by the appraiser. The form will automatically generate itself in the required format based on the type of appraisal report being prepared. Once the user starts filling the form, based on his or her choices, the system would generate the rest of the appraisal form customized to the user's needs. Also, a dynamic form structure can be used to dynamically adjust the length of the appraisal form based on the needs of the user.

Frontend languages such as JavaScript and backend languages like PHP, Perl, ASP, JSP and Coldfusion can be used to implement this function in the system. JavaScript can immediately change the content of the rest of the appraisal form after the user makes some choices on the page. Backend languages have to wait till the user finishes the entire page and clicks on the "Next Page" button to customize the content of next page. It is also possible to combine the frontend and backend languages in generating forms.

B) All of the primary sections, such as the neighborhood analysis and the value of property, should be included in the electronic appraisal form.

- A separate table can be created for each of the six sections that are part of the appraisal form. Every data entry can then be saved in the database. The sections will be inter-connected in the database for the purpose of conducting queries and for analysis.

  The database can be created using relational database software such as Oracle, Sybase, SQL, etc.

C) Numerical values, check boxes and drop-down lists should be used as much as possible to help standardize input data and reduce the likelihood of misinterpretation of the information included in the appraisal.

- Readily available functionalities in the programming language and database software can be employed to accomplish the implementation of these features. By asking the user to enter the data in this format, the system will be able to better correlate between similar appraisals, taking advantage of the standardization of the data input.

  To implement this mechanism, frontend languages such as JavaScript and backend languages like PHP, Perl, ASP, JSP and Coldfusion can be used.

D) For security purposes, the electronic appraisal form must contain a mechanism for applying an electronic signature.

- A secure network can be created by using the login IDs and passwords which can serve as an electronic signature.

  When the user first registers, he/she should be asked to choose a user name and a password and specify an email address. This information can then be encoded and saved in the database. The system will also ask the user to provide a reminder question like mother's maiden name, city of birth, etc, to help him remember the password if he/she forgets the same. Once the user

registers, an automated email will be generated with a link in the email. The user could then be asked to activate his/her account by clicking on the link. The user table in the database will have a column specifying the user's status. Once the user clicks on the link, the status will reflect "Activated" in the tabular column of the database. For security purposes, the IP address used by the user can also be stored in the database. Backend languages can be used to check the user name and password. The database can be created using Oracle, Sybase, SQL, etc.

- Alternatively, if a state DOT has adopted a procedure for electronic signature in its e-business protocols, this adopted procedure can be implemented in the EAS.

E) The electronic appraisal form should contain a provision for including visuals such as plats and pictures. The visuals required will be a function of the type of appraisal being completed.

- The appraiser can be asked to quantify the number of visuals to be loaded and the form would then automatically create the required number of spaces to load the visuals. The visuals can be loaded in the following ways:

  o The address of the visual can be filled up by the appraiser and the system would then automatically load the visual.

  o The appraiser can manually load the visual from the hard drive of the computer through typical windows navigation processes.

When the appraiser tries to upload a visual, the system will check the file to verify whether the file is a visual. This will be accomplished by checking the file types such as JPEG, GIF, TIF, and BMP. Files that are not visuals will not be allowed to be uploaded.

- The visuals can be saved in the database in two ways. The first way is to save the web-address of the visual in the database. The other way of saving the visual is to actually save the visual itself in the database. This is not recommended as it would lead to slower processing speed due to the large content in the database.

Any of the available backend languages can be used to create this mechanism.

F) The electronic appraisal form should include a cover page with essential information such as the certification of the appraiser and executive summary. The specific page will be altered by the individual states.

- This is a part of the system output design, where the appraisal report will include a cover page that would bear the essential information from the appraisal. This information would include data like the name and address of the property owner, address of the property, the parcel number, certification of the appraiser, legal jargon, etc. This cover page can be created after the system evaluates the data submitted by the appraiser.

PHP, Perl, ASP, JSP and Coldfusion can be used to create this page.

G) The electronic appraisal form should require identification and justification of the valuation approaches used during the appraisal process.

- The system can have a mechanism in the electronic form that will not allow the appraiser to continue with data input unless justification is provided for the valuation process being employed.

Before the specific valuation approach page is generated, a text box would be created. The appraiser would be asked to justify the reasons for using

the valuation approach under consideration. Only then will the next page bearing the data required for the valuation approach will be activated.

- The other way of accomplishing this user need is to ask the appraiser at the very start of the appraisal process, when he/she is specifying the appraisal type, to justify the valuation approaches that will be used in the appraisal. In this way, the appraisal form can be generated in the required format at the very outset.

Backend languages such as PHP, Perl, ASP, JSP and Coldfusion can be used to achieve this user need.

H) Navigation and control mechanisms should be provided to ensure that all of the required data fields are completely filled with valid data.

- Error handling can be done at the frontend (on the bR/Wser page) using Java Script. Error handling can be also done on the backend (on the server) using PHP, Perl, ASP, JSP, Coldfusion, etc.

Every time the user clicks on the "Next Page" button, the system will check the mandatory data fields before proceeding to the next page. If backend languages are used, the user will be brought back to the current page if required fields are not filled with valid data. To alert the user, error messages can be shown on top of the page in red or the data fields which have an invalid data entry can also be marked in red using an "*" symbol. If frontend language is used, an alert pop-up window is created informing the appraiser about such data entry errors.

I) A mechanism should be included to allow the appraiser to "save" input information on a personal computer and/or temporary database location so that the appraisal form can be completed in stages.

- The appraiser will be given the option to complete the appraisal report in parts. He/she can be provided with a mechanism to save his/her incomplete appraisal in the temporary queue database. The saved incomplete appraisal can only be accessible by the appraiser who prepared the appraisal. The status for such an appraisal in the database would reflect that the appraisal is incomplete.

    This feature can be easily accomplished using the available backend languages.

J) A mechanism should be provided to use existing standard information and/or appraisals for the creation of templates.

- The appraiser can be provided with the option of using default values which would be stored in the appraisal system. The server can allow the appraiser to save part of the information which he/she repeats in most of his/her appraisals.

- The other option is automatically saving the information from the reports the appraiser submitted recently. The appraiser could then edit the report to make a new report rather than re-typing the entire data.

    Backend languages can be suitably employed to create this feature. The database that stores the information can be created using SQL-compatible database software or any other database software.

K) The finished report (complete or abbreviated format) should be in electronic format and will be easily available in printable versions. Hard copies can be generated as needed.

- The proposed system is a web-based system. The appraisal report to be generated will be in electronic format and saved in the database. Once the appraisal is completed and submitted, a PDF version of the appraisal can be generated to allow for easy production of hard copies by simply taking print-outs.

- The other option would be to provide an MS Word version for printing purposes.

    Backend languages can be used to provide this feature.

L) The electronic appraisal form should include a summary page with statistical information that can be transmitted directly into the permanent database.

- Summary information can be generated to help the DOT personnel get a summarized record of an appraisal or a few selected appraisals.

    The summary could include any important information that is saved in the database. It will be easily searchable using the web browser by logging into the EAS. Data fields such as the appraisal number, property address, appraiser name, date or combined keywords, can be used to search a specific property data. It will also be possible to create ad-hoc statistical tables as needed.

    Any of the available backend languages can be used to provide this function.

M) A printable version of the complete report, including both the form and attachments, should be available.

- A mechanism to print the appraisal form can be provided in the following ways:

  o A PDF version of the form.

  o A MS Word version of the form.

  o A web version of the form.

  Backend languages such as PHP, Perl, ASP, JSP, and Coldfusion can be used to request the data from database, and convert it to html, PDF or MS Word format. The database software like Oracle, Sybase, and SQL can be used to store the data and the URL addresses of the files.

3.5.2 Data/File Transmission

A) The system should have a mechanism to retain a copy of the original acceptable appraisal in the database. States have the option to archive earlier versions.

- When an appraisal is submitted, it will be saved in the temporary database. The appraiser will be provided with the ability to refine the report upon request from the reviewer. Once the report is accepted, it cannot be edited anymore. If any further revisions are required at a later stage due one or the other reasons, that report will be saved with another version number.

  Backend languages can be used to create this mechanism.

B) A provision for automatically sending reviewers' comments back to the appraiser and corresponding district R/W office should be included in the system.

- The reviewer while reviewing the appraisal might want to provide comments or request clarifications. The EAS provides a function to facilitate such communications. This can be done in either of the following two ways:

    o The comments can be saved in the database and an email alert can be send to the appraiser to read the same.

    o The other option would be to send the comments as an attachment with the email.

Backend languages can be used for creating this feature. An on-site message system can be used for storing the messages.

C) A quality control mechanism for the appraiser to review the submittals to ensure that all data fields are completely and accurately filled must be provided.

- During the submission process, the appraiser will be asked to review and verify the information he/she is submitting with a PDF file that is generated with the data submitted by the appraiser. Once the appraiser has reviewed the appraisal in PDF format, he/she will be requested to confirm the submission.

- Alternatively, the appraiser can review the information he/she is submitting directly from the database, while a function button is provided for the appraiser to confirm his/her submission.

This feature can be implemented by using any of the available backend languages.

D) The system should have a mechanism to review the appraisal history for the property (i.e. multiple appraisals for a single piece of property).

- In cases where a property is appraised by two or more appraisers and in cases where the property was appraised again after some lapse in time, a mechanism will be provided to view the appraisal history of such a property. To achieve this mechanism, a link to the appraisal history of the property can be provided from the existing data in the database.

  PHP, Perl and other backend languages can be used to accomplish this user need.

E) E-mail confirmation/notification of successful submission of an appraisal should be sent to all parties involved in the process.

- When an appraisal is successfully completed and submitted, an automated email notification would be generated informing all the parties involved in the appraisal that the appraisal has been submitted.

  Backend languages can be used to communicate with the database and generate this automated email notification.

3.5.3 Queue Database for Review

A) The database should be accessible to the appraisers, the reviewers, and corresponding R/W personnel with controlled privileges.

- The temporary database will only be accessible when the user logs into the system using the secure login system. The appraiser and the reviewer will have different privileges. The appraiser would be the only user with the capacity to revise an appraisal. The reviewer will be provided with the feature to send his/her comments to the appraiser and relevant DOT personnel.

    Backend languages like PHP, Perl, ASP, JSP, and Coldfusion can be used to check the user name, user level, and password. The user information will be stored in the database which can be developed using any of the available database software.

B) The database must maintain the option to overwrite the previous version of the appraisal until it is finalized. This feature will be given only to the appraiser until he officially submits the report.

- Once the appraisal is submitted, upon request from the reviewer, the appraiser will be provided with the ability to overwrite the existing version and saving it in the queue database. He/she can make changes to the appraisal as long as the appraisal is not accepted. Once accepted, the appraisal will be shifted to the permanent database. Subsequently, the appraiser will not be able to revise the appraisal anymore.

    Backend languages such as PHP, Perl, ASP, JSP, and Coldfusion can be used to create this feature.

C) The system should provide access to the R/W appraisal review form to the reviewer to carry out the appraisal review.

- When a reviewer selects an appraisal for review, an appraisal review form will be generated along with the appraisal report. The reviewer will have the capability to fill the review form in stages. He/she can save the review form in the database. When the reviewer starts the review process, the status of the appraisal will change to "Under Review".

   This feature can be implemented using backend programming languages.

D) E-mail notification of a completed appraisal review should be sent to the appraiser and R/W personnel.

- When an appraisal is successfully reviewed and accepted, an automated email notification would be generated informing all the parties involved in the appraisal that the appraisal has been accepted.

   Backend languages will be used to communicate with the database and generate this automated email.

3.5.4 Statistical Process Control (SPC)

A) The goal of implementing such a system is to ultimately reduce the time needed to complete the appraisal process. The intention of the SPC is to flag inconsistencies in an appraisal to alert the reviewer. For example, when the land value from one appraisal significantly differs from the land value of similar appraisals, the reviewer should be alerted. In this manner, the SPC helps ensure consistency among similar appraisals. SPC should only serve as guidance for the reviewer; it is the reviewer who will make the final judgment.

- SPC can be accomplished using any of the following techniques:

- o SPC using statistical analysis.

- o SPC using neural network applications

- o SPC using data mining and knowledge discovery in database (KDD).

SPC will ensure consistency between similar appraisals. For more information on SPC mechanism, please refer to section 3.6.

B) The SPC should support the development of the summary information on appraisals for DOT's internal use.

- • Various 'summary information' on appraisals may be of interest to the DOT R/W personnel. Since SPC helps ensure the consistency of appraisal data and information, it will ultimately aid in developing the summary information. This information will be available for internal use by the DOT personnel.

Basic database features can be used to run queries and generate this information.

C) Ranges in key values must be used to help determine the consistency of the input appraisal data.

- • The SPC mechanism will basically check the data entered by the appraiser against similar appraisals. It will create a range of values for the appraisal under consideration. If the value entered by the appraiser is within this range, the value will be deemed consistent.

3.5.5 Approval Process

A) The system must have the capability to approve the appraisal online with the support of the electronic appraisal review form.

- After the reviewer completes the review form, he/she will be giving the option to approve the appraisal or send it to the official in-charge for approving the appraisals. The approval can be executed by clicking on a properly designed function button on the bottom of the page.

Any backend language can be used to create this mechanism.

B) E-mail notification of the approval should be sent to the appraiser, the reviewer, and R/W acquisition consultant(s).

- When an appraisal is approved, an automated email notification would be generated informing all the parties involved in the appraisal that the appraisal has been accepted.

Backend languages can be used to communicate with the database and generate this automated email.

C) Upon approval and after any necessary final adjustments are made, the finalized appraisal should automatically be uploaded and stored in the permanent appraisal database.

- After the appraisal is approved by the reviewer/DOT, the status of the appraisal in the queue database will change from "Under Review" to "Approved" and remain so until it is moved to the permanent database. Once approved, the appraisal report cannot be edited by anyone. When

changes are made to the appraisal, it will be stored with a different version number.

3.5.6 Permanent Appraisal Database

A) Access to the permanent appraisal database should be restricted to only the personnel authorized by DOT.

- The permanent database will only be accessible after the user logs into the system using the secure login system. Access to this database will be restricted to personnel authorized by the DOT.

  Backend languages can be used for implementing this function. The database can be developed using database software such as Oracle, Sybase, and SQL.

B) The database should provide a mechanism to conduct various queries based on attribute information.

- Using basic features of a database, the user will be provided with the capability to conduct various queries. This will help the DOT personnel to quickly get the relevant information about a specific appraisal or a group of appraisals along a corridor.

  The search function will be web-based. The user will be able to search the database based on attribute information such as appraisal number, property address, owner name, appraiser name, or combined keywords. Backend languages and database functions can be used to accomplish this user need.

C) Appraisals in the permanent database must be organized in a format that is compatible with the State DOT's administrative structure and policies in terms of the data access and management.

- The appraisals in the database will be organized in a format that is in accordance with the administrative structure of the state DOT. This can be accomplished through a solid understanding of the DOT's administrative structure and policies and the utilization of the basic database functions.

CHAPTER 4 Mechanism of Statistical Process Control

Statistical Process Control (SPC) is a methodology that is widely used in manufacturing and financial industries and is making in-roads in the appraisal industry. It is a method that allows users to separate random variations, in their data, from nonrandom variations, and then analyze the nonrandom variations to improve the quality and reduce the cost of products. SPC is a control philosophy concerned with continuous process improvements using a collection of tools for data and process analysis and making inferences about process behavior. SPC is a key component of total quality initiatives.

In the appraisal industry, there are several different interpretations of this technology. Therefore, the development of a SPC mechanism for the Electronic Appraisal System (EAS) proposed in this project is a complex task. In the sections that follow, SPC procedure and the various technologies that can be used to implement the SPC mechanism are explained. Then, the use of data clustering techniques for the implementation of the SPC mechanism is described in detail.

4.1 SPC PROCEDURE

As mentioned earlier, SPC is extensively used manufacturing and financial industries. To better understand the SPC mechanism, an example of a SPC mechanism in a manufacturing industry is considered. To run the SPC mechanism, the parameters that have to be measured, the sampling method, and the data sources have to be identified. To use statistics for the process, the system must be able to break the process down so that the statistics can be applied to a well-defined, repeatable, and measurable step.
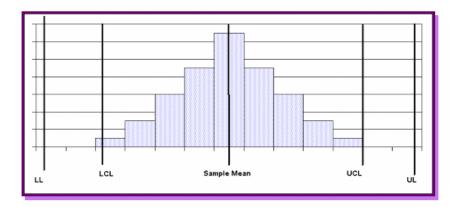
Figure 4.1: A Typical Histogram [Putman 98]

The easiest methods of displaying historical data are by using run charts and histograms. The histogram in the Figure 4.1 shows the desirable relationship between the upper and the lower test limits (UL and LL) in comparison to the upper and lower process control limits (UCL and LCL). It is desired that the control limits are always within the limits set by the test program. These limits are set based on the specifications required from the batch.

When the control limits fall outside the test limits, an inconsistency is said to occur. This inconsistency is flagged by the SPC to alert the reviewer. The inconsistency is depicted in the Figure 4.2.
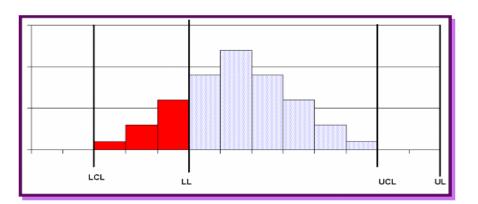

Figure 4.2: Inconsistency in Data Entry [Putman 98]

These inconsistencies can be easily noted by simple statistical analyses. To conduct an SPC analysis, sample data is required. The body and soul of the SPC is contained in two charts: the "Mean" (X) chart and the "Range" (R) chart. These charts are referred in tandem to find the inconsistencies in the batch by calculating the UCL and the LCL.

$$UCL = X + A*R \qquad (1)$$
$$LCL = X - A*R; \qquad (2)$$

where, A is a constant dependent on the size of the sample. When a data entry is made, its standard deviation is calculated. If the value is outside the control limits, that data field is flagged. As the entire system is computerized, these calculations are performed by the computer thereby carrying out the SPC analysis [Putman 98].

4.2 IMPLEMENTATION TECHNIQUES

There are several techniques that could be used to implement a SPC mechanism for the proposed Electronic Appraisal System. The noteworthy techniques are mentioned below:
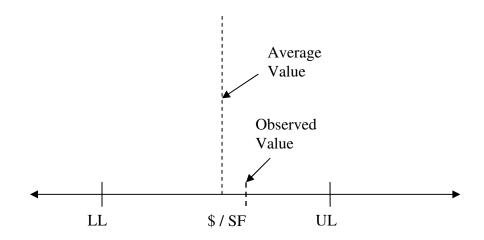
a)   Statistical Analysis

b)   Neural Networks

c)   Data Mining and Knowledge Discovery in Databases (KDD)

These techniques are discussed in brief in the sections that follow.

4.2.1 Statistical Analysis

Statistical analysis is one of the widest used methods for conducting the SPC mechanism. One example of a SPC mechanism for this project is a very simple process in which the data entered by the appraiser is compared with the range of
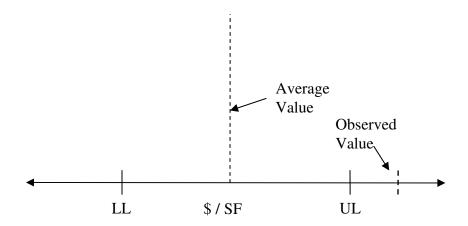
values that are possible for that data entry. If the data entered by the appraiser falls outside the given range, then the data is considered inconsistent.

Figure 4.3: Consistent Data

Simple statistical analysis is carried out to determine the mean of the values that are available from similar appraisals. The lower limit (LL) and the upper limit (UL) for the expected property value are found using an acceptable range based on historical data [Berger 83]. When an appraiser submits his/her data, the SPC mechanism compares the value entered by the appraiser with the range of values that are generated based on other similar appraisals. For example, as shown in Figure 4.3, the observed value, i.e., the value entered by the appraiser in $/SF, is within the acceptable range. This value is considered 'consistent' and is not flagged by the SPC.

Conversely, if the value entered by the appraiser is outside this limit, then the value is deemed 'inconsistent'. Such a data entry will be flagged by the SPC mechanism to alert the appraisal reviewer about possible inconsistencies in the appraisal. This has been shown in Figure 4.4 where the observed value in $/SF is greater than upper limit calculated using historical data.

Figure 4.4: Inconsistent Data

4.2.2 Neural Networks

According to Simon Haykin, "a neural network is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects:

- Knowledge is acquired by the network from its environment through a learning process.

- Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge." [Haykin 99]

Neural network technology uses multilayered approach that approximates complex mathematical functions to process data. It consists of many processing elements or nodes that work in parallel. Nodes are connected to each other in layers, and layers are interconnected. These nodes are simple mathematical functions; the connections between these nodes are how neural networks "think." As the complexity of the task increases, the network size increases, and the number of nodes increases rapidly.

To train a neural network, the developer has to feed the network with appraisal data from numerous completed appraisal reports. This data provides the neural network with information to create a unique configuration of network structure with a unique set of connection strengths or weights. As the neural network is modeled on the human brain, it learns new tasks with experience thereby improving its efficiency with time [Landas and Taylor 98].

When a new input is made, the network weighs the connections between nodes based on the data that has been fed earlier to it. Each connection node builds on previous decision nodes proliferating down to the final decision. For instance, in case of an appraisal, neural networks can be used to estimate the property value. This value is then compared against the average value of similar parcels, obtained from historical appraisal data. If there is an impermissible deviation, then the value is flagged.

Neural networks are very adaptable and complex. They are perhaps one of the best possible tools to be used for creating SPC mechanism for manufacturing industries. But, since the configuration of the network structure and the set of connection strengths or weights are not transparent to most users (many users refer to it as a "blackbox"), its use is not recommended for this study.

4.2.3 Data Mining and Knowledge Discovery in Databases (KDD)

Data Mining and KDD are analytic processes to explore and analyze, by automatic or semi-automatic means, large quantities of data in order to discover meaningful patterns and/or systematic relationships between variables and then to validate the findings by applying the detected patterns to new sub sets of data. The entire process basically consists of three main stages namely initial exploration, model building or knowledge identification, and deployment [Wang 99].

In the exploration stage, data preparation is done by cleaning data, transforming data and selecting the records that will be used for creating the data mining mechanism. Then, depending on the nature of the analytic problem, the variables are chosen.

In the model building and validation stage, various models are considered based on their descriptive or predictive performance (i.e. explaining the variability in question and producing stable results across samples). There are a variety of techniques that can be used for comparing the performance of various models. These include Bagging, Boosting, Stacking and Meta-Learning.

In the third and final stage, the model selected in the previous stage is applied to the data and descriptions/predictions of the expected outcome are generated.

This approach is very sophisticated and is ideally suited for applications such as credit card fraud detection, computer network intrusion detection, marketing and sales promotion, inventory management, and transforming corporate data into business intelligence, among others,. Although the SPC, using data mining and KDD, can be employed for the purposes of this project, this approach is better suited for the analysis of larger data sets (e.g.: millions of appraisal reports). Since the number of appraisal reports to be analyzed by the proposed statistical process control mechanisms is on the order of thousands, we believe that the extra complexity of DM/KDD approaches can not be justified for the needs of this study.

4.2.4 SPC Recommendations

After having carefully gone through the various alternatives and techniques available for implementing a SPC mechanism for the Electronic Appraisal System (EAS), it was decided that the use of statistical analysis best suited the proposed SPC

mechanism. The method chosen is simple and effective. It meets all the requirements that are desired from the SPC mechanism. Although the other noteworthy techniques of conducting SPC namely neural networks, and data mining and KDD can be used in this project, the extra implementation complexity, potential users' unfamiliarity with techniques used, and the limited size of the dataset limit the benefits of these approaches for this particular project.

4.3 GENERALIZED STATISTICAL PROCESS CONTROL MECHANISM

This section deals with the implementation of the Statistical Process Control (SPC) Mechanism in the Electronic Appraisal System (EAS) using statistical analysis. The sections that follow provide a detailed description of the SPC process discussing the procedure adopted to identify similar appraisals.

4.3.1 SPC Mechanism Overview

The Statistical Process Control mechanism as envisioned for the EAS is described as follows:

Let S_b be the group of appraisals in the database.

$S_b = \{B_1, B_2, B_3.........B_n\}$ where B_1, B_2, B_3 are the appraisals.

Also, the appraisals consist of various attribute data like property type, size among others. The appraisal value is a function of these attributes.

Consider the appraisal under review. Let it be B_x.
Now, $B_x = f(a_1, a_2, a_3.....a_n)$

For the SPC mechanism, the procedure would be to identify appraisals from S_b that have attributes very similar to B_x. Thus a good measure for comparison can be obtained.

This can be shown in the figure that follows:

$$S_b \longrightarrow S_b^{1}$$

Figure 4.5: Selection of Similar Appraisals

where S_b^{1} is the sub-group of S_b consisting of appraisals which are a function of similar attributes.

4.3.2 Data Clustering

As mentioned in the previous sections, identifying similar appraisals is a primary task in the SPC mechanism. An excellent means of selecting similar appraisals is by using the process of data clustering. Data clustering is an unsupervised classification of data items into groups based on some measure of similarity [Jain and Dubes 88].

There are various available algorithms to cluster the data. The most commonly used algorithm is the K-Means method [MacQueen 67]. K-means method is also one of the most efficient methods for data clustering. Although, more complicated and advanced methods are available for clustering, K-means is more than suitable for the purposes of this research. The mechanism is briefly described below:

K-means clustering is an iterative method. It is a type of partitional clustering method where the data is clustered into 'K' clusters specified by the user [Webb 02]. It assigns each object to the cluster whose centroid is the nearest. The centroid is the average of all the objects of the cluster. It is usually based on the squared error algorithm.

The basic steps of the algorithm are as follows:

a) Randomly generate k cluster centroids

b) Assign each object in the dataset to the centroid which is nearest to it

c) Recalculate the centroid of the clusters

d) Repeat until the assignment remains unchanged

The main advantage of this clustering method is that it is a very straight forward. It is fast and can be used with decent levels of accuracy on large datasets. The major disadvantage of this method is that the resulting clusters depend on the initial choice cluster centroids. This leads to the generation of different results on repeated running of the algorithm.

4.3.3 K-means Clustering Implementation

The clustering technique was incorporated in the Electronic Appraisal System using PHP. Before starting the process, the key was to identify the attributes that would be used to cluster the data. The attributes selected to cluster the data came from diverse fields. These include the attributes dealing with the property compensation, attributes of area and neighborhood and the highest and best use of the property. The list of attributes selected for data clustering have been presented in Table 4.1.

The SPC mechanism is initialized when the reviewer selects the "Run SPC" option available on the review page for the particular appraisal. The technique basically clusters the similar appraisals together and provides statistical information for appraisals in the same cluster as the subject appraisal.

Table 4.1: List of Selected Attributes for Data Clustering

S. No.	Attribute	Data Type
I.	*Compensation*	
1	Market value of the whole property	Continuous
2	Market value of the part to be acquired	Continuous
3	Land value	Continuous
4	Net damages	Continuous
5	Net enhancements	Continuous
II.	*Area, Neighborhood and Whole-Site Analysis*	
1	Total acre	Continuous
2	Acquired acre	Continuous
3	Improvement age	Continuous
4	Setting	Categorical
5	Shape	Categorical
6	Access	Categorical
7	Distance from CBD	Continuous
8	Frontage	Categorical
9	Topography	Categorical
10	Corner plot	Categorical
11	Soil conditions	Categorical
III	*Highest and Best Use*	
1	Property type	Categorical
2	Highest and best use as 'vacant'	Categorical
3	Highest and best use as 'improved'	Categorical

4.3.3.1 Data Preparation

Before clustering the data into their respective clusters, some data preparation is required. In view of the fact that some of the attributes selected for data clustering are categorical in nature, dummy variables are created for each of the individual categories. Also, since the scales of the various attributes are significantly different, the standardized scores (z-scores) for the attribute data are computed to avoid bias towards the attributes with large values. The z-scores are calculated using the following equation:

$$z = \frac{X - \mu}{\sigma} \qquad\qquad (3)$$

where,

    z - Standardized score

    X - Raw data value

    μ - Mean of the population

    σ - Standard deviation of the population

4.3.3.2 Clustering

Once the data preparation stage is complete, clustering can now be undertaken. For the SPC, a variation of K-means clustering has been developed. The procedure is as follows:
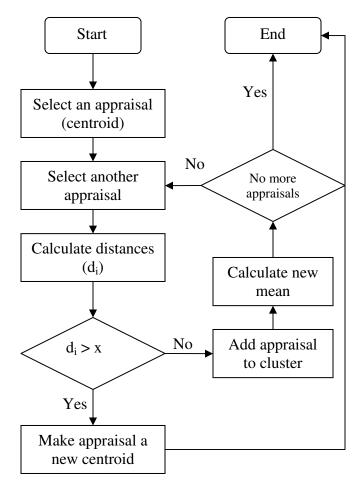
Step 1: Initialize the mechanism

Step 2: Select the first appraisal and let it be the centroid of the first cluster

Step 3: Select another appraisal

Step 4: Calculate the distance between the latest appraisal and all the other cluster centroids

Step 5: If the distance is greater than the threshold distance, make the later appraisal as the centroid of next cluster, else add the appraisal to cluster nearest to the appraisal and recalculate the centroid (mean) of the cluster

Step 6: Repeat step 3 through step 5 till no appraisal remains

Step 7: End

Figure 4.6: Flow Chart of Clustering Mechanism

To protect the integrity of the mechanism, the clusters obtained during the initial run of the mechanism are stored. Henceforth, whenever the SPC process is initialized, the mean value for these clusters serves as centroids for the clustering iterations. This method has the added advantage of reducing the number of data points to be clustered thus making the process less time consuming.

Once the clusters are obtained, statistical information for the appraisals that belong to the cluster to which the appraisal under consideration belongs can be calculated. These values are provided to the reviewer to assist him/her in the appraisal review process. A sample result obtained from the SPC mechanism is shown in

Figure 4.7. As can be seen from the figure, the red dot on the graph represents the subject property. The upper and the lower limits are calculated as the second standard deviations of the distribution curve. This curve is generated under the assumption that the appraisal values in the clusters are normally distributed.
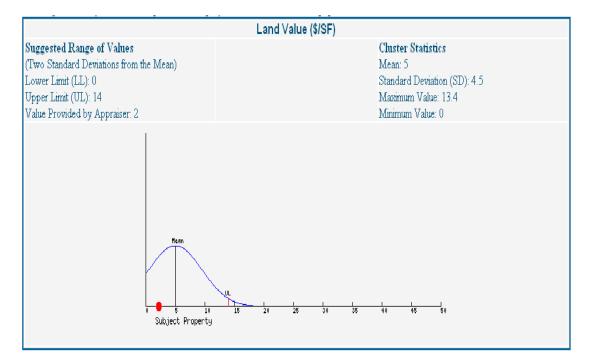

Figure 4.7: Result Obtained from SPC Mechanism

On analyzing the sample result, it can be seen that the land value provided by the appraiser for the subject property is $ 2 per square feet. The upper limit is $ 14/SF and the lower limit is 0. Hence, the appraised value lies within the range of recommended values and is thus deemed 'consistent'. The reviewer is also provided graphs for the 'Market Value for the Whole Property' and 'Total Compensation' in order to support the reviewing process.

4.3.4 SPC Summary

The Statistical Process Control Mechanism is a nice tool to make right-of-way acquisition process more efficient. It ensures quality control in the practice. It assists the reviewer in making judicious decisions. The procedure described in this thesis is an effective way of incorporating the SPC mechanism into the Electronic Appraisal System.

CHAPTER 5 Prototype of the Electronic Appraisal System

In Chapter 3 of this thesis, the framework and the requirements of the proposed Electronic Appraisal System (EAS) have been discussed and various techniques to implement and meet the requirements have also been investigated. To prove the applicability of the proposed EAS and to demonstrate its capabilities, a prototype of the EAS was developed.

This chapter presents the designs and the specifications of the prototype developed to serve as a proof-of-concept for the EAS. It consists of the prototype development plan specifying the various components and features of the prototype, the design of the prototype, and the prototype testing underlying the tests carried out to ascertain the proper working of the prototype.

5.1 PROTOTYPE DEVELOPMENT PLAN

The purpose of this section is to present a detailed work plan of activities that were conducted as part of the development of the prototype of the Electronic Appraisal System (EAS). This Prototype Development Plan is consistent with the framework of the Electronic Appraisal System (EAS).

5.1.1 General Architecture

The prototype of the Electronic Appraisal System (EAS) is a web-based system. It essentially has the following components: A login system, an appraisal form, a temporary queue database, a permanent database and a statistical process control (SPC) mechanism. PHP, a programming language that is commonly used for developing web-based applications, was used for the backend generation (server side) of the appraisal form and for submitting the data to the database. It was also used for creating a secure login system and to run queries on the database. Java script was used for the frontend (client side) development of the dynamic electronic forms. The

databases were developed using MySQL. The Statistical Process Control (SPC) mechanism was established through statistical analysis and database queries.
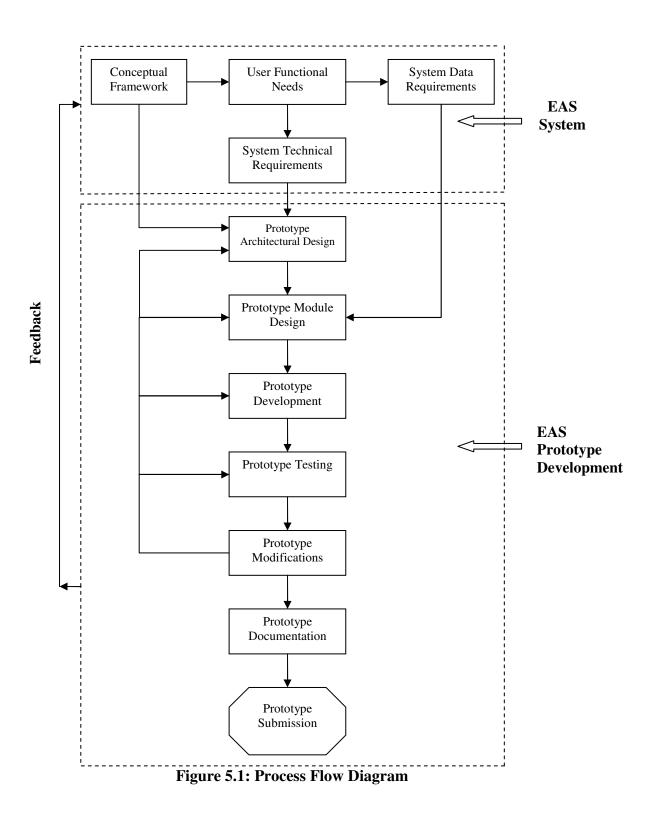
5.1.2 Key Functions

The key functions that are included in the prototype of the Electronic Appraisal System (EAS) are listed as follows:

- Logging into the system
- Filling the appraisal form
- Submitting the appraisal form
- Converting the appraisal form into PDF format
- Checking the consistency of data with Statistical Process Control mechanism
- Sending/Receiving emails from/to reviewers and appraisers
- Loading and deleting reports from the temporary database
- Transferring the reports from the temporary database to the permanent database
- Generating summary information and running queries

5.1.3 Process Flow Diagram for the Prototype

The development plan is basically divided into two stages. The Electronic Appraisal System (EAS) architecture and specifications and the EAS prototype development plan.

```
           ┌──────────────────────────────────────────────────────────┐
           │  ┌──────────────┐    ┌──────────────┐    ┌──────────────┐  │
      ┌───▶│  │ Conceptual   │───▶│ User Functional│──▶│ System Data  │  │
      │    │  │ Framework    │    │ Needs         │    │ Requirements │  │        EAS
      │    │  └──────────────┘    └──────────────┘    └──────────────┘  │        System
      │    │         │                   │                               │   ⇐
      │    │         │            ┌──────────────┐                       │
      │    │         │            │ System Technical│                    │
      │    │         │            │ Requirements  │                      │
      │    │         │            └──────────────┘                       │
      │    └─────────┼───────────────────┼──────────────────────────────┘
```

Conceptual Framework → User Functional Needs → System Data Requirements

System Technical Requirements

Prototype Architectural Design

Prototype Module Design

Prototype Development

Prototype Testing

Prototype Modifications

Prototype Documentation

Prototype Submission

Feedback

EAS System

EAS Prototype Development

Figure 5.1: Process Flow Diagram

The EAS architecture and specifications include the Conceptual Framework, the User Functional Needs, the Data Requirements and the Technical Requirements. These components of the EAS were generated by engaging in extensive discussions with Right-of-Way personnel and consultants from the appraisal industry and on the basis of a through study of the existing practices. These components have been presented in Chapter 3 of this thesis.

The next step of this research was to develop a prototype for the proposed Electronic Appraisal System (EAS). The steps involved in the EAS Prototype Development are briefly discussed as follows.

5.1.3.1 Prototype Architectural Design

The first step in EAS Prototype Development was to develop the architecture for the prototype system. There were various technologies that could be employed to develop the prototype. These technologies were carefully analyzed to arrive at the best possible and most feasible architectural design for the prototype, including the development environment and programming languages. The architecture was designed such that it was compatible with the technical requirements and the conceptual framework of the EAS.

5.1.3.2 Prototype Module Design

In this step, every module of the prototype was designed. Primary modules of the prototype include the electronic appraisal form, file transmission mechanism, the queue database, permanent database and SPC mechanism. In addition, data flows among these modules were also defined.

The electronic form and other modules were made compatible with data items specified in the data requirements document. The file transmission mechanism was designed so as to allow for easy storage of the file in the queue database. Also, a provision was made to transfer the approved appraisal to the permanent database. The

queue database and the permanent database share a common database structure, but provide varying features and privileges to their users. The SPC mechanism was built upon statistical analysis tools and database queries. The details of the prototype design are presented in section 5.2.

5.1.3.3 Prototype Development

Once the architectural design and the module design were completed, the prototype development was undertaken. The development of the prototype was as per the designs made in the earlier steps. During the development process, close communications with the state DOTs was maintained for their feedback and this information was suitably integrated into the prototype development.

5.1.3.4 Prototype Testing

After the prototype was developed, it was tested and evaluated with typical R/W appraisals to ensure that it had the robustness to demonstrate the requirements as specified in section 3.3 of this thesis. The tests were carefully planned and executed to ascertain a good quality product. The testing process is explained in detail in section 5.3 of this thesis.

5.1.3.5 Prototype Modifications

Subsequent to testing the prototype, the defects that were found as part of the testing process, they were modified and/or corrected. Further corrections will be made to all the modules and components as needed to ensure the system is as complete as possible.

5.1.3.6 Prototype Documentation

Throughout the development of the prototype, every effort was made to keep a complete record of the activities that were being undertaken. These records became a part of the project repository.

5.1.3.7 Prototype Submission

Once the prototype is carefully reviewed and finalized, upon the approval of the participating state DOTs, the prototype will be submitted to the DOTs in a format specified by them.

5.2 PROTOTYPE DESIGN

This section contains the design specifications for the prototype of the Electronic Appraisal System (EAS). It includes the system architecture, detailed descriptions of components, and other technical information. This document is written from the developer's point of view. The main purpose of the new system is to streamline the property appraisal process.

This section first provides an abstract view of the system architecture, including the components, structure and relationships, and user interfaces. It then describes each of these components in more detail, including design and architectural decisions.

5.2.1 System Architecture Description

This sub-section describes the various components of the prototype of the EAS. It also explains the structure and relationship of the components that make up the prototype of the EAS.

5.2.1.1 Overview of Modules / Components

The prototype of the EAS has the following major elements:

1) User Registration
2) User Login
3) Appraisal Form
4) Queue Database for Review

5) Statistical Process Control (SPC) Mechanism

6) Review Form

7) Permanent Appraisal Database

5.2.1.2 Structure and Relationships

The various components of the prototype closely interact with each other. When the user first accesses the system, he/she is requested to register. While registering, relevant information such as the user type (appraiser/reviewer), affiliation, user name and password is collected. Upon registration, the user will be directed to the login page to login into the system. On successful login, based on the user type, the appraiser home page or the reviewer home page will be loaded.

The appraiser home page and the reviewer home page have some common links. Both the appraiser and the reviewer are provided with the option of checking the status of a particular appraisal. The appraisal appears on the reviewer's home page only when the appraiser formally submits the same. The other common features include the ability to view the appraisal report in PDF format or as a webpage. When the appraiser/reviewer clicks on the buttons to access the webpage or the PDF version, the system will access the queue database and obtain the requested appraisal in the required format.

Apart from the common features, the appraiser also has links that enable him/her to create a new appraisal and to edit an existing appraisal. To accomplish this feature, the user is provided access to the electronic appraisal form. The appraisal form provides the appraiser the opportunity to complete the appraisal in stages. The appraiser can save the appraisal and come back to complete it at a later time. This saved appraisal is stored in the queue database. The appraisal form is composed of a number of pages. The appraiser will have to complete all the required data on the page and click on the 'Continue' button to go to the next page. When he/she clicks the 'Continue' button, the appraisal is automatically saved. Once the appraiser

completes the last page, he/she can now submit the appraisal. When the 'Submit' button is clicked, a PDF version of the appraisal is automatically generated providing the appraiser with an opportunity to completely go through the appraisal report and verify its contents. If the appraiser is satisfied, he/she can click on the 'Confirm Submission' button to formally submit the appraisal report. If not, he/she can cancel submission and edit the appraisal before resubmitting the same. If the appraisal is submitted, it will be saved in the queue database and an email will be sent to all parties involved in the appraisal informing them of the submission. The appraisal now appears on the reviewer home page as well.

The reviewer's home page has the additional options of reviewing the appraisal and initializing the Statistical Process Control (SPC) mechanism apart from the options that are common to the reviewer and the appraiser. The reviewer can review an appraisal by clicking on the 'Review' button corresponding to the appraisal that the reviewer wishes to review. This will open the review form where the reviewer will have the ability to comment on the appraisal report and finally approve/request changes/not approve the appraisal. To help the reviewer in reviewing the appraisal, an SPC mechanism is provided. SPC mechanism is initialized when the reviewer clicks on the 'Conduct SPC' button. The SPC mechanism will basically cluster similar appraisals together including the appraisal under review. This procedure is explained in greater detail in Chapter 4 of this thesis. If the reviewer approves the appraisal, the appraisal is transferred from the queue database to the permanent appraisal database and an automated email is generated informing all the parties involved about the approval. If the appraisal is not approved or if changes are requested, the concerned appraiser will be sent an email informing him/her about the changes requested and the appraisal will be retained in the queue database. In either case, the status of the appraisal is updated which will reflect in the user home page. Figure 5.2 shows the interactions and relationships between the components.

Figure 5.2: Relationship and Interaction among Components

5.2.2 Detailed Description of the Components

In this sub-section, the various components of the prototype are explained. Also, the programming languages and software used to create the different components have been listed**.**

5.2.2.1 Component Template Description

Using the template that follows, each component is explained with the help of a table which contains the following information: identification, type, purpose, function, subordinates, dependencies, interfaces, resources, processing, and data, as shown in Table 5.1.

Table 5.1: Template for the Component Description Table

Identification	The unique name for the component and its location in the system.
Type	A module, a subprogram, a data file, a class, etc.
Purpose	Function and performance requirements implemented by the design component.
Function	What the component does, the transformation process, the specific inputs that are processed, the algorithms that are used, the outputs that are produced, where the data items are stored, and which data items are modified.
Subordinates	The internal structure of the component, the constituents of the component, and the functional requirements satisfied by each part.
Dependencies	How the component's function and performance relate to other components. How this component is used by other components.
Interfaces	Descriptions of the interface as well as any additional mechanisms for communicating through messages, parameters, or common data areas.
Resources	A complete description of all resources external to the component, but required by the component to carry out its functions.
Processing	The function dispensation of the component.
Data	For the data internal to the component, describes the representation method, initial values, use, semantics, and format.

5.2.2.2 User Registration

      User registration is the first major component of the EAS. It collects the necessary information from the first-time users so as to allow the user to securely log into the system on a subsequent occasion. It also helps in determining whether the user is an appraiser or a reviewer. The details about this component are given in the Table 5.2.

Table 5.2: User Registration Description

Identification	Registration
Type	A module
Purpose	To gather user information from first time users
Function	Registration will create a login for the new users to provide access to the EAS. The data that will be collected includes the name, appraiser or reviewer, affiliation, certification number and state of the appraiser/reviewer.
Subordinates	Input boxes, drop-down list and submission buttons will be provided
Dependencies	This component has no dependencies.
Interfaces	When a user visits the website, the welcome screen will have the login boxes and also a link to register in case of first time users. All information entered by the user will be processed upon clicking the submit button and if any information is inaccurate, incomplete, or inappropriately configured, then the page will reload with a message informing the user about the error that prevented the completion of the registration.
Resources	The registration component will be completed using HTML and PHP for output and MySQL for logic and database.
Processing	On submitting the registration information, the information will be analyzed and validated using PHP and MySQL.
Data	Each input will be assigned a specific name to allow easy reference.

      In Figure 5.2, a screen shot of the user registration page has been shown.

Figure 5.2: Screen Shot of the Registration Page

5.2.2.3 User Login

The user login is the component that is used to validate the user when a user tries to access the EAS. This feature also determines the page that will be loaded once the user logs into the system. The specifics of this component are given in the Table 5.3 and a screen shot of the user login page is shown in Figure 5.3.

Figure 5.3: Screen Shot of the User Login Page

Table 5.3: User Login Description

Identification	User Login
Type	A module
Purpose	To authenticate the user and provide them with access to the EAS
Function	The function of this component is to allow the user access to his/her appraisals and information.
Subordinates	The computer will ask for the login information, verify the information, grant access if the information is verified or return the user to the login page if the entered information is incorrect.
Dependencies	This component is dependent on the registration component.
Interfaces	The login page will consist of two input boxes. One for the username and the other for the password and a submit button that the user will click upon entering the information. If the information entered by the user is correct, the user home page will be loaded by the system bearing the user information and his/her appraisals. If the incorrect information is entered, a page will be generated informing the user that incorrect information has been supplied to the system.
Resources	The user login will use HTML and PHP to present the output; and MySQL for logic and data storage.
Processing	The user will enter their password and username and click the submit button. Using backend processing, the password will be extracted from the database that corresponds to the provided username and will be compared with the supplied password. If the user enters correct information, the user home page will be loaded; otherwise the user will be taken back to the login page informing him/her about the error.
Data	The data will consist of the user provided username and password and the username and password from the database.

5.2.2.4 Appraisal Form

The appraisal form is the most important component of the EAS. It is made available to the appraiser once he/she logs into the system to carry out a new

appraisal or to edit an unfinished appraisal. The essentials of this component are described in the Table 5.4.

Table 5.4: Appraisal Form Description

Identification	Appraisal form
Type	A module
Purpose	To provide the information required to arrive at the estimated market value of a property
Function	The appraisal form systematically asks the appraiser to supply information that is required to estimate the market value of the property.
Subordinates	The appraisal form consists of six sections. Section 1 is a introduction and legal documentation section; section 2 deals with the area, neighborhood and whole property; sections 3, 4 and 5 deal with the cost estimation of the property before after acquisition; section 6 is the summary section.
Dependencies	This section has no dependencies
Interfaces	The appraisal form is a massive document. It consists of text boxes and dropdown lists for data entry. It also has mechanisms to load pictures into the system. There is an option available to the appraiser to save the incomplete form and return to it at a later time. Finally, before submitting the appraisal report, a PDF file is generated so as to allow the appraiser to check his data and confirm its submission. 'Save' buttons and 'Continue' buttons are provided after every page and a final 'Submit' button is provided at the end of the appraisal form.
Resources	The entire appraisal form is created using PHP and HTML. The pictures will be loaded using typical windows navigation processes.
Processing	When the appraiser clicks on the save button, the data entered by the appraiser is saved in the queue database. On clicking the continue button, the system scans the entire page to check whether required data has been entered by the appraiser. If the required data is present, the next page is loaded; otherwise, an error message is displayed to the user. On submitting the appraisal, a PDF file is created and on verification, the appraisal report is sent to the queue database.
Data	Each input will be assigned a specific name to allow easy reference in the database.

A screen shot of the appraisal form is shown in the Figure 5.4.

Figure 5.4: Screen Shot of the Appraisal Form

5.2.2.5 Queue Database for Review

This component of the EAS is a storage space to save and store the appraisals that are being reviewed and also the appraisals that are unfinished. The appraisals are moved from this database once they are reviewed. Table 5.5 describes the requisites of this component.

Table 5.5: Queue Database Description

Identification	Queue database for review
Type	Database
Purpose	To provide temporary data storage space for the appraisal.
Function	The primary function of the temporary queue database is to store the appraisals while they are being reviewed by the reviewer. The database provides a secure location for the appraisals to be saved and also does not allow tampering with the appraisals.
Subordinates	The database consists of subcomponents to retrieve the data as and when required and also consists of a reviewer form to be completed by the reviewer in response to the appraisal reports
Dependencies	This section has no dependencies
Interfaces	Since this is a database, it requires no interface. User interface is provided for the reviewer review form. It basically consists of a text box and submit button. It also has some check buttons to approve/request change/not approve an appraisal
Resources	The database is created using MySQL. The review form is generated using PHP and HTML.
Processing	Once the submit button is clicked, the appraisal is sent to the queue database and an email notification is sent to all the parties involved in the appraisal. The submitted appraisal cannot be edited by the appraiser unless requested by the reviewer.
Data	Each input will be assigned a specific name to allow easy reference in the database.

5.2.2.6 Statistical Process Control (SPC)

Statistical Process Control (SPC) is a quality control mechanism that is being provided to ensure consistency in the appraisal values of the properties that are similar in nature. This process basically consists of a clustering mechanism that will group similar appraisals together for further analysis. This component has been

explained in Table 5.6. The SPC mechanism and the resulting output have been discussed in greater detail in Chapter 4.

Table 5.6: Statistical Process Control Description

Identification	Statistical Process Control (SPC)
Type	A module
Purpose	To maintain consistency among similar appraisals.
Function	The primary function of the SPC is to separate the random variations from the non-random variations such that parcels that are similar in nature have similar appraised value.
Subordinates	The SPC mechanism will basically consists of a clustering mechanism which would cluster the similar appraisals together.
Dependencies	This section has no dependencies.
Interfaces	The SPC process is an automatic process which will be initiated when the reviewer clicks the 'Run SPC' button which will be available on reviewer's page.
Resources	Statistical software like SPSS will be used for clustering. MySQL queries will be used to obtain the appraisal data
Processing	Once the 'Run SPC' button is clicked, the clustering mechanism will be initialized. Based on the attribute data, the appraisals will be clustered such that similar appraisals are grouped together. The cluster to which the appraisal under consideration belongs will be selected and the price per square foot will be compared. If the difference in value between the appraisal under consideration and the appraisals from the cluster is within the permissible limits, the appraisal will be not be flagged; if not, the appraisal will be flagged and the reviewer will be notified to carry out a more detailed investigation.
Data	The data for the SPC process will come from the appraisal data that is provided by the appraiser on the appraisal form.

5.2.3.7 Review Form

This component of the EAS will be made available to the reviewer to carry out the review of an appraisal once the appraiser has submitted the appraisal. The review form has the options that would allow the reviewer to approve, request

changes or to not approve an appraisal. The detailed information is given in Table 5.7.

Table 5.7: Review Form Description

Identification	Review form
Type	A module
Purpose	To approve/request changes/ not approve an appraisal
Function	The function of this module is to allow the reviewer to carry out the review process and to report the results of the review.
Subordinates	The module consists of a review page with options to approve, request changes or not to approve an appraisal. It also has a mechanism to automatically generate an email to inform the status of the appraisal to all parties involved.
Dependencies	This module is dependant on successful completion and submission of the appraisal form and its storage in queue database. The appraisal only is available for review once the appraisal has been verified and submitted by the appraiser.
Interfaces	The interface for this module consists of a web page which is generated when the reviewer clicks on the review button present beside appraisal ID on the reviewer's home page.
Resources	This component requires PHP for its creation
Processing	When the reviewer clicks on the 'Review' button, the review page will be generated. On completing the form, the reviewer can approve, request change or not approve the appraisal. The reviewer then clicks the submit button which transfer the appraisal to the permanent database if approved or keeps the appraisal in the temporary database if the appraisal is not approved and the concerned appraiser is informed of the changes that are requested. In all of these cases, an automated email will be sent to all concerned parties about the status of the appraisal. Also, the status of the appraisal would be updated.
Data	The data required for this component is supplied by the reviewer and saved in the database.

A screen shot of the review form for a sample appraisal is shown in Figure 5.5

.

Figure 5.5: A Screen Shot of the Review Form

5.2.2.8 Permanent Appraisal Database

The permanent appraisal database is the final storage place for all the appraisals. The appraisals will be transferred to this database from the temporary appraisal database once the appraisals have been successfully reviewed. The table that follows describes the specifics of this component.

Table 5.8: Permanent Appraisal Database Description

Identification	Permanent Appraisal Database
Type	Database
Purpose	To permanently store the appraisals in secure and convenient manner.
Function	The major functions of this component are to save the appraisals permanently for records and for information purposes and to allow easy and convenient access to the R/W staff to the appraisal information.
Subordinates	The subordinates of this component include functions which enable access to the database and preparation of summary reports using MySQL queries.
Dependencies	This component is dependent on the login module. The permanent database will only be accessible if the user logs into the system as a reviewer. It is also dependant on the outcome from the review process.
Interfaces	Since this component is a database, it does not have an interface. But an interface in the form of a webpage will be provided to generate summary information and reports.
Resources	This component is created using MySQL for database and queries and PHP for web pages.
Processing	The result of the review process will determine whether the appraisal will be saved in the permanent database or not. If information about appraisals is required, queries will be generated by using MySQL. MySQL would identify the appraisals that need to be selected to run the query.
Data	The data required for this component comes from the review process.

5.2.3 Database Relationships

The permanent appraisal database is a relational database consisting of 19 tables that are connected to each other using a foreign key. Thus, the data is stored in the form of relations.

The database is comprised of the following tables:

1) Appraisal_forms: This table consists of all the essential information of the appraisals that are present in the database like the appraisal ID, status etc.

2) Subject_properties: This table consists of the addresses of the properties that are present in the database.

3) Users: This table has the information of all the users registered to use the system.

4) Appraisal_forms_sections1: The information required for the section 1 of the appraisal form is stored in this table.

5) Appraisal_forms_sections2: The information required for the section 2 of the appraisal form is stored in this table.

6) Appraisal_forms_sections3: The information required for the section 3 of the appraisal form is stored in this table.

7) Appraisal_forms_sections4: The information required for the section 4 of the appraisal form is stored in this table

8) Appraisal_forms_sections5: The information required for the section 5 of the appraisal form is stored in this table

9) Appraisal_forms_sections6: The information required for the section 6 of the appraisal form is stored in this table

10) Photos: This table stores the pictures provided in section 2 of the appraisal form.

11) Maps: This table stores the maps provided in section 2 of the appraisal form.

12) Accessory_improvements: The improvements made to the subject property are stored in this table.

13) Sales_comparison_approach_whole_land_value: The elements of the sales comparison approach are saved in this table.

14) Data_supplement: The information from the data supplement sheet which is used to collect the data of the properties that are used as 'comparables' is saved in this table.

15) Estimate_replacement_reproduction_cost: This table saves the information from the cost approach

16) Representative_comparable_rentals_grid: This table saves the information from the income approach

17) Site_improvements: This table saves the data collected pertaining to the site improvements made on the subject property.

18) Sales_comparison_approach_whole_and_improved: This table saves the information collected in the improved sales comparison approach.

19) Subject_lease_summary: The data pertaining to 'subject lease' is saved in this table.

The appraisal form consists of six sections. Section 1 is the summary section outlining the property and appraiser details as well as the legal requirements of the appraisal process. Section 2 deals with the area, neighborhood and whole property analysis as well as the highest and best use of the property as vacant and improved. Section 3 is the cost estimation of the whole property. Section 4 deals with the property valuation of the part to be acquired. The property valuation of the remainder after acquisition is estimated in Section 5. Section 6 is an overall summary section.

The foreign key that is used to connect majority of the tables is the 'appraisal_id'. The main table of the database is 'appraisal_forms'. All the other tables are connected to this table one way or the other. Each of the six sections that make the appraisal forms has a discrete table. Section two of the appraisal, which deals with the area, neighborhood and whole site analysis, has two dependant tables where the photographs and maps of the subject property are stored. The table for section three has seven tables which are used for storing data pertaining to various subsections of the section. Accessory improvements, site improvements have a specific table for themselves. Tables are also provided for the three estimation methods, namely sales comparison approach, income approach and the cost approach.

As mentioned earlier, these tables are all connected to the table 'appraisal_forms_section3' which is the specific table for section three of the appraisal form. The tables for sections four, five and six are independent are and all connected to the table 'appraisal_forms' by the 'appraisal_id' foreign key.

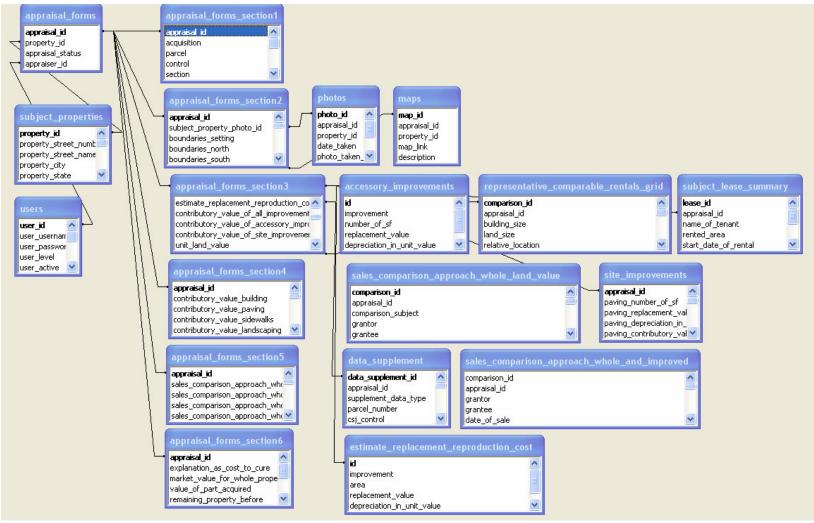The database structure and the relationships are shown in Figure 5.6 that follows.

Figure 5.6: Database Structure and Relationship

5.3 PROTOTYPE TESTING AND VALIDATION

After designing and developing the prototype of the EAS, the next step entailed the testing the EAS to validate its proper functioning. Also, this step was paramount in assessing the capabilities of the new system.

The purpose of this section is to outline the testing scheme for the prototype of the Electronic Appraisal System (EAS). It provides the guidelines in quality assurance, testing and other evaluation procedures that were followed to ensure proper and satisfactory functioning of the prototype product. Major functionalities that were tested are briefly discussed as follows.

5.3.1 Logging into the System

The prototype was tested to ensure that the logging system worked as per the expectations. The privileges offered to the appraisers and reviewers are different and this was verified by this test. To carry out this test, the users representing the appraiser, the reviewer, and the system administrator were made to participate in the testing process using their respective user IDs. Next, the privileges and the functionalities that were available to different users were verified to confirm the proper functioning of the logging system.

5.3.2 Filling the Appraisal Form

After logging into the system, the system should provide the appraiser with the appraisal form. The system was checked to ascertain that the form generated had the appropriate length that was consistent with the type of the appraisal undertaken by the appraiser. The form was also tested to ensure that data could be saved at anytime by the appraiser so that it can be completed in parts. Tests were also carried out to make certain that the visuals and plats could be included in the appraisal as pictures.

5.3.3 Converting Appraisal Information into Appraisal Report in PDF Format

In this test, the conversion of the appraisal information provided by the appraiser in HTML format to the PDF format was verified. The generated appraisal report in PDF format would allow the appraiser to first review the appraisal and then confirm the submission.

5.3.4 Submitting the Appraisal

In this test, the appraisal system was tested to validate the proper functioning of the submission mechanism. The appraisal was successfully submitted and a message confirming the submission was received. An email notification of the submission was also sent to all the concerned parties. It was verified that the submitted appraisal was saved in the queue database for review.

5.3.5 Checking the Statistical Process Control (SPC)

This test was carried out to ensure the proper functioning of the Statistical Process Control (SPC) mechanism. In order to check the effectiveness of the SPC, a control dataset was generated which are known number of clusters. The SPC mechanism was then run on this dataset to validate the functioning of the SPC mechanism. Testing of the SPC mechanism using actual data is still under progress.

5.3.6 Sending Email Notifications to Involved Parties

The prototype system has a mechanism to allow notifications of appraisal status to be automatically sent to the involved parties. By this test, the proper functioning of this mechanism was verified.

5.3.7 Transferring Reports from Temporary to Permanent Database

Once the appraisal report has been approved, it is transferred from the temporary database to the permanent database. Validation of the proper functioning

of this mechanism was carried out by approving a report online and checking whether the report was transferred to the permanent database.

5.3.8 Generating summary information through various queries

In this test, various types of summary information that is of importance to DOT R/W personnel were generated from the permanent database by conducting queries.

5.4 KEY CHARACTERISTICS OF THE PROTOTYPE SYSTEM

By following the development, testing, and the designs outlined in the previous sections, the final prototype system for the EAS is marked by the following characteristics.

5.4.1 User-friendly

The prototype system developed is user-friendly. It is easy to navigate and understand. The features provided are easy to comprehend and use.

5.4.2 Practical

The proposed EAS will only be acceptable by the industry if it is practical. The prototype developed is therefore both realistic and sensible. It has the features that are required and useful for producing quality appraisals.

5.4.3 Maintainable

Easy maintenance of any automated system is of immense importance. The prototype developed demonstrates the characteristic of easy and straight forward means and mechanisms for system maintenance.

5.4.5 **Flexible**

The prototype is flexible such that it can be used for different types of appraisals and for future modifications as needed. The system is also agile enough to accommodate any future needs.

5.4.6 Sustainable

Since the proposed EAS is closely related to evolving computing technologies and changing business procedures at state DOTs, the developed prototype should demonstrate its capabilities to meet these challenges, making it sustainable over time.

CHAPTER 6 Implementation Recommendations

This chapter discusses steps that can be taken in order to move from the prototype version of the EAS to an operational version. As has been indicated earlier, the prototype of the EAS is a proof-of-concept for the EAS. It was built to demonstrate the key features of the proposed EAS. Thus, the prototype was designed with limited functionalities. The development of an operational EAS can be accomplished with additional work that is recommended as follows:

a) Fine-tune the system to move it beyond the "prototype"

b) Customize the system to meet the specific needs of the individual DOTs

c) Improve the security of the system

d) Populate the system with real appraisals to test the key functions

e) Implement the system using a pilot study

f) Technology transfer

6.1 FINE-TUNE THE SYSTEM TO MOVE IT BEYOND THE "PROTOTYPE"

An operational EAS can be developed and implemented by enhancing the prototype of the EAS. The first step in the development of an implementation version of the EAS is the fine-tuning of the prototype. This involves the refinement of various components of the EAS. For example, the PDF conversion mechanism can be improved by replacing the open-source PDF conversion software that is used to produce the appraisal report with a superior commercial PDF converter. The current PDF conversion mechanism results in unformatted tables if some tables are left unfilled. The expandability of the tables and text boxes in the produced appraisal reports can also be suitably controlled using a more efficient PDF converter. Another area that deserves fine-tuning is the quality control mechanism for data entry. Although the prototype of the EAS has a good quality control mechanism to ensure the integrity of data elements when they are entered into the system, a more rigorous

mechanism that automatically rectifies the minor errors made by the appraiser, in terms of the data format among others, would be desirable.

The prototype of the EAS has a mechanism that allows the appraiser to specify the number of photographs that are going to be added to the appraisal. The same feature can be extended to enable the appraiser to specify the number of other visuals (such as maps, plats, etc.) that he/she might provide. Finally, the system should be fine-tuned so as to permit the appraiser to use an existing appraisal as a template while creating an appraisal for a similar property.

6.2 CUSTOMIZE THE SYSTEM TO MEET THE SPECIFIC NEEDS OF THE INDIVIDUAL DOT

The prototype of the EAS, developed as part of this research, is based on the broad requirements of the state DOTs. Although the state DOTs follow the general guidelines of the Uniform Standards of Professional Appraisal Practice (USPAP), various state DOTs have specific procedures in their appraisal process. Furthermore, the appraisal terminologies also vary across different states. For example, in the state of Texas, the subject property is identified using the Control, Section, and Job (CSJ) number. The term 'CSJ' is non-prevalent in many states. Thus, it is necessary to develop the operational version of the EAS individually for each of the participating states. The added advantage of developing the EAS specific to each state is that it allows the states to customize the data elements as per their predilection.

The prototype of the EAS has the capability to work on appraisals that are specific to 'residential', 'commercial' or 'land only' properties. Several other property types (such as industrial, agricultural, retail, etc.) are not included in the current version of the EAS. During this step of customization, based on the property classification schemes of the individual DOTs, the system should be modified to

include property types that are consistent with the business process of a particular DOT.

6.3 IMPROVE THE SECURITY OF THE SYSTEM

Enhancing the security of the prototype of the EAS is one of the most important tasks that need to be undertaken before the EAS can be made operational. Although the prototype of the EAS has some security features like login authentication, further advancements are highly recommended in the implementation of an operational EAS.

Significant improvements in the EAS's dataflow structure is also highly recommended. The dataflow in an operational EAS should take place through secure pages referred to as Secured Socket Layer (SSL). This can be accomplished by hosting the web-based system using a SSL configured server. A popular SSL protocol that can be used is OpenSSL.

The prototype of the EAS provides a secure login feature by asking the user to verify the email address provided. This is done by sending a link to the email address supplied by the user while registering. The user has to then click on the link provided in order to activate the account. The major drawback of this method is that it allows individuals who are not appraisers, reviewers or R/W administrators to secure a login ID and password. Also, since the system developed as part of this research effort is only a prototype, login authentication is not performed while giving access to every web-page of the system. In other words, a user familiar with the web-address for a particular web-page can access that page directly without him/her being authenticated. This can be avoided by using 'session objects' which would prohibit a user who has not logged in into the system from accessing any page of the system.

Database security is another concern that needs to be addressed. The database of the prototype version of the EAS has been developed using MySQL. Advanced database systems should be used for an operational EAS. An example of such advanced database system available in the market today is Oracle 10i developed by Oracle Inc. Apart from the security features available in Oracle 10i, it also has an excellent report generation tool called Discoverer. This tool can be useful in the context of the EAS for generating summary information among others. Oracle 10i also has a good concurrency control technique which allows multiple users to simultaneously work on the same data.

Finally, in order to attain a more secure system, reasonable redundancy should be introduced in the process. This can be achieved by providing a back-up server as well as back-up system to save and store the appraisal data. The users accessing the system should be continuously moderated by the system, and this information should be periodically evaluated by the system administrator to avoid potential mishaps.

6.4 POPULATE THE SYSTEM WITH REAL APPRAISALS TO TEST THE KEY FUNCTIONS

After customizing the EAS as per the needs and requirements of the individual state DOTs, the next step entails the testing of the developed EAS by populating the system with data from real appraisal reports. The primary objective of this step is to calibrate the SPC mechanism such that an optimal threshold value for the clustering process can be determined. The SPC process can be tailor made for diverse property types by providing unique threshold values for each of the supported property types. This can be accomplished by repeatedly clustering the properties, while incrementally changing the threshold value till the clusters of properties that are similar in nature are obtained. Populating the system also helps in testing various functionalities like the appraisal submission, PDF conversion, appraisal transmission, storage and review.

6.5 IMPLEMENT THE SYSTEM USING A PILOT STUDY

Once the testing of the EAS is completed, the next step should comprise of conducting a pilot implementation study in order to evaluate the feasibility of a full-scale implementation. The pilot study should be conducted on a small-scale with the R/W administrative zones (For example, using two districts in case of Texas). The pilot study is beneficial in identifying the potential problems that might occur during the implementation of the system at a larger scale. The pilot study is also helpful in convincing the various stake holders about the capabilities and resourcefulness of the new appraisal system. The results obtained from the pilot study should be carefully analyzed and suitable changes (if any) should be incorporated in the system.

6.6 TECHNOLOGY TRANSFER

On the completion of the pilot study, the EAS developed for a particular state DOT should be transferred to the DOT as an operational system. The technology transfer should include the project repository outlining the various designs and specifications used in the development process. The testing results and a log of the activities conducted during the development of the EAS should also be provided to the implementing agency. The technology transfer step should also include a training program for the end users of the EAS so as to acquaint them with the features and functionalities of the new appraisal system.

Thus, by following the recommendations that have been discussed in this chapter, an operational version of the EAS can be developed for states that are interested in the implementation of an electronic appraisal system.

CHAPTER 7 Summary and Recommendations

This chapter provides the conclusion of this thesis by summarizing the research effort and by giving recommendations for future research.

7.1 SUMMARY

This research had two primary goals; developing framework and requirements for the EAS, and producing a prototype of the new EAS.

Development of the requirements and designs of the EAS entailed carefully studying the current procedures adopted by various state DOTs in the acquisition and valuation of R/W. A series of meetings were held with the R/W staff at Texas DOT and also with independent fee appraisers in Texas. Based on the input received during the meetings, the Conceptual Framework of the EAS and the User Functional Needs of the EAS were prepared. These documents were presented to the R/W staff as well to the appraisers for their comments and suggestions. A comprehensive list of data requirements was also produced in association with the R/W staff and the appraisers.

A survey was sent out to the states that were participating in this research for their ratings, opinions and suggestions on the developed documents. The responses received from the state DOTs were analyzed using the Delphi Technique to reach a consensus. Thus, the primary documents required as part of this research namely the Conceptual Framework, User Functional Needs and Data Requirements were finalized.

The next step entailed the generation of the Technical Requirements of the EAS. This document listed the various options and technologies available to meet the different user needs. Analyzing the various options, suitable alternatives were chosen

to be incorporated in the development plan of the EAS. It was decided to produce a web-based EAS. Next, based on the development plans, a design for the prototype of the EAS was created. This design included the key functionalities that were necessary to demonstrate the advanced features of the proposed EAS. Finally, a testing plan was prepared in order to test the developed EAS.

Investigations were made to find suitable technologies that could be used for the creation of a SPC mechanism for the EAS. Analyzing various techniques, it was decided to develop a SPC mechanism using statistical analysis. Data clustering was selected as the preferred method for conducting this statistical analysis. Thus, a robust SPC mechanism was developed for the EAS.

The developed prototype of the EAS was taken up for exhaustive testing to ensure proper functioning of the various components of the EAS. The resulting product is an efficient, flexible, sustainable and user friendly system for R/W acquisition. The system demonstrates the effective use statistical analysis to create a benchmark to test the accuracy of the subject appraisal. It also portrays the applicability of latest technologies in R/W acquisition. The EAS provides a safe archiving feature to maintain proper documentation. Lastly, the EAS provides a secure and prompt communication channel to allow the appraisers and the district officials to interact with one another hastening the entire R/W evaluation process.

7.2 CONCLUSIONS

Most of the state DOTs currently use a paper-based appraisal system. These systems are arguably ineffective and laborious, and provide ample opportunities for divergences in appraised values. In order to overcome some of the deficiencies of the traditional methods of R/W acquisition, there has been a widespread desire to move towards an electronic appraisal system. An earnest endeavor has been made through this thesis towards the development of an Electronic Appraisal System (EAS).

This thesis makes significant contributions in solving the majority of problems that are associated with the current practices of R/W valuation and acquisition. First, this thesis specifies the data required for a complete and competent appraisal thus offering a solution to one of the primary cause for divergences in R/W valuation. The list of data requirements prepared as part of the research is based on consensus among experts which was formed using the Delphi Approach, and not through some arbitrary decision making process. Second, a conceptual framework and a list of user requirements have been developed as part of this thesis. This is an effective starting point for future appraisal systems. Third, this thesis has developed a modest Statistical Process Control Mechanism (SPC) mechanism which helps the reviewer in recognizing inconsistent appraised values. The developed system reduces the likelihood of condemnation hearings for acquiring the properties. It also improves the purchasing power of the state DOTs. Fourth, as part of this research, an advanced system to store and retrieve appraisals at a later point of time has been developed. This ensures proper documentation of the appraisals. Also, the EAS minimizes the time delay in conveying messages from the reviewer to the appraiser as well as the R/W administrator. Fifth, a prototype of the EAS has been developed to demonstrate the salient features and attributes of the proposed EAS. Since the EAS is a web-based system, it offers flexibility to the system users. The prototype exhibits the qualities that are desirable in any appraisal system. It offers a secure, professional and well-organized platform for the appraisers to submit their appraisal reports and for the DOT staff to review and accept the reports while maintaining proper communication between them.

7.3 RECOMMENDATION FOR FUTURE ADVANCEMENTS

Although the EAS developed as part of this research is an advanced system, there still exists opportunities for further enhancements to the EAS. The recommendations for future advancements to the EAS are as follows:

a) **Geographical Information System (GIS) Mapping**: There is an enormous scope for the introduction of GIS applications in the EAS. GIS can be used to map the parcels along the corridor. Information about the specific parcels can then be retrieved by clicking on the parcel on the map. Various other applications can also be developed. The acquisition status of the parcels along the corridor can be mapped using different color codes. Also, a link can be provided in the EAS beside the reviewer page to access the GIS map of the subject property and the surrounding properties. This along with the SPC mechanism can help the reviewer in detecting abnormalities in the appraisals.

b) **Statistical Process Control Mechanism (SPC):** The SPC mechanism provided in the prototype of the EAS is a sophisticated system. But, there is still scope for further improvements. In the recent past, SPSS Inc. developed a two-step clustering algorithm which could cluster both categorical as well as continuous variables. This method of data clustering could be useful for clustering complicated appraisals and can be further investigated for incorporation in the EAS.

c) **Automation:** The EAS can be made more robust and user-friendly by introducing a host of other features. A distance calculation tool can be provided particularly in cases of urban cities which could automatically calculate the distance from the parcel to the Central Business District (CBD), the nearest freeway etc. Also, the same logic could be used to locate the zoning for the area, the school district, the FEMA map number etc. This information could then be automatically filled into the appraisal forms. The appraiser should still have the flexibility of providing this information manually.

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