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# Electronic Appraisal Methodology for Right-of-Way Acquisition in Highway Projects

by Carlos H. Caldas, Zhanmin Zhang, Ragheb Al Halabi, and Elizabeth Kincaid

*When right-of-way is acquired for highway projects, state departments of transportation (DOTs) must ensure property owners receive a fair market value for their land by delivering high-quality appraisals. Despite recent technological advances, the highly complicated appraisal process often results in similar properties being assessed differently. Several DOTs sponsored a study to develop an electronic appraisal method to improve the appraisal process and to reduce the likelihood of inconsistent appraisal values by capturing, transmitting, storing, managing, and analyzing the appraisal data. The proposed method's framework is discussed and a prototype of the system has been developed to demonstrate its features.*

## 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, 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, which can be a complicated process in that it involves multiple stages and 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 cost 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. The valuation must 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 location of the property being acquired, and commonly causes variations in the valuation of similar or same properties appraised by different individuals. According to the National Cooperative Highway Research Program (NCHRP) Report 126 (1971), “the most important basic reason for divergence 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” (NCHRP 1971). The report also found that approximately 21 % of R/W valuation divergence occur as an outcome of the lack of proper or insufficient data, and many incongruities result from misguided information on the part of the appraiser (NCHRP 1971). 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.

There are three methods for determining property values: the cost approach, the sales comparison approach, and the income approach. The cost approach is based on the premise that a potential buyer should not pay more for a property than the cost of building an equivalent one. The sales comparison approach uses the price of recently sold properties that are comparable to the subject property in order to determine the value. The income approach is common on commercial and investment properties. It uses methods such as discounted cash flow, direct capitalization, and gross income multiplier to model the behavior of market participants. Since these methods are based on fundamentally different approaches and assumptions, the appraised property value may vary. It is

usually up to the appraiser to choose the best method for a given property, and justify the selection and final appraisal.

There are many motivations that triggered the research study discussed in this paper. First, as discussed above, the problem of property valuation is complex in nature and there is no consistent process used to determine it, resulting in dissimilar price valuations for properties that are alike in nature. Hence, it is essential to determine the data that are required to arrive at the just compensation for the property. Moreover, 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 property values in order to make the process more efficient. In addition, 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. Last, there is a substantial delay in the transfer of appraisals from the appraisers to the reviewers and from the reviewers to the R/W administrators. A system that reduces the time required for the entire appraisal submission and evaluation would be beneficial.

The objectives of the research are, first, to establish the list of data required by the appraiser so as to arrive at the just compensation for a property. It also aims to develop a statistical mechanism to reduce the likelihood of inconsistent appraisals by warning the reviewer of variations deemed to be conflicting with the expected values. Exploring emerging technologies for use in the R/W acquisition process and building a system that can efficiently organize, manage, and store the appraisal data would be very beneficial. Last, developing an effective communication mechanism would minimize the idle time spent during an appraisal acquisition process. Thus, the ultimate objectives of this research project are to develop the conceptual framework and technical requirements of a new electronic appraisal system (EAS), which could effectively support the transmission, analysis, and storage of the appraisal information, and also to construct a prototype of the proposed EAS to demonstrate its capabilities.

To ascertain the above objectives, a staged development process for the new EAS was conducted. This process included an overview of the current practices followed in R/W acquisition and the recent advances made in this field. Secondly, a conceptual framework of the EAS describing the data flow structure was developed. The results of a survey conducted at 13 DOTs were used as an input for the framework. The Statistical Process Control (SPC) mechanism that was used as a validation tool for the appraisal results was created and tested by comparing similar parcel appraisals. The SPC implementation was done through the use of data clustering; thus a suitable data clustering technique was selected for incorporation in the tool. Finally, a prototype of the EAS was designed and developed to prove its applicability. The prototype is briefly discussed in this paper.

## **LITERATURE REVIEW AND CURRENT PRACTICES**

In order to develop an effective understanding of the principles and practices followed in the appraisal community, a literature review has been conducted that 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.

Under the U.S. Constitution and state constitutions, states have the right to acquire either the entire amount of a privately-owned property (whole-taking) or a part of the property (partial-taking) depending upon the needs of the transportation project. Since the property owner must be properly compensated for his/her losses, states enlist the services of an independent fee appraiser, who must follow the framework specified by the respective state transportation agency to determine the appropriate value of the property being acquired (FHWA 2000; 2001; 2002a; 2002b), as well as follow the rules developed by the U.S. Appraisal Institute as a licensed professional.

Conventionally, the appraisal 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 1 (FHWA 2000; 2001; 2002a; 2002b).

**Table 1: Examples of Data Elements Collected During the 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 are inspected by the appraiser. The appraiser analyzes these data and the data listed in Table 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 and submitted to the DOT for review. The state makes an offer to the property owner based on the fee appraiser's recommendation. If the land owner declines the offer, he/she may make a counteroffer to the state. If the terms of the counteroffer are not acceptable to both parties, the state will institute 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 property's final value is decided by an impartial third party, such as a jury (FHWA 2000; 2001; 2002a; 2002b).

In the appraisal process, an enormous amount of data and information is collected. The 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 misplacement of information. According to a study conducted by Adkins and Buffington (1967), poor documentation of appraisals was a leading cause of discrepancies in more than half of the districts in Texas. As mentioned earlier, the valuation of properties and a host of different issues also lead to complications in the appraisal process.

Thus, a reliable computer-based system that can be used to store, transmit, and analyze this appraisal information would prevent the aforementioned problems and improve the appraisal process significantly. A few electronic R/W appraisal systems have been developed for use at state DOTs and other institutions to help organize appraisal and R/W information so that it may be analyzed, queried, and retrieved to aid in decision making. In Virginia, a Right-of-Way and

Utility Management System (RUMS) tool was developed to help upper-level managers track construction projects, R/W acquisitions, displaced/relocated persons, and the installation of utilities within R/W land (FHWA 2005). This system provides managers with an excellent tool to monitor key project dates to ensure that resources can be shifted for on-time completion. The RUMS tool allows a multitude of information, including that from 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 that utilizes Report Definition Language (RDL). Minnesota DOT has purchased the rights to the RUMS software (FHWA 2005). A few other DOTs are also considering purchasing the rights.

The Florida DOT has also ventured into the development of electronic R/W management tools by developing two systems: an appraisal document storage database that stores the R/W appraisal reports, and an R/W management system (FHWA 2004). The storage document can only store the information from the appraisals. Statistical analysis cannot be performed using the database. Attempts have been made by the Florida DOT to implement an 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 developed "Projectwise" to help organize appraisal and R/W information so that it may be analyzed, queried, and retrieved to aid in decision making (AEC 2004). Projectwise organizes the information for each piece of 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 highway projects (AEC 2004). Component indexing allows 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 R/W management obligations, such as payment, with highway design aspects like alignment information (Quorum Right-of-Way Management 2004). It comprises 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 site assessment captures and manages field data surveys and associated documents. It also validates the data and ensures accuracy and consistency (Quorum Right-of-Way Management 2004). MicroSolve (2006) developed a suite of software applications to manage appraisals. They are collectively referred to as Computer Assisted Mass Appraisal Solutions or CAMA 2000. The system helps in the actual valuation process by offering three types of valuation approaches: the cost approach, the market approach, and the income approach. The software package includes SPSS, which is used for carrying out the linear and non-linear regression required for the market approach. The software also has a data storage system to securely save the appraisals (MicroSolve 2006).

## **FRAMEWORK AND REQUIREMENTS OF THE ELECTRONIC APPRAISAL SYSTEM**

This research study on developing an EAS for R/W acquisition was funded by several state DOTs. All state DOTs have been invited to participate, but only 13 states DOTs agreed to fund this study: Alabama, Alaska, Florida, Idaho, Illinois, Louisiana, Mississippi, Montana, New York, North Carolina, Texas, Washington, and Wisconsin.

The main advantages of the proposed method over the existing approaches described above are: the method is based on the needs and the requirements of the participating state DOTs, supports the three types of appraisal methods, provides controlled access to different user types, contains

a statistical process control component, supports appraisal reviews, enables version control, and provides access to different users via the Internet.

In formulating the various requirements of the EAS, the research team worked extensively with consultants from the appraisal industry. Also, the participating state DOTs were requested to provide information and advice on critical issues concerning the entire development of the EAS. Various technical memorandums were prepared, and these documents were sent to the participating state DOTs as a survey for input on the conceptual framework, the user functional needs, and the data requirements for the EAS. With the help of the Texas Department of Transportation's (TxDOT) Right-of-Way Division as the contact point, the research team sent the survey documents to the 13 state DOTs that funded the study. 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.

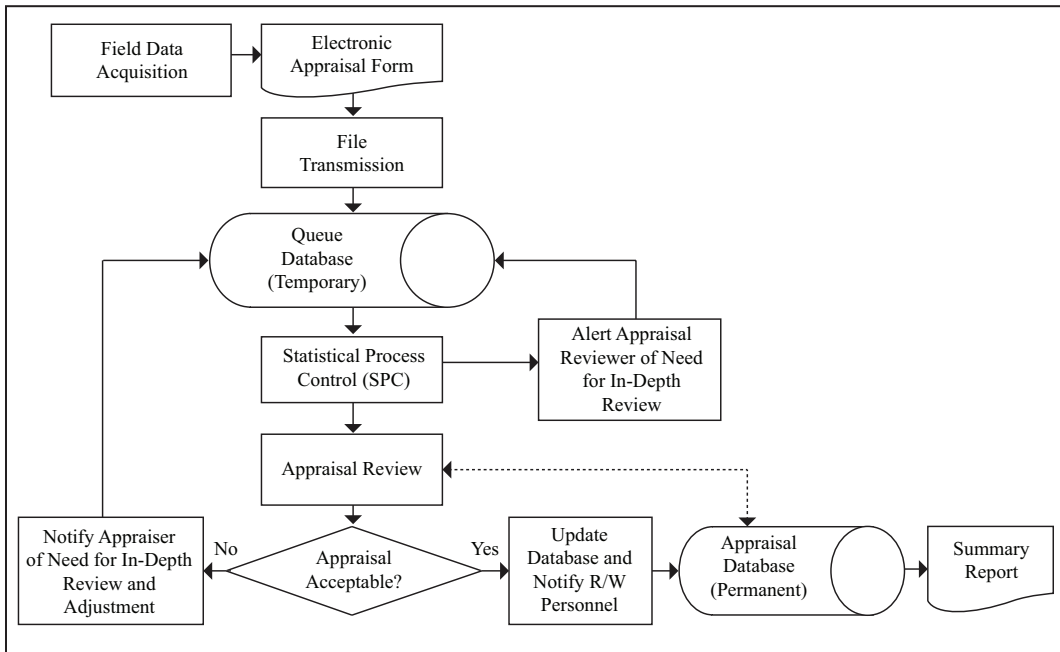
The responses received from the participating state DOTs were then analyzed using the Delphi Technique. This technique involves having the state DOT employees answer surveys and questionnaires, which are then grouped with the other comments and returned to all respondents. This process is repeated multiple times until a consensus about a particular opinion is reached. The idea is that by seeing the replies of other panel members, experts will rethink their prior responses. It replaces direct debate and committee activity with a carefully designed program, thereby reducing the influence of certain psychological factors such as the 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.

Based on the comments from the DOTs, the decision was made to develop a web-based system, as opposed to a File Transfer Protocol (FTP) system, which is a standard network protocol to transfer files across a network. Also, the survey influenced the decision that an appraisal can be changed only by the appraiser of the original appraisal. One of the most important outcomes of the survey was to clear misunderstandings surrounding the use of the 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. The DOTs also requested 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 wherever possible to accommodate that situation. 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.

The design of the conceptual framework lied in the core of the EAS. It helped elucidate the entire process envisioned in the proposed system. The framework for the EAS was prepared by the research team based on the literature review and fine-tuned with comments provided by the participating state DOTs. Figure 1 gives a schematic representation of the conceptual framework of the EAS.

The first component of the EAS, Field Data Acquisition, involves gathering basic information vital to making a value estimate. Data pertaining to site characteristics, such as physical features and dimensions, are collected onsite by the appraiser and recorded in either paper or electronic format. Afterwards, all data, including the appraisal, background information pertaining to the appraiser, the property owner, and other interested parties, are loaded onto the standardized EAS. 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 and completed by the appraiser. The electronic appraisal form is then transmitted from the office of the appraiser to a centrally located Temporary Queue Database via a secured web-based interface. Upon file transmission,

**Figure 1: Electronic Appraisal System Process**



the electronic appraisal form will receive an electronic signature, verifying its authenticity. The function of the temporary queue database is short-term storage of the appraisal while it is being reviewed by appraisal reviewers. Meanwhile, queued appraisals are protected from unauthorized persons tampering with them by providing authorization only to the appraiser, appraisal reviewers (including contract reviewers), and a limited number of DOT R/W personnel to view, modify, or suspend the appraisal as necessary.

The SPC, if initiated by the user, would examine and check all critical values on the electronic appraisal form against historical appraisal information currently stored in the permanent electronic appraisal database. The purpose of the SPC is to identify and flag any information contained within an appraisal that falls outside of historical and/or known levels of acceptability. The SPC will only guide the reviewer, who is the final judge about the acceptability of an appraisal.

The appraisal reviewer then performs the review and decides if any of the flagged data need 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. 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 the DOT for later use. At all times, all appraisals stored in the permanent database are available to authorized R/W personnel to perform various analyses and to generate summary information. This summary information may be viewed on personal computers and printed.

After the conception of the framework 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 the appraisers, the reviewers, and the R/W administrators. As can be imagined, each user type has a specific requirement and performs various functions. The Appraisal Form is the first component of the user functional needs. It should be expandable and include all of the primary sections (such as neighborhood analysis and value of the property). A cover page with essential information, such as the certification of the appraiser and executive summary, should be included

in addition to the identification and justification of the valuation approaches used during the appraisal process. For security purposes, the electronic appraisal form must contain a mechanism for applying an electronic signature via login IDs and passwords. 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 user page) using Java Script, or on the backend (on the server) using computer programming technologies such as PHP, Perl, ASP, JSP, and ColdFusion. Every time the user clicks on the “Next Page” button, the system will check the mandatory data fields before proceeding to the next page. Data/file transmission comes second in the user functional needs. The system should have a mechanism to retain a copy of the original acceptable appraisal in the database, and be able to automatically send reviewers’ comments back to the appraiser and corresponding district R/W office. Also, a quality control mechanism for the appraiser must be provided to review the submittals to ensure that all data fields are completely and accurately filled. As discussed earlier, the queue database should be accessible to the appraisers, the reviewer, and corresponding R/W personnel with controlled privileges, with only the appraiser having the capacity to edit an appraisal. The reviewer will be provided with the feature to send his/her comments to the appraiser and relevant DOT personnel. In the approval process, the system must have the capability to approve the appraisal online with the support of the electronic appraisal review form. E-mail notification of the approval should be sent to the appraiser, the reviewer, and R/W acquisition consultant(s). Access to the permanent appraisal database should be restricted to personnel authorized by DOT. The permanent database should provide a mechanism to conduct the various queries based on attribute information (appraisal number, property address, owner name, appraiser name, or combined keywords). This will help DOT personnel to quickly get the relevant information about a specific appraisal or a group of appraisals along a corridor.

The User Functional Needs as discussed above cannot be fulfilled without the appropriate support of adequate data. Hence, it was necessary to produce a list of data requirements that were required to be collected by the appraiser in order to use the proposed EAS to support making a sound and a judicious decision about the value of the property. To meet that 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 (e.g., categorical, text). 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. As 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 in Table 2.

**Table 2: Excerpt From the Data Requirements of the EAS**

5.7 Adjustment Explanation				
5.7.1	Financing Terms	Text	Text Box	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		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	Maps	Box	4.55



## MECHANISM OF STATISTICAL PROCESS CONTROL

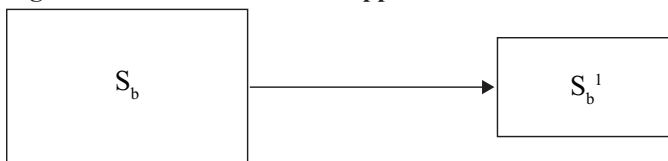
SPC is a methodology that is widely used in manufacturing and financial industries and is making inroads in the appraisal industry. It is a method that allows users to separate random variations, in their data from nonrandom variations and then to analyze the nonrandom variations to improve the quality 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 an SPC mechanism for the EAS proposed in this project is a complex task.

There are several techniques that could be used to implement an SPC mechanism for the proposed EAS. The statistical analysis method was chosen because it is one of the most widely used. One example of an SPC mechanism for this project is a very simple process in which the data entered by the appraiser are compared with the range of values that are possible for that data entry. 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 1986). 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. If the observed value, i.e., the value entered by the appraiser in dollars per square foot (\$/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.

The SPC mechanism as envisioned for the EAS is described as follows:

Let  $S_b$  be the group of appraisals in the database.  $S_b = \{B_1, B_2, B_3, \dots, B_n\}$  where  $B_1, B_2, B_3$  are the appraisals. Also, the appraisals consist of various attribute data, such as property type and size, among others. The appraisal value is a function of these attributes. Consider the appraisal under review. Let it be  $B_x$ . Now,  $B_x = f(a_1, a_2, a_3, \dots, a_n)$ . For the SPC mechanism, the procedure would be to identify appraisals from  $S_b$  that have attributes very similar to  $B_x$ . As Figure 2 illustrates,  $S_b^1$  is the sub-group of  $S_b$  consisting of appraisals that are a function of similar attributes. Thus a good measure for comparison can be obtained.

**Figure 2: Selection of Similar Appraisals**



To identify similar appraisals, the process of data clustering is used. Data clustering is an unsupervised classification of data items into groups based on some measure of similarity (Jain and Dubes 1988). There are various available algorithms to cluster the data. One of the most commonly used algorithms is the K-Means method (MacQueen 1967). The K-means method is also one of the most efficient methods for data clustering. Although other more complicated and advanced clustering methods were investigated during this study, K-means was deemed as better suited for the purposes of this research.

K-means clustering is an iterative method. It is a type of partitional clustering method where the data are clustered into “K” clusters specified by the user (Webb 2002). 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 to randomly generate k cluster centroids, assign each object in the dataset to the centroid that is nearest to it, recalculate the centroid of the clusters, and then repeat until the assignment remains unchanged. The main advantage of this clustering method is that it is very straightforward. It is fast and can be used with acceptable 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.

The clustering technique was incorporated into the EAS. 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 based on experts' opinions. 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 are presented in Table 3.

**Table 3: List of Selected Attributes for Data Clustering**

S. No	Attribute	Data Type
<b>I.</b>	<b><i>Compensation</i></b>	
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
<b>II.</b>	<b><i>Area, Neighborhood and Whole-Site Analysis</i></b>	
1	Total acre	Continuous
2	Acquired acre	Continuous
3	Improvement age	Continuous
4	Setting	Categorical
5	Shape	Categorical
6	Access	Categorical
7	Distance from Central Business District (CBD)	Continuous
8	Frontage	Categorical
9	Topography	Categorical
10	Corner plot	Categorical
11	Soil conditions	Categorical
<b>III.</b>	<b><i>Highest and Best Use</i></b>	
1	Property type	Categorical
2	Highest and best use as "vacant"	Categorical
3	Highest and best use as "improved"	Categorical

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, because 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:

$$z = (X - \mu) / \sigma$$

where

- z - Standardized score
- X - Raw data value
- $\mu$  - Mean of the population
- $\sigma$  - Standard deviation of the population

As part of the data preparation, appraisals will be represented as points in a multi-dimensional space. Therefore, distances between these points can be calculated. Once the data preparation stage is complete, clustering can be undertaken. For the SPC, a variation of K means clustering has been developed. The procedure is diagrammed in Figure 3 and presented 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 point representing the latest appraisal and all the other cluster centroids.

Step 5: If the distance is greater than the threshold distance, make the second appraisal as the centroid of the next cluster, or 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.

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 values for these clusters serve 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. As can be seen from the figure, the circle-shaped 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.

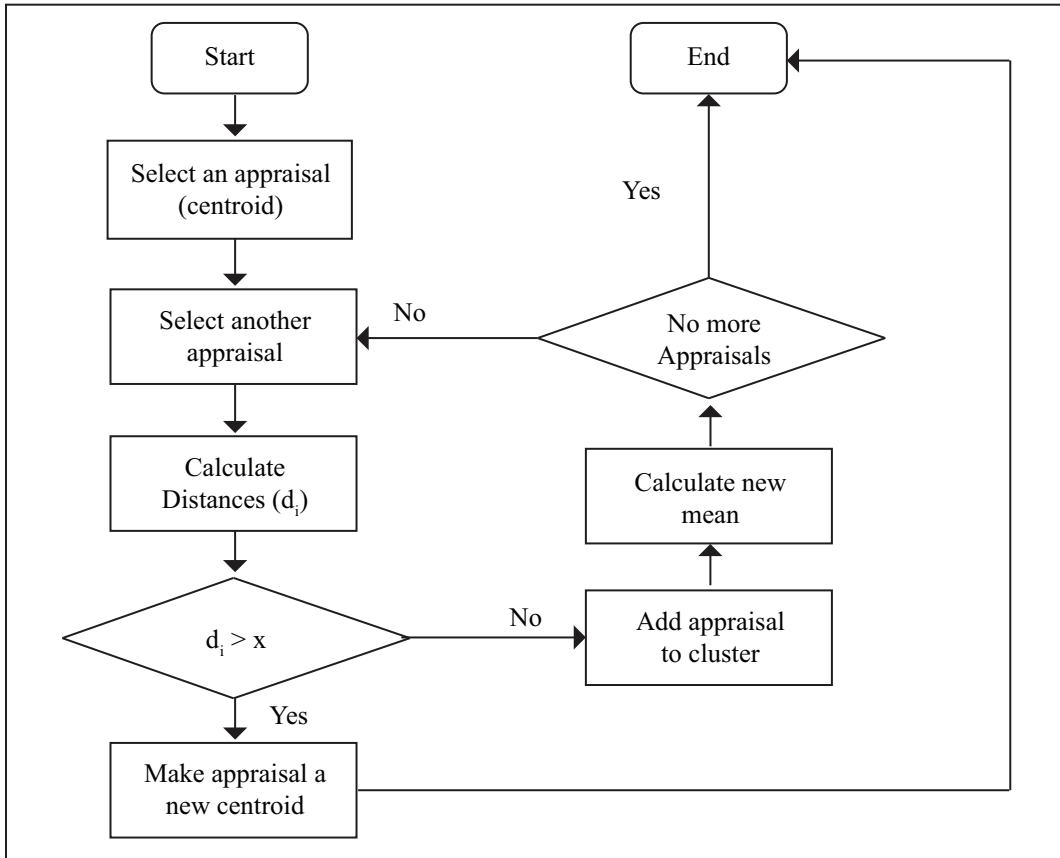
Analyzing the sample result, it can be seen that the land value provided by the appraiser for the subject property is \$2 per square ft (SF). The upper limit is \$14/SF and the lower limit is \$0/SF. Hence, the appraised value lies within the range of recommended values and is thus deemed "consistent."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

## **PROTOTYPE OF THE ELECTRONIC APPRAISAL SYSTEM**

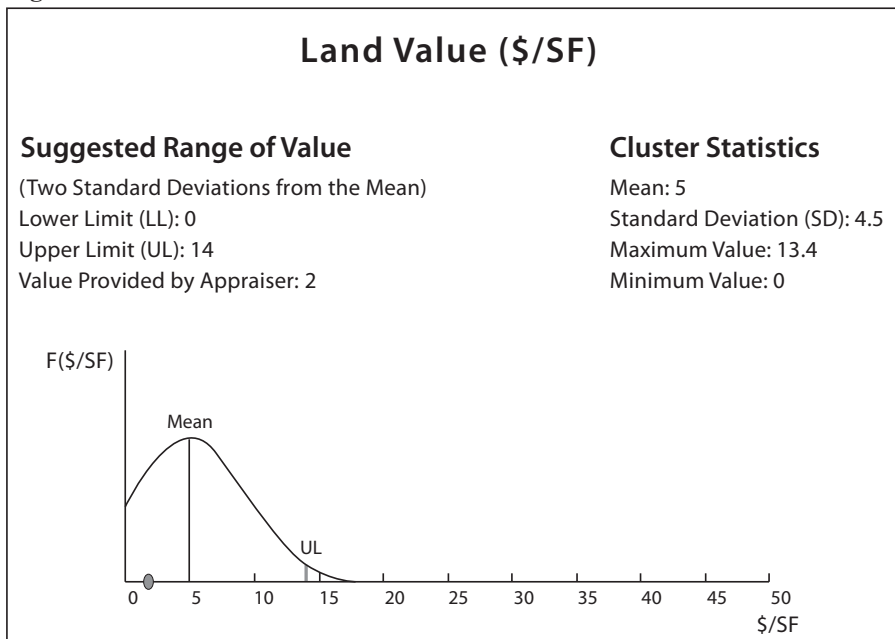
After the framework and the requirements of the proposed EAS have been discussed, the next step was proving the applicability of the proposed EAS and demonstrating its capabilities by developing an EAS prototype. The steps were to come up with a development plan specifying the various components and 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.

The prototype of the 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 an

**Figure 3: Flow Chart of Clustering Mechanism**



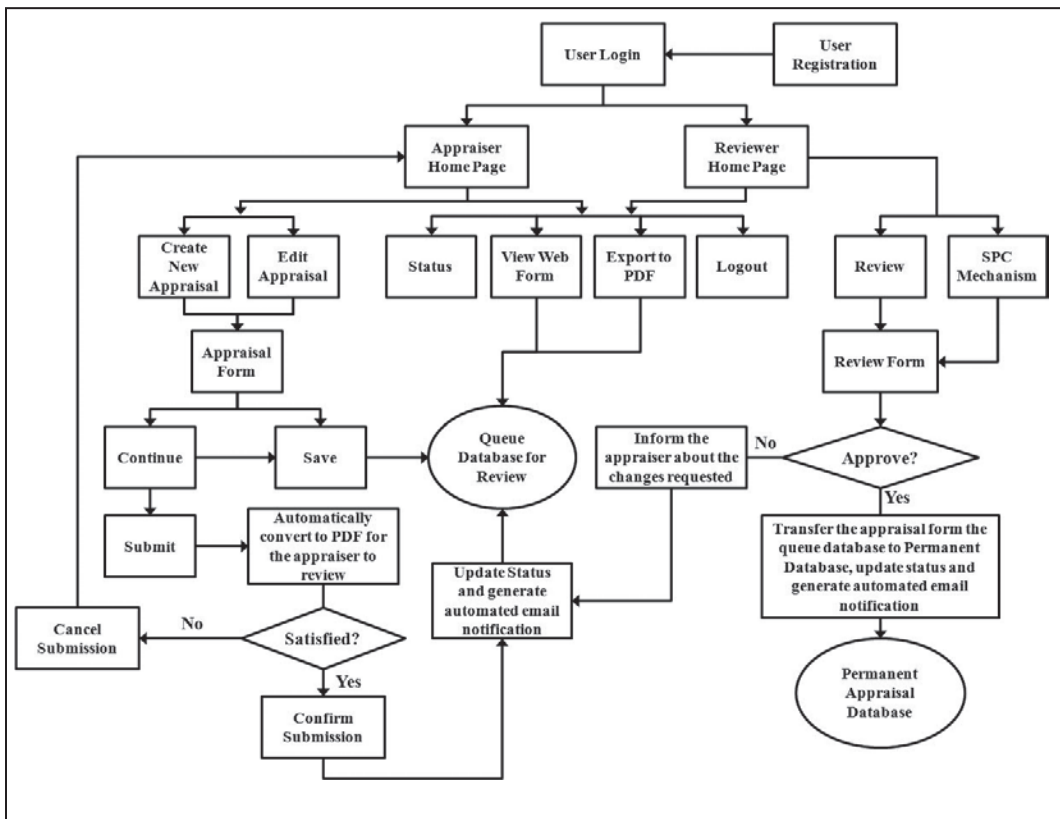
**Figure 4: Result Obtained from SPC Mechanism**



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 (W3Schools 2004). The SPC mechanism was established through statistical analysis and database queries.

The design of the structure and relationships were built on a close interaction among the various components of the prototype. Figure 5 shows the interaction and relationship between components. When the user first accesses the system, he/she is requested to register. The user will be directed to the login page to login into a system. Upon successful login, based on the user type, the appraiser home page or the reviewer home page will be loaded.

**Figure 5: Relationship and Interaction Among Components**



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 appraisal report. Another common feature is the ability to view the appraisal report in PDF format or as a web page. Apart from these shared 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. When the appraiser submits the appraisal form, 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 formally submit the appraisal report. If not, he/she can cancel the

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 SPC mechanism apart from the options that are common to the reviewer and the appraiser. In the review process, the reviewer will have the ability to comment on the appraisal report and finally approve/request changes/not approve the appraisal. The SPC mechanism can be initialized by the reviewer. If the reviewer approves the appraisal, the appraisal is transferred from the queue database to the permanent appraisal database and an automated e-mail 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 e-mail 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 be reflected on the user home page.

Once the architectural design and the module design were completed, the prototype development was undertaken. The development of the prototype was 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. After the prototype was developed, it was tested internally and evaluated with typical R/W appraisals to ensure that it had the robustness to demonstrate the requirements. The tests were carefully planned and executed to ascertain a good quality product.

One of the tests ensured that the logging system differentiated between the privileges being offered to the appraisers, reviewers, and system administrators. After successfully logging into the system, the appraisal form was next tested to ascertain if its length was consistent with the appraisal type selected by the appraiser, to ensure that data could be saved at any time, and to make certain that the visuals and plats could be included in the appraisal as pictures. Since this appraisal information provided by the appraiser is in HTML, its conversion to a PDF format was then verified. Next, the system was tested to validate the submission mechanism by confirming that after successfully submitting the appraisal, a message was received by the appraiser and all concerned parties. Subsequent messages concerning notifications of appraisal status were also verified. Then, in order to check the effectiveness of the SPC mechanism, it was run on a control dataset with a known number of clusters. To test the transferal of approved reports from the temporary to a permanent database, a report was accepted online and verified that it was moved. The final test involved conducting queries from the permanent database to generate summary information of importance to DOT R/W personnel.

After successfully conducting the aforementioned tests internally, the prototype was demonstrated to representatives of several DOTs where it was determined that the final prototype of the EAS is user-friendly. The features provided are easy to comprehend, navigate, and use. Moreover, the prototype developed is both realistic and sensible. It has the features that are required and useful for producing quality appraisals. Maintainability is assured by easy and straightforward means and mechanisms for system maintenance. The prototype is also flexible, such that it can be used for different types of appraisals and for future modifications as needed. The system is agile enough to accommodate any future needs.

## **IMPLEMENTATION RECOMMENDATIONS**

The demonstrations to the DOTs, however, indicated further steps that should be taken in order to move from the prototype version of the EAS to an operational version. After all, since the prototype was built to demonstrate the key features of the proposed EAS, it was designed with limited functionalities. In order to move the system beyond the prototype, various components of the EAS must be refined, such as improving the PDF conversion mechanism and the quality control

mechanism for data entry. Also, allowing an appraiser to specify the number of non-photograph visuals (such as maps and plats) that he/she might provide, and to use an existing appraisal as a template while creating an appraisal for a similar property, are beneficial features not included in the prototype. Thus, the development of an operational EAS can be accomplished by first fine-tuning the system and then through the following additional work: customize the system to meet the specific needs of the individual DOTs, improve the system's security, populate the system with real appraisals to test key functions, implement a pilot study for the system, and finally transfer the technology to the DOT. By following these recommendations, an operational version of the EAS can be developed for states that are interested in implementing an electronic appraisal system.

## **RECOMMENDATIONS FOR FUTURE ADVANCEMENTS**

Although the EAS developed as part of this research is an advanced system, opportunities for further enhancements to the EAS still exist. There are several recommendations for future advancements to the EAS. 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. Moreover, the SPC mechanism provided in the prototype of the EAS is a sophisticated system, but scope for further improvements remains. Finally, 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, or the nearest freeway. Also, the same logic could be used to locate the zoning for the area, the school district, or the FEMA map number. This information could then be automatically filled into the appraisal forms. The appraiser should still have the flexibility of providing this information manually.

## **CONCLUSIONS**

Most of the state DOTs currently use a paper-based property appraisal system. These processes are arguably ineffective and laborious and provide ample opportunities for divergence 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 process. An earnest endeavor has been made through this research towards the development of an EAS.

This research study makes significant contributions in solving many problems that are associated with the current practices of R/W valuation and acquisition. First, the data required for a complete and competent appraisal were specified, thus offering a solution to one of the primary causes for divergence in R/W valuation. The list of data requirements prepared as part of the research is based on a consensus among experts from several DOTs, which was formed using the Delphi Approach. Moreover, a conceptual framework and a list of user requirements were developed. In addition, this project has developed an 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. The EAS minimizes the time delay in conveying messages from the reviewer to the appraiser, as well as the R/W administrators. Afterwards, a prototype of the EAS was developed to demonstrate the salient features and attributes of the proposed EAS. Because 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 among them.

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