GIS and Human-centered Systems Design: Using Ethnographic Data Collection and Analysis Methods to Design a Utility Permitting Support System

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Abstract: *Ethnographic methods are increasingly being used to study social structures of the workplace as an aid in the process of human-centered systems design. Here, the ethnographic approach is used for data collection and analysis in support of requirements elicitation for a utility permitting support system. A summary of ethnographic methods is given and discussed in the context of other sociotechnical design methods. This is followed by an example case study in the state of Texas that includes snapshots of the final design. System designers found ethnographic methods to be useful in exploring human dimensions of the design problem, exposing fine details of the human aspects of work that might otherwise be overlooked, and for sorting out tenuous assumptions from important facts that affect requirements specification. Although the system is not yet implemented, preliminary reaction to the system design by the eventual users was positive. It is argued that ethnographic methods would be best used in combination with other sociotechnical methods.*

INTRODUCTION

The geographic information system (GIS) has undergone rapid changes over the past 20 years, moving from networks of expensive high-end workstations in government and university research laboratories to desktop personal computers in modest consulting firms. During this time, larger organizations have addressed data quality and redundancy issues by moving from project-level GIS programs to enterprise and cooperative GIS solutions. Problems of public access to spatial data are being addressed by research aimed at resolving spatial query and display issues over the Internet. In addition, numerous government spatial data clearinghouses have enabled public users to search for and download data directly from the Internet for use on their own systems. These developments have dramatically increased the accessibility and efficiency of GIS programs.

However, the design and implementation of GIS and procedural support systems within organizations often fail when the formal and informal social structures of the workplace are poorly understood. Earlier investigations into the problems of data sharing and GIS implementation have provided evidence of specific human and political conditions that can lead to the success or failure of such systems. This includes unforeseen social forces such as fear of losing control, autonomy, independence, complexity, or power (Onsrud et al. 1992, Obermeyer and Pinto 1994, Onsrud and Rushton 1995, Sussman 1996, Flanagan et al. 1997, Harvey 1997, Nedovic-Budic 1997, Kling and Star 1998, Nedovic-Budic and Pinto 1999a and 1999b, Reeve and Petch 1999, Kling 2000, Nedovic-Budic and Pinto 2000). In some cases, research has focused on developing human-centered design processes as a way to account effectively for human and social factors within the system prior to implementation. These include participatory design, soft-systems methodology, and rapid prototyping (Checkland and Scholes 1990, Harvey 1997, Reeve and Petch 1999). Another set of methods that is rapidly gaining popularity in human-computer interaction (HCI) and computer-supported cooperative work (CSCW) comes from the field of ethnography (Randall et al. 1994, Hutchins 1995, Ellis et al. 1996, Beynon-Davies 1997, Simonsen et al. 1997, Dourish 1998, Fetterman 1998).

Each of these methods requires special knowledge and skill to successfully examine the work environment and interact with the people in it. For instance, one method of participatory design described by Harvey (1997) develops detailed descriptions of boundary objects (Star 1989) and associated semantics to identify commonalities and differences in cultural meanings between groups or agencies. These are described as the key to connecting participants' world views and supporting successful collaborative action. To identify commonalities, designers hold a workshop or distribute documents to discuss and negotiate detailed descriptions of semantics involving the data objects. These can then be translated into data dictionaries and eventually a data model.

The key interactions with people in participatory design are described as negotiations. There is an implied assumption, however, that all participants in the negotiations are expecting to benefit from a successful outcome, which may not always be the case in organizational contexts. To be sure to capture the perspectives of all potential users and not just those who expect to benefit most, additional work is needed prior to conducting a participatory design workshop.

Another sociotechnical design approach is known as the Soft Systems Methodology. Checkland and Scholes (1990:4) describe this as a "methodology for operating the endless cycle from experience to purposeful action." This methodology starts with a problem situation that is first "expressed" and then analyzed to develop a set of "rich pictures." Rich pictures are not themselves models of the system but do represent structure, processes, and issues of the organization and can lead to a problem definition. They identify issues of concern to people in the design situation, the roles that these people play within the organization, and the types and hierarchy of power. The rich pictures are subsequently refined until they evolve into conceptual models of the system. The conceptual models are then compared with the original "real-world" problem situation to see if they are the same or different. The comparison of the models with reality becomes a basis for discussion and debate. After identifying feasible and desirable changes, recommendations for implementation are given.

While users are involved in much of this process, the key design steps are in expressing the problem situation and developing rich pictures. This can be done by observing the work context to identify relevant tasks, human interactions, tools used, etc. Informal interviews also help to clarify observed actions that are not fully understood or to expose other important tasks that were not previously observed. Workshops and discussions can also be used to create mock-ups and simulations, or to resolve conflict between competing interests. The emphasis for data collection is on developing an understanding of the culture and/or context in which the problem exists rather than on the problem itself.

In the process of developing system requirements for both the participatory and soft-systems methods, human and social aspects of work are identified and analyzed to provide a better fit between the system and its users. To aid in socially grounded requirements elicitation, many information systems specialists are turning to techniques used in ethnography (Randall et al. 1994, Hutchins 1995, Ellis et al. 1996, Beynon-Davies 1997, Simonsen et al. 1997, Ellis and Wunneburger 1999, Quiroga et al. 2001). Ethnographic methods are already well known for their use in case study research for gathering evidence to evaluate system design post-implementation. In this article, however, the focus is not so much on evaluating an existing design as it is on discovering opportunities and constraints during the needs assessment stage of a system design prior to implementation.

Ethnographic Methods

Numerous authors have described how ethnographic methods have advantages over other methods in investigating the subtle aspects of cultures that can affect design success. First, unlike laboratory work, ethnography is concerned with situated cognition (Hutchins 1995, Fetterman 1998). In the Soft Systems Methodology case, rich pictures are an attempt to illustrate the intricacies of work that is socially organized and carried out within organizations. Documented procedures can provide a starting place for understanding how work activities are organized. However, work activity or workflow is not always documented accurately and is often understood differently among participants. Situated studies have a greater potential to reveal these inconsistencies. In contrast, workshops, which are the basis for participatory design, are artificial environments that are not situated within the actual flow of work. This can result in an abridged or distorted view of workflow.

Second, some workers perform activities routinely without being able to articulate how they are done. Understanding this tacit knowledge can often be an important key to improved system relevance and usability. A combination of task observation with unstructured and open-ended interview techniques can be particularly effective in expressing tacit knowledge (Beynon-Davies 1997).

Third, competing interests among employees and departments can affect how and if a system is ultimately adopted for use (Obermeyer and Pinto 1994, Onsrud and Rushton 1995, Sussman 1996, Harvey 1997, Nedovic-Budic 1997, Nedovic-Budic and Pinto 1999a and 1999b, Reeve and Petch 1999, Nedovic-Budic and Pinto 2000). It is important to understand these competing interests before a system is designed and implemented. However, people are often unwilling to discuss issues of conflict in public forums such as workshops. In addition, these issues are rarely documented for inspection by system designers and are only likely to be discovered through personal contact with members of the organization. Again, unstructured interviews and observation can be helpful in revealing these kinds of situations.

To summarize, ethnographic methods have the potential to expose undocumented patterns of workflow, structure knowledge, and work processes that are otherwise difficult to express verbally, and to reveal both positive and negative social relationships and power hierarchies among members within organizations. These methods are made up of a variety of techniques, most of which use the researcher as the primary instrument for data capture (e.g., observation, interviews, document analysis, questionnaires, outcroppings, proximics, and kinesics, and folk tales). Each of these is briefly described below and is summarized in large part based on Fetterman (1998).

Primary Instruments for Data Capture

Observation is the method most often used for gathering data in ethnography. It occurs in situ, which requires some form of access to the environment under study. Observation does not mean that the observer must sit out of the way and keep quiet but, on the contrary, should "live among" the people in the environment and get to know it as an insider while simultaneously keeping a professional distance. This means keeping track of events, asking questions, documenting artifacts, getting to know people, etc. Understanding begins with a broad view and works toward the details in a cyclical fashion to develop both breadth and depth of knowledge. Data can be captured on tape or videotape, although the most common method is writing notes in a project notebook. The researcher should be most concerned with recording all of the details rather than filtering relevant information. Refining the data should normally be done after detail collecting is complete. On the other hand, observed events or actions that seem promising should be recognized and investigated in greater depth.

Interviews are used to organize and classify perceptions. They are also used to clarify information that is not clearly understood through observation. Interviews can be formally structured, semi-structured, or informally structured. Typically, informal interviews are used in the beginning as a way to explore the cultural context. Later, semi-structured and formal interviews can be conducted to test the researcher's knowledge or understanding of the context. Informal interviews are much like conversations in which questions are most often formed based on information given by the interviewee rather than prepared and ordered beforehand. Some questions are usually prepared ahead of time to move the interview in a desired direction, but participants are typically urged to elaborate on various points and are allowed to change directions when the subject matter appears to be relevant and enlightening. Kinesics (or body language) is often as important as a verbal answer to a question and should be noted when useful and appropriate. Body language may also be a signal to explore a topic further, change to another topic, or to end an interview.

Document analysis is particularly useful as a starting point in studying organizations because analysis can expose both the formal organizational structure and its ideals or philosophies. Mission statements, workflow diagrams, departmental hierarchies, job descriptions, products/artifacts, forms etc., all contain information that can help a researcher begin to understand how an organization works. In many cases, the documents are not totally accurate as organizations evolve over time and documents become outdated. Inaccuracies can often be a clue to problems or power relationships that exist within organizations and should not be discarded or set aside as simply being wrong. Analyzing documentation can occur at any time during a project, but it is also a good way to gain insight into an organization before an in situ evaluation takes place.

Surveys or questionnaires can be used to gather information. They are most useful when information is desired from large numbers of people. However, they disconnect the researcher from participants and can result in an understanding that is less rich than direct engagement. They can also result in the misinterpretation of questions or even a malicious or intentional distortion. When the number of participants is manageably small, an interview approach would normally be preferred to help ensure data consistency.

Outcroppings are observable conditions that can imply information about a context. For example, if one department uses old worn-out furniture while an adjacent department has expensive desks, tables, and shelves, it should alert the researcher to investigate further. Do the departments have different budgets to work with? Is the organization replacing furniture in phases? Is one department involved in serving the public or entertaining clients and the other providing support functions behind the scenes? Untested speculation can lead to erroneous conclusions, so is important to have participants provide explanations for outcroppings rather than having a researcher infer an explanation.

Proxemics (socially defined distance between people) and kinesics (body language) can provide useful clues about members of an organization and their relationships with other members. In isolation, these clues can be easily misinterpreted, but in combination with other data gathering devices such as observation or informal interviews, the clues can help system designers focus on issues critical to the adoption and use of a system. Excessive formality in conversation or a friendly smile can be as informative as a verbal explanation when supported by additional evidence. These should be noted so that they can be compared with other evidence in drawing conclusions and making design recommendations.

Folk tales (or often-repeated stories of events) can provide insight into organizational behavior. They can help explain unexpected behavior such as an unwillingness to share data when it would clearly be beneficial to both parties. They can shed light on agendas as well as perceptions of other's agendas. It is important to understand perceived agendas because it is often more the bases of behavior than actual agendas. That is, people act on what they believe to be true, not necessarily on the actual truth.

Analysis Techniques

Data analysis. The most common way of reviewing data collected as described above is through triangulation. This involves testing one source of information against another to improve the quality and accuracy of findings before drawing any conclusions. In an organizational setting, this might include comparing the explanations of power structures drawn from formal documents, member descriptions, observation, folk tales, and kinesics. The use of this technique does not have to wait until all data have been collected, but instead can be used as a strategy for tying up loose ends, verifying a hypothesis, or for guiding the research throughout the project. Isolated findings that are not supported by other sources of data either should be disregarded or serve as a basis for more investigation. The drawing of conclusions from isolated findings is tenuous and not recommended.

Another useful analysis technique involves the creation of visual representations or maps, charts, and diagrams that illustrate relationships and flows between important entities. These can be used to develop world views and to understand various types of networks connecting groups and resources. They force researchers to formalize their understanding of a problem domain and can be helpful for identifying errors and areas where knowledge is weak. The Soft Systems Methodology uses this technique for developing rich pictures.

Ethnographic methods require trust on the part of those who make up the cultural group under study. Without trust, the methods described above will likely yield a more limited amount of useful information to the systems designers. Along with this trust comes the responsibility to adhere to some basic ethical guidelines. The first and most important principle is to "do no harm to people or the community under study" (Fetterman 1998:129). Respect for individuals' feelings and the trust they impart on the researcher cannot be overemphasized. Second, Fetterman (1998) cautions that researchers should not assume a position of power and should limit activities to research and recommendations only. There is always a danger that a researcher may become a pawn in a political game. Maintaining an awareness of possible manipulation can help researchers avoid unwanted incidents and retain trust among all participants. Lastly, while sensitive information may be important to use in a study, it may be necessary to protect the identity of the source. In these situations, Fetterman suggests that pseudonyms can sometimes be used. When this is not possible, a balance must be considered between the sensitivity of the information and the size of the problem being addressed. As a matter of practice, all who conduct research involving human beings should become familiar with the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research 1979).

While there is redundancy between ethnographic and other methods, ethnographic methods are largely complementary due to their focus on situated actions and the position of their use within the design life cycle. Soft-systems methodology, participatory design, and rapid prototyping lean toward a user-assisted "learn-as-you-go" design strategy, while ethnographic methods attempt to establish a clear understanding of the social structures and workflow prior to—and as a basis for—establishing initial design requirements. In addition, an ethnographic approach places greater emphasis on documenting work processes and social interactions situated within the day-to-day environment of the workplace than in artificial settings such as specialist meetings, phone conferences, or workshops.

The additional time necessary to use ethnographic methods varies considerably depending on need. At one extreme, simply being aware of alternative sources of information, such as folk tales or outcroppings, and how to record, organize, and analyze them using triangulation can add to existing data collection methods with little extra time commitment. On the other hand, considerable extra time could be devoted to observation and unstructured interviews in the case where substantial changes in workflow or organizational structure are expected. While data gathering typically occurs throughout system design, good stopping points would include when implementation is clearly deemed infeasible or when system developers are reasonably sure that the major issues have been revealed and examined sufficiently. In any situation, investments of time and effort should be weighed against the overall benefits of implementation and the potential costs of failure.

The remainder of this article describes the use of ethnographic methods for designing an online utility-permitting support system that is used to inventory utility location and attribute data. It describes the various data and collection procedures, an analysis of the data leading to design implications, and the final design solution. As is common in ethnographic work, pseudonyms are used instead of specific identifying information about major participants in the study.

Problem Statement

In the 1950s, a large state agency in charge of public infrastructure design, construction, and management activities in Texas was given responsibility for permitting public utility installations on public land. The permitting process simply involved filling out an application form that described what would be installed and approximately where the installation would occur. Unless there were circumstances where safety was compromised or physical barriers made installation impossible, the applications would typically be approved and the paperwork archived. Over time, it was determined that a comprehensive map of utilities installed on public lands would increase the safety and efficiency of new design and construction projects.

For planning and executing public land improvements and for avoiding disruptions in the operation of the utilities, it is crucial to know where the utilities are located and their current status. An optimal and efficient use of public land assets is clearly in the best interest of both the state and the utility industry. Fundamental to the responsible management of these interests is a comprehensive and accurate inventory of facility locations and characteristics. Currently, the state agency has no system-wide capability to capture and inventory utility interests and no medium by which to document and display them in reference to existing and proposed public land improvements. This vacuum is evident at the local level where engineers, planners, and construction and maintenance crews constantly have to struggle with the lack of appropriate documentation and tools to assist in the process of locating utility facilities and managing utility facility data efficiently.

Having identified these needs, the state agency decided to develop a utility data inventory model and associated procedures. They determined that the model would need to be geographically referenced to allow the agency to tie the location of utility facilities to public lands and to associate the positional data with details of utility facility ownership, service or commodity type, infrastructure size, material, and other pertinent characteristics.

In 1999, a team of researchers (the authors of this article) was hired to develop a GIS platform to inventory these facilities. To begin the design process, a kick-off meeting was scheduled involving about 20 agency officials from the main and satellite offices as well as the research team. Discussions revealed three main activities that were associated with utility installation data: sub-surface utility engineering (SUE) contracting, lease contracting, and utility permitting. Since it was determined that the vast majority of utility-related activities involved issuing utility permits, it was decided to focus on the permitting process as the basis for developing a system. The research team learned that, although all permits were processed and issued using common forms, the actual permitting and approval processes were carried out differently at the various satellite offices. The challenge, then, was to design a GIS platform to inventory utility installations on public land that would use the permitting process as the basis for capturing data and would be flexible enough to respond to the differing procedures used at multiple satellite offices.

Data Collection

Given that the system was to be designed around an existing set of work processes that involved structured interactions between numerous personnel—both within and between organizations—the advantages of using ethnographic methods to explore the social and technical aspects of workflow were obvious. As described above, ethnographic methods include observation, interviews, document analysis, surveys or questionnaires, outcroppings, proximics, and folk tales (Fetterman 1998). The methods most heavily used in this particular study were observation, interviews, document analysis, and a survey. Each contributed to the formation of a rich, comprehensive picture of the social structure affecting the permitting process and revealed both opportunities and constraints on system design.

To start, an organizational chart was studied to help devise a strategy for gathering necessary information. The state agency is divided into a hierarchy of offices based on geographic region (Figure 1). There are four levels, with the highest level (Level 1) being composed of several specialized offices located in Texas' state capital; Level 1 offices provide coordination and specialized services to the Level 2 (and below) satellite offices. There are more than 20 Level 2 offices, each serving between 7 and 15 contiguous counties throughout Texas. This is the level in which utility permits are initially processed, approval is given, and files are archived. Levels 3 and 4 are further geographic disaggregations of Level 2 and primarily involve inspection. Altogether, several hundred regional offices are involved in the permitting process. In order to use ethnographic methods effectively, the team determined it was necessary to identify a manageable yet representative sample of offices to study that would yield an adequate understanding of the problem.

Survey Questionnaire

The team decided that a survey questionnaire would help identify important similarities and differences in permitting approaches between the various offices. A small sample of offices would then be chosen for more detailed study. These would be selected in such a way as to maximize the variation in the permitting approach. The questionnaires were sent via electronic mail to 25 directors at Level 2 offices; the directors were asked to distribute the questionnaires at their discretion to an appropriate staff member involved in the permitting process. Over a 2-week period, 13 questionnaires were returned via electronic mail (a 52% return rate). Questions covered topical areas such as the number of permits processed annually, who is involved, what the processing steps are, how the records are kept, how spatial data are used and maintained, etc. There were a total of 29 questions, with space for additional comments at the end. Some of the most relevant findings from the survey are listed below:

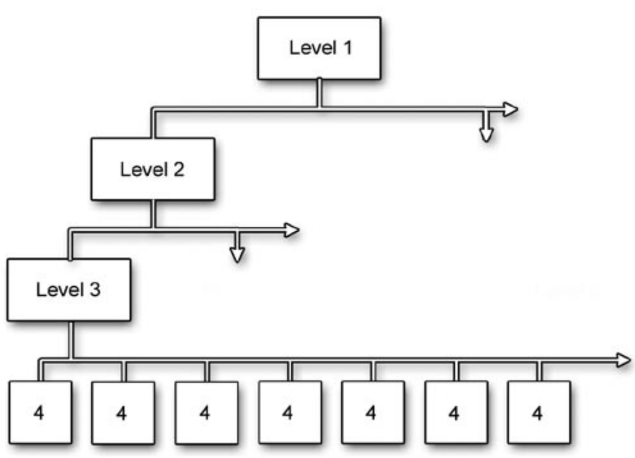

Figure 1 – Agency Hierarchy

- Roughly 60% of the Level 2 office areas process fewer than 500 permits per year. Of the remaining 40%, roughly half process 1000-2000 permits per year. In total, the state agency estimates that it processes around 10,000 permits each year.
- Most Level 2 office areas keep permit records in paper format (e.g., index cards, application forms, and file folders). Only a fraction use electronic documentation techniques such as spreadsheets or databases. An even lower number use other record archival techniques such as microfilm or microfiche.
- Only 20% of Level 2 office areas use a map or graphical display to show the location of utilities within public lands.
- Most Level 2 office areas conduct a visual inspection during the utility installation process. By comparison, only about 62% conduct a visual inspection after the utility installation process is completed. However, most Level 2 office areas do not have sufficient resources to inspect all utility installations.
- Pre-construction meetings are held only in the case of major utility installations. Most "routine" installations require only a Level 4 office official to be present in the field when the utility work starts.
- The usual permit processing procedure is as follows (although the procedure varies between offices):
  1. The utility company submits an application to a Level 2, 3, or 4 office area.. The date-stamped application includes the standardized form, drawings, and descriptions.
  2. A designated state agency official conducts an initial review and assigns the application to a Level 1 or 2 office.
  3. The Level 1 or 2 office reviews the proposed installation site.
  4. A designated official issues an approval and attaches special provisions, necessary maps, and comments.
  5. The state agency mails a copy of the standardized approval form to the utility company or contractor, as well as to the appropriate levels within the state agency (a Level 2, 3, or 4 office).
  6. If needed, a pre-construction meeting is scheduled.
  7. The utility company begins work.
  8. A Level 3 or 4 official verifies in the field that the requirements are met.

Also apparent from the survey was that the main differences between office procedures occurred between urban and rural offices. That is, if a Level 2 office area encompassed a large metropolitan area, the procedures used to handle the volume of applications were more complex and involved more people than in Level 2 office areas that did not serve major cities.

Following these results, and after consultation with the Project Director (appointed by the Agency), the research team selected two representative satellite offices to study in greater depth: an urban office and a rural office. In both offices, the research team observed and interviewed personnel who normally deal with utility data sources and examined available data forms and data processing, data archival, and data retrieval procedures. Contact began with an introductory meeting organized by the Project Director and researchers with the appropriate Level 2 office staff. This was followed by subsequent visits to observe task procedures in situ.

Observations

Observations revealed details about application processing tasks, interactions between affected staff, and the types of documents and forms. As with the survey, the processing tasks were found to be loosely structured and were somewhat similar across agency type. They are outlined as follows:

1. A standard agency form is submitted for approval by a utility company to the Level 2 office having jurisdiction over the proposed installation site.
2. As part of the application package, utility companies attach sketches or drawings documenting the location of the proposed installation. These ranged in quality from freehand sketches to computer-assisted design (CAD) drawings.
3. Upon receipt of the application form, a memorandum is printed and sent to the appropriate Level 4 office (or in some cases a Level 3 office) for an on-site inspection of the proposed work.
4. Depending on the results of the inspection, a recommendation for/against approval is made.
5. If the proposed installation is approved, a signed approval form (Agency standard) containing the approval notice is returned to the utility company and the affected Level 3 and 4 offices.
6. The approval document contains a list of special provisions and the name and telephone number of an Agency official that the utility company must notify 48 hours before proceeding with the proposed installation.
7. The original application form, attachments, and approval form are filed in an archive. In some Level 2 offices, the information is entered into a database.

An important note was made that there is currently no requirement for the submission of "as-built" documentation. The basic workflow is illustrated in Figure 2.

Most of the social interactions regarding permit processing were not carried out face to face. Typically, utility companies would call to request an application, which was mailed back to the agency. Site verification and approval feedback were carried out via memorandum. Approval forms were mailed back to the utility companies who notified the Agency by telephone 48 hours prior to the start date. Aside from this, very little interaction occurred among the various application processing staff.

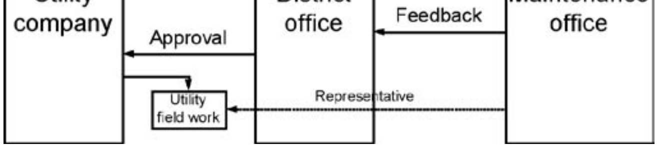

Figure 2. Existing Data Flow and Data Collection for Utility Permits.

There are two standard permit application forms—Form A and Form B—used by all Level 2 offices throughout the state. The difference between the two forms is based on restrictions on public accessibility to the installation sites. A single standard approval form is used to issue the permit that is actually printed on the reverse side of the application form. Other relevant documents included an Agency-wide basemap, utility leasing contracts, and sub-surface utility engineering documents. While these other documents were noted as relevant to the design of a comprehensive utility mapping system, no observations were made of them being used to support the permitting process.

Interviews

Interviews with both Agency officials and utility companies revealed helpful information about how the permitting process fit within the daily workflow of the participants, the type and quality of data used in other mapping activities, the different needs of diverse utility companies, and other work processes affecting utility data.

Attitudes regarding the permitting process varied. In the rural area studied, utility permit processes, although treated very professionally, were mostly viewed as an annoyance or "extra work." This is due in large part to the low volume because processing only happened a few times each year and the staff was forced to break from the normal daily workflow. In the urban areas where the volume could reach into the thousands each year, processing permit applications could be a staff member's primary responsibility. Still, since utility permitting was considered peripheral to the agency's primary mission, the position was not highly sought after.

In addition, officials responsible for inspections and permit authorization felt that too much of their time was consumed by doing repetitive work and manually processing applications. There was general agreement among the Agency personnel that there was not enough staffing to conduct inspections or field reviews in 100% of cases. Some suggested a figure as low as 50% might be more accurate. On several occasions, various personnel expressed sympathy to the research team for what was perceived as the impossible task of developing a workable system due to poor control over data quality.

Other mapping activities occur within Level 2 offices of the state agency. For consitency, however, all office levels involved in inventory activities were required to adopt a common mapping software. As a result, it was suggested by the project director that the research team adopt the same software for any platform developed to inventory utilities. Office GIS personnel indicated that GIS services were considered a necessary component of the state agency mission, but that the GIS program was not as fully developed as it probably could be. The main reason for this was described as a problem with data accuracy and resolution. That is, the accuracy and resolution were too coarse to support construction and design activities and even many management activities require higher data standards than were available through the GIS program. The state agency was said to be conducting pilot studies for producing a future sub-meter accuracy basemap of the public lands, but at the time of the query none of that information was available. The

Project Director agreed that regardless of a lack of descriptive details regarding the new basemap, the basic concept of the new basemap should be considered when designing the system.

Researcher experience and discussions with agency officials and utility company personnel revealed that varying utility data management practices frequently make the management process very difficult. For example, many utility companies have developed highly sophisticated automated mapping/facility management (AM/FM) information systems over the years and, as a result, they have the ability to document the location, status, and other characteristics associated with the assets they own and/or control fairly efficiently. Some of those information systems are GIS-based and a number of out-of-the-box (ready-to-use) software systems are available in the market. Other utility companies, particularly small "mom-and-pop"-type operations, follow what could be considered a very informal asset management approach and, consequently, their ability to document the location, status, and other characteristics associated with their assets is severely limited. Even in the case of major utility companies, geo-referencing standards and procedures vary widely; this has a significant impact on the amount of detail and overall positional accuracy associated with individual features.

Another problem identified has to due with the specialized nature of utility companies. For example, electric utility companies do not normally operate water utilities, and telephone companies do not normally operate gas utilities. In many jurisdictions where a utility company manages more than one type of utility, each utility is managed separately, including the data management aspect of the operation. In the field, however, there is a significant level of interaction among utilities. For example, electric poles are frequently used to anchor electric lines, telephone lines, television cable lines, and data communication lines. Likewise, duct bank underground installations have the capability to carry more than one type of utility. To complicate matters, utility ownership can change at any given time, even at the individual pole level. Still, utility data management systems tend to be utility-specific, with little room or flexibility to accommodate shared uses or changes in ownership.

This situation affects the state agency's ability to maintain an up-to-date, reliable utility data management system. During construction or maintenance work on public land, utilities often need to be moved or adjusted, and not knowing the location and characteristics of the utility facilities involved can result in unacceptably high cost overruns or, at the very least, in legal liabilities.

Documentation Review

Utility companies are required to submit a permit application every time they need to do work on a utility facility within the jurisdiction of the state agency. As part of the permitting process, utility companies must document the proposed work and attach drawings to illustrate the location and characteristics of that work. However, because of the different types of utilities and utility companies with which the state agency may be involved, there are large differences in the quantity and quality of data provided such as attribute data, map symbology, terminology, and geo-referencing data.

By examining standard forms, drawings, and other documents, important workflow details were revealed. For example, some documents require authorized signatures from one or more departments indicating a need to support coordinated efforts. Furthermore, examination of documents revealed inconsistencies in the data or procedures that had to be addressed. Terms, symbology, and classification schemes varied widely, both within the state agency and among utility companies, and this issue had to be resolved before the interface could be made fully functional.

Document analysis focused on existing application and approval forms, attachments, and existing mapping files. The primary documents used in the permitting process are the application form and the approval form, both of which are single-page forms. The application form is assigned a unique application number by the Level 2 office and information is obtained about the utility company, the proposed dates and location of the installation, a description of the work to be done, and a signature acknowledging that all applicable laws, policies, codes, and special provisions are understood and will be followed. Space is provided for work descriptions that may be continued on separate paper, and applicants are instructed to attach any drawings or sketches to the form. Typically, a single permit can be used to perform several actions, such as removing an old installation and installing a new one.

The approval form includes agency and utility company contact information and lists the dates, location, and all the conditions to be met in carrying out the installation including special provisions; it is signed by the Level 2 office director. Attached to the approval form are the explicit instructions for complying with the special provisions (such as revegetation requirements). The actual forms and attachments for submitted applications are archived at each Level 2 office in the state. Data examined from these archives are described below.

Due to the shear volume of permits in the urban area, a sample of public lands was selected for evaluation that appeared to have a substantial amount of utility permit and construction activity in recent years. The research team then obtained samples of the following data sources from agency officials: permit documentation, as-built plans, utility plan sheets, and agency plan sheets.

To analyze the spatial quality (positional accuracy and completeness) of existing utility data sources, the researchers evaluated whether those sources included a scaled map, suitable geo-referencing, and whether the utility data maps were available in digital format (e.g., AutoCAD or MicroStation). Based on these criteria, the researchers ranked the overall suitability of the utility data for inclusion in a GIS according to the scale given in Table 1. It should be noted that the ranking focused on spatial data quality as opposed to attribute (i.e., non-spatial, data quality). While attribute data were important and had to be evaluated, spatial data quality was considered more critical for determining whether existing utility data sources could be properly represented using a GIS-based system.

Rural Area Permit Data

There were 55 utility installation permits issued in the rural area over a period of 42 years, averaging 1.31 permits per year. Of

Table 1. Utility Data GIS Suitability Ranking

Ranking	Description
Very good	Utility data in digital format or a digital version would be easily available. Positional accuracy is good, and minor (if any) assumptions are required to import the utility data into a GIS.
Good	Positional accuracy is good and only a few assumptions are required to import the utility data into a GIS.
Weak	Positional accuracy is weak and several assumptions are required to import the utility data into a GIS.
Poor	Difficult to import utility data into a GIS. Major assumptions are required and substantial positional errors would be likely.
Very poor	Extremely difficult to import utility data into a GIS.

these, only 33% of the permits contained at least one drawing or "sketch." Sketches were not required for approval of the permit. Example sketches did not reveal any geometric scales or indication of drawn measurements. Given the "back-of-the-envelope" nature of the sketches available, the accuracy and reliability of the sketch data were considered questionable. No information was available regarding the relative distance of the utility from any setbacks. Surprisingly, the current permitting process does not accommodate the submission of data in digital format. Instead, the primary source of location information made available via permit includes a verbal/written description of the proposed location in relation to a described landmark, such as a road intersection or a structure. Distance values such a "500 feet" are interpreted as a rough estimate rather than an actual measurement. Most distance-from-setback measurements are expressed in rule-of-thumb terms such as "within 5 feet of the setback." However, all agency personnel interviewed indicated that this was never considered a reliable measurement. The percentage of permits that complied with each of the criteria items discussed above is as follows:

- Map was included 33%
- Type II data were included 27%
- Type I data were included 22%
- Location with respect to setbacks was included 0%
- Map included geometric scale 0%
- Map was available in digital form 0%

The distribution of overall data quality ranking values for the 55 permits, according to the suitability ranking schedule shown in Table 1, was as follows:

- Very good 0%
- Good 0%
- Weak 0%
- Poor 27%
- Very poor 73%

Urban Area Permit Data

There were 92 utility installation permits issued in the sample urban area. Most permit applications contained at least one drawing or map showing the approximate location of the proposed job. However, only about 25% of the drawings were scaled. In most cases, the drawings included locatable objects. However, because many of those drawings were not scaled or included only one locatable object, it was difficult to determine the relative location of individual items within the public land.

In fewer than 30% of cases, the utility permit documentation included a verbal description of the relative distance of the existing or proposed utility with respect to a setback. In some cases, the drawings showed the distance of the utility (mostly existing) with respect to a setback. In other cases, the distance was included in the permit approval special provision sheet. The reliability of these distances, however, may be questionable because no as-built documentation is required or available. Not surprisingly, even the drawings and other documentation provided by the utility companies contained clearly visible warning labels to the effect that they do not guarantee the accuracy of the location of their utilities and that it is the contractor's responsibility to contact the utility locator to determine the present alignment of all underground facilities.

None of the permit samples evaluated by the research team contained data in digital format. Only two utilities provided copies of MicroStation dgn files that showed the location of their facilities. This information was useful in a couple of cases where the drawings included in the permit documentation were confusing or incomplete. Unfortunately, there were problems with the electronic files provided by the utilities regarding the underlying geographic projection associated with their drawings.

The percentage of permits that complied with each of the criteria items discussed above is as follows:

- Map was included 88%
- Location with respect to setbacks was included 29%
- Map included geometric scale 26%
- Type II data were included 11%
- Map was available in digital form 0%
- Type I data were included 0%

The distribution of overall data quality ranking values for the 92 permits, according to the suitability ranking schedule shown in Table 1, was as follows:

- Very good 0%
- Good 1%
- Weak 31%
- Poor 48%
- Very poor 20%

State Agency Basemap Data

The research team also received copies of GIS-related public land basemap files from the state agency. These included various topographic data. The topographic GIS files were originally digitized from the United States Geological Survey (USGS) 7.5-minute quadrangle paper maps. Details of the projection used for these maps were given. Interviews had revealed plans for developing a new basemap with sub-meter accuracy (both horizontally and vertically), but no documentation was available for inspection by the research team.

Utility Company Data

Finally, the research team contacted a number of utility companies to inquire about available data, particularly in electronic format, and the possibility of obtaining data samples. Responses were received from a public service company that provided sample files of electric and gas utilities in MicroStation dgn format, a water system company that provided sample files of water and sewer utilities in MicroStation dgn format, a river authority that operates wastewater facilities and flood control facilities in other areas around the city but did not provide data, and a telephone company that provided paper copies of utility maps and indicated that electronic files would not be available.

The research team also obtained a copy of a project development flow chart from a consensus process that included the state agency, local government agencies, and utility companies. These entities formed a coordination council that meets on a regular basis to discuss projects, regulations, and other issues. The flow chart is useful because it illustrates the relationship among the state agency, the urban Level 2 office, and utility companies at all steps during the planning process of a public land improvement project.

In summary, the research team observed a wide range in the level of detail included in the drawings submitted by the utility companies. Some drawings contained barely enough detail to determine the location of the proposed (and existing) utilities. Although many drawings were much more detailed, the details were often difficult to read, had incomplete symbol legends, and contained information that was irrelevant to the state agency. This observation is important because it clearly identifies the need for the development of standards and requirements for the quality and content of utility documentation.

Data Analysis

The data collected in the survey, observations, interviews, and document review were collected and compared and analyzed to develop a more complete and consistent picture of the permitting process, and to identify opportunities and constraints to the system design. Table 2 summarizes some of the important findings described in the section below.

First, it was important to understand how utility permitting fit into the overall organization of the state agency. While the survey indicated that procedural oversight over the permitting process is housed anywhere from Level 2 to Level 4, it was clear that it was not centralized at the state level (Level 1). Every area seemed to have its own idea of what the process should be and who should implement it. The different implementations and degree of inspection have resulted in haphazard placement within the state's public lands. There is currently no manual for this function, no clear designation of who should implement or inspect the process and, most importantly, no mention of this function or process can be found in the classification system. This would mean that internal coordination of some type would need to be developed in order support a consistent and comprehensive statewide utility map. On the other hand, if system implementation were to minimize disruption of the current workflow, it would need to be flexible enough to accommodate some level of procedural differences within the different regions.

A review of the workflow for processing applications found the existence of distinct status levels based on the passing of responsibility from one office to another. These were first revealed in the survey and double-checked during various interviews. The status levels include submitted, reviewed (checked for completeness), field reviewed (inspected for potential conflicts), logged, approved/rejected, notified (utility company notifies the required agency contact 48 hours prior to construction), built, inspected, and archived. The team noted and verified that no expiration date is currently assigned to a permit. Proposed construction dates are required on the form but no enforcement mechanism or stated policy terminates the life span of a permit. Although no one seemed to know for sure, permits could theoretically be authorized in which construction was never carried out, or construction could begin next week on a permit authorized years ago. This could impact the integrity of the database and needed to be addressed.

In addition, it was important to note that field verification and inspection after or during installation are not conducted routinely. One survey respondent and several officials interviewed explained that inspections were carried out whenever possible but that, due to inadequate staffing, consistent inspection of all installations was not possible. This situation, along with permits that last in perpetuity, means there is currently little control over data accuracy. This is not a simple matter and would need to be addressed at the highest agency level if adequate support for the system is to be implemented.

Next, the team found that the permitting process typically includes transactions between the Level 2 office, which receives the applications, and the Level 3 and 4 offices, which typically approve applications and review installation proposals in the field, respectively. All of these offices are separated geographically and communication between them occurs via memoranda distributed through the agency mail. On rare occasions, telephone communication is used, but this

Table 2 – Summary and comparison of findings by data collection method.

Item	Survey	Observations	Interviews	Documents
Procedural oversight	Levels 2, 3, and 4	Level 2 office director	Level 2 office director	Level 2 office director
Offices involved	Utility Co., Levels 2, 3, and 4	Utility Co., Levels 2, 3, and 4	Utility Co., Levels 2, 3, and 4	Utility Co., Level 2 (authorized signature and contact info)
Transaction modes	U.S. mail, Internal memo, Pre-construction meeting	U.S. mail, Internal memo	Telephone, U.S. mail, Internal memo	U.S. mail
Face-to-face transactions	Pre-construction meeting	None	None	N/A
Processing status levels	Submitted Reviewed Field reviewed Logged Approved/rejected Notified Built Inspected Archived	N/A	Submitted Reviewed Logged Approved/rejected Notified Archived	Submitted Approved Archived
Inspection	Yes, during and after installation; Not done consistantly	N/A	During but not often; low staffing	No record of inspection
Archive method	Index cards, Application form, File folders, Digital spreadsheet, Database, Microfilm, Log book	N/A	Index cards, Application form, File folders, Log book, Electronic spreadsheet (urban only), Database (urban only)	Index cards, Application form, File folders, Log book, Electronic spreadsheet (urban only), Database (urban only)
Quality of permit spatial data	Absent or overall low GIS value; only one Level 2 office received as-built documents	Rural: very low GIS value Urban: mostly low GIS value	Low GIS value	Low GIS value
Utility map available	20% – yes 80% – no	Mostly sketches, sometimes maps	No comprehensive utility map	Sketches and drawings of low GIS value
GIS software types	N/A	1 software type	1 standard agency-wide software type	1 software type
No. of permits/yr	60%: <500/yr 20%: 500 – 1000/yr 20%: 1000 – 2000/yr	Rural: none Urban: several per day	Rural: several per year Urban: thousands per year	Rural: 55 total over 42 years Urban: 172 in sample area alone
Data meet GIS standards	N/A	Rarely	No	Rarely
Attitude toward permit process	N/A	Undesirable task	Undesirable task	N/A

occurs mostly when clarification is needed regarding information on the application form. Processing procedures typically do not require face-to-face contact. This implies that a system that supports distributed and asynchronous transactions might provide a more efficient procedural solution to the current practice without affecting any significant social interaction within the organization.

The current methods of archiving permit data vary throughout the agency, from summaries on index cards to electronic spreadsheets and databases. In most cases, permit information was rarely accessed for any purpose after archiving. Twenty percent of the survey respondents indicated that they had mapped the utilities, and this was supported by observation. The quality of the spatial data submitted with the applications is minimally sufficient for a field review prior to installation but without a measurable scale, geographic location, or as-built documentation, there was little that could be used to populate a GIS. Only a few applications in the specific urban area studied reported data of sufficient detail and control for use in a GIS. This resulted in a basic requirement for developing a good inventory: improve the quality and control of spatial data submitted with future permit applications.

The number of permits issued each year ranged from several in the rural areas to thousands in the urban areas. This suggested that while a simple database program might be sufficient for the needs of rural areas in the short term, database software that is more robust and scaleable would be needed to support inventories of urban areas. It was also found that the GIS software was available to all offices and that a single software product had been selected as the standard for the entire agency statewide. This limited the number of options available for system development. In addition, administrative computer support was not extensive in the rural areas, which could further limit system design options.

The research team also found that the topic of utility permitting was often met with a sense of indifference and irritation. It may be that the lack of control over inspections and permit expiration leaves a cloud over the permitting process. It may be the fact that utility permitting is peripheral to—and takes resources away from—the primary activities of the state agency that leads to a sense of diminished importance regarding the process. It may be a combination of these or other factors that causes the responsibility to be seen as an undesirable task. Still, the research team could not ignore signals in language, humor, and demeanor that led to some speculation that the various offices involved in permitting would prefer to reduce or eliminate their responsibility rather than maintain or increase their role. This will likely have a major influence over the system design and the effectiveness of implementation. Any solution that reduces both time spent processing applications and the responsibility over the process will likely increase the chances of success.

Finally, since utility permitting is organized at the Level 2 office and there is very little coordination between the Level 2 offices with regard to the permitting process, an agency-wide utility basemap effort might need to be organized at the highest level of the agency hierarchy (Level 1). Without a "champion" at the state level, coordination and implementation in the Level 2 offices could be problematic.

System Requirements

Data analysis resulted in a number of important system requirements for design. These are summarized below. It is important to note here that the role of ethnographic methods is to provide human-centered data collection and analysis. The jump from collecting and examining data to specifying a requirement, however, is a creative thinking process that is served in this case by justifying specifications with triangulated evidence. The actual process of specifying a requirement is itself not an ethnographic method.

- The agency needs to coordinate data standards across all office levels. This is important to maintain consistency in the data over the entire state, a stated goal of system development.
- Flexibility in procedural support is needed to accommodate different variations in permitting processes across office levels. This is evident by examining the processing status levels reported in the survey, interviews, and documentation.
- Procedural support should be designed around the different permitting status levels as identified by the different offices. This was suggested by agency officials at the start of the project and supported by other agency personnel during onsite interviews.
- Agency administration needs to develop an expiration policy for the life span of permits, and the system should be designed to support that policy. No expiration date was printed on the permit documents studied, and interviews revealed that no expiration date was required. The implication of this meant potential conflicts over future allocations of installation space.
- Management procedures and resources for overseeing data quality, such as thorough inspection of location and attribution during or after installation, need to be strengthened. This would include requiring as-built documentation and updating the official basemap. Data collected through survey, interviews, and documentation indicated that inspection and verification of installations were inconsistent, which could have a direct bearing on the quality of permit data collected. To ensure data quality, inspections will be required and are not optional. In addition, current data collection does not require as-built documentation, which is essential for an accurate up-to-date map.
- Procedural norms need to be established such as standardization of minimum data quality and types collected across the agency. The varying quality of data, mostly poor, was evident through the survey, observation, interviews, and documentation. To maintain consistency across Level 2 offices statewide, standards will need to be imposed.
- The system should support asynchronous and distributed permit processing. Due to the distributed nature of the process (i.e., little communication between responsible parties in the permitting process occurred face-to-face), the system should support this level of interaction. In some cases, pre-construction meetings were said to be held with the utility companies as described in the survey. However, observation and interviews with key personnel did not confirm this condition. Given the larger sample of the survey, further investigation is warranted.
- The system should be scaleable to accommodate heavy use. Given the large number of permits processed per year in the urban areas, scalability is an important issue. This finding was supported across all data collection methods.
- The system should significantly reduce the human effort involved in permit processing and/or additional resources should be made available to shoulder added burdens. Observation and interviews revealed that processing permits

was not considered a desirable task. Interviews with staff also found that the Level 3 and 4 offices did not consistently inspect installations due to low staffing. To ensure data quality, either the burden needs to be reduced to fit the staffing or the staffing needs to be increased to meet the burden. Decreasing the burden could have the effect of reducing the amount of time spent on an undesirable task.

In addition to the above requirements, a set of standard data acquisition procedures needed to be developed to facilitate a consistent and reliable utility data management system. To do this, several functional requirements listed below were followed:

- The data must be geo-referenced so that utility locations can be associated with public land maps. Given the a priori requirement to produce a GIS platform for the utility inventory and the evidence that current practices do not produce suitable GIS data, a new procedure will need to be required.
- The data must be standardized across agencies. In order for the system to be consistent statewide, data will need to be collected and made available in a common format.
- From an implementation perspective, support for automated data entry and data query procedures must be available. To minimize processing effort and maximize data consistency, automated data entry and query procedures should be designed into the system.

It was decided that a system based on global positioning system (GPS) data and associated collection procedures would provide the most versatile and feasible solution to spatial data consistency. Using a basemap-independent GPS approach for the inventory of utilities has a number of advantages. An increasing number of offices in the state agency already have surveying-type or mapping-type GPS receivers in their inventory. The same is true of many utility companies. Small utility companies and location services might not necessarily have GPS receivers. However, access to GPS technology is becoming affordable. For example, a 7-day rental fee for a surveying-grade GPS receiver with data dictionary and attribute data recording capabilities is now around $500. This makes a GPS-based approach for the inventory of utilities feasible.

In addition, a basemap-independent positioning system such as a GPS could provide the foundation for a utility data exchange mechanism between utility companies and the state agency. Practically all GPS receivers in the market output coordinate data in latitude-longitude pairs using the World Geodetic System of 1984 (WGS 84) datum. With this de-facto standard, it should be relatively straightforward for utility companies to include an attachment with their permits containing the latitude-longitude coordinates of their proposed fieldwork. The state agency could plot these coordinates, verify their location in the field, and provide comments tied to the latitude-longitude location of specific problem areas. When the utility work is completed, the agency could use the final latitude-longitude coordinates to update existing features or generate new features in the database. It should be noted that, even though GPS data are usually given in latitude-longitude pairs, the data could be easily projected in the GIS to other systems (e.g., to the State Plane or Universal Transverse Mercator (UTM) Coordinate System).

System Design

The system design is closely tied to the existing workflow. This strategy was chosen so as to minimize system complexity and the fear of change, two conditions that have been documented in the literature as leading to implementation failure. The ethnographic methods help to document the existing workflow with sufficient detail as to identify important application status levels and data flows. Based on the data acquisition procedures and the requirements specified above, it was determined that a centralized and automated Internet-based data entry system should be used to implement the utility permitting process. Online database transactions can occur at any time and place, and provide support for procedures that require minimal face-to-face contact and are inherently distributed and asynchronous. All of the procedures that were identified as affecting utility data documentation fit these requirements. The data flow of the system is shown in Figure 3. Conceptually, the system follows the existing workflow shown earlier in Figure 2, with two exceptions. First, it assumes that utility companies are required to submit as-built documentation after they complete the utility installation in the field. This requirement was specified based on the need to maintain data accuracy and consistency. Second, it assumes that a permit application is active for 6 months or until the utility basemap has been updated by GIS personnel in the Level 2 office based on as-built documentation provided by the utility companies. This was also specified in the requirements. These are important shifts in workflow identified during data analysis that will need to be addressed during implementation.

As specified above, the system is designed to reduce the internal and external communication workflow burden by using automated routing of paperwork and notification through electronic mail. In order to submit a permit application, a utility company user logs onto a web site that contains several options for viewing and submitting permit applications. The utility company user fills in basic information related to the permit application and uploads a file containing coordinate data for the proposed utility work. The database server converts the coordinate data file into temporary spatial features that can be displayed on a web GIS map and sends a confirmation email to the utility company. A printable electronic copy of the application and a map of the area where the utility company proposes to do the fieldwork are available for viewing at anytime through the interface. Upon submitting an application, the database server generates an entry for the utility permit in the database.

Based on the information received by the utility company, the system automatically sends an electronic communication to the appropriate Level 2 agency official responsible for initially reviewing the application. When the recommendation has been submitted, the system automatically sends an electronic communication to the official responsible for the next level of processing. Having received notification by the initial reviewer and/or field verifier, a designated agency administrator uses the system to approve or deny the application and sends an automated electronic notification to the utility company. The corresponding approval or rejection form is made available for retrieval through the system interface. Assuming that the permit application is approved, the utility company uses the interface to notify the state agency 48 hours prior to beginning construction and conducts the necessary fieldwork. Upon completion, the utility company is required to send an as-built attachment to the agency containing final coordinates and other characteristics. After a utility company has submitted as-built documentation and it has been verified, the data become available for download by the state agency personnel responsible for updating the utility basemap at the Level 2 office. Once the data have been downloaded and the utility basemap has been updated, the permit records can be moved to an archival database.

The system uses a centralized data management architecture with distributed map and data access capabilities (Figure 4). This architecture does not result in any loss of data access to individual Level 2 offices. Rather, it enables greater access to utility data in the form of online queries and display from a web browser, and data download to local computer systems. The system also provides utility companies with access to maps and data documenting all utilities located within the public lands, therefore facilitating the permitting process. Notice in Figure 4 that the system architecture uses two separate interfaces—a utility company user interface and an administrative interface. A centralized data management approach is advantageous because it relieves local state agency offices from the burden of having to provide personnel and expertise to maintain local web servers. This is particularly critical in the case of rural offices where appropriate personnel and expertise may be difficult to find.

The system adheres to a few simple design principles of human-computer interaction to reduce cognitive load and increase the chances that users would adopt the system. To the extent possible, the interface design taps into the familiar existing workflow of the expected users to make the system easy to learn and use. Interface simplicity is an obvious requirement but achieving a level of simplicity that is significantly "intuitive" requires numerous tests and redesigns. To comply with this requirement, a formal usability analysis procedure called a cognitive walkthrough (Polson 1992) was used to identify ambiguous task choices and to obtain feedback on potential redesign opportunities.

Utility Company User Interface

The utility company user interface supports all the workflow responsibilities of utility companies that wish to submit a permit application. This includes submitting new applications, viewing pending applications, viewing archived applications, viewing special provisions, managing user profile information, and looking up contacts within the state agency or other utility companies. Figure 5 shows a functional diagram of the utility company interface.

Submitting New Permits

The process of entering new permits includes a short sequence of data input screens that allow editing and review before submitting a permit application to the state agency (Figure 6). Where practical for purposes of database consistency, field entries are chosen from a drop-down list. It is important to note that users are required to upload coordinate data files indicating the location of the features

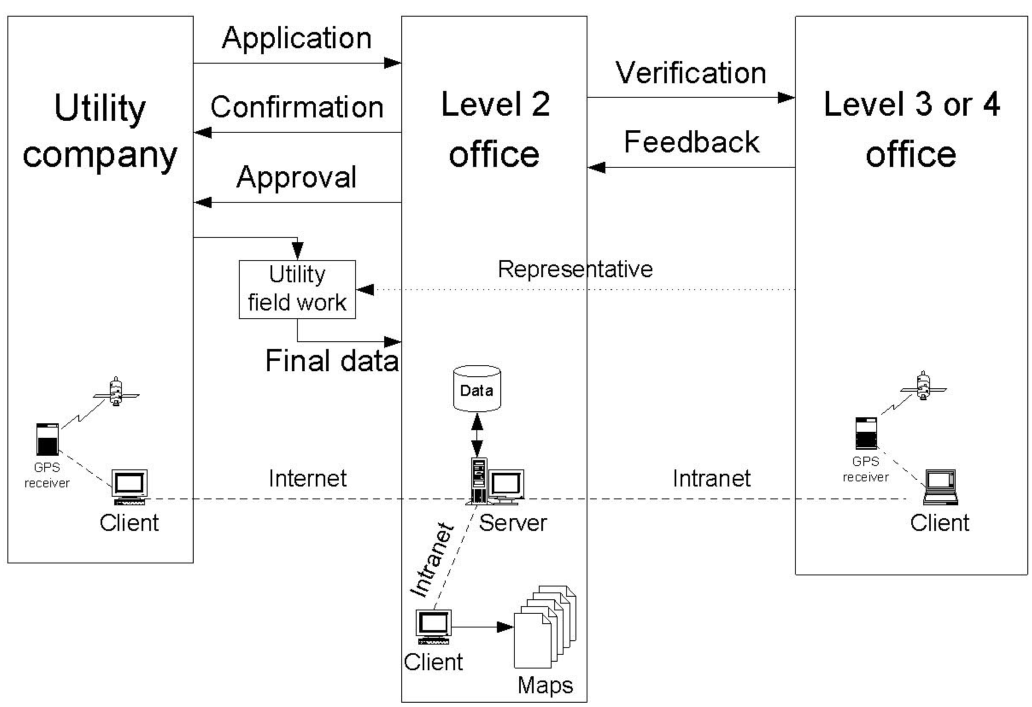

Figure 3. Sample data flow and data collection for utility permits

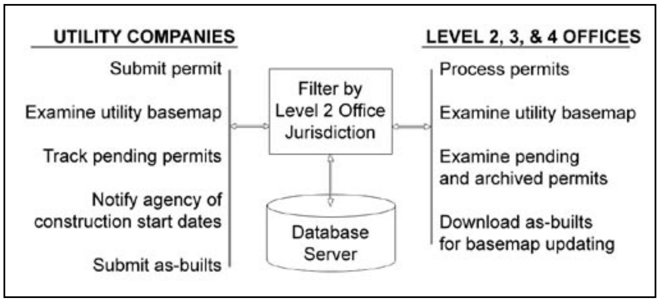

Figure 4. Functional Diagram of Utility Permitting Support System.

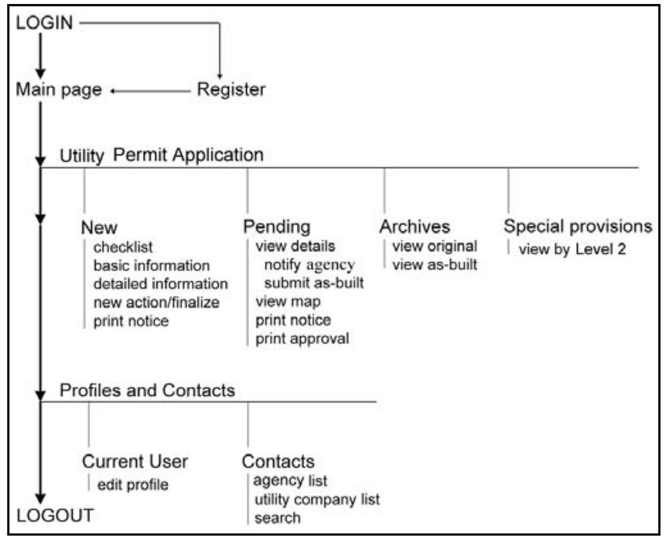

Figure 5. Functional Diagram of the Utility Company User Interface.

to be installed. As shown in Figure 7, the system includes a web mapping tool that allows users on client computers to view those coordinates overlaying the utility basemap, query utility features, and select and view data associated with other concurrent permit applications in the same area.

The user is given the opportunity, both during and after completing an application, to make changes to the data provided. When the user is satisfied that the permit application form and coordinate files are correct, the user submits the form to complete the process. At this point, all of the data are permanently stored in database tables on the central server and the application is given the status of "Submitted." The user has an opportunity to print an application form and is returned to the permit application home page. Electronic confirmation is automatically sent to the utility company's email address, and an electronic submission report is sent to the appropriate state agency representative indicating that an application is now ready to be processed.

The printable online permit application form loosely resembles the existing form. The actual layout and text included in the online form are expanded versions of a draft provided by the state agency. As shown in Figure 8, the form took the main elements included in the current state agency draft and added text elements that were obtained directly from data entered into the online permit application. The first section includes a summarized description of the proposed work as well as text elements such as application ID, proposed construction beginning and ending dates, application date and time stamp, and utility company user data. The second section provides a more detailed description of each action. It also provides links to coordinate data files, attachments, and a map. The online approval form works in much the same way.

The applications can be viewed by utility companies as they move through the approval and documentation process. Of primary interest to utility companies is the application status. For most status levels, applications may only be viewed. However, after approval has been given, the utility company is automatically contacted via email and is instructed to use the interface for notifying the state agency of the construction start date as well as submitting as-built documentation when construction is finished.

Administrative Interface

The administrative interface supports all the needs and responsibilities of state agency administrators in the process of reviewing permit applications. The interface keeps track of an application's processing status and automatically alerts specified administrators when an application has reached a status for which they are responsible. The specified administrator then logs into the system (a link is provided within the email for convenience), clicks on the appropriate processing link in the navigation bar, and processes the application.

The system includes six levels of administrative responsibility to process permit applications within the state agency. Table 3 provides a brief description of the activities associated with each level of responsibility. The system also includes 11 status options for utility permits. Table 4 provides a brief description of each status option and the corresponding relationship with the administrative responsibility levels. To encourage efficiency in the review process, the relationship between administrative responsibility and utility permit status is dynamic. Each time the status of an application changes, an email alert is automatically sent to the individual responsible for the next required administrative task. An action by that individual in response to the automated email triggers a change in application status that, in turn, results in an email alert to be sent to the next official. Depending on the status and/or action required, an automated email may also be sent to the utility company.

During system implementation or when there is a new administrator, he/she must register with the system (Figure 9). This requires contact information, levels of responsibility, Level 2 office designation, a login, and a password. "Levels of responsibility" may be assigned to multiple people or to individiuals. Individuals may be assigned more than one level of responsibility. This arrangement supports a flexible approach to assigning responsibility that may be determined differently across the Level 2 offices. After the profile has been completed, whenever the administrator logs into the system, all pending permits that correspond to the earliest status level are listed for which the administrator is responsible. For example, if he/she is in charge of both Field Verification and As-built Review,

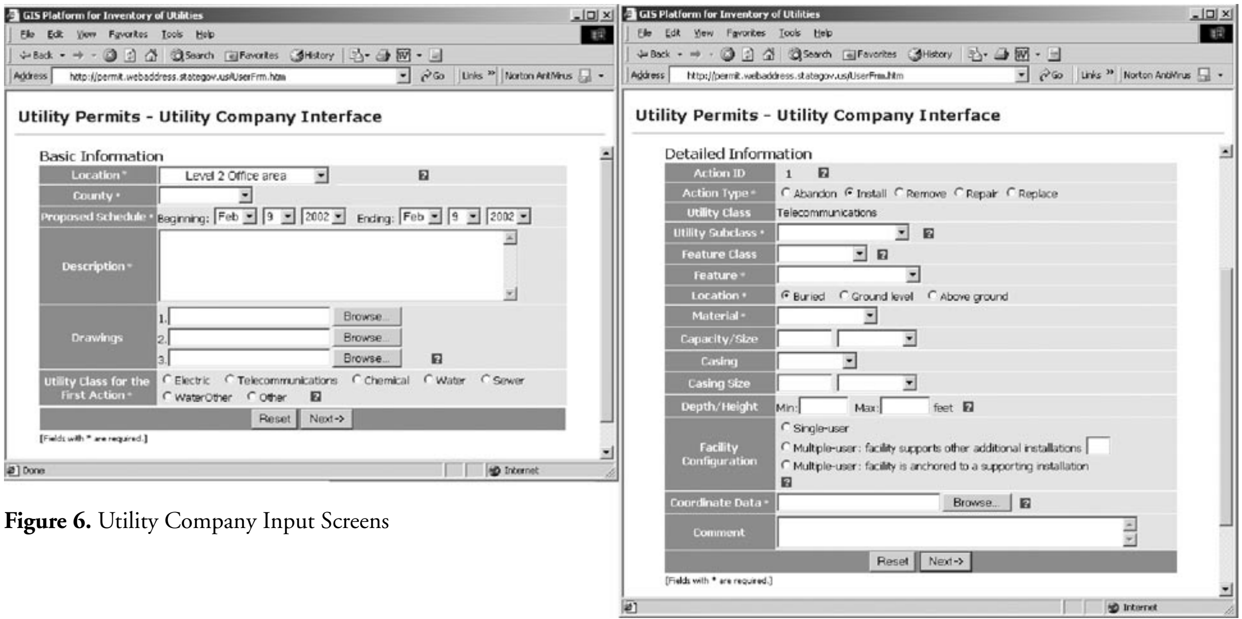

Figure 6. Utility Company Input Screens

a list of permits needing Field Verification would be shown (Figure 10). All administrators may view permits at any status level but they may only process permits for which they have been assigned responsibility. When a permit has completed the entire process and the utility basemap has been updated, the file is moved to a separate archival database.

Summary and Conclusions

To be certain that these methods are in fact effective for use in system design, the system would first have to be successfully implemented and adopted. There would also need to be some way to measure the success against a similar system that did not use these methods during design. Nonetheless, the system was evaluated by the agency officials every 6 months during development and was repeatedly met with praise and encouragement. A statewide training workshop held at the end of the project with personnel involved in permit processing resulted in full acceptance of the concept with only a few minor suggestions on how the interface could be modified to suit the individual needs of different Level 2 offices. About 6 months after completion of the prototype and submission of the final report, the agency featured the project as one of the “top research innovations and findings for 2002” in its annual publication. The agency has adopted the concept and will be implementing the system over the next 2 to 3 years.

The system designers feel that ethnographic methods were useful in organizing and analyzing information gathered during the requirements specification stage of system design. The four methods used for data collection (i.e., observation, interviews, documentation review, and a survey questionnaire) were helpful in exploring various dimensions of the problem while simultaneously providing multiple pieces of evidence upon which to base requirement specifications. While many system designers may use some of these methods intuitively, understanding how these methods exist within a larger suite of data collection and analysis methods may help them to be used more effectively. Comparing

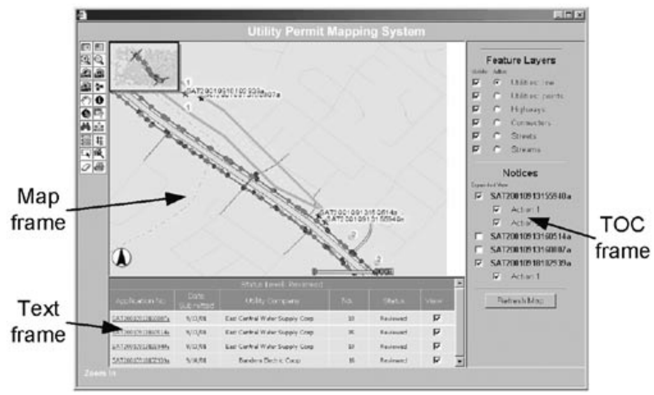

Figure 7. Mapping Utility with Coordinate Data Displayed

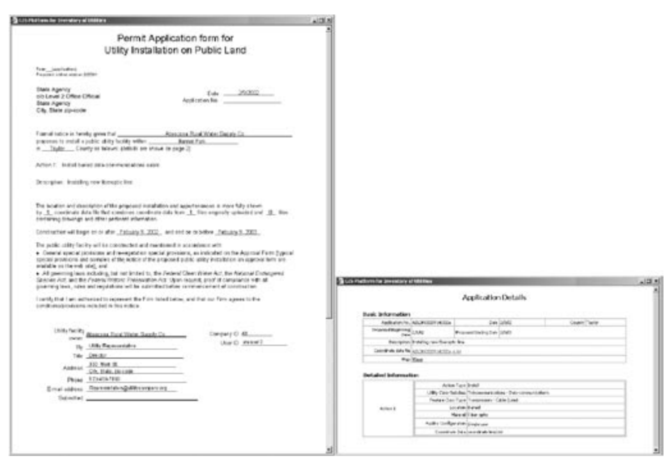

Figure 8. Printable Online Permit Application Form

Table 3. Administrative Responsibility Levels

Response	Description
Initial review	Conduct initial review of submitted documentation
Field verification	Conduct field verification and make recommendation for approval/rejection
Approval/rejection	Approve or reject applications
As-built review	Review as-built documentation after utility companies have finished the field work
GIS documentation	Update GIS utility maps based on as-built documentation
Archival	Archive application after completion or rejection; can also change the status of an "Archived" application back to an active status

Table 4. Utility Permit Status Options.

Status	Is Reached After	Next Responsibility Level
Submitted	Electronic confirmation that an application has been received by the server has been sent to the utility company	Initial review
Reviewed	Application has been verified for completeness. Normally conducted by a utility coordinator at the Level 2 Office	Field verification
Field verified	Maintenance Supervisor/Area Engineer recommends whether the proposed installation should be approved	Approval/rejection
Approved	Application has been approved and an automated email has been sent to the utility company	
Rejected	Application has been rejected and an automated email has been sent to the utility company	Archival
Notified	Utility company has given 48-hour notice to the state agency prior to starting construction	
Expired	Utility company has not notified the state agency of the construction start date prior to an expiration date set by the administrator responsible for approving the application	Archival
As-built submitted	Utility company has submitted a final set of coordinates indicating the location of the utilities installed	As-built review
As-built reviewed	The state agency has reviewed and approved the as-built documentation submitted by the utility company	GIS documentation
Completed	GIS personnel at the Level 2 Office have updated GIS utility map using as-built data provided by the utility company	Archival
Archived	All processing is complete	

the data documented through triangulation provided confidence in drawing design conclusions. The findings were used to establish requirements specification for choosing a system platform, developing an interface for procedural support, and identifying critical data requirements.

While the methods are used to ensure that a relevant and efficient system is developed, they can also be used to identify existing workflow procedures and attitudes about them that could cause the proposed system to fail in its primary purpose. While ethnographic methods themselves will not solve these problems, they can help in the following: 1) identify the problems, 2) reveal important details about the problems, and 3) inform recommendations for solving the problems during implementation. In this example, two needs were identified: mandatory inspection of all installations in all instances, and mandatory submission of as-built documentation after utility installation has been completed. These changes are important to note because changes in workflow are typically met with resistance unless the payoff for making the changes significantly outweighs the additional effort. It is not clear at this time if everyone who is affected by such changes, specifically officials at the Level 3 or 4 offices and utility companies respectively, will see them as significantly positive. Only after implementation is it possible to know whether all the potential problems had surfaced or if the problems that were identified were in fact important.

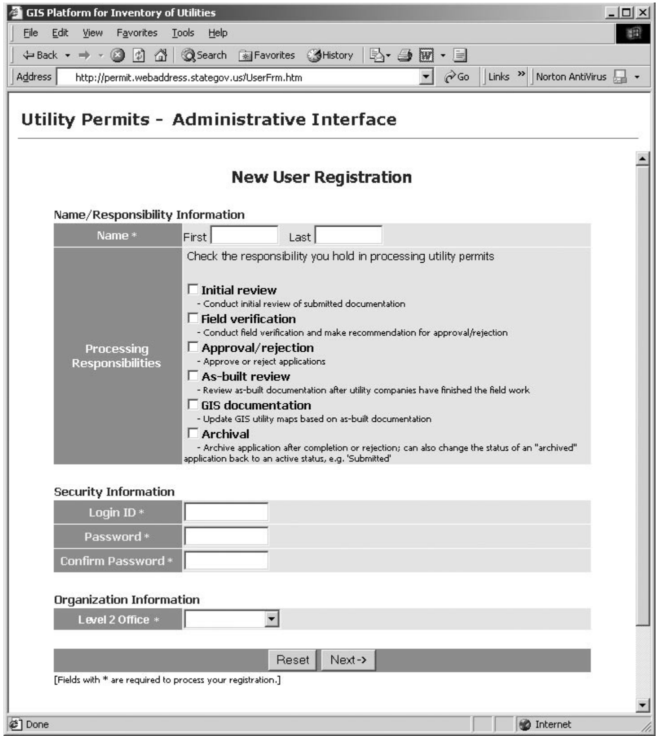

Figure 9 – New administrator registration form showing the levels of processing responsibility.

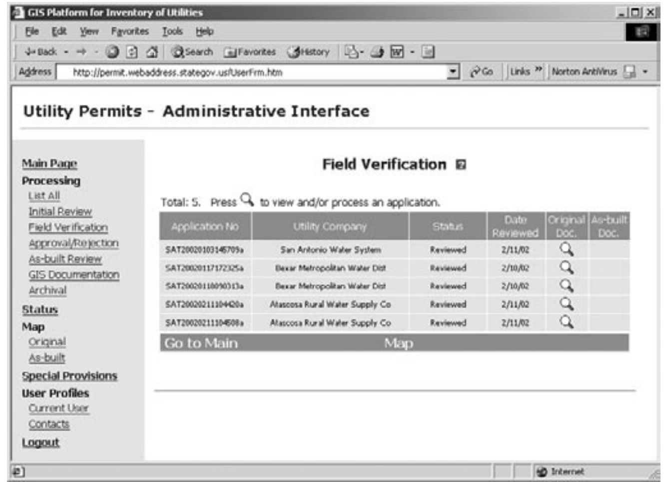

Figure 10 – List of permits associated with the administrator's earliest level of processing responsibility.

It is clear that ethnographic methods were useful in acquiring a rich understanding of the design problem at the start of the project, but that limitations exist in their the ability to capture all the finest details. For this reason, ethnographic methods should be considered an important aid to the design process but should probably be used in combination with other feedback techniques.

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Footnotes

1 The state agency uses two types of locational referencing systems (Type I and Type II) that are not specified in this document.

Ellis, C.D.; Quiroga, C.; Shin, S.-Y.; Pina, R.J. GIS and Human-centered Systems Design: Using Ethnographic Data Collection and Analysis Methods to Design a Utility Permitting Support System. URISA J. 2007, 15, 5â€“22. [Google Scholar].Â In Web and Wireless Geographical Information Systems W2GIS; Springer: Berlin/Heidelberg, Germany, 2007; Volume 4857, pp. 264â€“278. [Google Scholar]. Henzen, C. Usability von Webanwendungen in Geodateninfrastrukturen. Request PDF on ResearchGate | GIS and Human-Centered Design: Using Ethnographic Data Collection and Analysis Methods to Design a Utility Permitting Support System | Ethnographic methods are increasingly being used to study social structures of the workplace as an aid in the process of human-centered systems design. Here, the ethnographic approach is used for data collection and analysis in support of requirements elicitation for a...Â Here, the ethnographic approach is used for data collection and analysis in support of requirements elicitation for a utility permitting support system. A summary of ethnographic methods is given and discussed in the context of other sociotechnical design methods. In mobile field data collection, data gatherer requires to get geospatial information service to support in navigating to the right locations, describing context of observed object and providing thematic information for sampling or analysis. The framework In mobile field data collection, data gatherer requires to get geospatial information service to support in navigating to the right locations, describing context of observed object and providing thematic information for sampling or analysis.Â It represents a basic mechanism for GIS interface technology and facilitates the development of visual analysis and exploration tools. expand. Management and visualization of large, complex and time-dependent 3D objects in distributed GIS.