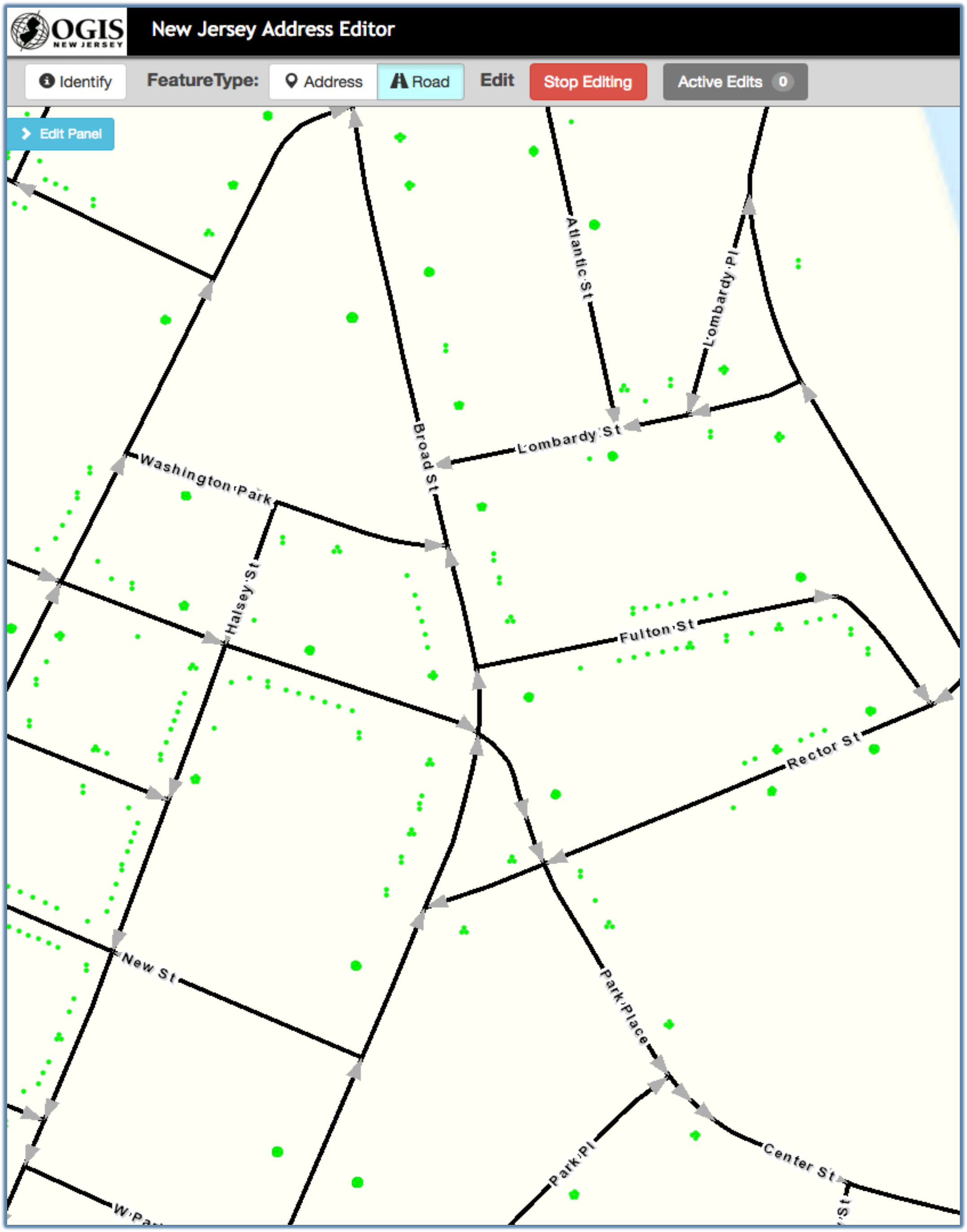

Development of an Address Point Editing Application for Local Governments & Public Safety Answering Points

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Table of Contents

Introduction and Background

Since the advent of web enabled GIS technologies and Web 2.0, government agencies have sought web platforms to collect and disseminate geographic data (Johnson, 2013). One example is in the form of a web-based platform for providing timely and accurate spatial address information. Since 2014, the New Jersey Office of GIS (NJOGIS) and the New Jersey Geospatial Forum's Address Task Force have been working on a project to develop an authoritative and comprehensive address points dataset that will support public safety and Next Generation 9-1-1 operations as well as general geocoding functions across the state. The NJOGIS and the New Jersey Department of Transportation (NJDOT), in partnership with several counties, have already built a comprehensive distributed editing model for the development of road centerlines information across the state of New Jersey (NJGIN, 2015). Although road centerlines ranges are the most prevalent and widely used dataset for current 9-1-1 public safety answering point (PSAP) address operations, address points are the best reference dataset for accurate geocoding in both public safety applications and general geocoding practice NENA, 2015; Zandbergen, 2008; and Zandbergen, 2009.

The NJOGIS has recently completed the first draft publication of a statewide address point model that will support the National Emergency Number Association's (NENA) data exchange standards and link directly with the NJ Road Centerline Data Model. (NENA, 2014). The model allows for the development of highly standardized address point information with associated landmark or placenames information (NJGIN, 2016). A majority of the points were derived from statewide parcel boundaries data from 2015, through a complex set of geoprocessing tasks that linked points to nearby NJ Road Centerline segments and standardized street names with the NJ Road Centerlines model. Address point postal delivery information (Postal Name, Zip Code, Zip 4) were also corrected using a US Postal Service Coding Accuracy Support System (CASS) certified address validation service. Address points were also extracted and transformed into the address point model from several county partners who maintain their own address point datasets.

The NJOGIS has built a complex distributed road editing model to support 9-1-1 PSAP's and local governments as they transition to Next Generation 9-1-1. An associated road editor web application simultaneously allows the state to improve its road centerlines layer through volunteered local knowledge from partner agencies and local governments, providing valuable volunteered geographic information that would otherwise be costly to obtain. Building a statewide data model and partnering with local knowledge holders also leads to a reduction in the duplication of effort. In order to ensure data quality and integrity in the roads model, a data curation workflow has been established to vet any incoming edits to the road centerlines data, which has offered the best compromise in obtaining valuable and authoritative data. A data curation model allows for mediating general concerns over data quality issues from volunteered data, as the edits are always reviewed before being incorporated into production (Johnson, 2016).

Although road centerlines are an important backbone to geocoding and 9-1-1 address search, address points are the best address storage format for promoting accurate geocoding and will become increasingly important to 9-1-1. While the NJOGIS has already developed an initial statewide address point layer for public safety use, much of the dataset remains incomplete in many areas across the state. For this reason, the NJOGIS hopes to provide a similar distributed editing environment for the development of address points. The first step in this process will be the development of a web-based editing application for local governments and 9-1-1 PSAPs to edit, update and download address point information for their own use. In its initial conception, the proposed application will show existing address points and related parcel and road centerlines information in a geographical context, and allow contributors to edit and update address points in the statewide database.

This paper will attempt to analyze the many challenges and benefits outlined in similar volunteered geographic information projects, provide a review of the types of user interface features that were used in similar projects and outline a prototype for an address point web editing application.

Building an Address Editing Application

The primary goal of this project was to develop a secure web application that would allow local government and public safety personnel to edit and correct address points information. Providing a simple web-based platform for editing this address data will allow many local agencies with the means to update and consume address point data, many of which not have specific GIS infrastructure and expertise of their own. Likewise, allowing local information holders with this platform will facilitate improvements and additions to the NJ Address Point model from local knowledge holders, which is a key motivator for using a VGI platform. The application will be centered on the search, editing and downloading of address information. Table 1 presents five main application tasks which were specifically outlined to meet these objectives.

Table 1. Application Tasks

Search for Addresses
View Existing Address Information
Modify Addresses (Update /Delete)
Add a New Address Point
Select Multiple Addresses and Download Information

The first four application tasks listed in Table 1 are relatively straightforward, and are common to all geographic editing applications. A user will need to be able to find and identify existing features before deciding upon any corrections or additions that need to be made. The final application task is proposed as an optional application feature that would allow a user to select and download a subset of address point features in geographic format. Offering this feature would allow users to consume the geographic data immediately in their local government or public safety enterprise at their own discretion.

The design workflow for the address application began with general concepts and gradually work into more specific aspects of the design, starting with a general needs assessment that includef a review of similar VGI projects, an exploratory analysis of the target user, an identification of user workflows or 'scenarios' and lastly a sketching of application prototypes that would be used to guide the final development. This workflow followed the essential GIS design process outlined in Figure 1.

Figure 1. GIS Application Design Process (Robinson, 2014)

A core feature of the GIS application design process is the idea that evaluation, whether by end users or the development team, is an exercise that is undertaken throughout the entire design process. The needs assessment began with a thorough evaluation of similar VGI projects discussed in the literature and an earlier application built by the NJ Office of GIS, after which the needs assessment focused on specific user needs and project needs that needed to be considered. Concept development involved the refinement of application interface traits and how they related to the needs of the project as a whole.

Volunteered Geographic Information and Government

Volunteered geographic information (VGI) is essentially a paradigm in which volunteers, whether specifically known or unknown, contribute geospatial data and local knowledge and is best understood as a spatial form of crowdsourcing (Goodchild, 2007). VGI may be used by government agencies for many reasons, including improving citizen engagement, increasing efficiency in reporting mechanisms and reducing costs in data development. With the development of Web 2.0 technology and improvements in web GIS platforms, many governments, at all scales, have begun to undertake projects that will open up their core datasets to volunteer contributions (Johnson, 2013). Sieber (2015) describe how government agencies, after providing internet infrastructure for open data, have begun to realize the possible benefits of leveraging internet technology and volunteers to improve upon their geographic data. Likewise, larger government bodies have begun to realize the practical benefits of collaboration with local government agencies. Local government agencies benefit from utilizing the IT infrastructure of the larger government for enterprise GIS resources, and the larger government body benefits from a reduction in effort and increased sharing of local geographic knowledge from the former (Johnson, 2013). Janakiraman (2010) describe a scenario in which multiple government agencies across scales, having a common interest in a core dataset, use a federated statewide editing platform to collaborate and reduce duplication and redundancy.

Another driver of government use of volunteered geographic data is the fact that for many larger government datasets, attributes may be lacking in accuracy and completeness, and would benefit from local expertise (Hackley, 2010). Although governments may benefit greatly from VGI at the local level, there are still significant hurdles to overcome in government agency acceptance and use of the data (Johnson, 2013). Significant hurdles include receiving data of questionable accuracy, regulations surrounding the use of data, and governments' ability to track and respond to incoming information (Johnson, 2016). Despite these hurdles, governments have begun to move toward a platform paradigm, whereby a former top down / closed door approach to GIS data management may be replaced in whole or part with a more hybrid approach that emphasizes bottom up contributions (Dobson, 2013 and Johnson, 2016). Other private sector corporations, such as Google, have also begun to embrace the use of VGI and a more hybrid approach to data development (Dobson, 2013).

Depending upon the nature of the geographic data and government requirements, data may be opened up completely to crowdsourcing, or curated by an agency through specific filters and workflows that attempt to alleviate and prevent data quality and accuracy issues (Johnson and Sieber, 2012). Johnson (2016) describes how a curated data model requires meeting both technical and organizational challenges, as difficulties in learning new tools and technologies and difficulties in providing staffing resources to review contributions may arise. As a result, technical systems for VGI should be based on augmenting existing datasets, practices and technologies as much as possible, in order to prevent issues with learning new technology (Sieber and Johnson, 2015).

Optimal Editing Interfaces

In order to create an optimal user interface in the editing application, it is important to understand the types of features that are successful in different types of VGI applications. Nakatsu and Charalambos (2014) discuss a process that they used to classify crowdsourcing applications along three dimensions of task complexity in order to compare and contrast user interface features. The three dimensions of task complexity were independent (accomplished by a single user) versus interdependent tasks, well-structured (specific, repeatable) versus unstructured tasks, and low commitment versus high commitment tasks. The authors investigated one specific commercial geo-located crowdsourcing application, called Waze, and found that simple, easy to use and mobile friendly interface features were crucial to these types of applications. Across all application task types, whether geographic or not, the authors support the idea that easy searchability and navigability were most important to the user interface.

Goodchild (2011) elucidates on the problems that are preventing the development of a simple and easy to use GIS interface, including a lack of formalized functionality, and a lack of understanding of the user's thought processes. Roth et al (2015) support this notion that a key component of user interface success is a deep understanding of the target user, their use cases and their thought processes. The authors describe the three tenets of user interface success; usability, utility and user. Understanding the target user will inevitably affect judgments on the other two categories of usability and utility of the interface.

Jones and Weber (2012) provide an in-depth analysis of learnability issues faced in a VGI web editor for Open Street Map. These issues are central to the overall experience of the user and thus may not promote wider adoption and contributions from users. The authors summarize nine rules of interface design that relate to key learnability issues found in VGI applications. They can be separated into three general themes: reducing editing errors and increasing editing efficiency, providing a standardized and consistent user experience throughout the application, and promoting active feedback and help interfaces throughout the application.

Jones and Weber (2012) suggest several improvements to reducing editing errors and promoting efficiency. Editing features must be clearly visible, understandable and labeled logically for the user. Many of the editing object names in the Open Street Map application were not easily understood by the user because the creators had used unusual terms in lieu of popular labels such as points, lines and polygons. In addition, user interface features should stay consistent in location and type, when a user moves between viewing and editing modes in the application. Inconsistency in the location of tools and editing workflows between different objects created a great degree of user dissatisfaction and errors in the editing process. Lastly, the application interface should strive to be dynamic and promote active feedback to the user. The authors mention several examples, including disabling unneeded tools during specific workflows and providing clear feedback on current, active and unsaved edits. All of these suggestions taken together can help reduce cognitive load, frustration and complexity for the user, which may promote more contributions from users.

In summary, the problematic user interface elements that were discovered in earlier VGI applications are all important to consider when designing an address point editing application. Many of the application elements are not necessarily specific to VGI applications but to all GIS web editing applications as a whole. Several broad themes of positive user interface traits have been recognized in the literature, and can be thought of as relating to searchability and efficiency, interface predictability and user guidance and feedback. All of the above themes provide a better user experience in terms of workflow efficiency and application learnability, and all of the these themes will be critical in building a successful address point editor.

The NJ Road Editor Application

A review of the previously developed NJ Road Editor application was conducted to critique common interface elements. The NJ Road Editor application (Figure 2) is a similar web application that was developed to allow trusted local sources to edit New Jersey road centerlines data in a web environment. The application was released in 2014 and has since built a strong user base. A review of the NJ Road Editor user interface features was conducted to determine what, if any, features might be beneficial to incorporate in the address point application. There were several notable features that were found in line with recommendations from the literature.

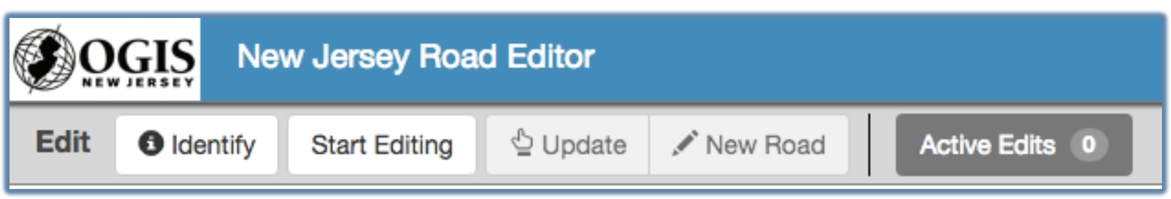

Figure 2. The New Jersey Road Editor Interface.

Foremost, the NJ Road Editor application made heavy use of a guided and dynamic user interface that promoted active feedback to the user as they stepped through the editing process. User interface features that were not part of the workflow or unnecessary during a specific step, were disabled. For example, the editing tools for updating a road and adding a new road were disabled when a user was not within an editing session. Likewise when a user opted to add a new road, all other interface elements were disabled to signify that the user must draw a road before moving forward. In addition, a message window provided consistent tips and suggestions to the user as they stepped through the application (Fig 3). Lastly, an active edits status window was provided to allow the user to view and change their suggested edits before committing them to the database. A user had the option of removing individual edits before committing others, thereby promoting accuracy and reducing editing errors (Fig 4).

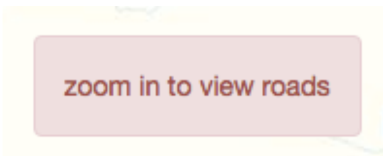

Figure 3. NJ Road Editor Message Window

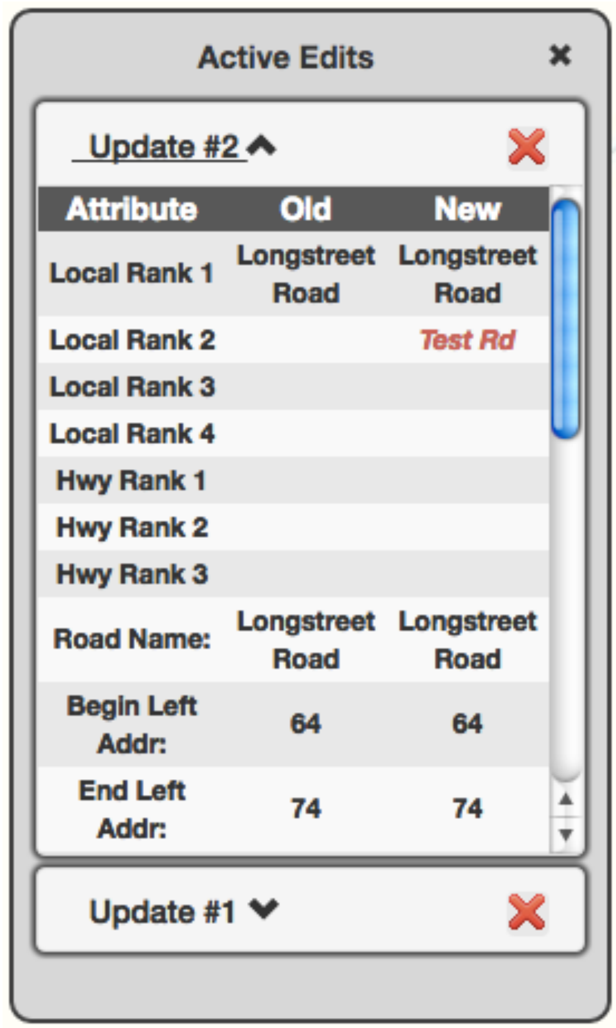

Figure 4. Edits Status Window

Designing the Application

Before any designing and prototyping of the application can commence, it is important to outline all of the application interface features that will be used. The NJ Road Editor application, like the similarly proposed address point editor application, allows for local contributors to edit geographic data, and can best be thought of as a government curated volunteered geographic information application. For this reason, it is important to understand the positive user interface features in the NJ Road editor application that can be used in future development. Many of the application features used in the NJ Road Editor application have met the criteria and recommendations outlined by previous research and meet the three broad themes of successful VGI application traits. Table 2 outlines application features from the NJ Road Editor application and additional proposed application features for the address point editing application , that align with these three categories.

Table 2. Application Features for Successful VGI Applications

Efficiency & Searchability	Interface Predicability	Active Guidance/Feedback
Find Roads/ Localities Easily & Quickly	Understandable/ Well Known Labels & Icons	Active Editing Feedback
Caching User Settings	Editing Workflows & Tools In the Same Location	Graying out/ Highlighting Interface Features
Simple Interface (not crowded)		Report Changes
Modal Windows to Focus Activities		Approve / Reject Individual Edits
Mobile Friendly		

Needs Assessment

A needs assessment for application features and functions is critical to the early stages of the design process. For this project, application needs were organized into two broad categories: Project Specific Needs and User Needs. (Figure 5) This paper will first outline the specific requirements of the application in meeting the data quality needs, and will then attempt to outline the needs of a typical user.

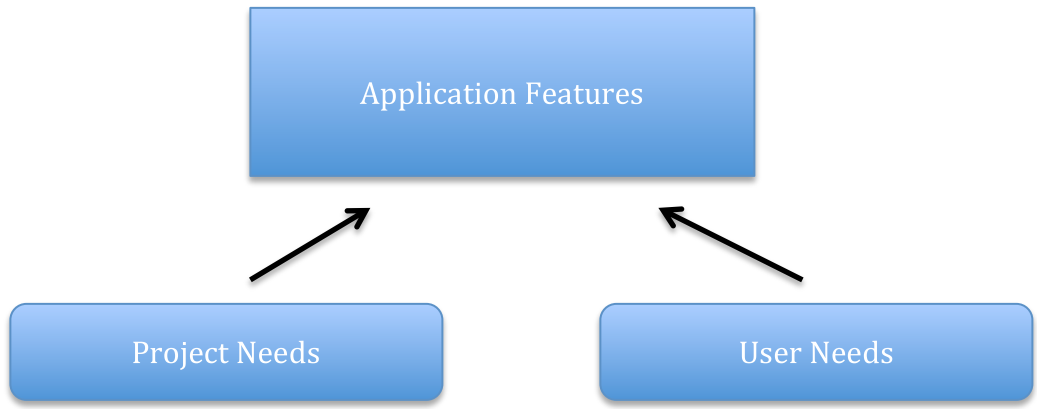

Figure 5. Application Requirements

There are a number of project needs that needed to be incorporated into the design of the application. These project specific needs included security restrictions, data model specific considerations and data quality needs that needed to be met to ensure data consistency and quality and address formatting validations to ensure accurate postal attributes for addresses.

Editing Restrictions

A specific project requirement was that users must be registered and vetted by the state GIS admin team before being allowed to contribute edits towards their jurisdiction. In this scenario, the application would require the user to login before gaining access to the editing interface. In addition, after a certain period of inactivity, a user session would be terminated automatically to ensure security.

Registering and vetting users is one example of an example feature that will support data quality. Any edits made will thus be easily tracked to specific users, and users may then be contacted for further clarification on specific contributions. Likewise forms for entering attribute information, will have to provide validation and limitations for specific domains of values, depending on what is listed in the accepted Address Point data model. This will ensure accurate data quality and consistency throughout the dataset.

Reducing Redundancy

One of the other project specific goals was to normalize or standardize road centerline street names with address point street names to the utmost extent possible. As mentioned earlier, the state already offers a very detailed and comprehensive road centerlines dataset with a rich database of standardized streetnames. Likewise, many current geocoding resources offered by the state use a combination of address points and road centerlines. Standardizing street names between these two datasets would assist in improving geocoding consistency and accuracy. Similarly, using existing streetname information (where available) would reduce redundancy and duplication of efforts.

Templating Features

In order to meet the goal of reducing redundancy, a specific user interface feature was proposed, whereby the user would be able to select the nearest road segment associated with a new address point feature, to automatically fill in the address point street name attributes. Doing so would allow the application to automatically standardize the address point street information with the road centerlines network and would help aid in efficiency and productivity for the end user. A simple and intuitive interface for linking address points to existing roads would offer the best potential for productivity once the user had learned the editing environment, which supported established recommendations for usability design (Behrens et al., 2015 and Nielsen, 1993).

Correcting Postal Information

In addition to automatically standardizing street name information, another project requirement identified in the planning stages of this data model is the need for accurate postal code information for addresses. Postal code information refers specifically to the US Postal Service address attributes of Postal City Name, Zip Code and Zip Plus 4. It is understood that not all addresses and subaddresses that will be captured in the address point data model will be valid and deliverable postal addresses. However, to the greatest extent possible, the goal of the address point data model is to capture accurate postal code information. To meet this requirement, another optional application feature was proposed that would validate newly added addresses against a US Postal Service certified address validation service. The user would then be prompted to accept or deny any postal code changes proposed by the address validation service (Figure 6).

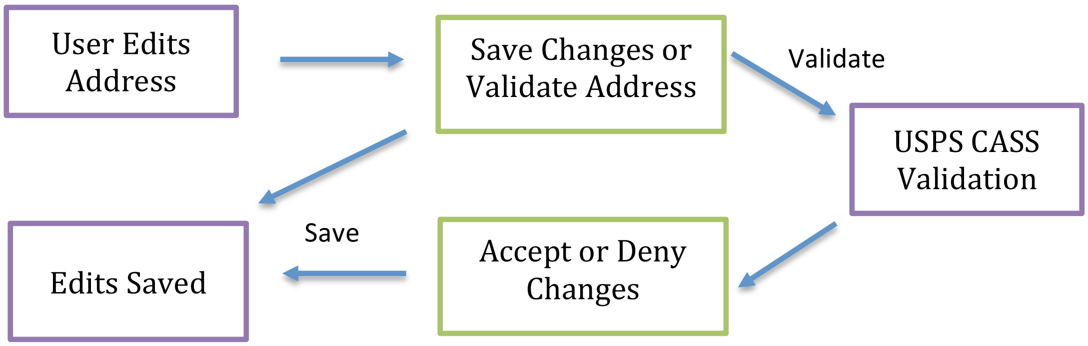

Figure 6. Address Validation Workflow

User Needs

In order to understand the specific needs of the average user or contributor of this type of application, a complete definition of the typical user must be created. One of the initially stated project goals was to offer public safety and local government agencies, the ability to edit and obtain address point information. In this scenario, the largest group of anticipated users would be local, county, regional or state government employees and personnel from public safety and emergency management agencies. These users are listed in (Figure 7).

Public Safety	Local Government	State Government
- 911 Dispatch Staff - Emergency Management Staff - Clerical Staff	- Municipal Employees - County Employees - Regional Agency Employees	- State Agency Employees

Figure 7. Anticipated Users

There are a number of user attributes that are not evident in the user groups listed in Figure 7, but which are important to consider in designing the application. The user may or may not have any previous GIS or spatial editing experience. The application design must consider this to ensure the interface is easy to understand and the work tasks can be accomplished without prior GIS knowledge.

Secondly, the user may not have much time to accomplish the editing tasks. Depending upon the user listed above and their existing work constraints, some users within the public safety domain, particularly 9-1-1 dispatchers and telecommunicators, will have very little time to edit existing address points. The dilemma lies in the fact that these users are often on the front lines of witnessing addressing errors and may indeed have the best local knowledge. For these reasons, it is important to take this specific user group's needs into account, specifically making the application editing tasks simple, efficient and swift.

Development Methodology and Timeline

The initial project timeline required that a working production application be completed by the first quarter of 2017. In order to meet this accelerated timeline, we used a two-step prototyping process that incorporated both low fidelity wireframes and a high fidelity application prototype to critique various user interface designs and workflows. Using both low-fidelity and high-fidelity prototypes allowed for the opportunity to review both the application interaction elements and the actual application representation (Roth, 2016). Throughout both prototyping exercises, we incorporated evaluation on the user interface design (Figure 8).

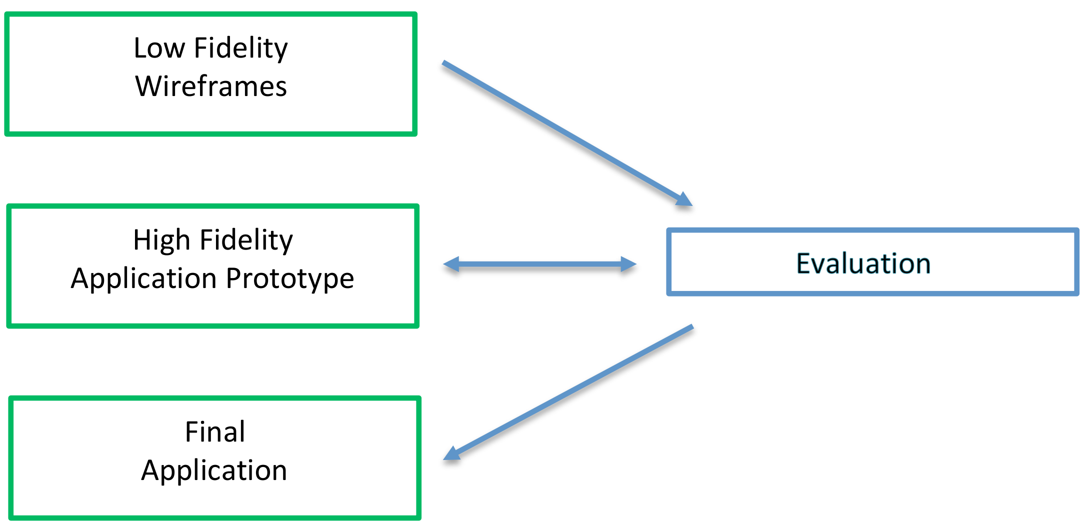

Figure 8. Development Workflow

For the low-fidelity wireframe prototypes, we used Balsamiq, a free and interactive wireframing tool. A high-fidelity functioning prototype was then created using Javascript and the Bootstrap development framework libraries. The prototype was then evaluated in a series of user tests to evaluate the functional user interface elements and application learnability.

The High Fidelity Application Prototype

Over the course of summer and early fall of 2016, a working prototype version of the application was developed. The application was developed using HTML5, JQuery, the ArcGIS Javascript API 3.18 and the Bootstrap UI framework. Other libraries that were used in the application included the JQuery Validation Engine library and the Bootstrap Tour library, which was used to create the map tour components. (CITE & CITE!). The application uses a test version of the State of New Jersey's authentication portal, which provides authentication with the state's ArcGIS Server services. The application was then staged on state test servers to be used for the user interface tests.

Experiment Methodology for User Interface Tests

Many different user interface testing methods have been applied to geographic information web applications in the past, including usability testing cognitive walkthroughs and predictive modeling (Nielsen, 2004). For this application usability test we decided to use a Think Aloud method for usability and learnability analysis, as it would allow use to understand user thought processes in real time as they interacted with the application (Jones & Weber 2012 and Nielsen 2002). In the Think Aloud usability analysis method, participants and encouraged to communicate their actions, intentions and reactions out loud as they progress through a user interface (Neilsen et al 2002).

In consultation with the project team that sponsored the application development, a series of 14 user interface steps were drafted for the Think Aloud session. The tasks covered all of the UI elements, functions and workflows within the application. The beginning tasks centered on the application help interface, map navigation and search, followed by a series of mixed tasks that covered all of the editing workflows and capabilities allowed within the application. The tasks ranged in complexity and size and were dispersed in order throughout the task sheet. Some of the tasks were somewhat redundant, such as updating an existing address, in order to investigate whether users improved in their understanding of the user interface as the workflow progressed.

All of the users were given the same instruction sheet and verbal instructions at the beginning of each user session. All of the users were instructed that they could not ask the moderator questions about the user interface and they were allowed to abandon any task at their discretion. All of the user test sessions were recorded using a mobile digital voice recorder application and task completion times were logged by the moderator using a stopwatch, while the user performed each task. The user test instructions and tasks can be found in can be found in Appendix A. After each user test session, the participant was asked to complete a five question survey regarding their experiences with the application. Survey questions centered on participant's opinions of the application ease of use, learnability and the particular user interface elements they found to be positive and negative. A copy of the post-test survey can be found in Appendix B.

Participant Demographics

A total of 12 participants (N=12) were recruited for the user interface tests. Participants were recruited through a state GIS committee and 9-1-1 committee email listservs and social media. Participants were evenly split into two major categories: those with professional GIS experience, and those without any prior GIS experience. Of the 6 non-GIS professional participants, 3 were former 9-1-1 dispatch and public safety personnel. Half of the participants were female and the other half were male, ranging in age from 24 to 61. None of the non-GIS participants had any prior experience with editing GIS data within a web application.

Results & Analysis

After each user interface session, task times, user comments, moderator notes, and the post-survey were then transferred into a digital format for further analysis. The results analysis centered on qualitative usability evaluation, as was performed in other similar learnability studies (Jones and Weber 2012). Of particular importance was the question of whether the application design had succeeded in making user interface features accessible and easy to use for GIS and non GIS professionals alike.

Task Durations and Success Rates

Task completion times were recorded an converted to minutes for each user. Overall, average overall times and task completion times were similar between the GIS and Non-GIS Professional groups. However, task completion and duration rates seemed to differ substantially amongst users in each group. Tables 3 and 4 show the breakdown of task durations and completion rates between groups and users.

Table 3.

Task Times (Minutes) for GIS Professionals							
Tasks	User10	User11	User12	User7	User8	User9	Average
1	3.7	5.0	3.8	3.1	4.8	5.2	**4.2**
2	0.2	0.8	1.6	0.2	0.2	0.4	**0.5**
3	0.2	0.3	0.4	0.2	0.2	0.6	**0.3**
4	0.7	1.2	0.4	0.4	0.6	1.2	**0.7**
5	0.3	0.2	0.2	0.2	0.1	0.2	**0.2**
6	7.8	6.8	7.6	4.1	5.3	4.5	**6.0**
7	0.7	0.2	0.2	0.1	0.3	0.4	**0.3**
8	4.2	1.9	5.9	1.2	1.4	1.3	**2.7**
9	0.9	1.3	0.9	1.0	1.3	1.3	**1.1**
10	0.6	4.2	2.4	3.2	1.2	3.1	**2.4**
11	0.9	0.6	0.2	0.1	0.3	0.3	**0.4**
12	0.9	1.2	0.5	0.8	0.8	0.3	**0.7**
13	1.7	1.1	1.2	1.4	1.4	1.1	**1.3**
14	2.0	2.3	1.1	1.3	1.1	1.7	**1.6**
Total Time in Minutes	**24.7**	**26.9**	**26.3**	**17.2**	**18.7**	**21.3**	**22.5**
Incomplete or Partially Complete Task							

Table 4.

Task Times (Minutes) for Non GIS Professionals							
Tasks	**User1**	**User2**	**User3**	**User4**	**User5**	**User6**	**Average**
1	4.8	3.9	3.0	8.8	5.9	4.4	**5.1**
2	0.6	0.6	0.5	0.4	1.2	0.5	**0.6**
3	0.4	0.1	0.0	0.4	0.4	0.3	**0.3**
4	1.7	0.4	1.6	0.8	0.5	1.2	**1.0**
5	0.3	0.2	0.2	0.9	0.6	0.2	**0.4**
6	5.0	5.3	4.2	2.8	7.1	5.0	**4.9**
7	0.6	0.2	0.6	0.7	0.2	0.3	**0.4**
8	2.3	2.6	2.0	2.8	4.6	1.5	**2.6**
9	1.4	0.9	1.7	0.5	0.4	1.3	**1.0**
10	2.1	1.1	0.0	6.0	4.1	1.5	**2.5**
11	0.5	0.1	0.8	0.5	1.5	0.5	**0.6**
12	0.5	0.5	0.5	1.3	1.3	0.5	**0.7**
13	1.4	0.7	2.4	3.5	1.1	1.3	**1.7**
14	1.0	0.8	5.2	4.1	0.7	1.0	**2.1**
Total Time in Minutes	**22.4**	**17.3**	**22.5**	**33.4**	**29.7**	**19.4**	**24.1**
Incomplete or Partially Complete Task							

Overall, users in the GIS professional category had lower task completion times and a higher task completion rate, with an average test completion time of 22.5 minutes, compared to non GIS professionals with a time of 24.1 minutes. The tasks with the highest average durations in both user groups were Task 1 (Help Tours) and Task 6 (Adding a new address point), however these average task times may have been skewed by the participants who abandoned tasks after attempting them for long periods of time.

The tasks with the lowest success/completion rates among all participants were Task 8 (Add a new road) and Task 10 (Extend a road segment). Both Task 8 and Task 10 include making edits to road segments, which may point to unoptimized user interface components in this area. The second lowest success/completion rate occurred for Task 6 (Adding a new address point). For all of these tasks, many users struggled with using the application's template functionality to select template features. In addition, users unwittingly encountered two application bugs when attempting to draw new road features and led to general confusion and less than optimal user interface feedback. The first bug occurred when users attempted to draw a road segment by clicking in the buffer area near the edit panel. Due to a map alignment issue, users were not able to add road vertices in this area, leading to a great amount of confusion and requiring the user to pan the map or close the edit panel in the middle of road edit. This is shown in Figure 9, below.

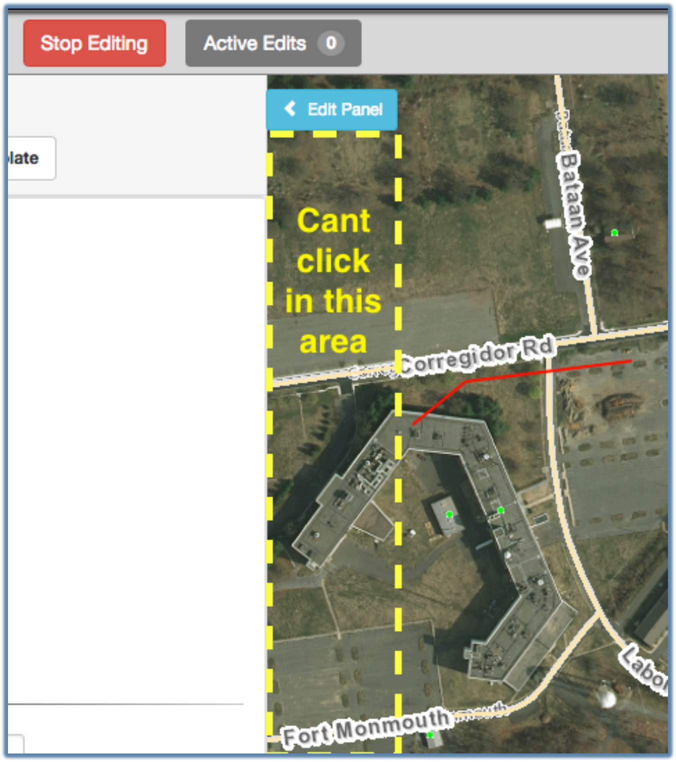

Figure 9. Map Alignment Bug

The second bug occurred when the user attempted to double click and finish drawing a new road segment. The new road lines would disappear from the map when the user is finished drawing. This confused many users in Tasks 8 & 10, who believed they had done something wrong when drawing the road.

"After double clicking, my road segment disappeared."
"I can't see the new line that I drew after I stopped drawing."
"I didn't know that I drew a road because the red line didn't stay there after I drew it."
"I drew a road, but when I double clicked the road is gone."
"The road disappeared after drawing it."
"Uh oh, I double clicked to end it and the road disappeared."
Comments on Task 8

The users were unaware the road was successfully drawn, despite the fact that the application purposefully grays out the map area to direct user attention to the road attributes panel after drawing. This issue seems to point to a crucial aspect of the map user interface feedback that users would expect, namely immediate visual cues of their newly added features. In addition to these issues, many users experienced confusion when following the steps within Tasks 6 & 10 that required them to use the attribute template features. Users had trouble with selecting only 1 template road segment to use, as they either accidentally selected multiple features at once, or didn't realize that they needed to drag a bounding box to select features. This is despite the fact the alerts window offered detailed instructions at the top of the map. Many users still seemed unaware that they were there. An example of the map alerts window is shown in Figure 10.

"It's hard to select only 1 road feature."
"I didn't even see the instructions panel when selecting new road. It'd be better if they were more visible…maybe in the edit panel."
Comments on selecting features and map alerts

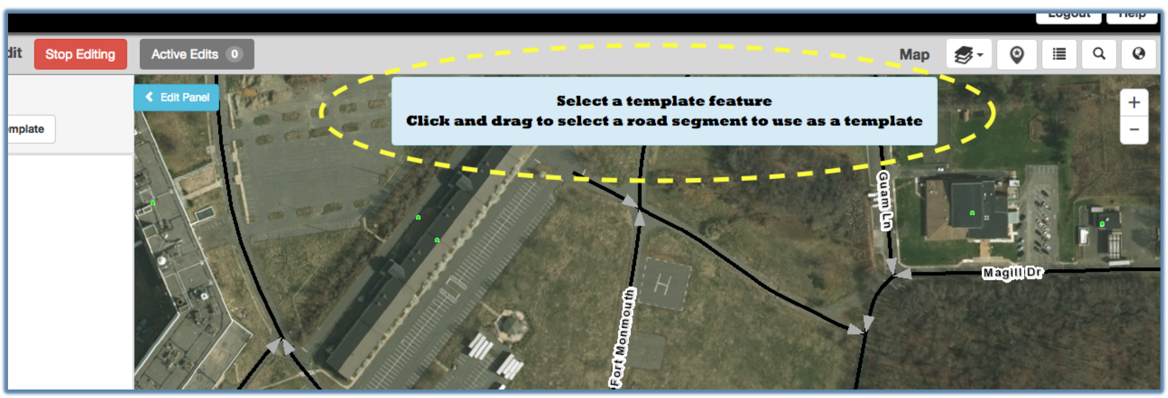

Figure 10. Map Alerts

Application Help Tours

The first task in the application workflow was to click on the "Help" button in the navigation bar and run through both application help tours. These tours depicted click through popup windows with descriptions for each button and piece of functionality in the map application. The tours were purposefully placed in the first task to give the users a brief introduction into the application functionality (Figure 11).

Based on user comments and the post-test surveys, it has become very apparent that these passive click-through tours were not the best piece of functionality to use as a help or tutorial in the application. Users did not seem to get much benefit from the help tours, and several were confused about the navigation of the help tutorials. In addition, several users were under the assumption that they should be actively testing out the functionality as they ran through the tutorials. Several users suggested created a help video tutorial in lieu of the click through tour.

"It'd be nice for the tutorial to allow the user to try out the functions as they learn them."
"It might be better if you could place a GIF or video tutorial showing the functions instead of reading about it."
Comments on the tour functionality

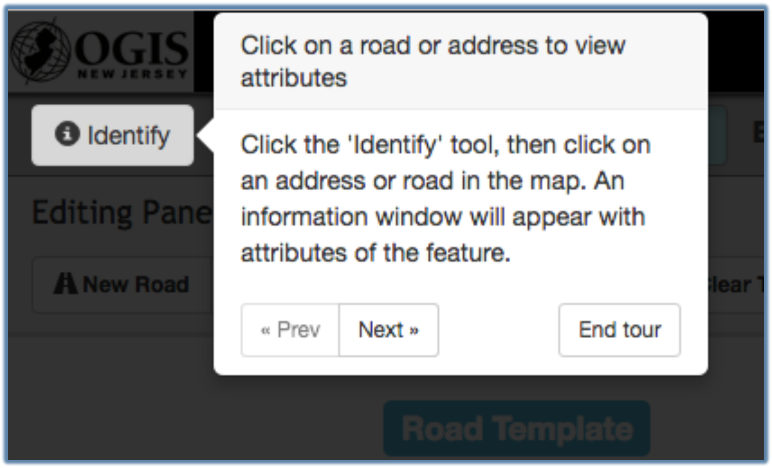

Figure 11. Help Tours

Map Rendering

One of the most significant issues encountered by all users, that often led to confusion and longer task durations was the basemap rendering. After running through the application tours, most users had no problem with finding the 'Layers' button and switching the background basemap. There were, however, many instances in which the imagery basemap failed to load of rendered extremely slowly. This was unfortunately a byproduct of the external basemap service, however it did seem to have a profoundly negative impact on user experiences and task efficiency.

"The mouse is spinning and I'm not sure why (map not loading fast)."

"The aerial imagery is loading really slowly."

"The imagery is very slow to load and update."

"The map is not loading right and I'm having a hard time finding the point."

Comments on map rendering

The resulting map loading errors could substantially deteriorate user interface usability if they are not addressed in the future. This is due to the fact that user satisfaction and application efficiency are two of the five key concepts in usability (Nielsen, 2003).

In a similar vein, road segment labels were not always apparent or legible, depending on how far the user chose to zoom in, this impacted the user's ability to efficiently complete several tasks and eroded the efficiency and satisfactions as well. A better rendering for road labels needs to be addressed.

"I cant see the label for Shafto Road. Not sure if the right road segment was selected."

"I didn't know where Shafto Road was at. I didn't see a label."

Comments on map labels

Missing Active Feedback

As suggested earlier, the map alerts panel in the top center location of the map, did not seem readily apparent to most users. The map alerts panel was designed to give the user constant feedback about what functions and steps the user is currently in, particularly when they are in an edit session. The map alerts provide instructions on how to perform the edit functions. Despite this feature, it seemed as though many users did not seem to recognize it, as they continued to be unsure of what functionality they were using at different times.

In addition, there were several other areas of the mapping interface that lacked prompt and active feedback. The search window did not automatically close or provide confirmation when an address search was successful, as evidenced in the user quotes below.

"I think I saved it."

"Presumably it found the address."
"It'd be helpful if the search panel closed after a search is successful."
"I'm a little confused, if I don't hit save on the bottom, but choose stop editing at the top, it doesn't save my edits. Doesn't seem to make sense."
"I think I saved it but I don't see where it tells me that…"
Comments on application feedback

Particular emphasis in subsequent versions of this application should be placed on actively notifying the user that search and save operations were successful, as well as active feedback if the user attempted to use the application in an unintended manner.

User Surveys

Despite the wealth of feedback and information gleaned from the Think Aloud user test sessions, a substantial amount of feedback was received in the post-test surveys. The survey incorporated five questions, four of which allowed the user to submit open ended responses about their experiences.

The first question featured a matrix in which the user could designate how much they agree with several statements about learning the application. The responses to question 1 are listed below.

<u>Question 1:</u>

	Strongly Disagree				Strongly Agree
	1-	2–	3–	4–	5-
–	0.00%	0.00%	33.33%	41.67%	25.00%
I think that I would like to use this system more frequently.	0	0	4	5	3
–	50.00%	41.67%	8.33%	0.00%	0.00%
I found the application unneccessarily complex.	6	5	1	0	0
–	0.00%	0.00%	25.00%	50.00%	25.00%
I thought the application was easy to use.	0	0	3	6	3
–	50.00%	25.00%	0.00%	8.33%	16.67%
I think that I would need the support of a technical person to be able to use this application	6	3	0	1	2
–	0.00%	0.00%	16.67%	66.67%	16.67%
I found the various functions in this application were well integrated.	0	0	2	8	2
–	50.00%	41.67%	8.33%	0.00%	0.00%
I thought there was too much inconsistency in this application.	6	5	1	0	0
–	0.00%	0.00%	16.67%	25.00%	58.33%
I would imagine that most people would learn to use this application very quickly.	0	0	2	3	7
–	66.67%	25.00%	0.00%	8.33%	0.00%
I found the application very cumbersome to use.	8	3	0	1	0
–	0.00%	8.33%	25.00%	58.33%	8.33%
I felt very confident using the application.	0	1	3	7	1
–	50.00%	16.67%	16.67%	16.67%	0.00%
I needed to learn a lot of things before I could begin using this application.	6	2	2	2	0

Most participants answered the first question in an overwhelmingly positive manner. Despite the issues discussed in the Think Aloud session, most participants did not find the application cumbersome to use and agreed that the application could be easily adopted by others.

Question 2: Which task did you find hardest? Why?

The most common answer among participants described the tasks that involved adding and editing road segments, namely tasks 8 and 10. The chief reasons that users listed were the fact that the new segment drawing disappeared and the user had a hard time understanding how to draw or extend a road segment.

Question 3: What did you like most about the user interface setup?

Most of the participants described how they found the user interface to be clean and simple, and the editing functions pretty straightforward. Despite earlier suggestions to change the application tours format, a number of participants suggested the help tours were effective.

Question 4: What did you like least about the user interface setup?

This particular question featured the most varied responses from all of the participants. Although many of the participant's responses were unique, the most common survey responses centered on the confusing setup and workflow for saving edits and the disappearance of newly drawn line segments. In terms of complaints over saving edits functionality, participants felt that having two locations to save edits (one for immediate feature changes, and another to confirm and save all edits) was confusing and misleading.

In future versions of the application it might be beneficial to increase the amount of active feedback and introduce a warning message in the case that a user is attempting to exit an edit session without saving edits.

Question 5: What would you change about the application to make it more intuitive/easier to use for people?

The most common answer to this question among participants was related to overhauling the help tours and tutorials in the application. Many of the participants suggested putting a direct link to a video tutorial, or set of tutorials that would play in the center of the screen.

Several other interesting suggestions were suggested as well. One user suggested allowing users to save and name multiple bookmark location. Another user suggested the map alert panel was not as visible as it should be.

Conclusions

The central question for this entire investigation centered on a single premise: How do we design a volunteered geographic information application in such a way that it promotes increased user satisfaction, engagement and adoption. There are many strategies and technologies that a central GIS enterprise can take in order to refine and acquire better data from local data stewards, and a remote web editing application, such as the NJ Address Editor, is just one of many tools to do so. This project has been extremely beneficial in streamlining user interface design and the development workflows.

Although the NJ Address Editor prototype did attempt to incorporate many interface design elements that would improve usability and learnability, ultimately the Think Aloud user sessions proved the most valuable in sorting out the unique features that are a hindrance or benefit to the average user. Although the prototype was found to have many flaws and omissions in terms of active user feedback, ultimately the user interface was found to be simple, clean and easy to navigate for most users. The lessons learned and concepts taken from the literature review and this Think Aloud session will continue to help refine the NJ Address Point Editor so that it leads to the greatest adoption by local agencies.

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APPENDIX A – User Test Tasksheet

Introduction

The NJ Address Editor is a web application designed by the New Jersey Office of Information Technology that allows local agencies the ability to edit the state's road centerlines and address point GIS data. The application allows a user to zoom to an area of interest or neighborhood, search for an address and add or update either road centerlines or address points on the map.

The following task sheet was designed to be performed during a think aloud user test session. The task sheet involves predefined tasks that cover most of the application's capabilities, including interacting with the map and editing address data.

As a participant, you will be timed and your voice recorded as you work to complete each task. As this is a think aloud user test session, you are encouraged to talk out loud and offer your opinion as you attempt to complete each of these tasks.

During the user test session, there are also two rules to keep in mind:
1) You are not allowed to ask the moderator any questions about using the application.
2) If you are stuck and unsure of how to proceed on a certain task, you are allowed to abandon it and move onto the next task at your discretion.

Task 1: Application Tour

1) **View the Help Information**
   Click on the Help button and run through both the Map Navigation and Editing Tours.

Task 2: Save Bookmark

2) **Search for a Township**
   Click on the Search button, zoom to Tinton Falls by selecting “Monmouth County” then “Tinton Falls Borough” from the dropdown selections. Close the search window.

3) **Bookmark the Tinton Falls Location**
   Save the view of Tinton Falls as your home Bookmark location.

Task 3: Add an Address Point

4) **Search for an address**
   In the search panel, search for this address: 1540 West Park Ave Tinton Falls, NJ. Close the search window.

5) **Change the basemap**
   Click the Select Layers button and choose “2015 Imagery” as the basemap.

6) **Add a new address point:**
   - Start an edit session for address points
   - We’re going to select the nearest road segment to use as a template for the address
   - Click on “Select Template” from the Editing Panel
   - Drag to select the nearest segment of “Shafto Rd” as a template feature (see blue arrow in image). The road segment should be highlighted in blue on the map and the road’s attributes should now be listed in the “Address Template” pane.
   - Click on “New Address” from the editor panel
   - Click on the map and drop a new point at the location depicted in yellow circle.
   - In the New Address pane on the edit panel, enter the following address information:
     - -Address: 2000 Shafto Rd Tinton Falls, NJ 07712
     - -Placename: Wawa
     - -Location Type: Rooftop
     - -Use Type: Commercial and Retail

-Address Source: Test User

Task 4: Add a new road

7) **Switch Feature Type**
   Stop Editing, save your edits, and switch the feature type to "Roads"

8) **Add a new road**:
   - Start editing roads
   - Select the 'New Road' button
   - Draw a new road behind the Wawa (shown below by the red arrow).
   - Enter the following attribute:
     -Local 1: Wawa Way

   -Leave all other attributes blank and hit 'Save'

Task 5: Extend a road

9) **Search for an intersection**
   In the search panel, search for: Public Rd & Prospect Plains Rd, MONROE TOWNSHIP, NJ 08831

10) **Extend a road segment**
   - In the current map extent, find "Landmark Road." The road should be highlighted in red.
   - Select the "Select Template" button, then drag to select "Landmark Road."
   - Select "New Road" then add another segment to the existing segment of Landmark Road. Extend this segment to the first intersecting road (from imagery)

Task 6: Update an address point

11) **Switch Feature Type**
   - Select Stop Editing
   - In the Stop Editing popup window, choose "Save Edits"
   - Switch the feature type of interest to "Address"

12) **Search for an address**
   Use the search panel to locate: 100 South St Morristown, NJ

13) **Update an address**
   - Select "Update Address" from the edit panel
   - Drag to select the address point for 100 South St Morristown, NJ 07960
   - Update the following attributes:
      - Placename 1: Mayo Performing Arts Center
      - Location Type: Rooftop
      - Use Type: Public Attractions and Landmarks

Task 7: Delete an address point

14) **Delete an address**
   - Find the address: 301 E Lotus Road Wildwood, NJ 08260.
   (Located in Wildwood Crest Borough, Cape May County)
   - Using the 'Update Address' function, flag the address for deletion by checking the box for 'Delete Point'

APPENDIX B - User Test Survey

1)

	Strongly Disagree				Strongly Agree
	1	2	3	4	5
I think that I would like to use this system more frequently.					
I found the application unnecessarily complex.					
I though the application was easy to use.					
I think that I would need the support of a technical person to be able to use this application.					
I found the various functions in this application were well integrated.					
I thought there was too much inconsistency in this application.					
I would imagine that most people would learn to use this application very quickly.					
I found the application very cumbersome to use.					
I felt very confident using the application.					
I needed to learn a lot of things before I could get going with this application.					

2) Which task did you find hardest? Why?

3) What did you like most about the user interface setup?

4) What did you like least about the user interface setup?

5) What would you change about the application to make it more intuitive/easier to use for people?