MDOT Right-of-Way Conversion to GIS

Final Report

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16. Abstract

The goals of this project were to research the best method of utilizing information to update ROW maps, determine the best method to create a ROW map product that could integrate future Real Estate functions, determine what ROW map product would be best for moving towards a GIS and create a simplified map search functionality. To accomplish the project goals, the research team identified best practices being used by other state DOTs, catalogued existing MDOT data and methods, conducted a needs assessment, drafted modernization designs, developed additional designs for incorporating new data and developed a web mapping application. Final designs were selected and recommended for implementation. This project built upon previous work completed by MDOT staff and lays the groundwork of how to implement a ROW to GIS conversion at the Michigan Department of Transportation. It also successfully brought different units together within MDOT, increasing the likelihood that implementation will occur. Lastly, specific instructions were provided for implementing the selected designs. This will serve as a blueprint moving forward.

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Table of Contents

List of Tables (Appendix 2)

List of Figures (Report)

List of Figures (Appendix 1)

Project Scope

Through the funded research project, *ROW Conversion to GIS*, the research team of Remote Sensing and GIS Research and Outreach Services (RS&GIS) at Michigan State University and DLZ, Inc. were tasked with finding solutions to the following objectives:

1. Determining the best method of utilizing information to update ROW maps.
2. Determining the best method to create a ROW map product that can integrate future Real Estate functions.
3. Determining what ROW map product would be best for moving towards a GIS.
4. Creating a simplified map search functionality.

To adequately address project objectives, the research team completed the following tasks:

- Researched best practices for ROW to GIS conversion
- Identified and Catalogued existing MDOT ROW data (Cataloguing limited due to ProjectWise access issues)
- Assessed current MDOT modernization plan
- Conducted needs assessment and developed project requirements
- Drafted modernization designs and completed a pilot project for the selected design
- Developed methods for additional designs to incorporate new data and more fully incorporate historic data
- Developed a web application to allow for data searches / queries

Best Practices

For this task, surrounding States were contacted to review their GIS implementation efforts and identify best practices for moving right-of-way (ROW) parcels to GIS on a Statewide basis. After initial conversations and review with adjacent States, it was determined that the research could not be constrained to these States alone. This task was then expanded to over twenty other States to further explore this topic and capture GIS Modernization attempts at various State Departments of Transportation (DOT). Multiple States have a robust GIS program, but they tend to focus on construction plans, physical assets, and control.

To locate parcel level GIS implementations, the focus moved to Colorado, Nevada, Utah, Vermont, Minnesota, Iowa, and South Dakota, who have all moved forward with GIS Modernization. These States were able to identify and implement practices and improved from "lessons learned" along the way. At this point "Best Practices" have not been fully vetted by DOT's since only a handful of States have made considerable progress. Furthermore, each state has differing strengths and priorities compared to others. Colorado utilized a private consultant to migrate their parcels on a Statewide basis while Nevada utilized a private consultant to create their exterior right-of-way limits under the initial phase of their implementation. Both States used current .DGN imports and digitizing to reach their goals. Utah has created their right-of-way parcels internally over the past 20 years. Multiple States contacted through this effort reiterated common hurdles impacting modernization and lessons learned. A summary of hurdles and lessons learned have been summarized below.

Hurdles Encountered by States

- ✓ Finding enough resources to operate at capacity.

- ✓ Identifying a project driver or champion, which was often derailed by staff turnover and retirement.
- ✓ Securing and maintaining funding in the face of budget restrictions
- ✓ Resources and skills needed to modernize the data did not necessarily lie within the unit responsible for maintaining the data.
- ✓ An overall lack of defined "Best Practices."
- ✓ The effort is viewed as an overwhelming task without a perfect solution that would save a lot of time.
- ✓ Inconsistent data collection and naming conventions.

Lessons Learned by States

- ✓ Sell modernization to upper management.
- ✓ Right-of-way modernization – Move from "To-Do" to "Must-Do."
- ✓ Devote dedicated resources rather than allowing ongoing projects to supersede modernization efforts.
- ✓ Strong standards needed to bring data forward as well as allow for semi-automated ETL (Extract, Transform, Load) and FME (Feature Manipulation Engine) applications to move forward.
- ✓ Understanding that updates using Historic Data is a manual process and automation currently is not available to extract unreferenced static data and move it to a spatial platform.
- ✓ Divide the effort into two projects: Present & Past. Stop adding to historical data and capture current projects moving forward. Import historic information at a future time.
- ✓ Data organization is crucial.
- ✓ Prevent data links from being disrupted.
- ✓ Incorporate future acquisitions into the project workflow.
- ✓ Harness existing information and databases.

Best Practices

- ✓ Implement Strong Standards
- ✓ Capture new data as it is created.
- ✓ Reduce creation of additional legacy data and capture supplemental information that can assist with bringing Historic Data forward at a future time.
- ✓ Create success and take advantage of the momentum to further advance the process.

States were not overly concerned with the technical aspect, other than saving time. They were more concerned with implementation hurdles.

Catalog of Existing MDOT ROW Data

MDOT has maintained static ROW maps for many decades, beginning in the 1940's through the present. Static ROW sheets are the origin of right-of-way research. The current ROW maps function as a manual GIS System. These maps are a solid source of information to move forward with GIS modernization and build the backbone of the GIS. For this task, the team analyzed data stored in ProjectWise. Note that the available data set, other than the current static maps and associated .DGNs), was very limited due to security concerns.

ROW map sheets produced by MDOT, as well as vendors, have evolved over the years from hand-drawn maps to scanned maps and exported .DGN files (Figure 1). Modernization will change them once again as they become based in GIS.

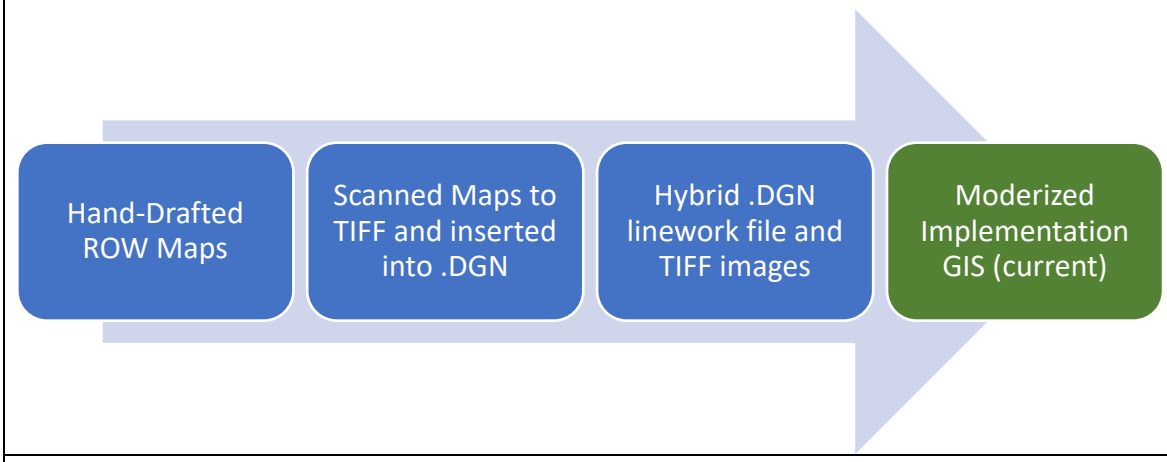


Figure 1. Evolution of ROW maps.

Most ROW sheets are a hybrid of .DGN-generated linework and TIFF imagery. Over the years, multiple MDOT staff members have hand entered data on these sheets making any form of Optical Character Recognition (OCR) applications complicated if attempted.

Currently, there are an estimated 7,258 ROW maps (not including Title Sheets) and they are a combination of .DGNs, TIFFs, and a Hybrid of the two formats. Of the 7,258 ROW maps, there are over 6,000 in the Hybrid format. The counties that appear to be predominantly TIFF based include Antrim, Baraga, Benzie, Cheboygan, Clare, Crawford, Houghton, Huron, Iosco, Kalkaska, Keweenaw, Lake, Missaukee, Newaygo, Oceana, Ontonagon, and Presque Isle. This represents approximately 15% of total ROW sheets.

It was determined that, due to the nature of the existing ROW sheets, supplemental data will be required to move this information into a Modern GIS.

Prime Data Sources to implement ROW to GIS Modernization

- ✓ Existing Static ROW Maps - .DGN and TIFF Imagery (ProjectWise Real Estate)
- ✓ S-XXXXXX_Align_ROW_20YY-MM-DD.DGN (Spatially referenced from 2006-Present-Future) (Design Survey) or equivalent for the time period.
- ✓ P.A. 132 - XXXXXX_Parcel_20YY-MM-DD.DGN (2016-2022 may be spatial referenced. 2023 – Required to submit spatially referenced .DGN) (Design Survey) or equivalent for the time period.
- ✓ Government Land Corners - (Office of Land Survey and Remonumentation. State Plane Coordinates when available from LARA) or mine S-XXXXXX_ControlPts_20YY-MM-DD.txt or equivalent for the time period.
- ✓ County Parcel Maps (DTMB)
- ✓ Vesting Documents (ProjectWise Project Folder or Real Estate Historic File. Links from LAM DA when present)
- ✓ LAMDA (Land Asset Management Data Application) Data Base (Real Estate - Attributes)

Attempting to utilize too many data sources could encumber implementation and potentially stall the project. Additional files could be resourced following a professional determination of data quality on a file-by-file basis.

It would be helpful if the ProjectWise Team within MDOT were tasked to mine the above referenced files since consultants will not have sufficient access.

Justification to include supplemental data.

Although the Real Estate Division would like to minimize the amount of data input and focus on parcels, there are sound reasons to include information other than parcels. For example, government corners are the foundations for the Michigan Rectangular Land System and parcels, as well as alignments, are eventually referenced back to them.

Prior to 2016, many parcels were acquired with a "Tract Description". This involved taking a portion of a property based on a described line that was referenced typically to a portion of an alignment. This method makes the alignment location a critical feature in plotting many acquired parcels or easements.

Assessment of Current MDOT Modernization Plan

Presently, Real Estate is focused on updating their current static ROW maps and perpetuating the current system. The current system, which was implemented in the late 1990's, consists of importing a TIFF image of the hand-drafted map into an unreferenced .DGN file. Many features are traced and incorporated, but embedded TIFF imagery remains. This system allows updates to be made in the .DGN file and exported as a static file. This work has been completed by internal and external organizations. Upwards of 80% of the current maps are a hybrid of TIFF imagery and .DGN. Through this process, Real Estate or other MDOT staff currently take spatially accurate information and manipulate it to fit within the current unreferenced .DGN files. New pdfs are created from these data and published.

The current maps are a solid source of information to build out the backbone of the GIS, but the challenge is spatially fixing these ROW maps. Since the ROW maps are not spatially referenced, any advanced applications would require resources to go into each sheet and apply some form of control point for transformation. The problem with this methodology is that spatially-fixed control is not available Statewide and resources must be dedicated to amending previous work. This is extremely time-consuming. In addition, the current maps do not have closed parcel figures making export and integration time consuming as well. This makes advanced data capture implementation impractical with the current static sheets.

The ROW map updates have not been integrated with project workflows at this time. There is a period of about 10 years where new acquisitions were not updated on the ROW maps. This period also correlated with "The Great Recession," which impacted the resources of many State Agencies. The exact number of remaining updates cannot be quantified at this time. MDOT Real Estate has been actively searching ProjectWise Project folders for acquisitions that have not been updated to the ROW maps.

Real Estate started tracking acquisitions using Fiscal Year ROW Certification spreadsheets, which allows for more consistency in tracking potential updates to the static ROW sheets. This will improve the process moving forward.

No universal Modernization Plan has been implemented within MDOT at this time. Multiple discussions and potential implementation guidelines were discussed between 2006 and 2022. Many of the proposed recommendations, such as integrating LAMDA into the process, have been included in the proposed GIS to ROW Modernization Plan being reviewed under this Research Project.

Major milestones that laid the groundwork for Real Estate to capture spatially-referenced parcels moving forward have been implemented within the MDOT network.

- ✓ 2006: Design Surveys Required to be spatially-referenced
- ✓ July 2016: Real Estate migrated from Tract Descriptions to P.A. 132 Surveys
- ✓ 2023: MDOT Design is working to create requirements that all P.A. 132 surveys be submitted with spatially-referenced .DGN files.

The Grand Region has moved forward with a pilot project. Their efforts were beneficial in demonstrating that data could be created within GIS in a form, similar to the current ROW sheets. The methods, however, were not region-wide and did not harness existing Real Estate Databases. Their pilot project efforts focused on providing similar information shown on the existing static ROW sheets to some degree. Through the needs assessment, it was determined that certain data could be obtained from other sources, thus streamlining the process. The internal pilot completed within the Grand Region did not focus on making the data available MDOT-wide nor to the public, but did demonstrate the value and need for such a system as well as confirming that the skills to complete this work do reside in existing staff at some of the Regions.

MDOT is actively seeking an implementation plan to put the findings of this Research Project into practice. MDOT units have expressed willingness to modify their procedures to accommodate future data integration with GIS. The challenge is identifying why the previous nine efforts did not materialize and avoiding a repeat.

Needs Assessment and Project Requirements

A needs assessment was completed that focused on determining MDOT business needs related to ROW GIS data. MDOT staff from all regions and all units were involved, including real-estate, planning, survey and more. Information was gathered through three regional forums, a central office debrief meeting, and follow-up interviews with selected MDOT staff.

- **Regional Forum #1 (July 22, 2021):** Bay, North and Superior Regions
- **Regional Forum #2 (July 27, 2021):** Southwest and Grand Regions
- **Regional Forum #3 (August 4, 2021):** University and Metro Regions

Appendix 1 provides a detailed description of the forums and results. However, a summary has been presented below showing results from the forums.

Icebreaker Results

During the forum icebreaker, prior to any discussion, participants ranked the following data as most important to include in the MDOT GIS.

- ROW Boundaries
- ROW Widths

- Alignments
- Parcels

The lowest ranked items included:

- Ancillary Sheet Information
- Bearing and Distance Information
- Government Corners
- Vesting Documents

Focus Group Results

For each forum, focus groups invited discussion on a selection of 16 total questions. The most common themes are listed below.

- Applications most commonly needing ROW data included: inquiries from public and private companies concerning installation of infrastructure, determining ownership and access, preliminary scoping by design engineers or consultants, parcel acquisitions and sales, instrument identification, identifying easements, and providing information to citizenry.
- The usefulness of existing ROW data was described as: useful but with much information missing, not user friendly, inaccurate and outdated so untrustworthy, limited due to the inability to overlay other information and difficult to find and access.
- Primary concerns included: data is static, so data overlay and query are not possible, data is outdated, maintenance of information is lacking, public views data as truth leading to misuse, data are difficult to interpret, and limited time and resources make it difficult to keep data current.
- Georeferenced maps would save time, but usefulness may be limited by inaccuracy and problems may arise when users expect the information within to be highly accurate.
- Data considered essential to include in the MDOT ROW GIS included: alignments, stationing, easements, parcels, instruments, ROW limits and type, and conveyance documents.
- Desired ROW data features and formats that should be preserved in the new design included: information within the .DGN files, links to plan sets via Job number, update process at the Region level, links to instruments, ROW and ROW Type, easements, PDF maps, process for importing GIS information into MicroStation for project scoping, parcels, and parcel information.
- Desired accuracy for ROW data, including parcels varied from “anything better than what we have” to approximate location to survey-grade.
- Current workflows at regions included: making edits to local ROW books only, email updates to Lansing and no current updates occurring.
- Current links between real-estate transactions and ROW data occur in Lansing at the Central Office.
- Regions currently involved in updated ROW data to GIS format include Southwest and Grand.
- Level of GIS expertise in region or TSC reported as limited to non-existent in most cases. For regions who do have expertise it is generally limited to one or two staff.
- Access to GIS software and data in the regions reported generally as widely available but that ownership and access settings can reduce usefulness of existing applications and data.

- Historic ROW information is generally reported as being very important and essential for many activities.
- Top priorities listed for MDOT ROW data included: up to date information, simpler access, links to documents, accuracy, and availability of parcels.
- Very little input was provided concerning the importance of linking MDOT GIS data to design software, such as MicroStation, however, participants generally thought that this was a good idea.

From both the icebreaker and forum discussions, it was clear that the data itself is challenging to use in its current state and that it is generally outdated, therefore difficult to trust. Preserving historic information, as well as presenting it in a georeferenced format, was important to most participants. There was no real agreement on the level of accuracy required. The data deemed most important included ROW limits, alignments, parcels, and documents (instruments). Most participants agreed that these data should be searchable, easy to access, and paired with other data layers such as section corners, orthoimagery, roads and other data.

Information obtained from the forums, interviews and central office debrief was used to develop business requirements, which were used to draft design plans. Following the needs assessment, the project scope was refined to include four (4) primary items.

1. Database Design: Building Enterprise Geodatabase of ROW features
2. System and Methodology: Moving existing ROW data into a GIS database.
3. System and Methodology: Entering newly-generated ROW data into the GIS database.
4. Simplistic viewer that displays ROW data and related data.

A detailed review of project requirements can be found in Appendix 2.

Modernization Designs

Several designs for integrating ROW data into the GIS were drafted and presented to MDOT central office staff. These designs were then updated over a period of several months after testing, completion of a pilot project, and additional internal and external discussions. These designs are described below.

Design Plan 1

Design plan 1 focuses on two primary tasks, 1.) Creating points representing the geographic center of existing static ROW map sheets and linking these points to the map sheets for simple access, and 2.) Linking parcel data in the MDOT Land Asset Management Data Application (LAMDA) to these points. **This plan <u>was not</u> selected by MDOT ROW personnel for implementation**.

Design Plan 2

Design plan 2 (Figure 2) incorporates historic, static data quickly into a format that is retrievable and linked to LAMDA parcel data, which is also edited during the process. Static data is defined as either ROW maps without an accompanying .DGN file or an unreferenced .DGN file that has been exported as a map file (e.g., TIFF, PDF). Design plan 2 is very similar to design plan 1 in that it creates points for each static map and links parcel records in the LAMDA database to the points. However, it also involves georeferencing the static ROW maps to include in a GIS service layer for viewing in both desktop and online GIS applications. This design focuses on making historic right-of-way (ROW) data accessible

quickly to users both within and outside MDOT. Following discussions with MDOT project staff, design plan 2 was selected as the plan most attractive for incorporating historic data into the GIS due to its relatively low cost of implementation.

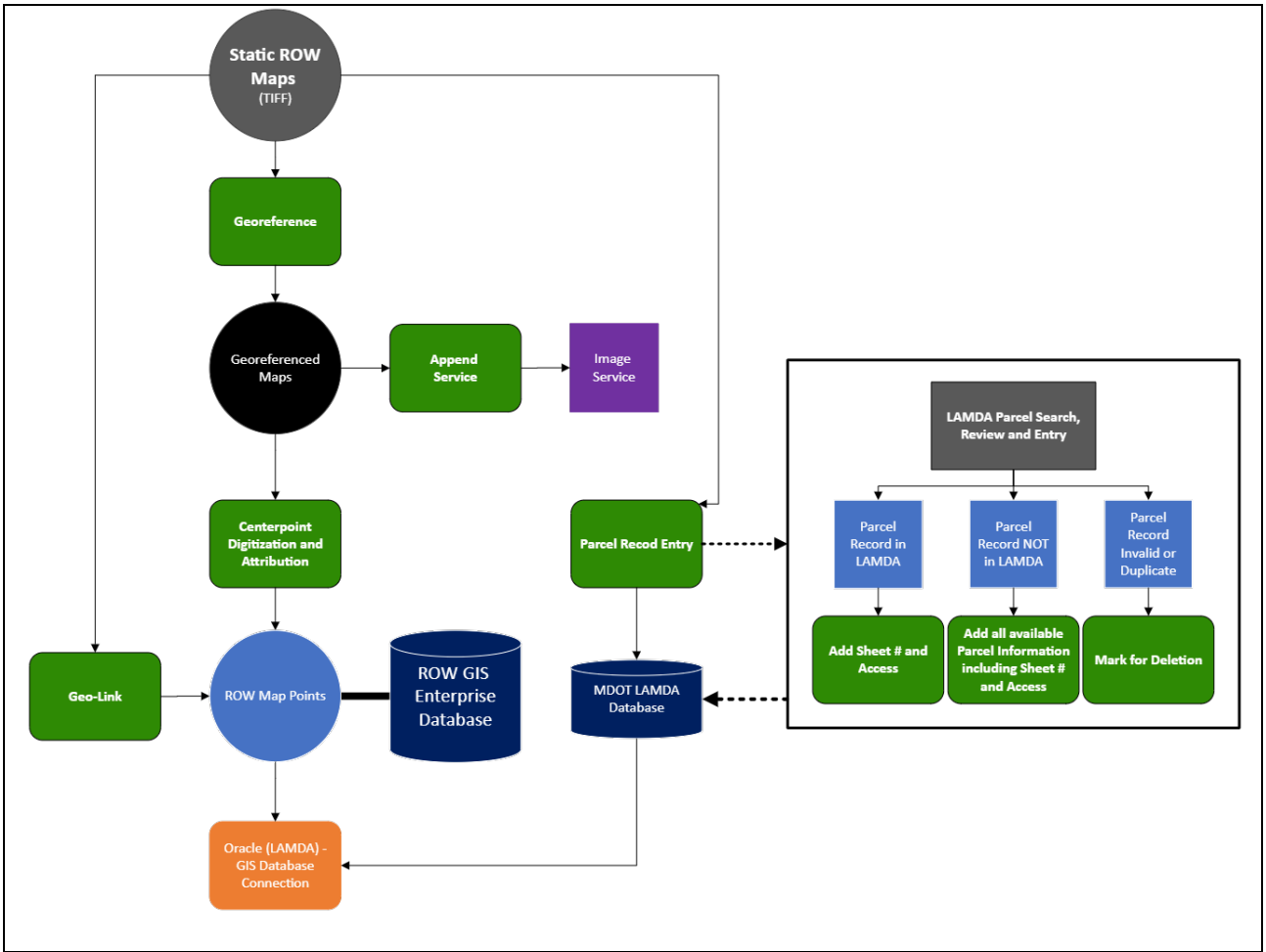


Figure 2. Design plan 2. ROW map points and parcel table are linked via a common field (COUNTY_SHEET) through a relationship class. Parcel information is provided through a database view supplied from LAMDA.

From the perspective of RS&GIS and DLZ, design plan 2 is the best implementation when the following are true:

1. Data *only* exists as static ROW maps, or…
2. Data exists as an *unreferenced* MicroStation design file (.DGN) *and* there are limited resources for bringing individual layers within the file into the GIS.

Specific details of the steps involved to complete design plan 2 are contained within the project implementation plan.

Design Plan 3 – Historic Data

Design plan 3 is full implementation of ROW data into GIS. There are two pathways to incorporating historic ROW data. First, if there are no MicroStation design files (.DGN), only a static map, the map is first georeferenced and then features are digitized into GIS data layers (feature classes) within a preliminary geodatabase and attributed (Figure 3). Second, if unreferenced .DGN files are available, the files are first imported into a GIS program (e.g., ArcGIS Pro). These files are then georeferenced, attributed and integrated into a preliminary geodatabase. Once data is considered complete and meet desired accuracy requirements, they are imported into the ROW GIS database (Figure 4). While this process is time-consuming compared to design plan 2, it vastly improves data retrieval and efficiency related to MDOT project tasks. Regardless of the path, the focus is incorporating individual layers into the ROW GIS database, including ROW limits, alignments, parcels, and annotation (if desired).

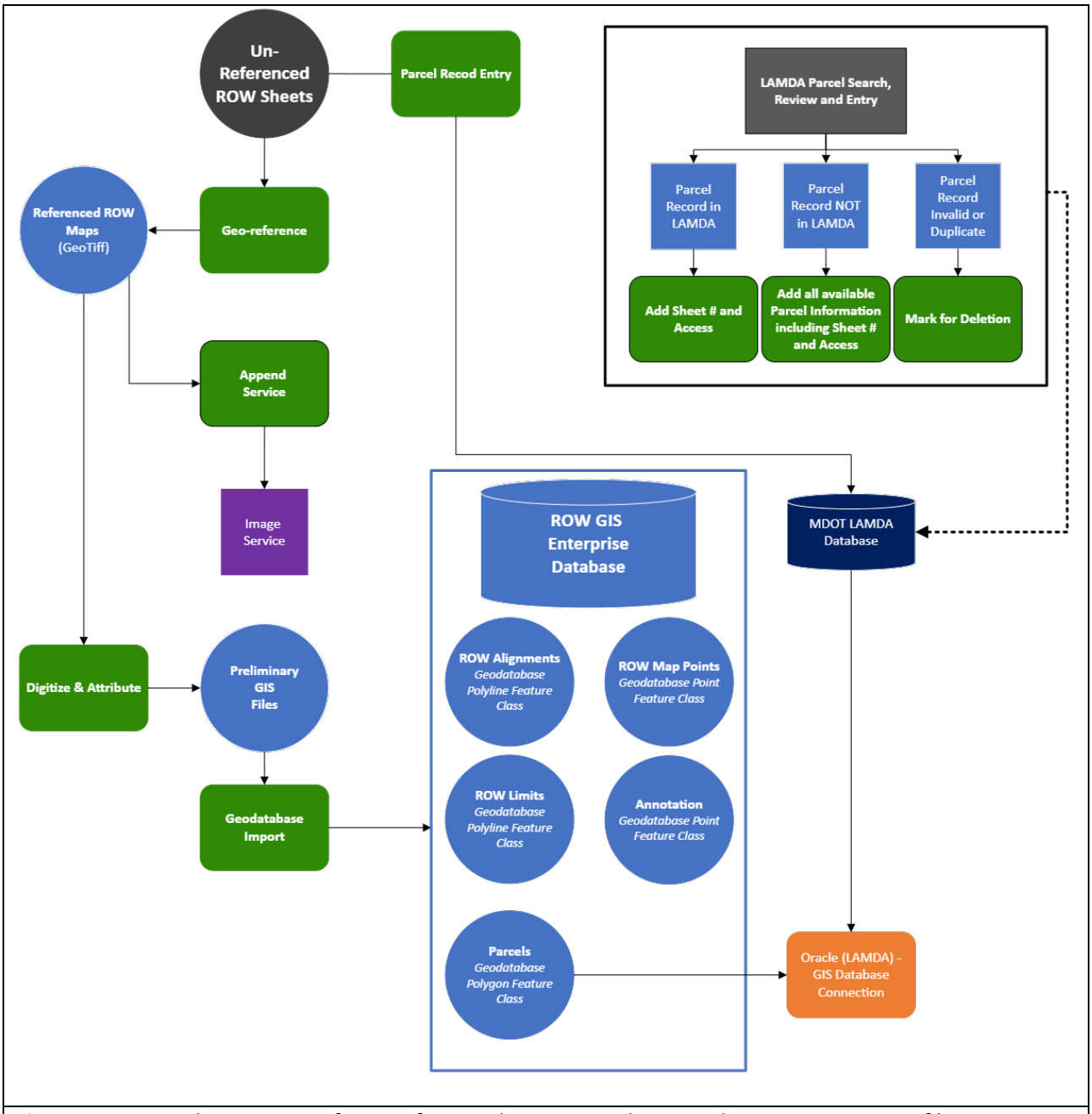


Figure 3. Design plan 3 process for unreferenced ROW map sheets without a parent .DGN file.

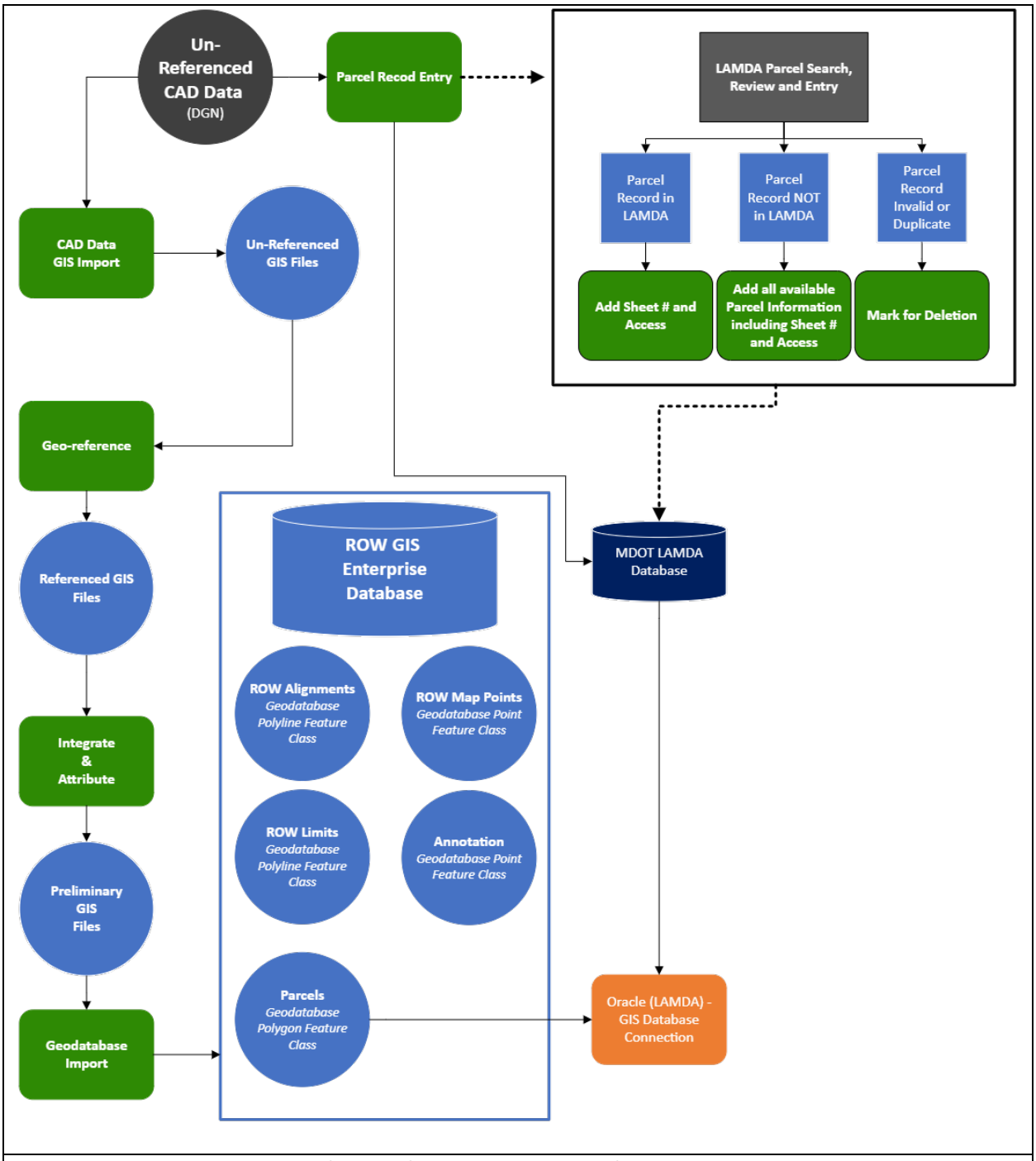


Figure 4. Design plan 3 process for unreferenced ROW .DGN files.

Design plan 3 is the preferred method for incorporating existing historic data contained within MicroStation files into the GIS. Specific details of the steps involved to complete design plan 3 for historic data are contained within the project implementation plan.

Design Plan 3 – Modern/New Data

There is a considerable difference in content, in most cases, between historic unreferenced ROW .DGN files and modern georeferenced .DGN files. The latter are unlikely to represent a standard ROW sheet. Rather, they are typically referenced .DGN files for P.A. 132 surveys, alignments or other design files. Incorporating these data into a GIS is much simpler since the features within the files are already referenced. That being said, the files may be quite variable. The process for integrating these data into the ROW GIS is straightforward compared to historic unreferenced data. It is, in fact, essentially the same as design plan 3 for unreferenced files without the need to georeference the data. The main tasks include importing .DGN data layers into the GIS, integrating and attributing the data into a preliminary geodatabase, and entering parcel data into the LAMDA geodatabase. The process is complete once data is imported into the ROW GIS database (Figure 5).

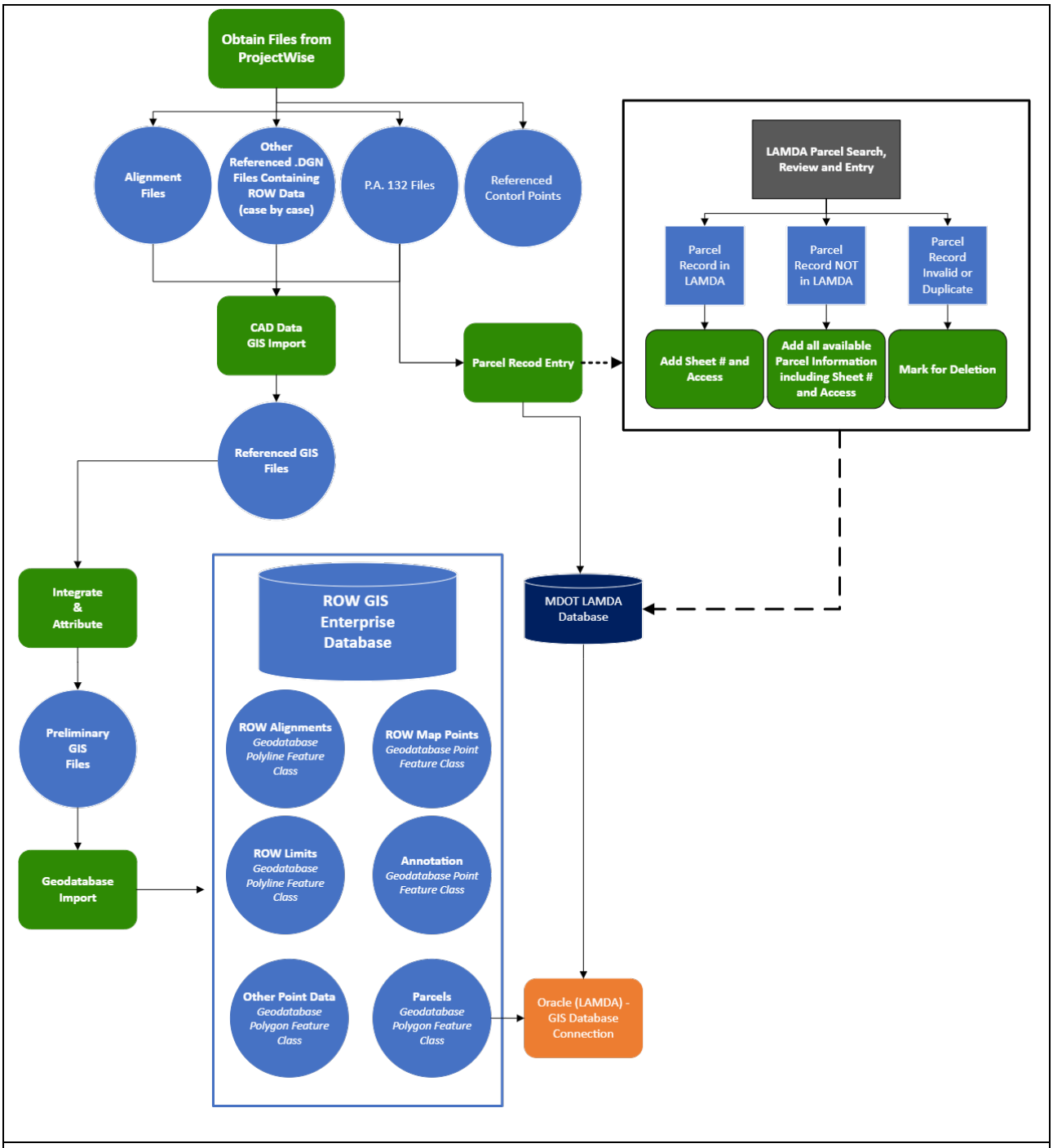


Figure 5. Process for incorporating modern data and new data into the ROW GIS.

Specific details of the steps involved to complete design plan 3 for modern and new data are contained within the project implementation plan.

Pilot Project

After drafting initial designs, and subsequent review by MDOT project staff with directions to proceed with design plan 2, a pilot project was conducted to develop and test methods, as well as estimate costs. A total of 20 ROW maps in Ingham County served as the source data for the pilot project. Both newer and older maps were selected for the process to account for map variability.

The pilot project included 4 main tasks.

1. Build a draft ROW GIS Database.
2. Prepare and georeference static maps.
3. Create and attribute map points.
4. Record parcel information.

Further, time estimates of task completion were documented to provide cost estimates for completing design plan 2 for all static maps.

ROW GIS Database

A draft ROW geodatabase (Figure 6) was developed based on project requirements created after forums and discussions with MDOT project staff. MDOT GIS staff were consulted to assist with database schema decisions. The database was developed to function with data from both design plan 2 and design plan 3. The database evolved over time as decisions were made by a GIS-Real Estate working group as to how the GIS data would interact with parcel data from LAMDA. In the end, the layers within the ROW database included: ROW limits (polylines), ROW alignments (polylines), parcels (polygons), annotation points, survey points, and map points. The main difference between the initial ROW database and the eventual final design was the removal of parcel data tables and relationship classes linking map points and parcel polygons in the database to LAMDA parcel data. Instead, MDOT GIS, in coordination with DTMB, is developing a process whereby GIS features are linked to LAMDA parcel data records. In this way, it is not necessary to store parcel attribution in the ROW database.

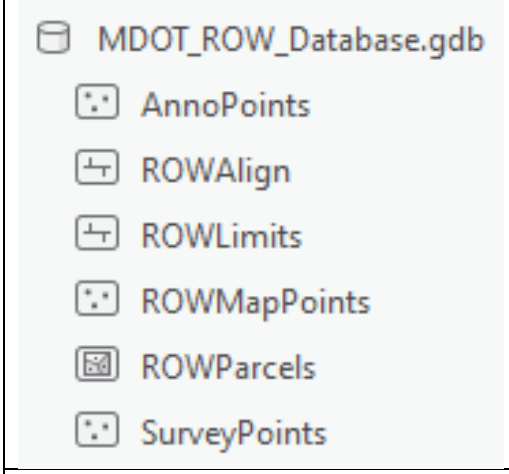
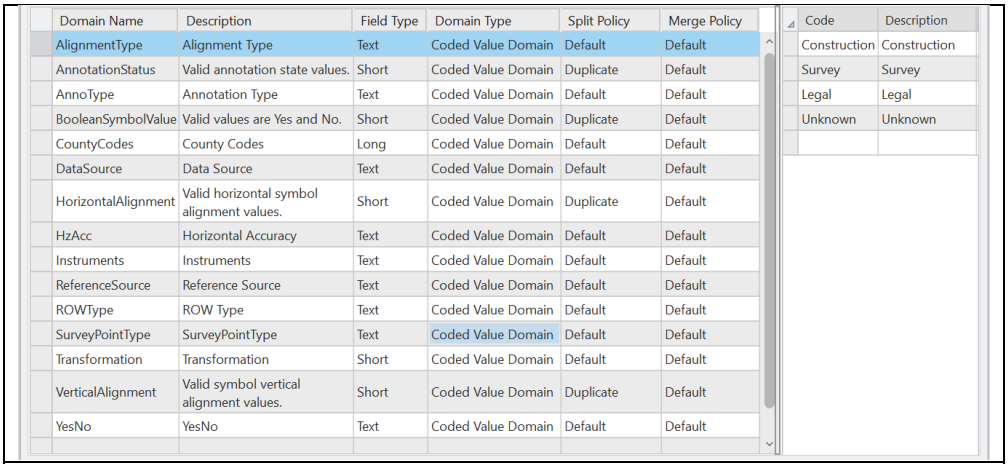


Figure 6. Current ROW GIS geodatabase.

The database, once complete, was shared with MDOT GIS staff so that it could be incorporated into the MDOT spatial database engine (SDE). From there, data layers are made available as GIS service layers that can be viewed and edited by users within both mobile and desktop GIS applications, including ArcGIS Pro and online web mapping applications. MDOT GIS staff manages the database and services.

The database schema, which will likely evolve, includes standard values for several of the fields in each feature layer's database table. These are referred to as attribute domains (Figure 7). Attribute domains improve efficiency and reduce data entry errors.



Domain Name	Description	Field Type	Domain Type	Split Policy	Merge Policy
AlignmentType	Alignment Type	Text	Coded Value Domain	Default	Default
AnnotationStatus	Valid annotation state values.	Short	Coded Value Domain	Duplicate	Default
AnnoType	Annotation Type	Text	Coded Value Domain	Default	Default
BooleanSymbolValue	Valid values are Yes and No.	Short	Coded Value Domain	Duplicate	Default
CountyCodes	County Codes	Long	Coded Value Domain	Default	Default
DataSource	Data Source	Text	Coded Value Domain	Default	Default
HorizontalAlignment	Valid horizontal symbol alignment values.	Short	Coded Value Domain	Duplicate	Default
HzAcc	Horizontal Accuracy	Text	Coded Value Domain	Default	Default
Instruments	Instruments	Text	Coded Value Domain	Default	Default
ReferenceSource	Reference Source	Text	Coded Value Domain	Default	Default
ROWType	ROW Type	Text	Coded Value Domain	Default	Default
SurveyPointType	SurveyPointType	Text	Coded Value Domain	Default	Default
Transformation	Transformation	Short	Coded Value Domain	Default	Default
VerticalAlignment	Valid symbol vertical alignment values.	Short	Coded Value Domain	Duplicate	Default
YesNo	YesNo	Text	Coded Value Domain	Default	Default

Code	Description
Construction	Construction
Survey	Survey
Legal	Legal
Unknown	Unknown

Figure 7. Attribute domains within the ROW GIS geodatabase. These are applied to individual fields and the values within represent "allowed" values.

Map Georeferencing

Once the database was complete, the pilot project moved on to the next task – Map Georeferencing. For the pilot project, a total of 20 static ROW maps were selected from ProjectWise within Ingham County. Prior to georeferencing, ROW sheets with multiple maps per sheet were cropped to create separate files (Figure 8). This was accomplished using Adobe Acrobat Pro using the original PDF maps. Files were saved in TIFF format. All ROW map sheets that contained only one map were converted to TIFF files as well. This situation turned out to be quite common. For this reason, during cost determination, it was estimated that, on average, there were two maps per ROW map sheet.

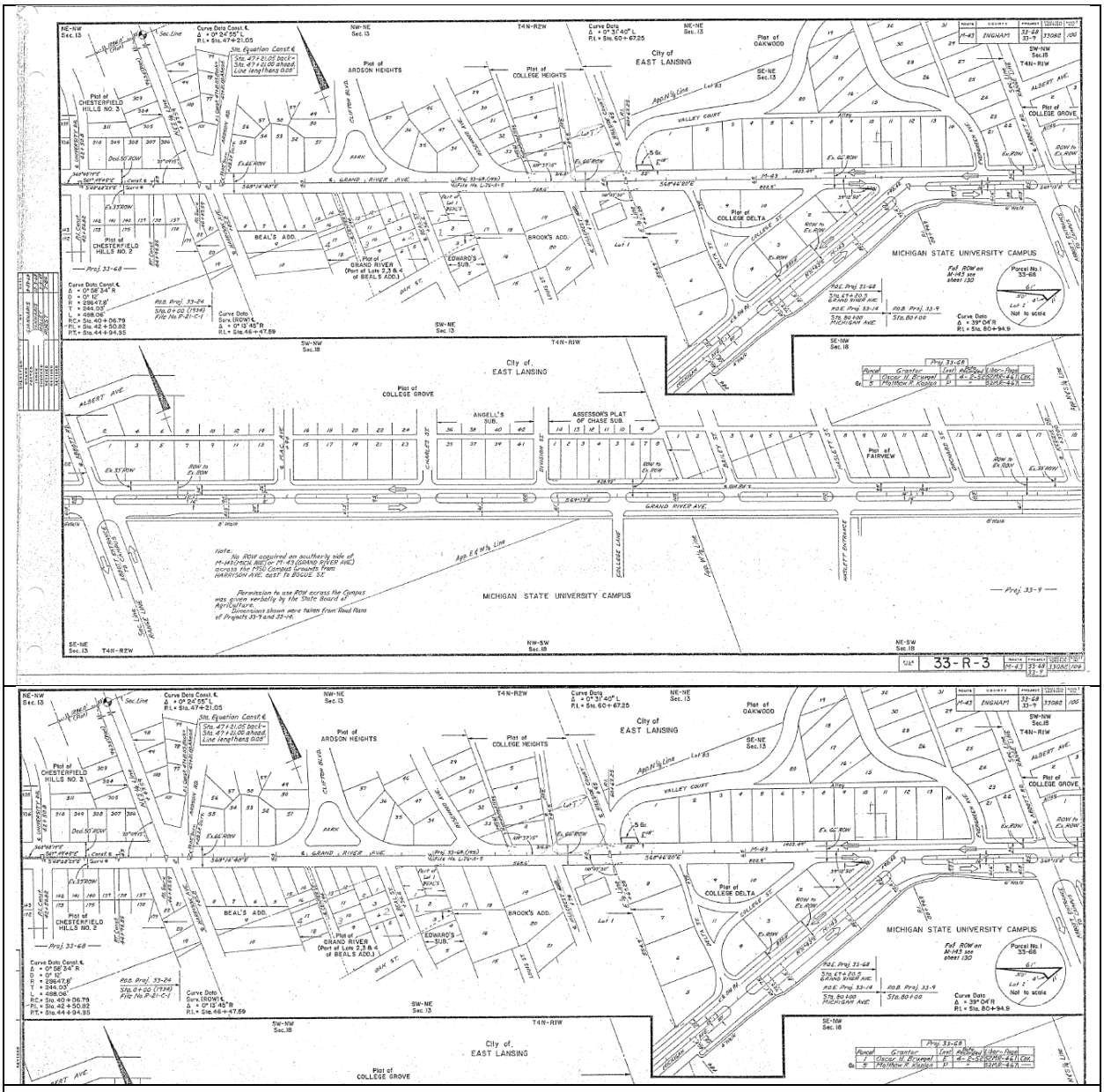


Figure 8. Some ROW Map sheets contain more than one section of ROW (top). Each section of ROW must be georeferenced separately so individual sections were cropped out of the original map and converted to TIFF files (bottom).

Georeferencing was completed in ArcGIS Pro and involved pairing locations on each unreferenced map with referenced locations from an existing GIS dataset (Figure 9). Common GIS datasets used for referencing these maps included re-monumented public land survey system (PLSS) corners, existing orthoimagery, and survey points. These datasets were obtained from the DTMB Open GIS Data Portal or through the Michigan Imagery Solution (MIS).

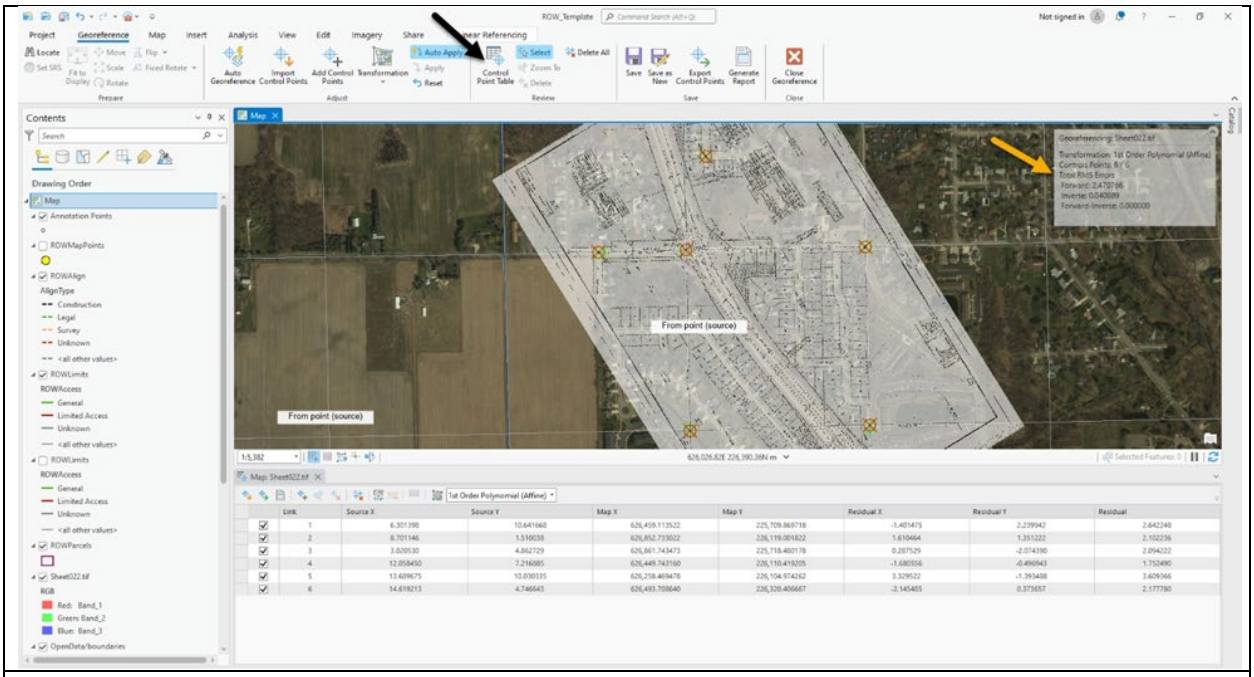


Figure 9. Georeferencing occurred in ArcGIS Pro. Control points were added to properly reference the data. A measure of accuracy is reported within the software.

Reference data layers had variable spatial accuracy. PLSS section corners that had not been re-monumented could be off by more than 30 feet, while survey points, when available, were often accurate to +/- 0.02 meters. Road centerline data, which may have been digitized from 1998 digital ortho quarter quads (DOQQs), are of variable accuracy (Figure 10).

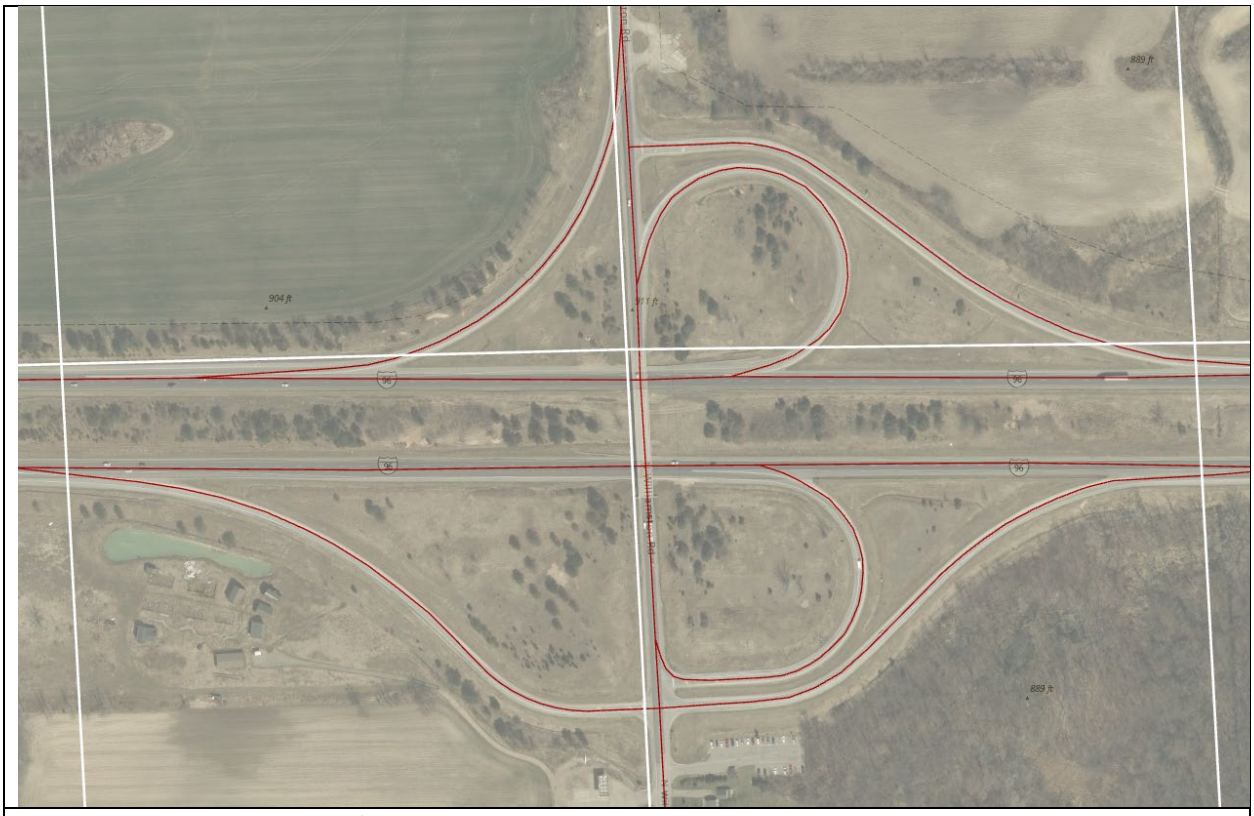


Figure 10. Some common reference GIS datasets include PLSS, road layers and orthoimagery. This example shows the differences in accuracy between the PLSS polygons (white outlines), the roads (red lines) and orthoimagery (MiSAIL Michigan Imagery Public image service). While none of these layers approaches the accuracy of surveyed points, the orthoimagery is likely the most accurate of the three. It is notable that the current PLSS data does not seem to match well at all. The reason for this is that it is not based upon recent survey data from the statewide re-monumentation effort. As this effort is completed, it is likely that the PLSS data layer will be adjusted to match the new surveyed points. Until then, the dataset ***Public Land Survey Corners and Remonumentations*** available from the Michigan GIS Open Data portal, could be used, though this dataset is incomplete.

During the pilot project it was found that there were other complications with georeferencing static ROW maps. Sometimes there is a considerable difference between the date of a map and that of the reference data. New construction may have changed the landscape significantly, thereby reducing the availability of usable ground control points (GCPs). Additionally, maps often had limited geographic extent, reducing opportunities for locating suitable GCPs (Figure 11).

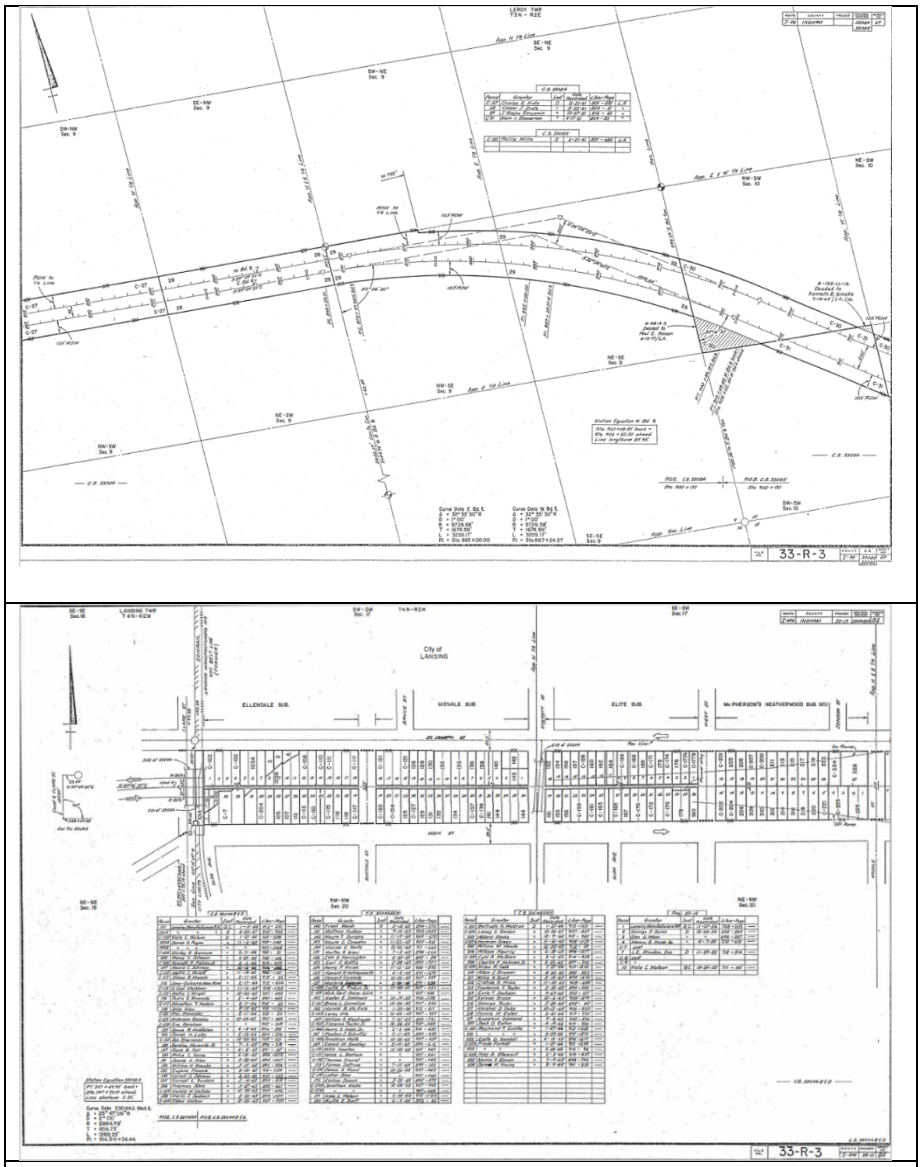


Figure 11. Some ROW maps may be difficult to georeference because of the lack of obvious GCPs. The top example offers few opportunities other than PLSS corner points. The bottom example offers many more opportunities for identifying GCPs.

In some cases, georeferencing was difficult to impossible due to the lack of available GCPs. In these instances, rather than utilize GCPs, the TIFF files were simply scaled, rotated and moved to match underlying orthoimagery data. This process is not ideal because it does not provide any quantitative measure of accuracy. However, it is often the only way to "reference" the data. For example, consider a small section of ROW shown in Figure 12 that was contained within a map sheet.

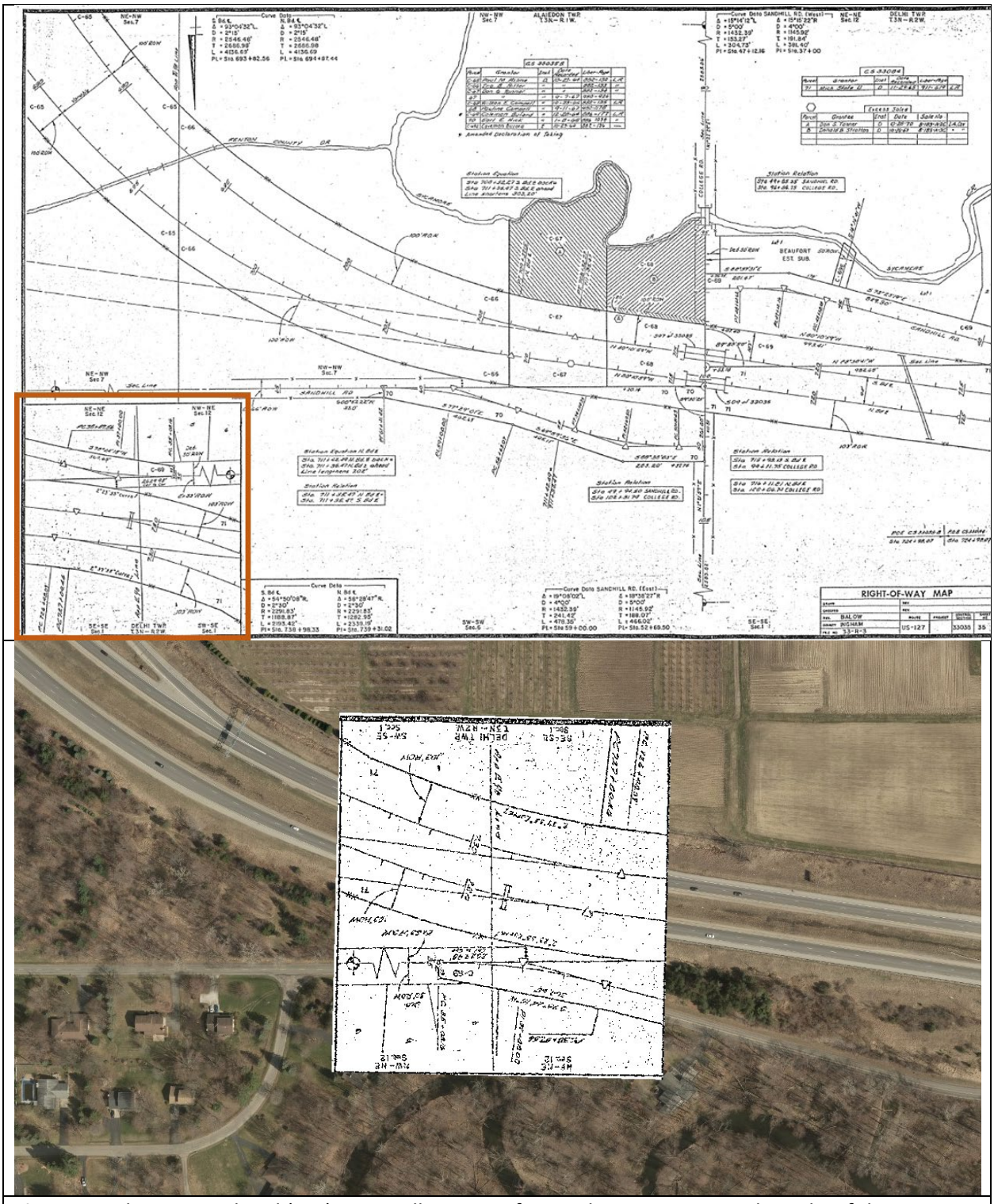


Figure 12. The area outlined (top) is a small section of ROW that continues to the right of the main section of ROW shown on the Sheet. This small section has no available locations that can be used as GCPs and so had to be referenced roughly through movement, scaling and rotation (bottom). Note that on the original map sheet, north is down so the section of ROW now appears upside down.

For specific instructions on this process, please reference the project implementation plan.

Based on repeating the georeferencing process during the pilot project, including map cropping, when necessary, it was estimated that it took an average of 2 hours to reference a single map sheet, assuming an average of 2 map sections per sheet. A detailed cost breakdown is provided in the project implementation plan.

Georeferenced ROW Map sheets will eventually be included in a map service managed by the State of Michigan Department of Technology, Management and Budget (DTMB). This service will allow users to view all georeferenced maps available in both online and desktop software clients.

Map Point Creation

For the project pilot, map points representing the approximate geographic center of the ROW area covered within each map sheet were created within the ROWMapPoints feature class in the ROW GIS database. This was completed by digitizing their approximate location in ArcGIS Pro and then populating attributes for County, Sheet Number and ProjectWise map URL, among others (Figure 13). A concatenated field called County_Sheet was generated for each record in the table. This served as the primary key for relating parcel records back to the points. When a map sheet contained several sections, a single map point was created that represented the center of the entire length represented by all sections.

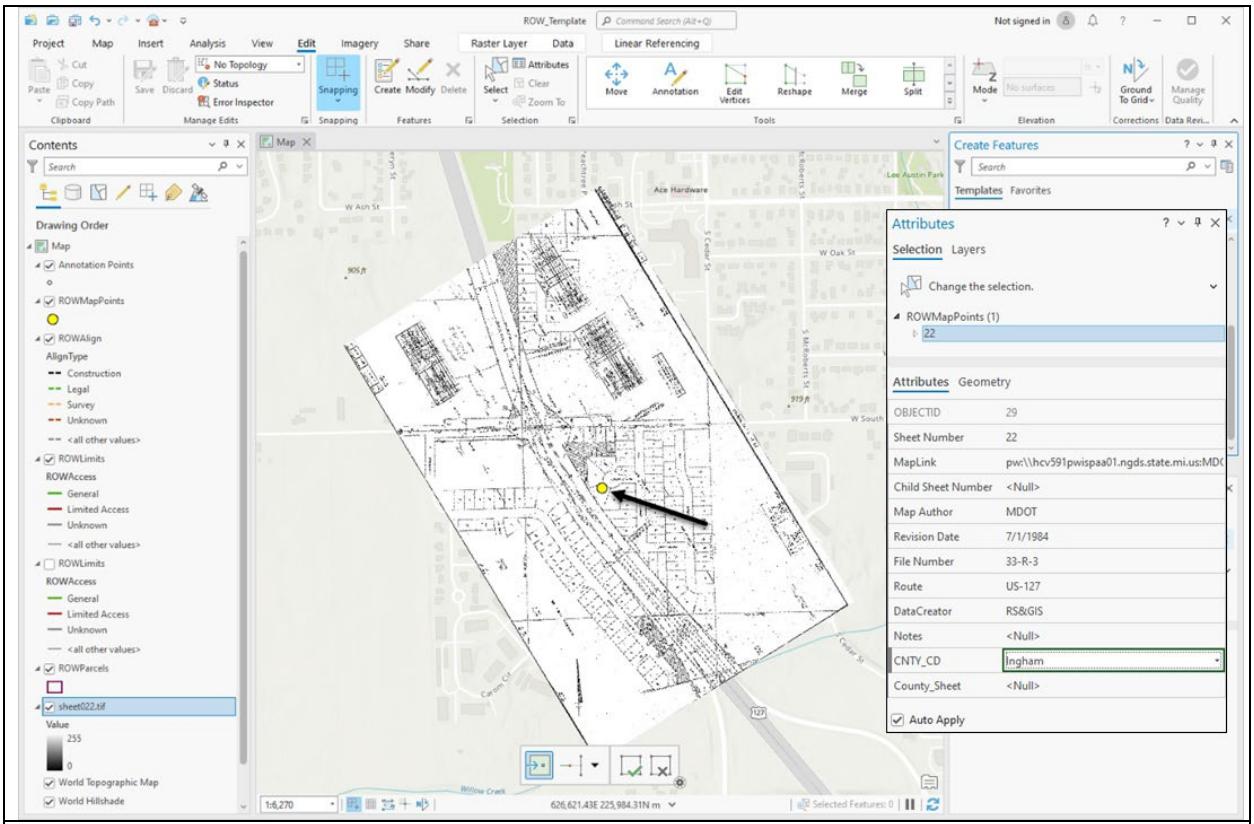


Figure 13. Map points representing the approximate center of each ROW map sheet were digitized in ArcGIS Pro. Attributes for County, Sheet Number, ProjectWise URL and others were recorded in the Map Points attribute table. The County_Sheet field was calculated following data creation. This field serves as the primary key linking parcel information in LAMDA to the Map Points.

It is important to mention that the purpose of these points is to quickly locate an area containing parcels recorded in the LAMDA database. Through the data relationship established between the LAMDA database and the map points (via the County_Sheet field), users are able to query parcels in LAMDA and then view the related points in the GIS. From there, georeferenced ROW sheets provided by an established map service are available for inspection. Additionally, links to original map sheets in ProjectWise are available.

After this process was completed for the pilot map sheets, it was estimated that the time required to create these points, as well as add attribution including the ProjectWise link, was 0.5 hours per point. This estimate is likely high; however, the time is impacted upon the ability to quickly enter attribution for each point, which is highly variable. A detailed cost breakdown is provided in the project implementation plan.

Recording Parcel Information

Based on internal requirements, authoritative parcel attribution resides in the LAMDA database. In this way, LAMDA represents the single source of MDOT parcel attribution. The LAMDA database contains parcel information for migrated parcels (from other databases) and new parcels added during the property acquisition phase of each project. However, there are parcels within older ROW map sheets, and possibly older unreferenced MicroStation files, which are not currently present in LAMDA.

At the time of the pilot project, the project team was unaware of internal requirements for storing the bulk of parcel attribution within LAMDA alone. Additionally, access to LAMDA was restricted and so editing data there was not possible. For these reasons, a parcel table was created in the ROW GIS database whose data schema matched the structure of the LAMDA database at the time. This allowed parcel information from the ROW sheets to be recorded. Eventually, once it was understood that this data should only exist in LAMDA, discussions began about how to import the data from the GIS parcel table into the LAMDA database.

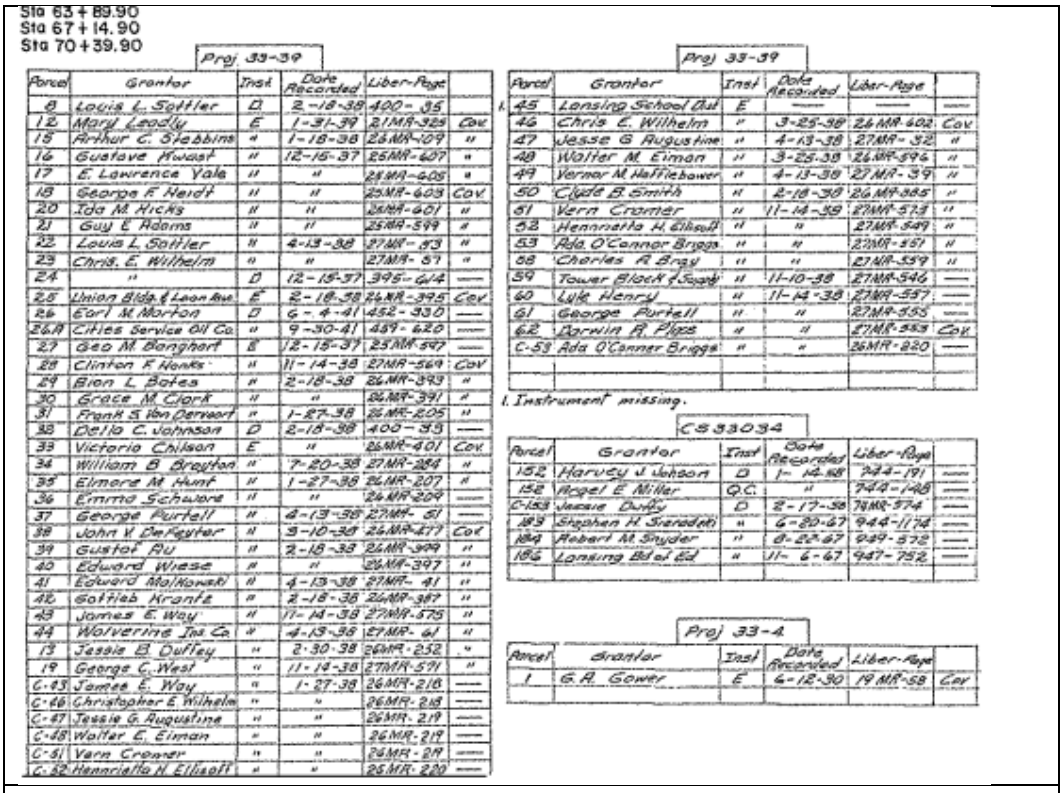
As a result of lessons learned during the pilot project, as well as subsequent discussions with MDOT staff, a collaborative effort between MDOT Real Estate staff associated with LAMDA, MDOT GIS and DTMB was initiated to develop a process to address the following:

1. Creating a tool allowing for direct creation and editing within LAMDA.
2. Linking ROW GIS features to LAMDA parcel records.

This process, which is ongoing. The final solution has not yet been determined. That being said, it will involve linkage through common attributes.

It is important to note that Design plan 2 does not involve creating GIS polygons for each parcel. Instead, parcel information is related to map points. This relationship is based upon a field called County_Sheet. Therefore, it is necessary to include County_Sheet information for each map point as well as each parcel record. In this way, map points may be found through the relationship between map points and LAMDA parcel records.

For the pilot, all parcel information available on the ROW map sheets was recorded in the parcel table as discussed previously. This included parcel number, grantor, instrument type, date recorded and liber-page (Figure 14). For excess sales a sale number was recorded.


Sta 63+89.90
Sta 67+14.90
Sta 70+39.90

Proj 33-39

Parcel	Grantor	Inst	Date Recorded	Liber-Page	
8	Louis L. Sattler	D	2-18-38	400-35	
12	Mary Leadly	E	1-31-39	21MR-325	Cov
15	Arthur C. Stebbins	"	1-18-38	26MR-109	"
16	Gustave Rwast	"	12-15-37	25MR-607	"
17	E. Lawrence Vale	"	"	25MR-605	"
18	George F. Heidt	"	"	25MR-603	Cov
20	Ida M. Hicks	"	"	25MR-601	"
21	Guy E Adams	"	"	25MR-599	"
22	Louis L. Sattler	"	4-13-38	27MR-93	"
23	Chris. E. Wilhelm	"	"	27MR-87	"
24	"	D	12-15-37	395-614	——
25	Union Bldg & Loan Ass	E	2-18-38	26MR-395	Cov
26	Earl M Morton	D	6-4-41	452-330	——
26A	Cities Service Oil Co	"	9-30-41	489-620	——
27	Geo M Bonghart	E	12-15-37	25MR-597	"
28	Clinton F Hanks	"	11-14-38	27MR-569	Cov
29	Brian L Bates	"	2-18-38	26MR-393	"
30	Grace M Clark	"	"	26MR-391	"
31	Frank S Van Derveer	"	1-27-38	26MR-205	"
32	Della C. Johnson	D	2-18-38	400-33	——
33	Victoria Chilson	E	"	26MR-401	Cov
34	William B Brayton	"	7-20-38	27MR-284	"
35	Elmore M Hunt	"	1-27-38	26MR-207	"
36	Emma Schwarz	"	"	26MR-209	——
37	George Purtell	"	4-13-38	27MR-61	——
38	John V DeFeyter	"	3-10-38	26MR-477	Cov
39	Gustof Au	"	2-18-38	26MR-399	"
40	Edward Wiese	"	"	26MR-397	"
41	Edward McKonski	"	4-13-38	27MR-41	"
42	Gottlieb Krantz	"	2-18-38	26MR-387	"
43	James E. Way	"	11-14-38	27MR-575	"
44	Wolverine Ins Co	"	4-13-38	27MR-61	"
13	Jessie B Duffey	"	2-10-38	26MR-252	"
19	George C. West	"	11-14-38	27MR-571	"
C-45	James E. Way	"	1-27-38	26MR-216	——
C-46	Christopher E Wilhelm	"	"	26MR-218	——
C-47	Jessie G Augustine	"	"	26MR-219	——
C-48	Walter E. Eiman	"	"	26MR-219	——
C-51	Vern Cramer	"	"	26MR-217	——
C-52	Henrietta H Ellisoff	"	"	25MR-220	——

Proj 33-39

Parcel	Grantor	Inst	Date Recorded	Liber-Page	
1. 45	Lansing School Dist	E	——	——	——
46	Chris E. Wilhelm	"	3-25-38	26MR-402	Cov
47	Jesse G Augustine	"	4-13-38	27MR-92	"
48	Walter M. Eiman	"	3-25-38	26MR-396	"
49	Vernor M Hafflebower	"	4-13-38	27MR-39	"
50	Clyde B Smith	"	2-18-38	26MR-385	"
51	Vern Cramer	"	11-14-38	27MR-573	"
52	Henrietta H Ellisoff	"	"	27MR-549	"
53	Ada O'Connor Briggs	"	"	27MR-551	"
58	Charles R Bray	"	"	27MR-559	"
59	Tower Block & Supply	"	11-10-38	27MR-546	——
60	Lyle Henry	"	11-14-38	27MR-557	——
61	George Purtell	"	"	27MR-555	——
62	Darwin R. Pipes	"	"	27MR-553	Cov
C-53	Ada O'Conner Briggs	"	"	26MR-220	——

1. Instrument missing.

CS33034

Parcel	Grantor	Inst	Date Recorded	Liber-Page	
182	Harvey J Johson	D	1-14-68	944-191	——
182	Nigel E Miller	Q.C.	"	944-148	——
C-183	Jessie Duffy	D	2-17-38	26MR-574	——
183	Stephen H Sneadell	"	6-20-67	944-1174	——
184	Robert M Snyder	"	8-22-67	949-572	——
185	Lansing Bd of Ed	"	11-6-67	947-792	——

Proj 33-4

Parcel	Grantor	Inst	Date Recorded	Liber-Page	
1	G.A. Gower	E	6-12-30	19MR-58	Cov

Figure 14. Parcel information contained within ROW map sheets was recorded into a parcel database table during the pilot project. During implementation this data will be added directly to LAMDA.

After parcel entry was completed for the pilot map sheets, it was estimated that the time required to enter all parcel information was, on average, 2 hours per sheet. The time it takes to complete the process varies widely depending on the number of parcels on each sheet and how many are already currently present in the LAMDA database. The time to complete parcel entry could be as little as 10 minutes per sheet or as much as several hours. A detailed cost breakdown is provided in the project implementation plan.

Pilot Project Summary

Results from the pilot project, mainly methods documents detailing the steps to complete for each task, and cost estimates, are detailed in the project implementation plan. The process generally proceeded as expected with few problems. That being said, methods went through a series of evolutionary steps due, primarily, to the following:

1. Multiple changes to the database and schema occurred throughout the pilot, which were influenced by conversations with numerous MDOT project staff, RS&GIS and DLZ staff.
2. Changes in software and software versions, including Esri ArcGIS Desktop and ArcGIS Pro.
3. Varied skillsets and experiences of project staff.
4. Improved understanding of the LAMDA parcel database.

A New Focus – Moving on from the Pilot Project

The primary focus of the pilot project was to develop and test design plan 2 methods and estimate costs. Methods documents and detailed time and cost estimates for each task were successfully documented and presented to MDOT project staff, as well as integrated into the implementation plan.

At the same time the pilot was being completed, efforts were under way to establish better methods for incorporating new data into the GIS, as well as more fully incorporating historic data. Through results and conclusions derived from this effort, it became apparent to RS&GIS and DLZ staff that more resources should be devoted to design plan 3 and refining LAMDA-ROW GIS data integration. This led to a change in project scope and a dedicated effort between MDOT GIS and LAMDA staff.

Project scope was amended from the original requirement of applying methods developed from the pilot to two counties. Funds were redirected to further develop design plan 3, as well as research automated methods. At the same time, LAMDA and MDOT GIS staff began in earnest to discuss and develop a process that would link LAMDA parcel information to GIS data layers. This process is ongoing. When complete, it will be possible to view and query parcel data from LAMDA and find the ROW map points or parcel polygons associated with those records in a GIS viewer. Similarly, it will be possible to locate parcel information linked to map points or parcel polygons in the GIS.

Development of Methods for Additional Designs

The pilot project focused on incorporating historic data on a statewide scale using methods outlined in design plan 2. However, following the pilot, MDOT project staff agreed that additional effort should be dedicated to developing methods that lead to a more complete ROW GIS integration, namely including ROW feature geography into the GIS database rather than just a point referencing the location of a static ROW map sheet. In a practical sense, this meant methods for design plan 3 (Figures 3 and 4).

As described previously, design plan 3 has two pathways for historic data integration into the GIS depending on the type of input data – unreferenced ROW map sheets or unreferenced .DGN files. Additionally, there is a defined pathway for referenced .DGN files representing modern and new data, as well as an opportunity for semi-automated extraction.

Methods investigations, as well as cost estimates, completed for this additional effort beyond the pilot included:

1. Generating ROW features (points, lines, and polygons) from unreferenced map sheets.
2. Generating ROW features (points, lines, and polygons) from unreferenced .DGN files.
3. Generating ROW features (points, lines, and polygons) from referenced .DGN files.
4. Automated data extraction.

Generating ROW Features from Unreferenced Map Sheets

For this investigation, unreferenced map sheets were georeferenced using the same process as design plan 2. Individual features representing parcels, ROW limits and alignments were digitized into their respective feature layers in a preliminary geodatabase and attributed as appropriate. At the same time, parcel information within the sheets was entered into a parcel table. Parcel entry was completed using the same methods described in design plan 2. The process was much more time-consuming than simply creating a map point centered on each ROW map sheet, however having all ROW features within the GIS is highly beneficial to users.

Creating ROW Features

Esri ArcGIS Pro software was used to digitize and attribute ROW features, including ROW limits, ROW alignments and ROW Parcels. As already mentioned, data were created in a preliminary database, which is a duplicate of the working ROW GIS geodatabase with a matching data schema. During data creation, common boundaries and intersections were snapped to reduce topologic (connectivity) errors. For all features, a subset of attributes was entered for each feature, such as County Code, Sheet Number, Control Section, and others. Once implementation has begun, this preliminary data, once complete, will be appended to the ROW GIS enterprise geodatabase.

When individual parcel polygons are created during this process, they are attributed with a value for PARCEL_SEQ_NUM (parcel sequence number). PARCEL_SEQ_NUM is an attribute present in the LAMDA database that serves as a unique key for relating attributes stored in LAMDA to MDOT-owned parcel polygons.

Once data is created for individual features, they can be viewed directly in a GIS (Figure 15).

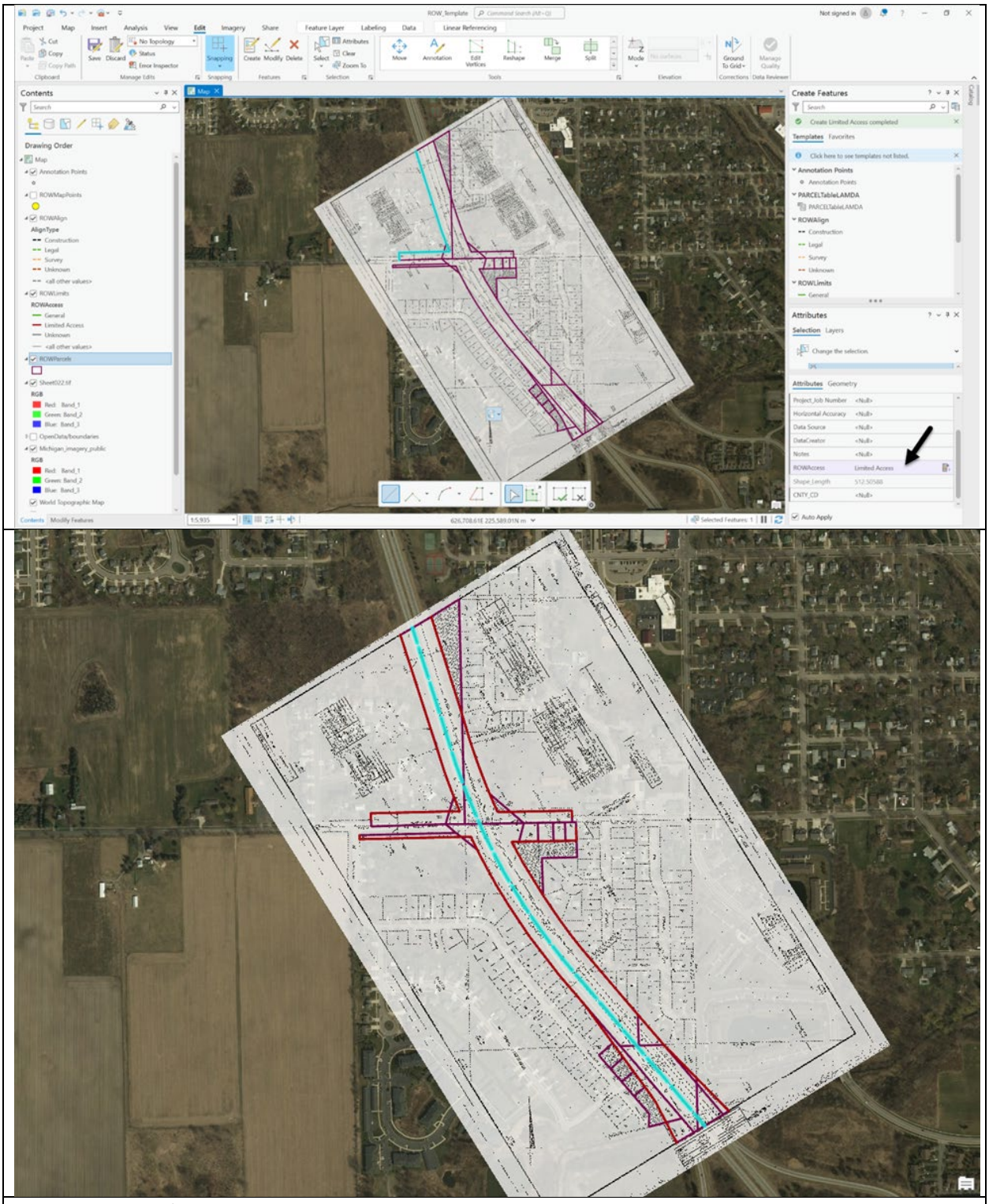


Figure 15. ROW feature geography was created and attributed in Esri ArcGIS Pro, including parcels, ROW limits and alignments. Once data are complete and deemed accurate, they can be appended to the Enterprise ROW GIS geodatabase.

For more detailed information about the process for incorporating data from unreferenced ROW maps into the ROW GIS, refer to the project implementation plan.

The estimated time per ROW sheet to complete this process was estimated to be 12 hours, assuming an average of two maps per sheet. Tasks include map preparation and georeferencing, parcel data entry, and creation and attribution of ROW map features. The bulk of the time is devoted to the digitization and attribution process. Again, the time to complete the process is heavily dependent on the number of features, particularly parcels. A detailed cost breakdown is provided in the project implementation plan.

Generating ROW Features from Referenced .DGN Files

For this investigation, referenced .DGN files were incorporated into the GIS without the need for georeferencing since the data itself is already referenced. A data integration process, however, was necessary to move the data from .DGN format to GIS format. Parcel data entry, for .DGN files containing parcels, was completed in the same way as design plan 2 (LAMDA) and design plan 3 for unreferenced map sheets (GIS). The process of incorporating ROW features with referenced .DGN files is much less time-consuming than digitizing features from georeferenced ROW map sheets or unreferenced .DGN files. The main difference is that the data are already referenced, so the georeferencing step can be skipped. That being said, the data may not have consistent level assignments or other standard labeling, which may lead to some manual selection and editing once data is in GIS format. Consistent data schema is more likely to occur in newer data.

Data Integration and Attribution

Since these data are already referenced, they were imported directly into a default Esri project geodatabase where data was converted to point, line and polygon feature classes (layers). Feature classes are similar to Esri shapefiles but reside within a geodatabase and offer several advantages. In some cases, the data does not have a defined coordinate system and needed to be defined prior to import. At this point, within Esri ArcGIS Pro, a user selected all features that represented a specific layer. If level values were assigned correctly in the .DGN, features could be selected through an attribute query. If level values were not assigned correctly, selection was accomplished through manual feature selection within the map (Figure 16). For point and line features, the selected features were appended directly to the preliminary ROW GIS database and named accordingly (e.g., ROWAlign, ROWLimits, etc.). For parcels, whose linework needs to be represented as polygons in the GIS, the selected data were processed into polygon features and then exported to the preliminary ROW GIS database. Features were then attributed and appended to the working ROW GIS database feature classes.

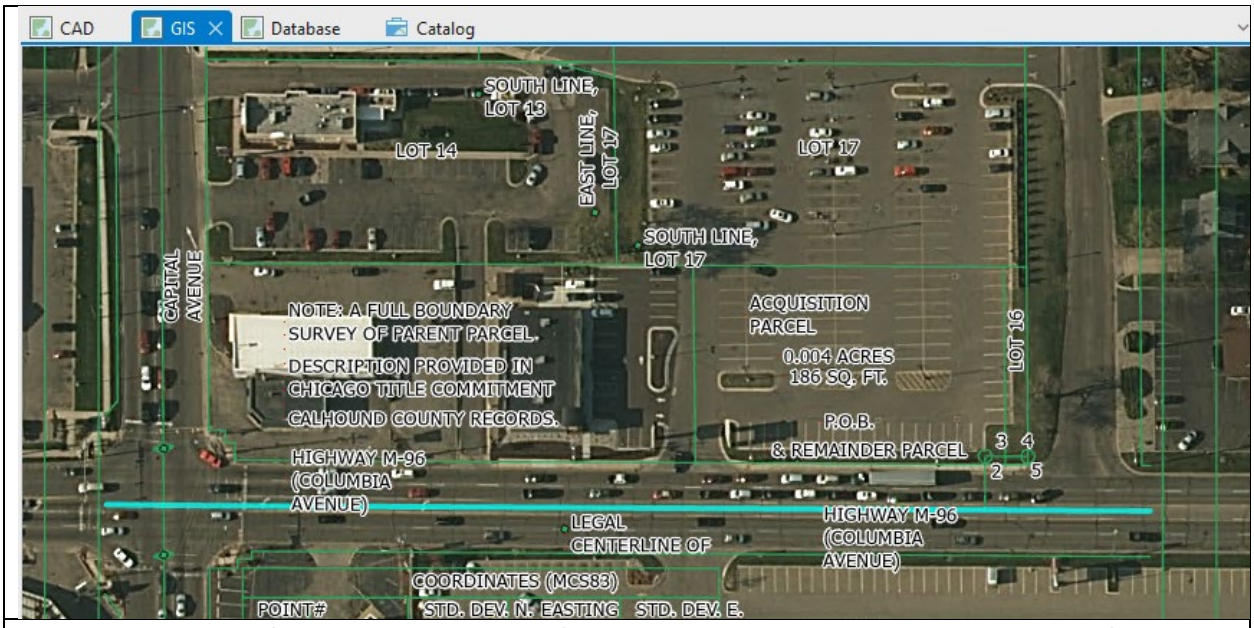


Figure 16. Individual features that match the feature layer desired are selected in the map if they cannot be selected through an attribute query. From there, features can be appended to the appropriate layer in the working ROW GIS database.

Note: *Most georeferenced .DGN files are referenced to the State Plane Coordinate System with units designated as international feet and the datum designated as some realization of the North American Datum of 1983. Common NAD83 realizations are NAD83(1986), NAD83(CORS96), NAD83(NSRS2007) and NAD83(2011).*

For more detailed information about the process for incorporating data from referenced .DGN files into the ROW GIS, refer to the project implementation plan.

The estimated time per .DGN file to complete this process is highly variable based on the information within. That being said, the estimated time is expected to be between 1.5 and 6.5 hours with the lower estimate for individual P.A. 132 .DGN files. A detailed cost breakdown is provided in the project implementation plan.

Generating ROW Features from Unreferenced .DGN Files

For this investigation, unreferenced .DGN files were incorporated into the GIS by importing them into a GIS program, georeferencing the .DGN data, and then performing the same data integration process used for referenced .DGN files. Parcel data entry was identical to the process used for referenced .DGN files. Current MDOT procedures for updating ROW data contained within unreferenced .DGN files involve updating the .DGN file with new information and exporting that data to a new static ROW map sheet. This perpetuates the process of creating static data. The methods created during this investigation allow MDOT to move past this process.

Georeferencing .DGN Data

Georeferencing .DGN data was a different process than for static, scanned ROW sheets. For unreferenced .DGN files, the data was brought directly into Esri ArcGIS Pro and defined according to the

proper coordinate system. From there, the data was rotated, scaled and moved to a location closely matching reference data, such as current orthoimagery or map data (Figure 17). Lastly, in a process very much like georeferencing scanned ROW map sheets, data were georeferenced when sufficient locations for GCPs were available. At this point, the data were referenced but still in .DGN format.

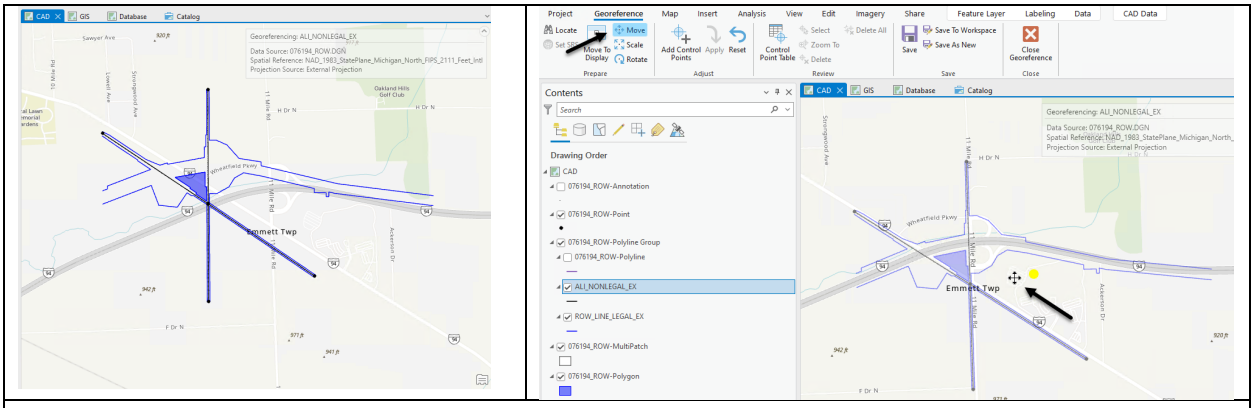


Figure 17. Unreferenced .DGN data was brought into ArcGIS Pro (left) and then move, scale and rotation tools were used to position the data. When control points are available, data can be more accurately referenced.

It is likely that sufficient GCPs will not be available in many cases. In those cases, it is important to move, scale and rotate the data as precisely as possible. If the data have good internal relative accuracy, this process can be quite accurate. Additionally, if existing modern data have been incorporated into the GIS already, it is possible to georeference the unreferenced .DGN data to that data.

Data Integration and Attribution

Most unreferenced .DGN data lacks consistent schema. In other words, linework is not always attributed properly according to feature type within the .DGN file. This causes issues during conversion to GIS features. In most cases, the level value for linework associated with parcels, for example, is not consistent, even within a single .DGN, so it cannot be assumed that a selection of all linework with a designated level all belongs to the same type of ROW feature. This is unfortunate and is only overcome through manual selection and editing.

Once .DGN data was georeferenced, it was imported into a default Esri project geodatabase where data was converted to point, line and polygon feature classes (layers). At this point a user selected all features that represented a specific layer, such as parcels. For point and line features, the selected features were appended directly to the preliminary ROW GIS database and named accordingly (e.g., ROWAlign, ROWLimits, etc.). For parcels, whose linework needed to be represented as polygons in the GIS, the selected line data were processed into polygon features and then exported to the preliminary ROW GIS database. Once in the preliminary ROW GIS database, features were attributed accordingly. The last step involved appending the features to the working ROW GIS database feature classes.

For more detailed information about the process for incorporating data from unreferenced .DGN files into the ROW GIS, refer to the project implementation plan.

The estimated time per unreferenced .DGN file to complete this process is 5 – 7 hours. A detailed cost breakdown is provided in the project implementation plan.

Investigation of Automated ROW Data Extraction

As has been discussed, the process for incorporating ROW features from static files and referenced .DGN files into the ROW GIS usually involves a fair amount of manual selection, processing and editing. For this reason, as well as the opportunity to reduce errors, automated methods are a desirable alternative. This process is often referred to as Extract-Transform-Load (ETL). While there are existing ETL methods, they are often complicated by inconsistent data schema. For that reason, it is important that new data be created in a way that ensures data schema is consistent across data produced both within and outside of MDOT. If this occurs, ETL methods would be much more useful.

For this project, two programs were investigated – Esri ArcGIS Pro ModelBuilder and Safe Software Feature Manipulation Engine (FME). Additionally, ETL tools exist within Bentley OpenRoads to convert .DGN files to Esri Shapefiles. OpenRoads has been used by current MDOT staff to convert newer .DGN data to GIS format.

Goals for automating .DGN to GIS conversion, regardless of the program used, are shown in figure 18.

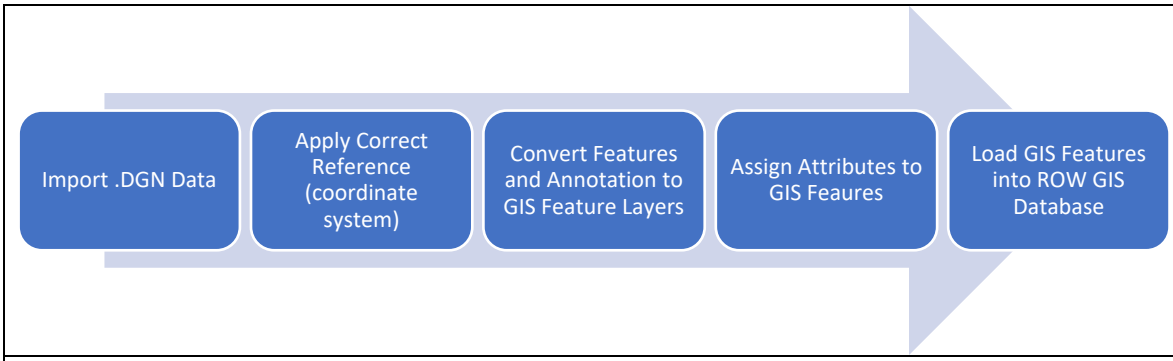


Figure 18. ETL methods for ROW .DGN data should import data, assign the correct geographic reference, convert features to GIS, assign necessary attribution and load data into the preliminary ROW GIS database. This process can reduce manual data entry and errors.

Feature Manipulation Engine (FME)

FME is a model-based software program that can be used to automate various tasks. It has been used successfully to convert .DGN data into GIS data. For example, the Iowa Department of Transportation uses FME in its workflow to do just that. However, like any automated program, implementation of FME is dependent upon data consistency. If level assignments vary across or within datasets, the process will not succeed, and manual editing will be necessary. If, however, data is consistent, it is a straightforward process to create a model that automates data import, reference assignment, GIS conversion and attribution.

FME is an expensive program. However, the State of Michigan does own some licenses for this software. If data consistency can be established, FME software would be a good solution for completing automated .DGN to GIS conversion.

ArcGIS Pro ModelBuilder

ModelBuilder functionality within ArcGIS Pro can be used to build logical automated models for processing a variety of geospatial data. These models, once complete, can be shared between users and even converted to Python scripts if desired. An advantage to using Esri ModelBuilder is its availability to MDOT employees. MDOT maintains a site license with Esri to provide staff with access to ArcGIS Pro. As with FME, data schema consistency is essential for successfully processing .DGN data to GIS.

ModelBuilder was used to test the efficacy of automating the Extract-Transform-Load (ETL) process for referenced .DGN data. Two different datasets were tested – an alignment .DGN and a P.A. 132 .DGN. Because the contents of each dataset were different, two separate models were created and tested.

Alignment Model

For the alignment model, the user defines several parameters including the input line and annotation feature classes (after the CAD to Geodatabase tool has been run) as well as some basic attribution. The model selects specific features, based on the assigned CAD level, and appends them to the appropriate preliminary database feature class with the user-defined attributes. The model currently selects stations, station annotation, limits, and alignment lines. After running the model, the data appended to the preliminary geodatabase is then reviewed and any additional attribution is applied. See figure 19.

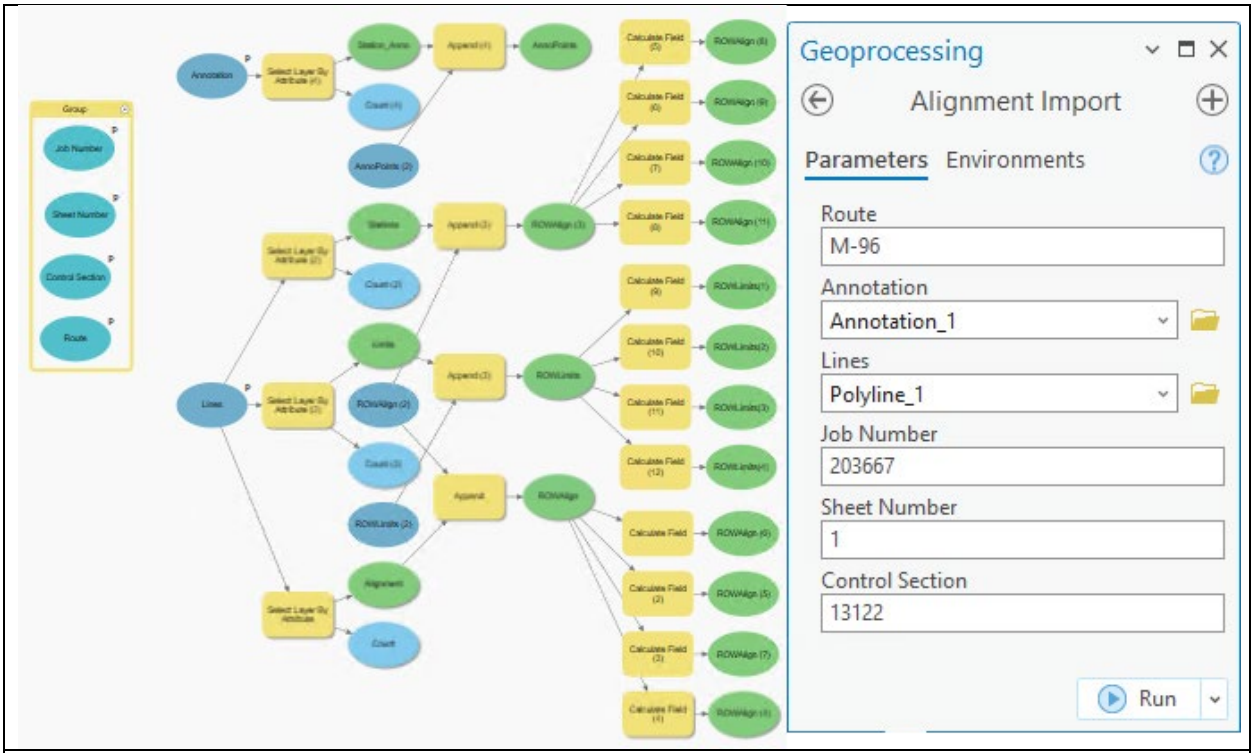


Figure 19. The alignment model created in ArcGIS Pro ModelBuilder successfully processes referenced .DGN data with little manual work necessary. Entering attribution for features is still necessary as is final loading of the data into the working ROW GIS database.

P.A. 132 Model

For the P.A. 132 model, the user defines several parameters including the input line feature class (after the CAD to Geodatabase tool has been run) and the Parcel Sequential Number. For this model to function, it is imperative that the lines that represent the ROW parcel are entirely contained on their own CAD level. The model selects these lines, converts them to a polygon feature and appends them to the preliminary geodatabase feature class. After running the model, the polygon is then reviewed and any additional attribution is added. See figure 20.

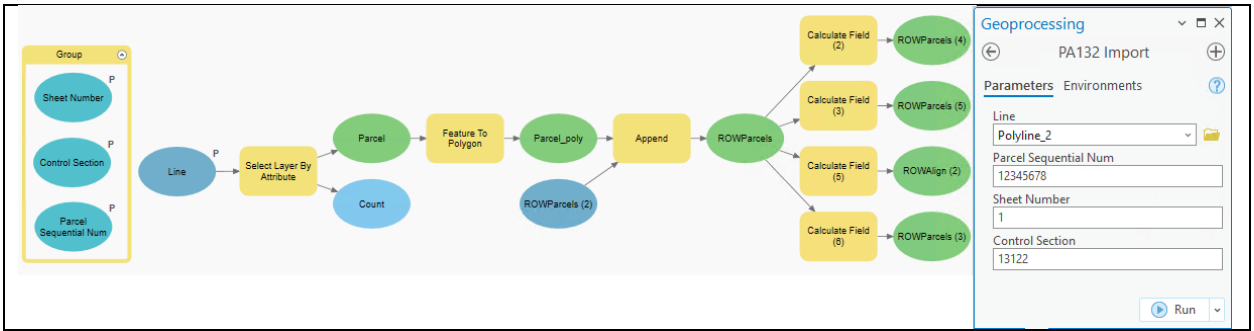


Figure 20. The P.A. 132 model is much simpler than the alignment model since its only purpose is to extract parcel geography and attribution. It too successfully processes referenced .DGN data with minimal manual attribution and subsequent data loading needed.

The models created during this testing are just examples of what is possible if referenced .DGN data have consistent data schema. It is expected that automated ETL methods could reduce labor considerably since much of the time required for incorporating data is represented by manual selection, export, processing, and attribution.

Bentley OpenRoads

In addition to issues with data consistency, some automated methods may affect feature integrity. For example, the current Bentley OpenRoads ETL process that converts .DGN data to Esri shapefile format results in lost curves. Shapefiles cannot support true arcs and so the precision of any curves is compromised. Instead of an arc, the curve is represented by many small, straight segments. Additionally, shapefiles have a field length limit of only 10 characters. If any field is the .DGN file is longer than 10 characters, it will be shortened in the output shapefile. This could cause confusion or result in duplicate fields.

Web Application Development

One of the primary requirements of the project was to provide simplified map search functionality for ROW data, particularly MDOT-owned parcels. To address this requirement, a web application was created within the Michigan State University ArcGIS Portal. The process for creating a web mapping application was to share GIS feature layers and tables as GIS services. These services were in turn added to web maps. Web mapping applications, which contain various widgets (i.e., tools), consume the web maps. It is expected that a minimum of two final web mapping applications will eventually be created: one for internal consumption and one for public consumption (Figure 21).

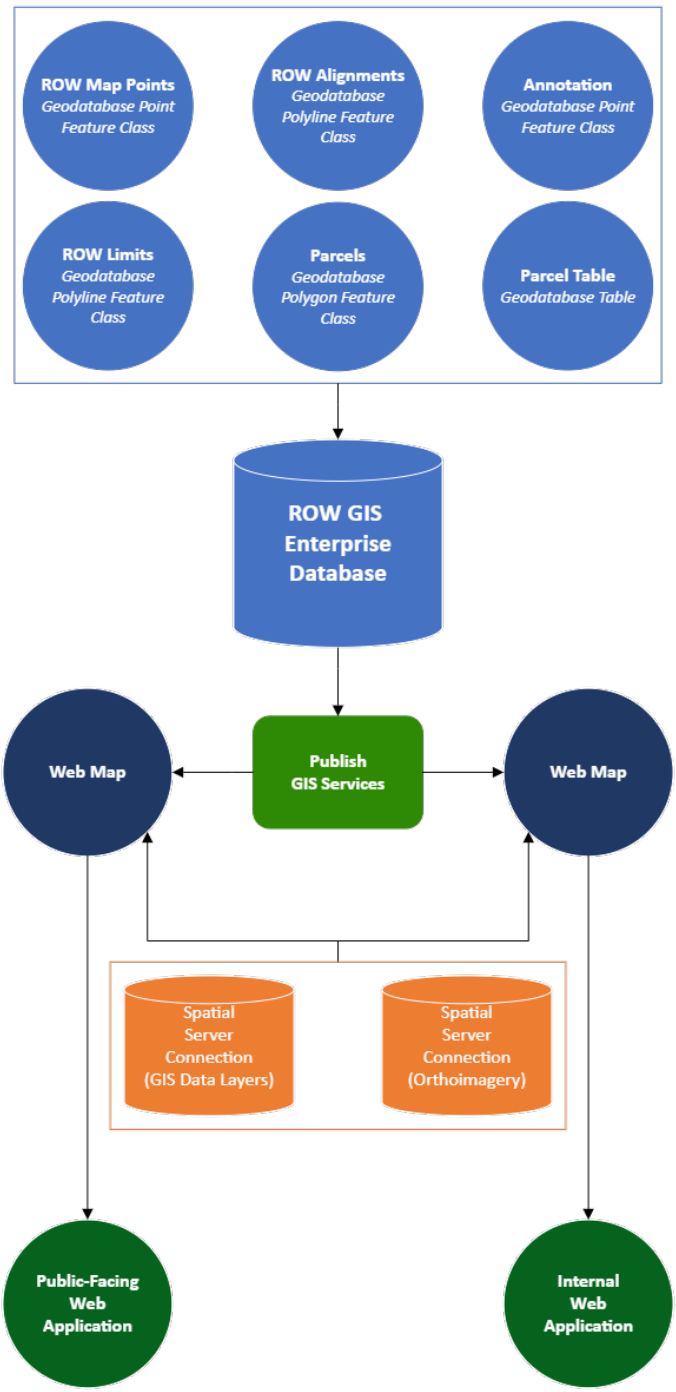


Figure 21. Basic diagram of web mapping application. Data layers are published from the ROW GIS database, which are consumed by web maps. Additional layers, such as image services are added to the web maps. These web maps are shared as custom web applications accessible via a web URL.

Data from both the pilot and design plan 3 were included in the web application and demonstrated to MDOT project staff. The web application included map points, georeferenced ROW maps, static ROW maps (via link), ROW feature layers, related tables, and ancillary data, such as DTMB MiSAIL orthoimagery (Figure 22).

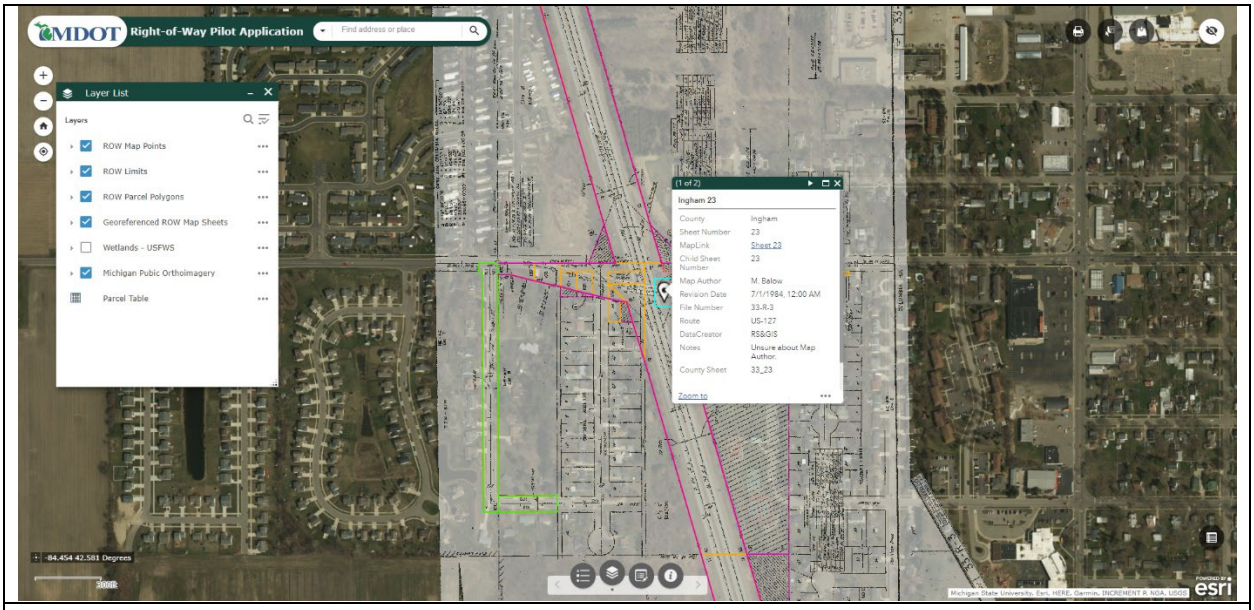


Figure 22. Preliminary web mapping application produced for the project.

The delivery of final web applications was not possible due to system access limitations for RS&GIS and DLZ staff. Instead, final web applications will be built by MDOT GIS staff once the LAMDA-ROW GIS integration has been completed. Web applications will take advantage of group permissions to segregate users who may view sensitive information from those who may only view limited information. It is expected that these web applications will evolve over time.

Web applications are not expected to be used for complex editing tasks, such as editing ROW feature geography, although it may be possible for some users to be given attribute editing permissions. GIS feature services that are displayed within the web applications will also be available from a desktop client (e.g., ArcGIS Pro). This is where edits to geography will occur.

Implementation Plan

A project implementation plan has been developed that specifically details ROW GIS conversion methods, costs, and recommendations. The plan, which is the culmination of extensive research, is designed to be a blueprint for Statewide efforts in this regard.

Recommendations

Recommendations for converting ROW data to GIS, including costs and staffing, are described in detail in the implementation plan. That being said, broadly speaking, it is the opinion of both RS&GIS and DLZ staff that the tasks listed below (and presented in figure 23) should occur **concurrently** within the MDOT ROW modernization effort.

1. Incorporate all new and modern referenced ROW data into the GIS. These include, primarily, alignment, ROW limits and P.A. 132 .DGN files. This would be a coordinated effort between MDOT Real Estate and Design Survey.
2. Implement design plan 2 for counties that have a low amount of right-of-way, such as rural areas and areas with few planned projects over the next 10 years. These are primarily unreferenced ROW sheets or unreferenced .DGN files. This effort is best completed by MDOT Real Estate.
3. Implement design plan 3 for areas that have a high amount of right-of-way and where many projects will be occurring over the next 10 years. Implementation could be by region, county or project. These may include unreferenced ROW sheets, unreferenced .DGN files or even referenced .DGN files. This is also best completed or coordinated by MDOT Real Estate, however Design Survey, as well as Planning should be involved in the process.
    a. This work could also be completed by a consultant.

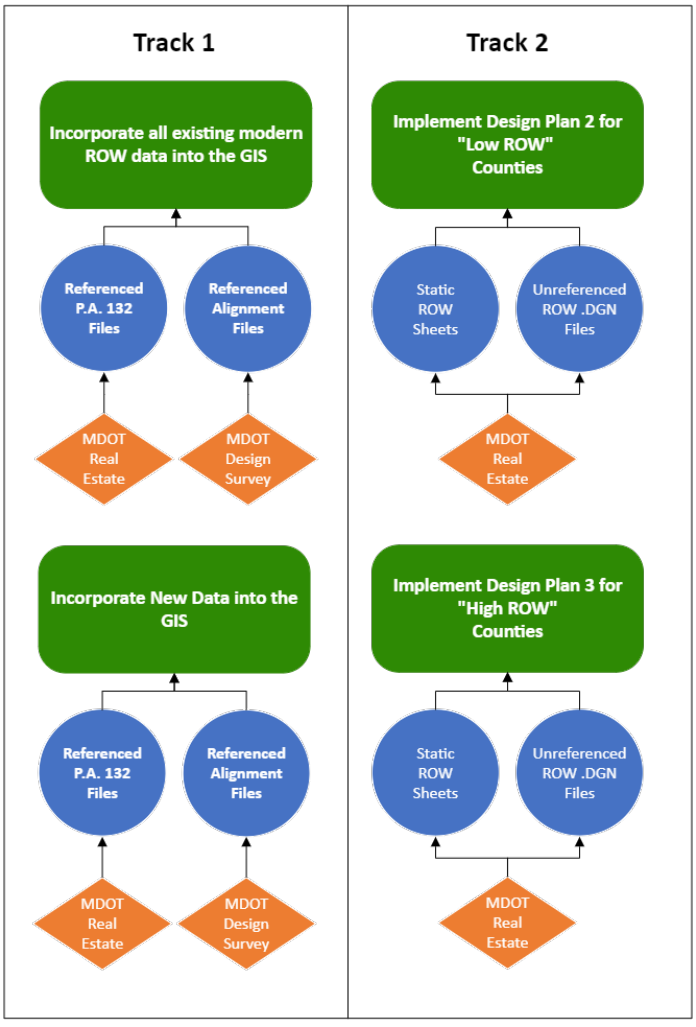


Figure 23. Recommended, concurrent, implementation tasks.

Note: *Concurrent with modern data and new data efforts, LAMDA staff could also begin the process of updating parcel information in the LAMDA database through review of historic data. This would reduce parcel entry efforts in Design Plans 2 and 3 as well as improve the LAMDA database sooner.*

Data Updates

When small changes occur, such as the purchase or sale of just a single parcel, it is recommended that the entire job area be updated to GIS if funds are available. The extra cost is not considerably different than that required to make the change to the .DGN, export the .DGN file to a TIFF image, re-georeference the ROW Map and update the ROW Map service.

Additional Recommendations

- In the view of the research team, while it may be tempting to utilize consultants on a wide scale to speed up the implementation process, MDOT should consider this project as a rare opportunity to rebuild institutional knowledge within the Central and Regional offices by employing MDOT staff for the majority of the work. In this way, internal staff, through data review and development, will gain a strong understanding of the historic right-of-way limits, unique situations, and new data integration. This keeps knowledge and key skills "in house" rather than in the hands of consultants.
- The research team recommends that an immersive, online training program be developed to train new employees and provide reference materials to existing employees. The online training would be asynchronous with support provided by supervisors and would include hands-on exercises, demonstration videos and a Frequently-Asked Question (FAQ) section.
- The research team recommends completion of a cost-benefit analysis if funding cannot be secured for the ROW conversion to GIS effort. Though considerable circumstantial evidence shows the value of static data being converted to GIS format, it would be useful to identify estimated total funds lost through inefficiencies related to employees using static, non-ideal data.
- The research team recommends establishing a panel composed of representatives from MDOT GIS, MDOT Real Estate, MDOT Design, MDOT Survey and DTMB CSS to identify and assign tasks to the most appropriate group to ensure success. The panel should also include a representative from both the Grand and Southwest Regions as these are the regions that have had the most success implementing ROW GIS workflows.
- Unless MDOT decides to contract out the bulk of the data development, dedicated staff should be tasked with completing the effort, particularly within Real Estate. Utilizing current staff that already have established duties is not conducive to sustaining a long-term effort.
- ROW GIS conversion should not be treated as a separate project. Rather, it should be integrated into daily workflow within Real Estate, particularly for new data.

Appendix 1: Needs Assessment Forums and Results

Needs Assessment Overview

The objectives of this research project include, 1) Determining the best method of utilizing information to update ROW maps, 2) Determining the best method to create a ROW map produce that can integrate future Real Estate functions, 3) Determining what ROW map product would be best for moving towards a GIS, and 4) Creating a simplified map search functionality. To adequately address these objectives, it is necessary to understand the status of ROW data within MDOT and current procedures for using, managing, and maintaining that data. RS&GIS determined that the best way to obtain this information was directly from MDOT personnel through ROW GIS forums. Beyond the forums themselves, RS&GIS conducted interviews with key personnel to refine the information captured in the forums. A fourth forum was held to present information obtained in the regional forums and follow-up interviews, as well as confirm and define primary ROW business and technical needs.

All information developed through the forums and interviews was used to develop ROW GIS system requirements needed for the design phase.

ROW GIS Forums

From late July through early September, the RS&GIS-DLZ team conducted four Right-of-Way (ROW) GIS forums. The first three forums were focused on regions, while the fourth was centered on central office staff, selected region staff and other key State of Michigan personnel.

Regional Forum Sessions

The three regional forums included:

- **July 22, 2021:** Bay, North and Superior Regions

  A total of 36 people registered for the forum, all of which were MDOT employees. Of those who registered, 28 attended and participated.

- **July 27, 2021:** Southwest and Grand Regions

  A total of 25 people registered for the forum, all of which were MDOT employees. Of those who registered, 21 attended and participated.

- **August 4, 2021:** University and Metro Regions

  A total of 36 persons registered for the forum, of which all but one was MDOT employees. Of those who registered, 29 attended and participated.

The goals of the regional forums included:

- Inform participants about current ROW mapping efforts within and outside the State of Michigan.
- Identify application-specific business needs of MDOT personnel as they relate to ROW data.
- Determine the status and usefulness of existing ROW data within MDOT regions.
- Identify essential ROW information needed by MDOT personnel, as well as desired accuracy.

- Identify current ROW editing and maintenance activities.
- Identify priorities and essential data and information needed in a new design.
- Develop an understanding of resources and expertise available within regions.

Regional Forum Format

Forums, which were offered virtually due to the ongoing health crisis, were scheduled for 3 ½ hours. Presenters included Dr. Erin Bunting and Robert Goodwin from RS&GIS and Tim Weir and Andrew Murry from DLZ.

Forums were divided into seven segments.

1. **Research Team Introductions**

   Introductions of primary project personnel from RS&GIS and DLZ.

2. **Icebreaker Activity**

   Using a Microsoft Teams form, participants were asked to rank ROW map items by order of importance based on their applications. A representative ROW map in Adobe Acrobat format (.pdf) was shown as a reference. If items they deemed important were not listed, participants had the ability to list them in addition to the ranking. This activity was meant to get participants thinking about ROW data.

3. **Project Overview and Participant Expectations**

   A short presentation was given by Robert Goodwin describing the ROW Conversion to GIS project, including objectives and components. This was designed to educate participants about project scope and priorities.

4. **Presentation on Non-Michigan DOT ROW Practices**

   Tim Weir from DLZ presented on the effort to identify ROW mapping practices in other States. This included examples of activities from Colorado, Vermont, South Dakota, California, Ohio, Minnesota, Oregon and others. This information helped participants understand where other DOTs were focusing their efforts.

5. **Grand Region Presentation**

   Personnel from the Grand Region (Tom Cate and Ben Bozek) provided a short video demonstrating a pilot effort for mapping and managing ROW data. Their presentation primarily focused on using geo-referenced ROW maps and survey information to populate a ROW GIS database. This presentation helped participants understand how and why data was entered into a GIS.

6. **Focus Groups**

   The largest and most important segment of the forums consisted of 90-minute focus group discussions containing 8 – 11 participants each. After describing the format of the discussion, a project team member served as moderator (Goodwin, Bunting, Weir, Murray) for an open dialogue focused on 16 questions. These questions, which were determined beforehand and

accepted by the Human Research Protection Program at Michigan State University, were developed through conversations between RS&GIS and DLZ, as well as information gained from MDOT personnel and DLZ research into non-MI DOT practices. Audio was recorded of each focus group session and transcribed to text for review and summary. The purpose of the focus group discussions was to gather knowledge and opinions from participants about MDOT ROW data, procedures, and practices. Requirements will be developed, in large part, from input provided in these sessions.

7. **Open Discussion**

   The open discussion was the last segment of the forum and allowed participants to ask additional questions or comment.

Central Forum Session and Format

The fourth and final forum was focused on MDOT Central Office staff, selected region staff and other key State of Michigan personnel. The primary goals of this session were to confirm and define primary ROW business and technical needs before moving forward with design requirements.

The Central Forum was intended to review information provided in the regional forums and follow-up interviews to refine ROW business and technical needs. Summary information for this session will be used to develop detailed ROW GIS system requirements.

The Central Forum session included five segments:

1. **Research Team Introductions**

   Introductions of primary project personnel from RS&GIS and DLZ.

2. **Regional Forums Summary**

   Information summarized from the regional forums, including the icebreaker activity and focus group information, was presented to participants.

3. **Business and Technical Needs Refinement Discussion**

   Results from the forums were discussed and business and technical needs for a new design were confirmed and fully defined.

4. **Preliminary Design Components Discussion**

   Discussion concerning data, processes and methodologies for both historic and newer data, real estate applications, and search functionality.

5. **Next Steps**

   The final part of this forum focused on the next steps, including data and network access, estimating costs, follow-up meetings and project requirements.

Follow-Up Interviews

Follow-up interviews with LAMDA staff were conducted to identify real estate needs and required functionality. A total of three meetings were held to discuss LAMDA database structure, access to LAMDA information and LAMDA-GIS functionality.

Findings

This section summarizes findings from the Regional and Central Forums. Information will be used to develop ROW GIS system requirements, which will be presented to MDOT project staff.

Summary of Icebreaker (Ranking ROW Items)

Each participant ranked 10 ROW items in order of importance. The highest-ranking items, based upon being selected as 1st, 2nd or 3rd, were ROW Boundaries, ROW Widths, Alignment, and Parcels. The lowest ranked items were Ancillary Sheet Information, Bearing and Distance Information, Government Corners and Vesting Documents.

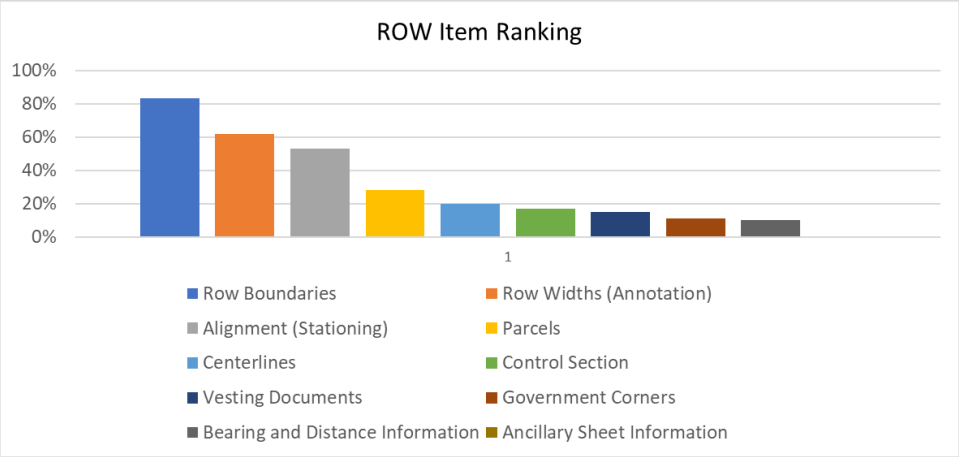


Figure 1. *Percentage of respondents ranking each 1st, 2nd or 3rd. 83% of participants ranked ROW Boundaries in the top 3. ROW Widths, Alignment and Parcels followed with 62%, 53% and 28%, respectively. Bearing and distance information (10%) and Ancillary Sheet Information (0%) had the lowest rankings.*

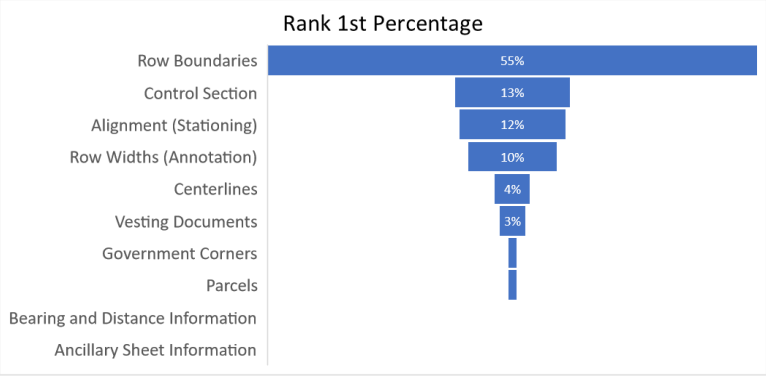


Figure 2. *Percentage of participants ranking each item first (i.e., most important).*

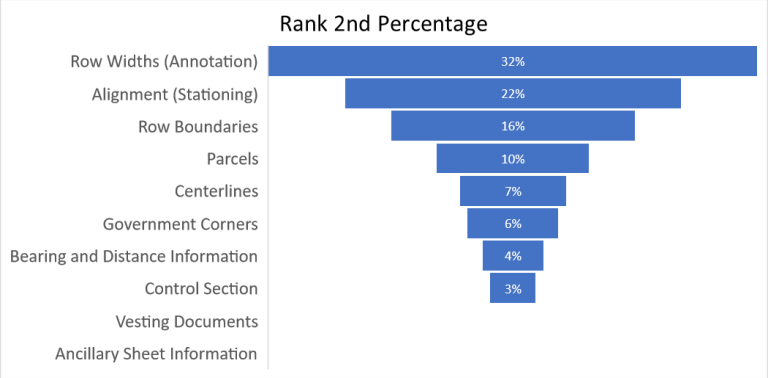


Figure 3. *Percentage of participants ranking each item second (i.e., second most important).*

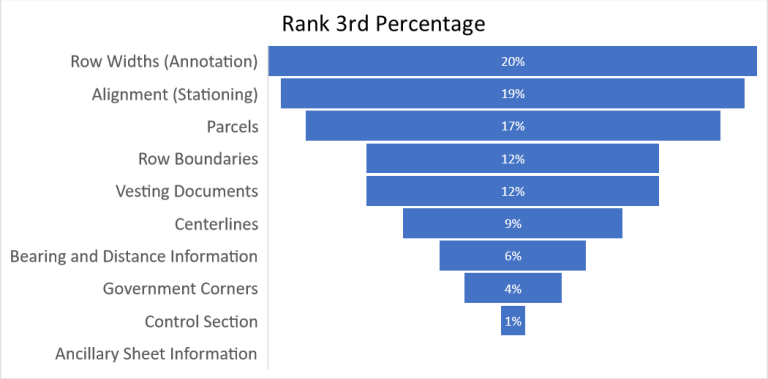


Figure 4. *Percentage of participants ranking each item third (i.e., third most important).*

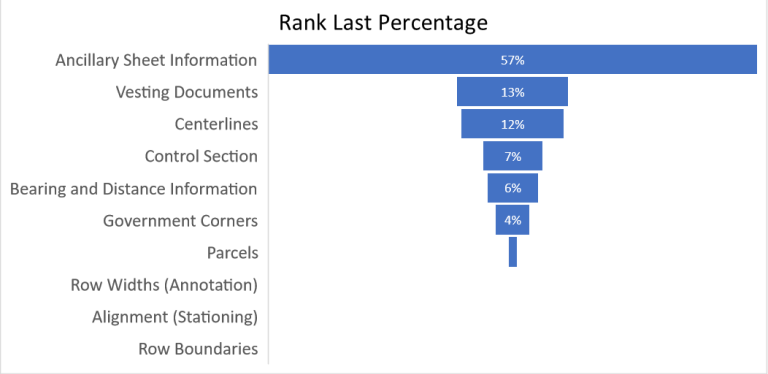


Figure 5. *Percentage of participants ranking each item last (i.e., least important).*

Other items to note:

- Control Section was ranked first by 13% of participants, but only 17% of participants ranked it in the top 3.

- 50% or more of participants ranked Government Corners, Bearing and Distance Information and Centerlines from 4th to 7th, indicating middlinig importance.
- While Parcels were only ranked first by 1% of participants, 50% ranked parcels in the their top 5.

Summary of Focus Groups

The focus group sessions gathered information from participants for 16 total questions. Responses for each question are listed below. The most common answers are in **Bold**.

Q1: Describe specific applications where you utilize ROW data in your current position at MDOT?

- **Questions from public and private companies (Developers, Utility Companies, etc.) inquiring about where they can install infrastructure (e.g., signs, utilities, etc.)**
- **Determining ownership.**
- **Determine access.**
- **Used by design engineers or design consultants for preliminary scoping (ROW location, width, stationing).**
- **Parcel acquisition activities (property research).**
- **Identifying and locating parcel instruments.**
- **Determine alignments, parcel locations/information, locate deeds, find alignment points.**
- **Identifying easements.**
- **Excess property research and sale inquiries.**
- **Inform citizens.**
- **Job scoping.**
- Address encroachment issues.
- Use ROW sheets to scope maintenance activities, Including determining where they can work and if they need to speak to adjacent property owners, establish consents for grading, determine if an easement is needed, etc.
- Use to determine location of ROW for environmental projects.
- Provide information to private surveyors.
- Obtain stationing and station equations.
- Identifying utilities.
- Identify how much ROW MDOT owns to determine if additional land needs to be acquired for installing ditches, culverts or utilities.
- Permit issuance (ROW type, width, etc.) and ROW enforcement.
- Pre-survey scoping.
- Roadside vegetation management.
- Locating assets, such as culverts.
- Reviewing alignments.
- Determining what deliverables will be needed from a contractor.

Q2. Please describe the usefulness of the existing ROW data in your Region and/or TSC for the applications you described?

- **Useful but there is a lot of information missing.**
- **Not user friendly.**
- **Not up to date. Can't trust the information.**
- **Not possible to overlay other information.**
- **North not always at top of sheet.**
- **Finding correct sheets is time-consuming.**
- **Can only use information as reference due to inaccuracy and dated nature.**
- **The public views them as truth, which is problematic due to inaccuracy and dated nature.**
- **Inaccurate and outdated.**
- **Due to outdated nature, local copies are maintained at the region.**
- Not useful at all. Existing ROW data is awful and worthless. Can't find half the information needed. Can't rely on distances. Accuracy is awful. We have survey alignment from previous years that are not in the maps.
- Useful for ROW construction, Maintenance activities and permits.
- Cumbersome.
- Complicated and difficult to use.
- Clunky with lots of cryptic writing and symbology.
- Chart detailing parcel acquisitions is useful.
- Property transactions are not always shown on the map (sales, splits, merges), which requires plan chasing.
- Lack ROW information for side streets.
- Other than historical deeds and ROW ownership, nearly everything else is worthless for surveys.
- Data is not accurate enough for survey activities.
- Difficult to find information for parcels.
- Very useful for determining ROW boundaries and ownership (and therefore responsibility).
- Useful as a guide, but deeds are the authoritative source.
- Lots of typos and errors.
- Only as good as last update.
- Information not centralized.
- Invaluable for real estate activities.
- Difficult to do my job (Acquisition and Excess Sales) without the ROW maps.
- Useful but have gaps/holes.
- Data is static and therefore difficult to use in its current form.
- Maps are often not to scale so measurements are not accurate. Adjacent sheets may be of a different scale.

Q3. What are your primary concerns with existing MDOT ROW data and how do you believe they should be addressed?

- **Static data. The ability to overlay with other data would be useful, such as aerial photos, roads, corners, etc.**
- **Can't rely on maps to give you most up to date information. Map information needs to be updated.**

- **We are relying on outdated information. Process needs to be put in place to update the information more quickly. Maintenance of information is key.**
- **The public views ROW maps as truth leading to misuse. A disclaimer needs to accompany future data to address misuse.**
- **Not referenced. It would be amazing if all the ROW maps were geo-referenced.**
- **Roads often have multiple names. A way to capture both historic and current names would be useful.**
- **ROW maps are busy and difficult to interpret. Having data layers in a GIS that can be turned on and off would be useful.**
- Need to find a way to convert .DGNs to shapefiles and get them into GIS. Getting the right spatial reference is key so data aligns properly.
- Modernize (move into GIS) to allow information to be located more easily rather than accessing multiple sheets.
- Notations made by region personnel are not always understandable. Need standards to capture information in a consistent way.
- When a survey is not possible, we need the ROW maps to be up to date.
- Finding the correct sheets is difficult. Having information available in a GIS would allow for more efficient data retrieval.
- Permit applicants often draw their proposed project area on ROW maps. Having this capability in a new system would be useful.
- We have routes without published ROW maps. This complicates the permit process. There should be a way to include these "rationalized" routes in the new system.
- The public does not understand the difference between ownership and jurisdiction. Capturing and displaying this information would be useful.
- Data is not centralized. Finding a way to centralize all the data would go a long way to improving efficiency.
- Older ROW maps have inaccurate linework that cannot be repaired through geo-referencing. A process for geo-referencing ROW maps may include guidance on when not to geo-reference certain maps.
- The ROW maps do not include design intent. It would be good to capture this information, so property acquisitions and sales did not result in MDOT re-purchasing property or establishing incorrect access (e.g., why establish an entire parcel as limited access when only a small portion is needed for limited access?)
- Information on maps, such as long term holds, does not include reasoning for the hold. Capturing this information would be useful for future acquisitions and sales.
- ROW maps do not include abandonment information. Capturing this would be useful.

Q4. Describe the current-ness of ROW data in your Region and/or TSC.

- **Online ROW maps are not current.**
- **Region books, when available, are kept current (hand drawn on hardcopies).**
- **Current at Region, not in Lansing.**
- **Need method for region staff to update information.**
- **Too much work to do. Limited time and resources to update the maps.**

- **Local copies in the regions are necessary to know the status of the ROW.**
- **Current-ness is difficult to determine. We don't always know what isn't on the maps.**
- Many maps have not been updated since the 1990s.
- Outdated nature leads to misuse both internally and externally.
- Counties in Grand and Southwest are working to be current up to 2018.
- A folder in ProjectWise containing updated maps exists for SW Region, but these maps are not publicly available.
- Not current, but we have ways around this. Project plans, PA 132s, etc.
- While our local maps are current, they notes are handwritten, not online.
- Guess is that maps have not been updated in the Metro region for at least 8 years.

Q5. What is your opinion of the usefulness of geo-referenced ROW maps?

- **Would be easier to find where you are. Saves time.**
- **Usefulness is dependent upon application. Not as useful for applications requiring high accuracy.**
- **May lead to permit applicants, utility designers, etc. taking the information for gospel, leading to misuse.**
- ROW maps need to be geo-referenced since moving all the information in ROW maps to a GIS would be too time consuming.
- Useful in the field when fielding inquiries, overlaying other data such as no-spray zones.
- Useful in the field for encroachment issues.
- Would be useful when doing Typicals.
- Useful during the permit process.
- More useful to real estate than anyone else at MDOT.
- Step up from Static maps.
- Effort needed to get all maps referenced could be a problem.
- Very useful internally.
- Useful and surprisingly accurate in my experience.

Q6. What information on ROW maps, besides the ROWs themselves, is essential for MDOT business activities?

- **Alignments (and alignment source).**
- **Stationing.**
- **Easements.**
- **Parcels.**
- **Parcel information (Liber, Page, Deeds).**
- **ROW type.**
- **Conveyance documents.**
- **ROW widths.**
- Everything on the ROW map sheets is essential.
- Government corners.
- Job and project numbers.
- Natural features, such as stream crossings.

- ROW information for local roads.

Q7. What ROW data features and formats would you like to preserve in a new design?

- **Preserve the information in the .DGN files.**
- **Links to plan sets via Job number.**
- **Update process at the Region level.**
- **Links to instruments**.
- **ROW and ROW Type**.
- **Easements.**
- **PDF maps**.
- **Process for importing GIS information into MicroStation for project scoping**.
- **Parcels and Parcel Information.**
- Historic centerlines.
- Legal alignments.
- Municipal ROWs.
- County drains.
- Map sheet extent polygons.
- Feature attribution.
- Subdivision plats.
- Boundaries (twps., counties, cities, etc.).

Q8. In your opinion, to what level of accuracy should ROW data conform?

- Anything is better than what we have.
- **+/- 2 feet.**
- **Approximate location.**
- **Accuracy could vary based on application.**
- **Lack of accuracy results in more research effort.**
- **Survey grade for design.**
- GN information – survey level. Historic information – approximate.
- Within 1 foot.
- Survey grade.
- It will never be accurate enough for survey and design.
- Updated information from new projects or surveys should be highly accurate.
- Should be as accurate as possible.
- Historic data can only be so accurate.
- A lot of times we are showing ROW as approximate when we don't have a survey. In these cases, the approximate location is important and fine.

Q9. In General, describe your current workflows for editing and managing ROW data.

- **Not currently editing or updating ROW data.**
- **Only making edits in local ROW books**.
- **Email updates to Lansing.**

- Draw the ROW lines, legal and non-legal, depending on where the job is and what is requested by Real Estate people. Use Open Road Designer. Keep it internally. Provide to designer. If I find errors, I contact Matt Fitch, who will make changes if I provide the right documentation.
- We scan everything into ProjectWise and send it to Matt Fitch. We physically write this out in our ROW books. We will draw the lines as close as possible and add dimensions.
- All ROW updates occur in the Central Office.

Q10. How do you currently link other data, such as real-estate transactions, to your ROW data?

- **Not aware of any data linked to our ROW maps or data.**
- After the real estate transaction is complete, ROW certification goes to Lansing and the easement is recorded. ROW data is then updated at the Central Office.
- Central Office will get a copy of permanent ROW easement and will update manually.
- For Real Estate, find the parcels then send them to Survey to get a survey completed. Then send it to Design. In that process a new, more updated dataset is created which we can then, theoretically, be integrated into the GIS.
- Central Office: Build a new parcel data box on the ROW map. In ProjectWise, for acquisition part, there is an acquisition folder that has all the instruments and consents. Region personnel let me know when all the surveys are recorded. However, there could be information that surveyors don't provide.
- We don't link permits back to the ROW.
- Hand drawn on local copies in the office. No information can be linked.
- Central Office: Grand and Southwest are doing some of their own updates. Getting copies of .DGNs, making updates and then sending them to central office for QAQC before distribution.

Q11. Are you currently involved with updating ROW data to GIS format in your Region and/or TSC? If so, please describe the process briefly.

- **Bay, North, Superior, University and Metro Regions: Not currently.**
- Southwest Region: Yes and no. We have not updated anything but are working on a solution.
- Grand Region: Somewhat.
- When we certify a project, we send the ROW certs to Lansing and along with that the links to ProjectWise that contain the executed or recorded documents, including consents. Believe this gets to the Techs in Lansing and update the maps.

Q12. What level of GIS expertise is present at your Region and/or TSC?

- **In-house GIS expertise is non-existent or very limited.**
- **Few GIS staff.**
- **Need more GIS staff in the Regions.**
- Some resources are available but not dedicated.
- Southwest Region: Expertise high but only 1 staff.
- Several staff with limited GIS experience or knowledge.
- There are GIS units in Lansing but not in the Regions.
- Training from MSU has helped but staff need to "use it or they lose it."
- We have the ability to make a map, but not much more.

Q13. Describe what access you have to GIS software and data.

- **Everyone at MDOT should have a login for ArcGIS Pro and AGOL.**
- **Lots of maps/data at MDOT, but many are not accessible due to user ownership settings.**
- **GIS maps and apps need to be simple and intuitive.**
- **We have a Permit application that is very useful**.
- MDOT employees may not be aware of existing maps, leading to duplication.
- Tools are becoming available, but many end users do not know how to use them.
- Lots of base data is available, including Framework data, traffic volumes, carpool lots, culverts and other layers.
- I am not aware of any available GIS ROW data.
- The existing PR finder is difficult to use. It used to be simple but is now almost too complicated to be useful.
- We use Collector on an iPad.
- We access GIS apps from counties.
- There are many viewers available to design. New design should integrate or work with these existing viewers.
- Need to establish and internalize GIS.
- Our permit inspectors use ArcGIS Online.
- We often rely on County data.
- Central Office: Every Region and TSC allocates their funding differently so internal resources may reflect that.

Q14. Describe the importance of historical ROW information in a new design.

- **Historic information is very important.**
- **Historic information needs to be updated.**
- **Updating historic information at the Region level would be ideal.**
- Surveyor side of me says, “Give me all the data.” Real Estate side of me says, “Just tell me what I need right now.”
- For new project designs, we typically get a survey and don’t necessarily compare with historic.
- Very important for scoping prior to survey.
- We need historic data for access and Real Estate functions.
- Without a recent alignment survey, we would need all the historic information to hunt down the records for the original deeds.
- Use historic information all the time.
- Use historic information in the field for locating drainage easements.
- We can’t do our job without the historic data. It is the starting point.
- Our ROWs are based upon historic documents.
- Historic information is very important. We make decisions, at least in part, based on information on the maps.
- It is important for me to know what property we have and what we don’t.
- Displaying historic information is the primary function of ROW maps.
- We need to make sure we preserve historic information in the new system.

Question 15: What would be your top priority for improved MDOT ROW data?

- **Updated** (current)
- **Easier to access.**
- **ProjectWise links to design surveys, project plans, parcel instruments and other documents.**
- **Include Parcels and Parcel documents.**
- More accurate.
- Reduce the amount of time referencing other documents.
- Get historic information added.
- Get DNG data into the system.
- Including alignment information.
- Zoom capability.
- Layers for ROW boundaries. Information for ROW widths.
- Include alternate road names.
- Show all easements.
- Integrate new information into the existing Permit Map/Application.
- Overlay information with existing data layers.
- Centralize all information.
- Fix orientation of all maps.

Q16. Describe the importance of linking MDOT GIS data to design software such as MicroStation?

- **Allowing GIS data to be viewed in MicroStation would be useful for initial scoping.**
- We need to link MicroStation to GIS, but not necessarily GIS to MicroStation.
- Linking MicroStation to GIS would be very useful as a reference for planning and design if it could be done accurately and in a standardized way.
- From our perspective, data would be updated into the ArcGIS database using the MicroStation file. To submit a new drawing to the ArcGIS database, there would be a standardized process. Don't change the MicroStation data.
- Data from MicroStation should be attributed accordingly so its source and accuracy are known.
- We would have to be careful and take coordinate systems into account.
- As a designer I would not feel comfortable using data from ROW sheets in a design, except as a reference.
- Bentley has a product called Bentley Map that can bring data into MicroStation from an Esri Geodatabase.
- Critical to be able to go back and forth since all design occurs in MicroStation. Workflow standards would be important.

Other responses

- The resulting application or applications needs to be very simple.
- There are times when you will want to print something to take into the field. We want to make sure the solution allows for printing on 11" x 17" paper.
- If we were able to locate a parcel by address or intersection that would be very helpful.

- We have ROW certification reports from 2008 onward. We do have ways to track ROW maps that need updates. There is a backlog. We do have this way of tracking ROW acquisitions. May need to do searches at courthouses prior to this date.
- Would it be ROW data in a GIS or just a referenced ROW sheet?
- Lot of instances where MDOT sold excess property and relied on new owner to record the deed, who did not do so.
- Earlier sale documents were not written by surveyors so they may not have described it properly.
- Question from participant: How do we update information to a geo-referenced map?
    - Matt Fitch: We create ROW maps from a .DGN. If we have new information, this should come into MicroStation fine. We can then regenerate the ROW map.
- Parcel restrictions are often overlooked. This could be the need to preserve trees or some other item. There are operational ROWs designed to preserve natural states, scenic areas, etc.
- Some of our roads travel through USFS lands. If we are there for roadside vegetation management via a permit rather than an easement this can be contentious. Tribal and military lands can be similar.
- Having a database of easements would be great.
- We do not have private utility easements on ROW maps.
- Once thing I would like to see is quarter section lines. Things that help identify the correct location. Control sections are helpful, but we need PLSS QQ.
- One thing that is important is in the past, when metes and bounds were used, they would leave out the bounds. We would need to know the project or job number for the basis of bearing. Important to reference job number. How are we going to put multiple projects on a sheet?
- We need to establish a standard for recording alignments. Need to show both alignments. We also need to know whether it is limited access or fee access.
- Limited access becomes important with permitting. If it is limited access, it may be difficult getting approvals from the Feds.
- One thing lacking is current road names. Sometimes the old name is there or not at all. It would be helpful if we could find this. Some of our deeds reference different names. How do we not lose the information but also not confuse everyone? Is there a way to add ancillary information?
- Resources (Staff) are a big problem at MDOT.
- The new system needs to interface with other programs. Don't want it to stand on its own.
- It is a big, expensive effort to get ROW data into the GIS. Long but straightforward. The difficult part is getting a system and workflow to keep everything updated. Who does it? How do you make it all work so that things are not missed? We are seeing this with our culvert inventory. Easy to get the culverts located, but how do we update the data when we change things during construction, etc. There needs to be commitment to this.
- We keep our own updated maps in our region. We are always using them.
- We need the legal documents. Can't just rely on ROW maps alone. Legal documents hold the most weight. Always start with the ROW maps.
- Often use Google Maps to help get accurate measurements. Correlate Google Maps with ROW maps.

- We are still using books with handwritten notes in our office. Disconnect between what we have and what the State has.
- Having PA132 surveys from consultants is important, including .DGNs, PDFs and other documents. Often all the information is not uploaded to ProjectWise.
- One of my concerns is integrating survey level data into ROW information. This causes issues about what data accuracy for each. Contractors will make decisions based upon the ROW maps, so they need to either be accurate or have some information indicating their inaccuracy.
- Is it worth updating something if it is only off by a couple feet? Who is going to do this? Do we have the resources?
- There have been several different Geoids and Datums and a new coordinate system is coming. Is there a way to include what datum each project was based upon? Anything better than GIS-grade quality may cause problems.
- Historic ROW data is only so accurate, so can't get very good until a new project results in a survey. If the public has access to the data, is there a way to limit their access to a certain scale so the public does not see data as being more accurate than it really is?
- I think from a staffing perspective, updating maps in the region would be difficult. We would need an assigned person. As a real estate tech, it would be difficult because it is not in their job description. It makes sense to do it at the region or there needs to be better communication between regions and Lansing, such as notifications when updates were made in Lansing.
- Techs working on the project from the beginning should make the updates to the maps.
- We currently are moving toward Lambda Land Asset Management Database. That will replace REMIS and RESAL (excess sale program). These are older programs where we could search on a parcel and see what the land acquisitions were and describe them. This was dependent upon the diligence of the data entry person. Not sure when Lambda will take over.
- Everyone is trying not to do more than they must but keep things updated and accurate.

Appendix 2: Project Requirements

Project Requirements Overview and Project Scope

In July and August of 2021, RS&GIS and DLZ held three regional forums and one central forum to discuss and identify needs of MDOT personnel in regard to MDOT right-of-way (ROW) activities and how these could be addressed within a geographic information system (GIS). Based on those discussions and follow-up interviews, RS&GIS has refined project scope and developed general system requirements. This working document will be used to develop GIS ROW system designs for consideration by MDOT project personnel.

Project scope was refined following the central forum and includes four (4) primary items.

1. Database Design: Building Enterprise Geodatabase of ROW features.
2. System and Methodology: Moving existing ROW data into a GIS database.
3. System and Methodology: Entering newly-generated ROW data into the GIS database.
4. Simplistic viewer that displays ROW data and related data.

Expected Outcomes

The requirements detailed in this document will result in numerous outcomes affecting accuracy, efficiency, and accessibility. Expected outcomes include the following.

1. A newly-created GIS database of ROW features will establish a standardized schema for ROW features, improving data consistency.
2. A process for linking and retrieving documents will improve design and real estate transaction efficiency.
3. Right-of-Way data accessibility for all users will be greatly improved once it has been converted to GIS format and made available in a web-based viewer.
4. Improved decision-making will result from the ability to obtain data quickly and overlay ROW data with other GIS datasets.

Requirements

1. Database Design

Project database design has four components, 1) A list of required data layers, 2) A well-developed database schema, 3) Links to documents in ProjectWise, and 3) Access to existing State of Michigan Data and information.

1.1. Data Layers

Primary data layers present on existing, static ROW maps identified as most important during the regional and central forums are listed below. These are the suggested ROW data layers for inclusion in the ROW database moving forward.

- **ROWPolys:** Right-Of-Way Polygon Boundaries, including easements
- **Right-of-Way Widths:** Right-Of-Way Widths (annotation)
- **Parcels:** Property Parcel Polygons
- **Alignments:** Alignment Polylines

It is important to note that the layers listed above represented the consensus from the forums of what should be included in the GIS from the ROW maps. Other data that may be useful will be preserved on the historic maps.

Primary data layers must be represented in the ROW GIS database as individual feature classes (i.e., GIS layers). Requirements for completing this component include:

a. Access to ROW maps (.PDF and .DGN) stored in ProjectWise
b. GIS Software (e.g., ArcGIS Pro)

1.2 Database Schema and Permissions

The database schema, which outlines necessary feature database fields, legal field values, feature access, and other rules is necessary to ensure consistency as data layers are edited and updated or data is transmitted to contractors outside of MDOT. The database schema must be composed of all necessary database fields and allowable values (i.e., attributes) defined by database domains. The final data schema must align with MDOT business needs and, therefore, must include input from MDOT ROW GIS project personnel. Preliminary data fields for each ROW data layer are listed under the Attribution heading in Table 1.

Table 1. Basic suggested ROW database schema.

Data Layers			
Item	**Item Type**	**Attribution**	**Source**
ROWPolys	Polygon Feature Class	JobNum, ProjectNum, Control Section, Access, Source, Estimated Accuracy	ROW Maps and/or .DGN Files
ROWWidths	Annotation Feature Class	Font, etc.	ROW Maps and/or .DGN Files
Parcels	Polygon Feature Class	ParcelNum, Control Section, ParcelType, Liber, Page, Grantor, Recipient (sold to), Date Recorded, SaleNum, Access, Source, Estimated Accuracy, Tier, Range, Section	MDOT LAMDA, SOM and/or ROW Maps
Alignments	Polyline Feature Class	AlignmentType, Source, Estimated Accuracy	ROW Maps and/or .DGN Files

Allowable, or legal, values for each field will be determined through consultation with MDOT project personnel.

RS&GIS, along with DLZ, has been in communication with LAMDA personnel and will continue to work closely with them to determine final fields and field values for parcel data. Currently, the most crucial attributes to allow for GIS-LAMDA database linkage are ParcelNum and Control Section. Additionally, it has been determined that parcel attribute entry will occur within LAMDA, rather than in a GIS solution. Requirements for completing this task include:

a. Access to ROW maps stored in ProjectWise
b. GIS software (e.g., ArcGIS Pro)

c. Input from MDOT personnel to confirm final required data fields and legal values (attribute domains) in the database
d. Continued coordination with MDOT personnel administering LAMDA to establish correct parcel schema needed in the GIS database.

1.3 ProjectWise Data Links

The scope of this project requires any new system or methodology to integrate future real estate transactions. An important part of that process is organizing and accessing property-related documents. These documents are stored inside ProjectWise. Currently, the new LAMDA property system includes a process for uploading parcel-specific documents into ProjectWise and generating links to allow for document retrieval. Since this process is already being completed in LAMDA, it is not necessary to complete the linkage in a GIS system. However, retrieving these documents through a GIS viewer is important. Additionally, although the linkage will occur in LAMDA, developing a GIS-LAMDA workflow, whereby document linkage occurs within LAMDA immediately following parcel editing in a GIS, would be useful.

Other documents useful for ROW activities include the ROW maps themselves, particularly very old maps that may or may not be targeted for geo-referencing due to their poor accuracy. These documents can be linked to a feature layer in the geodatabase, such as a ROW map data extent polygon, point feature layer or a section of roadway. It is important to preserve these historic files.

Design plans are also useful documents for ROW activities so linking to these could assist with a variety of tasks. While linking plan documents is currently out of scope, demonstrating a process for doing so would be fairly straightforward.

Requirements for completing this component include:

a. Continued collaboration with MDOT personnel administering LAMDA to determine the best method for linking the GIS system to the LAMDA system.
b. Access to documents stored in ProjectWise.

1.4 Access to MDOT and DTMB Data

Access to ROW information and supporting data is essential for designing a ROW GIS solution. While it is not necessary for access to be granted to Statewide data for this project, a successful design requires access to data and information for a selected geographic area. Access is needed for the following:

a. Existing ROW Map Sheets and related .DGN files (ProjectWise)
b. Existing Parcel Instruments and Design Plan Sets (ProjectWise)
c. Existing Geo-Referenced ROW Maps (Location unknown)
d. Existing Property Surveys – PA 132 (Location unknown)
e. State of Michigan Parcel Partnership Repository (SOM DTMB)
f. State of Michigan Framework Data (SOM DTMB)
g. State of Michigan MiSAIL Orthoimagery (SOM DTMB)

2. Moving Existing ROW Data into a GIS Database

Once a preliminary ROW GIS database is complete, designs for moving existing ROW data into a GIS database can proceed. There are three components to this part of the project, 1) ROW map sheet feature extraction, 2) .DGN file import and integration and, 3) Parcel Instrument linkage. Furthermore, spatial accuracy of extracted features must be documented to ensure proper data use.

2.1 ROW Map Sheet Feature Extraction

A large number of ROW map sheets have been scanned and converted to PDF format. Some of these are very old maps, while others are more recent. Many of the maps, and therefore the data within them, are not geo-referenced, so a process must be developed for extracting the data into a GIS whereby the data is referenced correctly to real-world coordinates. Furthermore, this selected process must result in data meeting project accuracy requirements. The primary methods for accomplishing this include, 1) geo-referencing the maps and then digitizing features and, 2) using coordinate geometry (COGO) techniques to directly extract the features. Requirements for both of these processes are detailed below.

a. Map Georeferencing and Subsequent Feature Digitization Requirements
    1. Scanned ROW map sheets
    2. GIS Software with geo-referencing capabilities
    3. Reference source for geo-referencing (e.g., orthoimagery, existing parcels, road features, section corners, GPS points, etc.)
    4. Existing GIS database with defined schema
b. COGO Data Creation
    1. Scanned ROW map sheets
    2. GIS Software with COGO capabilities
    3. Public Land Survey System (PLSS) GIS polygon dataset of sections and quarter sections
    4. Legal descriptions of features (ROW boundaries, alignments, parcels, easements)
    5. Existing GIS database with defined schema

2.2 MicroStation File Import and Integration

If data are available in MicroStation native file format (.DGN), these data can be imported into a GIS software product and used to update a GIS database. Since .DGN files and standard GIS files, such as File Geodatabases or Shapefiles, are structured differently, it is necessary to develop a process whereby the essential information required by the GIS database schema is preserved during integration. There are current activities occurring within MDOT that are testing this process. Requirements for moving forward with this component include:

a. Access to information and techniques developed internally at MDOT (e.g., Southwest region efforts).
b. Access to existing ROW Map .DGN files
c. Access to ArcGIS Pro software, which is capable of importing .DGN files

2.3 Parcel Instrument Linkage

MDOT is currently deploying their new Land Asset Management Data Application, LAMDA. LAMDA includes functionality for uploading parcel acquisition and conveyance instruments to ProjectWise and establishing links for later retrieval. Since this functionality is built into LAMDA it does not also need to be created in a GIS solution. However, since instrument retrieval is an important task for ROW activities, it is important to utilize ProjectWise links established through LAMDA during two specific GIS activities. First, when parcels are being created within the GIS system, it will be necessary to open LAMDA to enter parcel attribution. At this time, it will be useful to upload any instruments not already present in ProjectWise. Second, when researching property using the project GIS viewer, it will be useful for users to retrieve parcel instruments. The final design and methodology of the GIS ROW GIS system should incorporate the functionality described for these two activities.

Requirements for moving forward with this component include:

a. LAMDA Oracle Database Link (service)
b. Oracle client software (to consume information from LAMDA database)

2.4 Spatial Data Accuracy

There was no consensus during the forums for required ROW data spatial accuracy. Due to the nature of the data, which ranges from survey-level accuracy for new data to approximate locations from hand-drawn historic maps, no single value for accuracy is possible. Instead, it is necessary to develop categories of accuracy and apply these through attribution to inform users to ensure proper data use. For example, accuracy for a specific feature or features could be listed as SURVEY (< 0.5 feet), GIS (0.5 – 3.0 feet), APPROXIMATE (> 3 feet to 25 feet) and UNKNOWN. Primary requirements regarding recording the correct accuracy value include:

a. Metadata, or other information, for existing ROW feature data that indicates spatial accuracy
b. Understanding how accuracy is affected by specific data creation methods, including reference data

3. Entering Newly-Generated ROW Data into the GIS Database

The process for entering newly-generated ROW data into the GIS database falls into two categories, 1) Editing existing ROW features and parcels, or creating new features, based on new design and construction or real estate transactions, and 2) Linking new documents to edited or newly-created features.

3.1 Editing existing, or creating new, ROW features or parcels

Following completion, certification, and implementation of project-based designs, or parcel transactions, it is necessary to edit any existing, or create new, ROW features or parcels. This includes both feature editing and attribute editing and entry. Multiple methods may be used for updating the GIS database, including digitizing features directly into the GIS or importing data from existing MicroStation files. The requirements for this process are similar to converting data in existing ROW map sheets into GIS data and include:

a. Current ROW GIS database.
b. Established process for importing MicroStation data into GIS.

c. Access to MicroStation .DGN files for import into GIS database.
d. Access to GIS software (e.g., ArcGIS Pro) capable of importing .DGN files
e. Established methodology for editing or creating ROW and parcel features
f. Parcel legal descriptions, acquisition details and ownership information (parcel instruments)

Note: *Moving forward, it is suggested that a new requirement of surveyors (internal and contracted) is to provide GIS files following PA 132 completion. This would allow for the import of extremely accurate feature data into the ROW GIS.*

3.2 Linking new documents to edited or newly-created features

This task has the same requirements as document linkage when extracting features from existing ROW map sheets. Again, additional consultation with LAMDA administrators will result in establishing between parcel geography and attributes through a GIS-LAMDA database connection.

a. ProjectWise access to required documents
b. Comprehensive list of documents requiring linkage
c. GIS database structure supporting document linkage

4. Simplistic ROW Data Viewer

The scope of the project includes the authoring of a simplified data viewer that allows for data display and investigation. The best way to provide access to ROW data for these purposes is an online application. In this case, a searchable, map-based application is the preferred solution. While considerable functionality is available, it is important that the web application or applications designed for this project are simple and easy to use and do not include unnecessary functionality. Additionally, the web application(s) should leverage existing resources at the State of Michigan, such as hardware, software, and data. Lastly, data should be available to both SOM employees and the public. Requirements for this component include:

a. Access to the existing Enterprise GIS implementation at the State of Michigan
b. ROW GIS database, complete with data layers for all required features and established schema
c. Access to all datasets needed within the application
d. Defined functionality required for the system for both internal and external users
e. Web application authoring application

Existing, non-ROW GIS data layers whose accessibility within the viewer is deemed necessary are detailed in Table 2 below.

Table 2. Existing GIS data layers available from the State of Michigan or other agencies that may be available within the viewer.

Existing GIS Data Layers					
Item	**Description**	**Item Type**	**Attribution**	**Importance**	**Notes**
PLSS	Public Land Survey System Sections and Quarter Sections	Polygon Feature Class	Town, Range, Section, Quarter Section	High	From SOM DTMB
MCD	Michigan Minor Civil Divisions	Polygon Feature Class	Civil Division name	High	From SOM DTMB
County	Michigan Counties	Polygon Feature Class	CountyName	High	From SOM DTMB
Allroads	Michigan Roads	Polyline Feature Class	RdName	High	From SOM DTMB
Railroads	Michigan Railroads	Polyline Feature Class	RailroadName	High	From SOM DTMB
Rivers	Michigan Streams and Rivers	Polyline Feature Class	FeatureName	Moderate	From SOM DTMB
Lakes	Michigan Lakes and Ponds	Polygon Feature Class	FeatureName	Moderate	From SOM DTMB
Wetlands	Michigan Wetlands	Polygon Feature Class	WetlandType, etc.	Moderate	From USFWS
Culverts	Michigan Culverts	Polyline Feature Class	TBD	Low	From SOM DTMB - in progress
MIS	Michigan Imagery Solution	Orthoimagery	-	High	From SOM DTMB