DEPARTMENT OF TRANSPORTATION

GIS Tools and Apps—Integration with Asset Management

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Pro-West & Associates

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Asset management is critical for local and state governments to not only track assets but to also plan for maintenance of assets that will provide the greatest return on investment for the agency. The use of geographic information system (GIS) applications, tools and geospatial data can provide agencies with the most accurate inventory of assets, a basis to determine and maintain condition, cost-effective mobile tracking and maintenance of assets such as signs, culverts, roads and bridges, and reporting tools to justify asset expenditures.

The research team's two-part survey effort gathered information about the use of GIS mobile technology by Minnesota local agencies. A review of selected mobile technologies highlighted the specific tasks and functionality the technology provided to assist with an agency's asset-management program. Using this information and the results of extensive interviews with selected local agencies, the research team developed three case studies that offer recommendations for agencies at different stages in the use of GIS for asset management:

- Case Study 1: Getting Started
- Case Study 2: Utilizing Mobile Technology for Asset Management
- Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting

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LIST OF ABBREVIATIONS

AADT – Annual Average Daily Traffic

ADA – Americans With Disabilities Act

API – Application Programming Interface

AVL – Automated Vehicle Location

CAD – Computer-Aided Design

CORS – Continuous Operating Reference Station

CSAH – County State Aid Highway

CSV – Comma-Separated Values

DRG – Digital Raster Graphs

DTP – Develop/Test/Production

ELA – Enterprise License Agreement

EPA – U.S. Environmental Protection Agency

Esri – Environmental Systems Research Institute

ETL – Extract, Transform, Load

FDR – Full-Depth Reclamation

FEMA – Federal Emergency Management Agency

FTE – Full-Time Equivalent

GIS – Geographic Information System

GNSS – Global Navigation Satellite System

GPS – Global Positioning System

GRIT – Geographic Roadway Inventory Tool

HOLL – Hands-On Learning Lab

IAM – Institute of Asset Management

LACP – Lateral Assessment and Certification Program

LOMA – Letter of Map Amendment

LRS – Linear Referencing System

MACP – Manhole Assessment and Certification Program

MnCMAT – Minnesota Crash Mapping Analysis Tool

MnDNR – Minnesota Department of Natural Resources

MnGeo – Minnesota Geospatial Information Office

MOOC – Massive Open Online Course

MS4 – Municipal Separate Storm Sewer System

MXD – Map Exchange Document

NDSU – North Dakota State University

PACP – Pipeline Assessment and Certification Program

PCI – Pavement Condition Index

REST – Representational State Transfer

ROI – Return on Investment

RWIS – Roadway Weather Information System

SDE – Spatial Database Engine

SIMS – Structure Information Management System

UGPTI – Upper Great Plains Transportation Institute

VMware – Virtual Machine Ware

EXECUTIVE SUMMARY

Asset management is critical for local and state governments to not only track assets but to plan for maintenance of assets that will provide the greatest return on investment for the agency. The use of geographic information system (GIS) applications, tools and geospatial data can provide agencies with the most accurate inventory of assets, a basis to determine and maintain condition, cost-effective mobile tracking and maintenance of assets such as signs, culverts, roads and bridges, and reporting tools to justify asset expenditures.

However, GIS use for asset management varies among local agencies in Minnesota depending on agency size and urban/rural location, access to accurate and timely geospatial data, and the use of applications and tools, making it difficult for agencies to understand the best data processes, applications and tools to use. This project examined current local agency practices and reviewed existing mobile technologies to recommend best practices for the efficient, cost-effective use of GIS mobile technology by different types of local agencies in Minnesota seeking to better manage agency assets.

Information for this study, gathered in the three phases briefly described below, sought to address **three critical questions**:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond "what and where"?

Surveys of Practice

A two-part survey effort sought preliminary information about GIS use to categorize respondents; a follow-up survey gathered details from agencies using GIS and mobile technology to better understand the depth and breadth of agency services and practices.

Preliminary Survey

Level of GIS and Mobile Technology Use

The preliminary survey received 79 responses from 75 cities and counties. Relatively few respondents consider themselves to be fully integrated users of GIS (only 16.5%). Almost half of respondents use GIS for asset management without full integration; just over 6% of all respondents have used GIS for three years or less. Almost one-third of the agencies responding are nonusers of GIS. All but two of the nonusers expressed interest in using GIS to manage agency assets. Only two respondents have been using mobile technology to track assets in the field for more than 10 years.

Needs, Plans and Interests

Respondents are seeking a GIS tool that can be used for asset inventory that is simple to use for field staff, provides an asset history and allows for changes to assets in the field, and gathers accurate data in the field. Half of respondents have plans for some type of asset management data initiative in the next three years, and almost half of respondents expressed interest in collaborating with other local agencies on development of a suite of lightweight GIS apps for asset management.

Follow-Up Survey

Current GIS and Mobile Technology Practices

The follow-up survey received 33 responses from 32 cities and counties. Almost three-quarters of the respondents use Esri products, with almost all of these respondents reporting use of ArcGIS Desktop. Most agencies are supplementing the use of GIS tools with other methods and systems, most often with spreadsheets. Agencies are most often using tablets and GPS devices to capture field data. The GIS functions most often used by respondents are asset inventory, maintenance, field data entry, asset history and desktop mapping. More than 40% of respondents employ connected mobile collection practices. Low-end map grade and survey grade are the data standards reported most frequently by respondents.

Data Use

More than half of respondents are not using state-provided data. The respondents using state-provided data are most likely to use LiDAR or aerial imagery. Almost all agencies store asset data in more than one data format; respondents are most likely to store data as shapefiles. Almost 60% of respondents use some type of data model for collecting asset data.

Staffing Levels

Respondents are most likely to have dedicated GIS staff within various departments. The most typical staffing level among respondents is one or more full-time equivalent staff member. More than two-thirds of respondents plan to either hire or train GIS staff in the next three years.

Reviewing Mobile Technology

An online webinar demonstrated selected mobile technologies used in asset management by local agencies. The recorded demonstration included five presenters who described the software they used in various functions of asset management. The research team supplemented this demonstration with independent research about five of the software products often used by Minnesota local agencies. Detailed information about these software products appears in Appendix H.

Developing Case Studies

Using the information gathered through the surveys and follow-up contacts to selected agencies, the research team developed three case studies with recommendations for agencies at different stages in the use of GIS for asset management. Information culled from these case studies directly answers the **three critical questions** in Chapter 5, Mapping Assets in Minnesota, and the Quick Start Guide appearing in Appendix I.

Highlighted below is a sampling of the recommendations associated with each case study:

> **Case Study 1: Getting Started**. The goal of Case Study 1 was to answer this question: *What is out there for agencies to get started with GIS for asset management?* Agencies are advised to focus on starting simple and developing GIS for asset management incrementally. Use data models and make use of publicly available data. Select software to be configured in-house or by the vendor, and purchase only the software needed, possibly under a cost-sharing agreement. Consider outsourcing GIS for asset management when it's cost-effective and explore the use of shared positions for GIS

staff. Get started or grow without a dedicated budget by requesting funding for changing technology as a project rather than a program. Take advantage of user groups and low-cost or free training options to provide the training that is crucial to staff adoption of technology.

Case Study 2: Utilizing Mobile Technology for Asset Management. This case study showcases agencies using scalable, cost-effective mobile technology by GIS and non-GIS staff in the field. Smaller or rural agencies included in the case study have implemented mobile technology from out-of-the-box applications; larger agencies are using customized queries and work orders and provide administrative oversight. Case study agencies started with data models and configured applications to use data for tracking and reporting.

Creating asset teams to inform the mobile technology collection of asset locations guarantees ownership of the data product and creates buy-in from staff. Agencies are advised to purchase software that is capable of collecting assets in the field and easy to set up. Ensure needs are being met by conducting a survey of department needs before purchasing software or equipment. Recognize that mobile technology will standardize and automate field processes and provide tools to collect information that can be shared and used for multiple purposes, making better use of staff time. Training and technical support are crucial to staff adoption of technology.

Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting. The goal of Case Study 3 was to discover the agencies that have effective and efficient functioning GIS systems and document how it is done—what is being used for data development, software and staffing, what works best, and the lessons learned about what doesn't work. Recommendations for Case Study 3 move agencies to an enterprise level of asset management. The move to an enterprise level for asset management is tightly linked to the agency's organizational alignment, funding, resource availability, and need for GIS for asset management beyond knowing "what and where."

Case study agencies have data organization in common at the enterprise level. These agencies capture priority data as it is going to ground, ensuring up-to-date asset features. A paradigm shift is required for operative GIS for asset management—a shift to managing assets in a preventative manner. At this level, agencies must understand that return on investment will not be immediate. The success of GIS for asset management lies in continuous and tiered training for staff.

Critical Findings

Find some of this report's critical findings using the links below:

- Table 3. Critical Takeaways of the Case Studies. A quick review of case study findings.
- Table 4. Case Study Lessons Learned. Recurring themes gleaned from the case studies.
- Chapter 5, Mapping Assets in Minnesota. A comprehensive summary of study findings.
- Appendix B, Publicly Available Data and Data Models. Information about data models and data available for download or purchase.
- Appendix I, Quick Start Guide. Concise recommendations on how to get started with GIS and mobile technology or grow a great asset management system using these tools.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Asset management is critical for local and state governments to provide the greatest return on agency investments. Many agencies seeking to enhance agency asset-management practices to include or enhance the use of geographic information system (GIS) technology for asset management may lack the in-depth information and analysis needed to upgrade current practices. To provide information that can inform local agency decisions on the use of GIS tools for asset management, the research team gathered information about current agency practices and supplemented that information with an examination of current mobile technology, a review of relevant research and follow-up interviews with selected agencies.

This information-gathering effort culminated in the development of case studies that demonstrate proven processes for getting started or expanding GIS applications and tools for asset management. The case studies also recommend cost-effective, scalable options for taking an agency's GIS for asset management from the "what and where stage" to the use of more advanced asset management functions such as work orders, inspections and administrative dashboards. These case studies were used to develop a Quick Start Guide that addresses **three critical questions**:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond "what and where"?

1.2 PROJECT APPROACH

This research effort included the following tasks:

- Surveys of practice — Chapter 2
- Review of mobile technology — Chapter 3
- Development of case studies — Chapter 4
- Mapping assets in Minnesota — Chapter 5

1.2.1 Surveys of Practice

A two-step survey effort gathered information about the use of GIS technology by Minnesota local agencies to manage assets such as pavements, bridges, culverts and signs. A preliminary, high-level survey identified categories of practice with regard to the use of mobile technology for asset management and other GIS-related activities. A follow-up survey addressed the different user categories and probed for details of agency needs, interests and practices.

1.2.2 Review of Mobile Technology

An online webinar showcased a range of technologies used in asset management by local agencies. The demonstration included five presenters who described the software they used in various functions of asset management, the assets collected and managed using GIS mobile technology, and the specific tasks and functionality the technology provided in connection with an agency's asset management practices. The mobile technologies demonstrated in the online webinar included:

- Esri (ArcGIS Online, Collector, Survey123, Workforce)
- Cartegraph
- Cityworks
- Freeance
- Geographic Roadway Inventory Tool (GRIT)
- GeoMoose

1.2.3 Development of Case Studies

Case studies were developed to assist different types of GIS users in starting, enhancing or advancing their GIS practices to collect and manage data on agency assets, including the use of mobile technology. Three case studies represented different levels of agency engagement with GIS:

- Case Study 1: Getting Started
- Case Study 2: Utilizing Mobile Technology for Asset Management
- Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting

1.2.4 Mapping Assets in Minnesota

Chapter 5, Mapping Assets in Minnesota, brings together the findings from this multifaceted research effort to answer **three critical questions**:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond "what and where"?

A condensed version of the information in Chapter 5 appears as a Quick Start Guide (Appendix I).

1.3 REPORT ORGANIZATION

Findings from this study are presented in six chapters. Chapter 2 provides a high-level summary of results of two surveys of practice that sought information about the use of GIS technology by Minnesota local agencies to manage assets such as pavement, bridges, culverts and signs. Chapter 3 is a review of some of the mobile technology available to collect and manage asset data in the field. Chapter 4 provides a high-level summary of three case studies developed using the information gathered from the surveys and evaluation of mobile technologies. Follow-up interviews with agencies with relevant

experience also informed the case studies. Chapter 5 describes how Minnesota agencies at all levels of sophistication can map agency assets using GIS technology, and Chapter 6 offers a brief summary of findings and conclusions. Following Chapter 6 are appendices that provide supplemental information about the research team's activities and a Quick Start Guide for agency application of the research findings.

CHAPTER 2: SURVEYS OF PRACTICE

The research team conducted a two-part survey effort that sought information about the use of GIS technology to find out what is successfully being used by Minnesota local agencies, and what can be developed to get started with managing assets such as pavement, bridges, culverts and signs.

- *Preliminary survey*. This survey identified categories of practice regarding the use of mobile technology for asset management and other GIS-related activities.
- *Follow-up survey*. Distributed to agencies indicating experience with GIS in the preliminary survey, this survey probed for details of agency tools and practices.

The survey questions for both surveys are provided in Appendix C.

2.1 PRELIMINARY SURVEY

The preliminary survey was distributed to Minnesota Department of Transportation's (MnDOT's) county and city engineer distribution lists and sought general information about each agency's needs and interests in connection with GIS, the agency's level of experience with GIS and mobile technology, and respondents' plans, practices and interests associated with asset management.

Findings from the preliminary survey are important for agencies to discern where they fit in the statewide GIS asset management landscape and allow them to learn from other agency accomplishments. For those agencies not yet using GIS for asset management or agencies just getting started, knowledge of GIS use in the state supports efforts to gain funding and buy-in from local agency administration.

A brief summary of key findings from the preliminary survey appears below. Further details of preliminary survey findings are included in Appendix D.

2.1.1 Using GIS to Manage Agency Assets

The survey sought to categorize respondents based on their agencies' current use of GIS to manage agency assets. Survey responses organized agencies into one of five categories[1]:

- Group 1: Fully integrated users of GIS for asset management
- Group 2: Using GIS for asset management without full integration
- Group 3: Using GIS for asset management for three years or less
- Group 4: Nonusers interested in using GIS to manage assets
- Group 5: Nonusers uninterested in using GIS to manage assets

[1] The categorized respondents were used to select and interview respondents to inform the three project case studies presented in this report.

Figure 1 illustrates the categorization of respondents into the five groups based on their agencies' use of GIS.

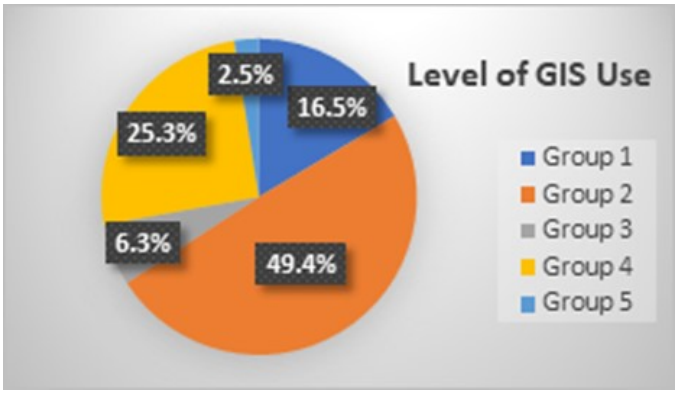

Figure 2.1 Categorizing Respondents Based on the Use of GIS in Managing Assets

Only 16.5% of respondents consider their agencies to be fully integrated users of GIS. Almost half of respondents (49.4%) use GIS for asset management without full integration; just over 6% of all respondents have used GIS for three years or less.

Almost one-third (27.8%) of the agencies responding are nonusers of GIS. All but two of the nonusers responding to the survey expressed interest in using GIS to manage agency assets.

The same respondent provided responses for the two counties in Group 5, noting the lack of resources (equipment and employees) as the reason these counties are uninterested in pursuing the use of GIS to manage assets.

2.1.2 Needs and Interests

When asked what would be required for their agencies to use GIS to manage assets, Group 4 respondents—nonusers interested in using GIS—most frequently cited additional staff, funding and time, user-friendly software, implementation guidance, and better organization of asset inventories.

Respondents were asked to rank eight general functions associated with the use of GIS for asset management, with 1 being most important and 8 being least important. Averages of respondents' rankings are reflected below, in order from most to least important:

- Asset inventory = 1.81
- Condition assessment = 2.91
- Determine appropriate maintenance = 3.87
- Determine appropriate Capital Improvement Plan = 4.51
- Assign risk/criticality = 5.06
- Determine replacement cost and date (life cycle costing) = 5.11
- Determine residual life = 6.28
- Set target level of service = 6.30

Information about agency needs and the eight important general functions identified in the survey provided a starting point to examine what agencies are successfully using and what is out there for agencies to get started, as well as what exists for mobile technology and what can be developed.

2.2 FOLLOW-UP SURVEY

To further define the needs, successes, and available resources and software, the research team distributed a follow-up survey to selected agencies responding to the preliminary survey (all respondents categorized into Groups 1, 2 and 3, or respondents reporting some level of experience with GIS). The follow-up survey gathered details of agency practices in the following topic areas:

- **Agency use of GIS tools**. The survey sought information about the specific products used, other methods or systems employed, types of mobile devices used, and the GIS-related functions agencies currently use and would use if made available.
- **Agency use of mobile technology**. Respondents were asked about investments in mobile technology, the collection of asset data and data accuracy.
- **Asset management system integration**. Respondents indicated whether separate systems are used to manage different asset types, and if mobile data technology integrates with other local government processes.
- **Data**. The survey sought information about agency use of state-provided data, the frequency with which data is collected, data formats and the use of data models.
- **Other technologies**. Respondents described their agencies' IT infrastructure, and their use of imagery for asset data digitization, and LiDAR and drones for asset data collection.
- **Staffing and training**. Respondents described current and planned staffing allocated to GIS activities and any formal training provided to staff regarding software use and field data collection.
- **Lessons learned**. The survey concluded with a request for respondents to describe successes and challenges associated with their agencies' use of mobile technology for asset management and provide any relevant documentation.

See Appendix E for a comprehensive review of findings from the follow-up survey. Key information collected from the follow-up survey is also presented in other sections of this report.

CHAPTER 3: REVIEW OF MOBILE TECHNOLGY

3.1 AGENCY USE OF MOBILE TECHNOLOGY

The use of mobile technology to collect and maintain locations and attributes for assets is mission-critical for asset management. **Mobile technology standardizes and automates field processes** and provides tools to collect information that can be shared and used for multiple purposes—collect once and use many times. The project surveys queried respondents to determine what currently exists and options for development to assist agencies in moving forward with mobile technology or expanding on current practices.

While 61.1% of counties have been using mobile technology to track assets in the field for five to 10 years, just 38.9% of cities have been using mobile technology during this period. For those agencies not yet using mobile technology, 63.2% are planning to implement mobile technology in the next year.

Table 1 provides the reasons respondents cited for not using mobile technology to track assets in the field[2]. While some agencies are preparing to add this technology, others reported a lack of resources and staffing- and technology-related concerns.

Table 1. Reasons for Not Using Mobile Technology to Track Assets in the Field

Category	Reason for Lack of Use
Accuracy Concerns	GIS not integrated into asset management system; agency gets better accuracy using a Trimble unit.
Adding Mobile Technology	Currently working on adding a mobile solution for sign management.
	Migrating to a new asset management system that will have mobile capabilities (phone and tablet apps); new system will integrate with the agency's GIS system.
	Purchasing GIS enterprise January 2020 and will begin using GIS mobile technology to track assets in the field.
Decision in Process	Agency "in the middle of the process to better utilize mobile technology."
Lack of Resources	Insufficient resources.
	Lack of equipment and training.
	Lack smartphones to use the technology.
	Lack the technology to do so.
	Requires data subscription.

[2] Use of mobile technology by agencies in Group 1: Fully integrated users of GIS for asset management, and Group 2: Using GIS for asset management without full integration, along with mobile needs and reasons for lack of use informed development of Case Study 2: Utilizing Mobile Technology for Asset Management.

Category	Reason for Lack of Use
Multiple Areas of Concern	Costs, time constraints, lack of expertise/experience in users, lack of expertise/experience in technical staff to design, set up and manage a fully integrated system.
	Not found an easy, inexpensive, user-friendly option yet.
Staffing-Related Concerns	Lack staff experienced in GIS.
	Learning curve.
	Starting but progress is slow due to lack of IT staff to get it going and user knowledge.
Technology-Related Concerns	Need to update tablets with GPS.
	Technology does not give the same capability.
Technology Not Needed	Not needed at this time.

Respondents indicated no consensus in practice when asked about the data accuracy standards they employ. The data accuracy **least likely** to be employed by respondents: recreational grade (30 to 100 ft). Low-end map grade and low-end survey grade units were reported **most frequently** by respondents.

To gain a better sense of what exists and/or can be developed for mobile technology, the preliminary survey, follow-up survey and case study interviews focused on key areas such as software use, examples of data collection, staff resources required, and interest by agencies for collaborative development of work order and other field applications and tools.

3.2 ASSET MANAGEMENT SOFTWARE DEMONSTRATIONS

An online webinar showcased a live demonstration of asset management technologies used in asset management for local agencies. The recorded demonstration included five presenters who described the software they used in various functions of asset management, the assets collected and managed using GIS mobile technology, and the specific tasks and functionality the technology provided in connection with an agency's asset management practices. Below is a summary of the five demonstrations. Additional software use relevant to field data collection and mobile use is documented throughout this report.

3.2.1 Geographic Roadway Inventory Tool (GRIT)

Brad Wentz, from North Dakota State University's (NDSU's) Upper Great Plains Transportation Institute (UGPTI), demonstrated the Geographic Roadway Inventory Tool (GRIT), an online web application that shows linear highway transportation assets including construction history, construction planning and load restrictions. GRIT was initially developed by UGPTI to assist in a needs study for the State of North Dakota. Using Becker County, Minnesota, as an example, Wentz showed the GRIT inventory process, including creating and editing linear roadway and maintenance data, accessing construction history, and adjusting linear segments in real time. The GRIT application can be used on tablets and smartphones, and data in the application can be published to a GIS service, such as ArcGIS Online.

3.2.2 GeoMoose

Christy Christensen, McLeod County, demonstrated GeoMoose, a free and open source GIS software built on a Web Client JavaScript Framework for displaying distributed cartographic data. Christensen demonstrated accessing culvert asset data. Imagery and construction plans are included and can be accessed by a link within the data feature. For McLeod County, about 15 staff collect various assets and information in the field on tablets. When data collection is completed, staff bring tablets back to the office and manually sync to and from the GeoMoose software.

3.2.3 Cityworks and Freeance

Matt Reitter, City of Minnetonka, demonstrated Cityworks and Freeance. Cityworks is a GIS-centric enterprise asset management system that manages, tracks, analyzes and scores infrastructure assets. It is integrated with Esri ArcGIS. Freeance is a third-party software that is partnered with Esri, Cityworks and Microsoft for integrated use. Reitter demonstrated how staff use Freeance as a mobile solution to complete inspections, work orders and service orders in the field and in the office through its GPS Collector, Mobile for Cityworks and Leak Survey apps.

3.2.4 Cartegraph and Esri's Survey123

Perry Clark, Carver County, demonstrated Cartegraph and Esri's Survey123 application. Cartegraph is a software that tracks assets, condition, cost and work history. Asset data in Esri ArcGIS shares a bi-directional integration with Cartegraph. Clark demonstrated how field staff are able to receive and complete work orders using the Cartegraph One app on iPhones and using the Cartegraph for iPad app. Workers log in to view assigned tasks, input data related to the work order ticket, and attach photos of assets. This method records labor done on a task and any equipment, mileage or materials used and allows the county to track cost on the asset where the work happens. Part of the Esri Geospatial Cloud, Survey123 is used by Carver County to create, share and analyze data. Clark discussed how paper inspection forms were migrated to Survey123 for county parks to provide a user-friendly environment for staff to record maintenance on park equipment. Clark also explained how Cartegraph is used to monitor the life cycle of an asset, forecasting costs and budgeting for future needs.

3.2.5 Various Esri Products

Kyle Wikstrom, Pro-West & Associates, demonstrated the life cycle of a street sign using Esri products such as ArcGIS Online, Survey123 and Workforce. Wikstrom showed how Collector for ArcGIS can be used in online/offline modes, methods to customize symbology, and use of related tables for asset history and maintenance records in conjunction with the app. He demonstrated a configured sign manager app built using ArcGIS Web AppBuilder containing street sign tables and various tools to query information. The user fills out the form, adds photos of an issue, and using a citizen report manager feature communicates the issue to staff for review. Using Workforce for ArcGIS, Wikstrom showed common asset management tasks such as inspection reporting, identifying signs that need inspections, creating an inspection work order, editing the assignment, collecting additional information, and

integration with Collector for ArcGIS. Approximate costs for these Esri apps are subscription-based and vary.

3.2.6 Mobile Technology Software Use

Software were also reviewed by the Pro-West team based on use by survey respondents and case study participants: Esri products, Cartegraph, Elements XS, GRIT and ICON. Software use relevant to field data collection and mobile use is documented in Chapter 5, the Quick Start Guide and Appendix H, Software Matrices.

CHAPTER 4: DEVELOPMENT OF CASE STUDIES

4.1 BACKGROUND

Using guidance from the Technical Advisory Panel (TAP), results of two surveys that gathered information about current Minnesota city and county practices and plans for the use of GIS in managing agency assets, and a series of follow-up interviews and additional research, the research team developed three case studies with recommendations for agencies at different stages in the use of GIS for asset management:

- Case Study 1: Getting Started
- Case Study 2: Utilizing Mobile Technology for Asset Management
- Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting

Agencies were chosen from the preliminary and follow-up surveys to inform each case study. Seventeen interviews were conducted with agencies at the county and city levels, supplemented by interviews with four state agencies and five software vendors. Interview participants were selected from the preliminary and follow-up surveys based on responses for level of GIS for asset management use, mobile technology use, software integration, staff engagement and data development status.

4.1.1 Six Key Agency Needs

Six key agency needs were identified and further developed by reviewing and summarizing responses to the two surveys. Table 2 highlights these six key agency that are used to structure the case studies described in this report.

Table 2. Six Key Agency Needs

Data Development and Management	• Data development planning, creating, storage and use
Software	• Practical and user friendly • Simple tools for non-GIS staff to use
Staff	• Staff skills and allocated time to create, expand and maintain the data • Staff resources to manage a system
Funding	• Purchase, development, implementation and maintenance of a system • Need a champion • Understanding of costs and benefits—benefits outweighing cost
Equipment	• Hardware to collect and manage GIS asset data
Training	• Guidance for implementation and assistance to set up a system • Effective, proven approach

Information related to creating buy-in, champions, and asset management concepts and planning were not included in this project about GIS for asset management since those topics have been researched and reported nationwide and in Minnesota in the past few years. Published research and other relevant publications examined by the research team appear in Appendix A.

Chapter 5 offers highlights from the three case studies, providing important takeaways from survey findings and follow-up interviews. Appendix F includes supplementary interview narratives for the case studies. These narratives present the results of extensive interviews with agencies describing their experiences with GIS and mobile technology. Included are descriptions of effective practices and recommendations for other agencies wishing to replicate these experiences. Detailed descriptions of the software addressed in these narratives and the case studies appears in Appendix H.

4.2 CASE STUDY 1: GETTING STARTED

The goal of Case Study 1 was first mentioned during TAP meetings for the project, echoed in the survey questions, and then validated by responses to the surveys and interviews with agencies: **What is out there for agencies to get started with GIS for asset management?**

As stated during an agency interview, using GIS for asset management requires a paradigm shift for agencies from reactive to proactive. The principles applied to equipment maintenance for practical and preventative measures should be applied to all assets. These maintenance principles include appropriate and timely maintenance, considering asset features (not an entire roadway), and targeting life cycle and asset performance rather than only maintenance and cost of maintenance.

The recommendations in Case Study 1 focus on starting simple and developing GIS for asset management incrementally to meet each agency's individual needs. Recommendations were informed by survey responses, agency interviews and research.

See Chapter 5 and Appendix F for further details of Case Study 1.

4.3 CASE STUDY 2: UTILIZING MOBILE TECHNOLOGY FOR ASSET MANAGEMENT

Information presented in Case Study 2 serves as a baseline of GIS for asset management using mobile technology.

The goal of Case Study 2 is to provide information about GIS systems used in the field for inventory, data collection, work orders, software use and staffing. This critical case study showcases agencies using scalable, cost-effective mobile technology by GIS and non-GIS staff in the field. Smaller or rural agencies included in the case study have implemented mobile technology from out-of-the-box applications; larger agencies are using customized queries and work orders and provide administrative oversight.

Each agency highlighted in the case study has performed mobile collection starting with data models and configured applications to use data for tracking and reporting.

See Chapter 5 and Appendix F for further details of Case Study 2.

4.4 CASE STUDY 3: MOVING BEYOND "WHAT AND WHERE" TO ANALYSIS AND FORECASTING

Case Study 3 builds on recommendations from Case Study 1 and Case Study 2.

The goal of Case Study 3 was to discover the agencies that have effective and efficient functioning GIS systems and document how it is done—what is being used for data development, software and staffing, what works best, and the lessons learned about what doesn't work.

Recommendations for Case Study 3 move agencies to an enterprise level of asset management. Not all agencies have the need, desire or resources to conduct asset management for GIS at this level. Moving to an enterprise level for asset management is tightly linked to the agency's organizational alignment, funding, resource availability, and need for GIS for asset management beyond knowing "what and where." Every organization's needs are unique at the enterprise level.

For Carver County, organizational preparation was key to the success of GIS for enterprise asset management. As a best practice, the County has implemented GIS and asset management in a cross-division arrangement that ensures data and processes are not siloed. In addition, developing GIS for asset management beyond knowing location for an asset requires knowing what is sustainable for an agency. While developing suites of lightweight applications may meet the needs of smaller agencies, sustainability of many applications may become an issue due to the resource skills and time needed to develop and maintain, or the growing demand for technical support as a GIS program grows.

Enterprise-level organizations understand that organizational alignment is key to support GIS for asset management at the enterprise level. Staff require empowerment to define and execute the processes, becoming authoritative for their area of expertise. As an example, Carver County's asset management program wasn't built overnight but began showing benefits incrementally. Enterprise asset management software required two years to implement but it built upon eight years of GIS work in preparation.

See Chapter 5 and Appendix F for further details of Case Study 3.

CHAPTER 5: MAPPING ASSETS IN MINNESOTA

Questions from the project TAP at the beginning of the project were investigated with preliminary and follow-up surveys to discover the state of GIS for asset management in Minnesota and to get insight into what works and what doesn't work for agencies. The surveys were followed by demonstrations of location-focused asset management software used by TAP members and survey respondents. Both the surveys and software demonstrations provided direction for conducting more than 26 interviews with local government and state agencies, and vendors to develop case studies. The culmination of TAP input, surveys, demonstrations and case studies is presented here in response to these initial questions:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond "what and where"?

In addition, a Quick Start Guide to assist agencies getting started is included as Appendix I. Full case study interview narratives are included as Appendix F.

5.1 WHAT IS OUT THERE FOR AGENCIES TO GET STARTED?

WHAT CURRENTLY EXISTS FOR MOBILE TECHNOLOGY AND WHAT CAN BE DEVELOPED?

5.1.1 Data Migration, Collection and Development Examples

Most agencies are supplementing the use of GIS tools with other methods and systems, most often with spreadsheets (84.8%) and PDF maps that link to other systems (24.2%). An agency getting started using GIS for asset management will need to set priorities for data migration from spreadsheets and PDF documents to data development and data collection to fit available staff resources and their own agency's needs.

Survey respondents were asked if their agencies are planning some type of asset management data initiative in the next three years. Half of respondents do have such plans. These plans include expanding data collection to include new asset groups, integrating asset management software and survey tools with GIS, and updating all asset data using mobile devices. Forty-three percent of respondents do not have plans for an asset management data initiative but are interested in reviewing options and costs. Just 7% of respondents have no plans or interest in pursuing such an initiative.

Figure 2 provides a summary of all survey responses.

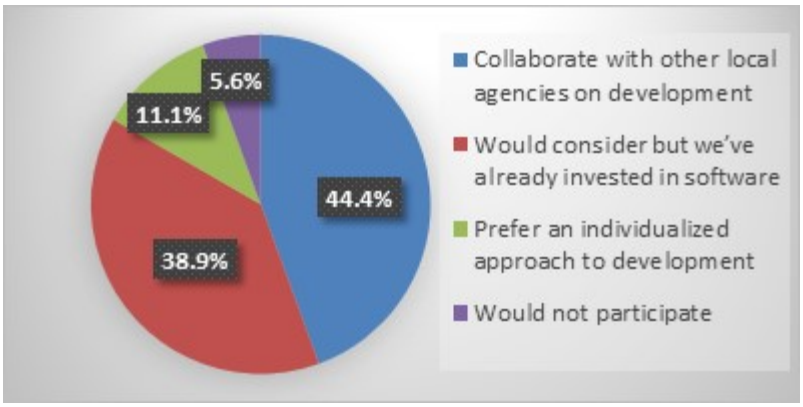

Figure 5.1. Respondent Preference for Participation in Development of GIS Apps

Data priorities from the surveys and mobile data collection common to the case studies are highlighted below.

There are several ways to collect data depending on the staff and equipment resources of an agency. The examples below highlight mobile data collection and heads-up digitizing discovered from case studies. Successful data development occurred when agencies used the highest level of accuracy that was cost-effective to collect asset data, eliminating the need to recollect data again in the future as unforeseen data needs surfaced.

Don't underestimate the value of planning data collection and development. It is a temptation to purchase software and equipment and then jump into a collection process. The most successful collection efforts by agencies occurred when asset database development is a coordinated effort between GIS and maintenance workers, technicians and engineers. The staff who will work with the asset data should be the staff who assist with development of the data model to ensure data relevancy and effective, efficient data. Staff need data ownership.

Brainstorm attributes and collection information with staff on a trial basis and review after being used in the field. **Ask questions of the data** to determine if collected correctly and if the data will meet the needs of the department.

- **St. Louis County** used the Esri Collector for ArcGIS application to **develop data in a pilot project** that could be used as representative for mobile data collection for other assets. A pilot project builds on a mobile collection process, incrementally adding other assets as the process is proven. An agency should plan for an explosion of requests to collect assets as mobile technology is proven and adopted by staff.

5.1.1.1 Start Simple

If an agency has not begun mobile data collection of asset locations and information, starting with simple collection and building a program based on priorities and lessons learned is the best option. Below are examples of data collection and digitization conducted by Minnesota local government agencies.

SIGNS

Signs are an example of a simple mobile data collection process that is common to all GIS for asset management needs.

The field process used for signs can also be used to collect many other asset features, including, but not limited to, culverts, erosion, potholes, guardrails, ADA inventory, bridges, noxious weeds, playground equipment, signalized systems or pavement markings.

- **Jackson County** hired a summer student worker for 1.5 summers (approximately 4.5 months of part-time work) to collect 5,000 signs.

  Software used: Esri Collector for ArcGIS configured application on a tablet with Bluetooth linked to a Trimble GPS receiver for sub-meter accuracy. The data model was migrated from SimpleSigns software with a full history for each sign. Migration from SimpleSigns to Esri Collector was done to enable use of GPS Bluetooth capability when collecting in the field. Cost: one free Collector license with each seat of ArcGIS Desktop or Pro.

  Staff resources required: Jackson County staff configured and maintain the Collector app. Configuration required staff skilled in Esri Collector configuration and one day of staff time. A non-GIS student worker collected the sign information with minimal training and oversight. Cost: The cost for the student worker and the tablet to collect the signs and input attributes was approximately $3,000.

  Other equipment required: Trimble GPS receiver, sub-meter accuracy $12,000-$14,000 (if cost is a limiting factor, GPS receivers are available at meter accuracy with a cost of $2,500); tablet $300.

  Challenges: Attracting GIS and non-GIS workers for hiring to collect data can be difficult for a rural county.

  Successes: For Jackson County it worked to start simple and build a program. Teaching non-GIS staff to run GIS applications for asset management "has been a game changer."

- **St. Louis County** is an example of **the power of a simple application** configuration. The County collected 40,000 signs, up to 100 signs a day, taking 100 pictures a day. The collection rate was doubled when there were two crews collecting data. The simple Esri Collector application was able to handle the collection intensity, and the proven process was used for six additional asset types.

  Software used: Esri Collector for ArcGIS configured application

  Staff resources required: The Public Works Department has two GIS specialists to manage all data development and application support. Both GIS specialists are dedicated 100% to the Public Works Department.

Equipment: In the field, staff are using cell phones, laptops, tablets and GPS (Bad Elf and Garmin) units for mobile data collection. Public Works owns and maintains its own GIS-related equipment.

Cost to get started with mobile technology: Initial cost: Less than $10,000 (cost of mobile devices only, server infrastructure already existed). Maintenance cost: Less than $10,000 (cost of mobile devices only, server infrastructure already existed).

Challenges: As Collector applications are being configured and loaded onto tablets, the need for internal support has increased. Tablets don't work all the time, and staff need to become acclimated to the new ways of collecting and using data. During the first few months of implementing mobile technology there were hiccups; staff complained that the technology was a "piece of junk" that "didn't work." It was crucial to have immediate support in place to support users.

Successes: The use of mobile technology in St. Louis County has had proven benefits. The County is large geographically requiring two crews of staff each collecting data and pictures. The sign crews are now dependent on the application and process after using it for two years. They even like it.

- **Beltrami County** began data development in the Highway Department with the collection of road signs. Also, ditch inspections are performed on an Esri Collector application configured for Ditch Inspections. Some asset data continue to be managed in spreadsheets and mapped in the office by segment of road, such as dust control status, striping and weed control.

  Software used: Esri Collector and GRIT. The County is currently testing GRIT software. The County would be interested in further collaborative development of GRIT for functions not currently in the program such as reporting and budget forecasting.

  The County has also been using ICON for some roadway analysis during the past seven years. The pavement deterioration curve in ICON software is preferable to the standard curve in GRIT software for calculating the performance curve.

  Staff resources required: Data collection and inspections are conducted by Highway Department and Environmental Services Department staff. Summer GIS intern staff to collect attributes on roads, including year built, width, depth and construction history, as needed for GRIT use. Construction program features are also input to the data and utilized by the software.

  Equipment: Location data are collected by staff starting with laptops, and now using tablets as well. Spreadsheets store unique IDs and sign attributes. In the future, staff will be using GPS units (Trimble) to collect condition data.

  Cost to get started with mobile technology: Summer intern salary. The County doesn't have a dedicated budget for asset management or mobile technology.

Challenges: Although ICON is favored for some analysis, the software is complicated for staff. A consultant runs the software as needed for the County, and the County uses ICON technical support when updates to the data are required.

Successes: GRIT software has been a benefit to the department because it is simple to use for staff that need to pick it up and put it down without a significant time investment to learn or retain knowledge. GRIT meets the County's need for functionality, however more output as reports and greater ability to extract information for use in other GIS applications are requests for enhancement of the software.

CULVERTS

Culverts are another asset feature considered important by survey respondents. Digitizing asset features using a heads-up digitizing method, such as the culvert digitization method below, is another option for capturing asset data. The most efficient method for digitizing or collecting data will be dependent on staff skills and staff resource time, and resolution of available imagery.

- **Washington County (heads-up) digitized culverts** using Pictometry 6-inch imagery as base data. Georeferencing plans, digitizing and updating GIS data required approximately 40% to 50% of 1 FTE for four to six months. The County maintains approximately 800 culverts under county roads, each with an inlet and outlet point to total 1,600 points requiring field checking. Data are field checked as an ongoing process as time allows.

  Software used: The County is using an agency-designed data model, with data hosted in ArcGIS Online, providing web access and a SQL Server database. Washington County relies on a combination of Esri products, ICON software and spreadsheets to conduct asset management.

  The Public Works Department uses dashboards and web map viewers to display and analyze the data that are created using Esri's Web AppBuilder and ArcGIS Online. The platform primarily is used to share information with engineering staff and administrators, such as scanned plans associated with a segment of road. All engineering staff have ArcGIS Online accounts.

  The use of ArcGIS Online streamlines the use of GIS for asset management since all data is in the same location, and the dashboard and applications all look and function the same. This also allows the use of apps to be simple and user-friendly.

  ICON software is used for Pavement Condition Index (PCI) rating and pavement data. Data is acquired from MnDOT for the video log and input into ICON. The County is able to analyze the degradation of PCI ratings over time. The data in ICON is extracted to merge with centerline features to make maps in Esri ArcGIS.

  Aerial imagery cost: Imagery is flown every two to three years, sometimes as part of a collaborative effort with other agencies in the region. **NOTE**: Cost of aerial imagery for an individual agency will vary based on geographical size and imagery resolution, and contracts specific to the agency. Washington County imagery costs:

- Standard 6” orthophotography average around $50,000.
- Pictometry (includes obliques) flight cost $120,000. The county budgets $60,000 a year from the Recorder Technology Fee to pay for aerials.

SIGNAL WORK ORDERS

- **Washington County** paper signal work orders have been converted to Esri Survey123. Orders are entered into a digital form on an iPad and stored in ArcGIS Online. Work order information is exported as an Excel spreadsheet and forwarded to the accounting unit for billing. The signal work order application will likely expand to other uses.

  Staff resources required: Charlie Parent, Engineer Technician, maintains the Esri applications. Development of asset databases was a coordinated effort between GIS and maintenance workers, signal techs and engineers to create a process based on the workflow of the specific staff. Occasionally, a field is added to the data. **The technical staff who work with the asset data are the staff who helped develop the data model and ensure data relevancy. There is ownership in the data.** Staff want effective, efficient data because they need to work with the data for their daily jobs.

  Equipment used: Within the Parks and Highway departments there are approximately 20 tablets. iPads are used for data collection using the Collector application and Bluetooth connected to a Trimble R1 for sub-meter accuracy. The Trimble R1 receiver is shared by the Parks and Highway departments.

  Challenges: The workload for the dedicated staff varies depending on the projects for the year. Time management is a challenge. **Time to locate and organize information was a limiting factor** for developing asset data. Case study feedback from agencies indicate that it required more time to gather information from project files, CAD drawings, paper documents and staff knowledge than the amount of time that was required to enter the information into the software.

  Successes: The success of GIS for asset management is in training non-GIS staff to collect and update asset data so it’s not just the “GIS guy.”

5.1.2 Software Options

For agencies just getting started in GIS for asset management, migration of data and processes should be conducted as is appropriate or cost effective for the agency. That means the most cost-effective method for budgeting or planning within small agencies getting started may still be spreadsheets, as reported in the project survey and by case study agencies. Take into consideration whether GIS mapping technology is crucial for the specific asset management process before selecting a software. The best solution for your agency may be a combination of spreadsheets, scanned documents and focused software to fit your agency’s immediate needs.

The highest-rated application features as discovered in the preliminary survey for GIS asset management software include:

- Simple to use for field staff
- Field collection accuracy
- Maintain asset history/changes to asset
- Input maintenance work/activities and history
- Provide condition rating
- Provide mapping and reporting

In the experience of the case study participants and the Pro-West team, it is essential to select software options that are scalable to perform functions from simple data collection, display and query, to more complex analysis and administrative functions. Case study and vendor interview information below provides mobile technology software specifications. As discussed during project TAP meetings, and in comments from the surveys and case study participants, mobile technology software requirements include:

- Cloud-based so that applications and tools don't need to be installed or maintained on-premise, lessening the need for a dedicated GIS or IT professional to maintain the software.
    - Data and software stored and served from the vendor's web-accessible cloud-based system.
- Unlimited users to enable scaling number of users as the system grows.
- Easy to use mobile capability to collect asset location and attributes in the field by non-GIS staff on any mobile device including phones, tablets and laptops.
- Work order functionality in the field. Work order functionality is currently available for all software except GRIT, which plans to develop work order functionality in the future.
- Data schemas included in the application or software that can be edited to fit the agency.
- Capability to integrate asset databases with other agency systems.
- Ability to iteratively develop applications such as Esri products for specific tasks, GRIT enhancement or Cartegraph focused applications. Developing asset-focused applications iteratively by priority and over time allows an agency time to vet and become familiar with the function before developing the next application. Each enhancement or focused application creates buy-in from staff and administration based on end user success.

Agencies successful in the use of mobile technology for asset data collection conducted a survey of department needs prior to software demonstrations from vendors to ensure needs are being met when selecting software. The software should fit the agency.

Keep in mind that **more is not necessarily better.** Agencies should start simple with scalable software apps and tools focused on small agencies, then increase the asset types being collected and add asset types and apps over time. Staff become familiar with an interface so extending the interface to collect additional assets will be confirmation of a proven process.

All software listed below are capable of collecting assets in the field and can be configured and maintained by the vendor or the agency. Each software has practical and user-friendly interfaces, focused solutions for asset management, and pricing intended for small agencies. Contact the points of contact for specific details. See Appendix H, Software Matrices, for software specifications.

Cartegraph

Cartegraph has two options for small agencies.

1. **Cartegraph focused applications:** Cartegraph just rolled out three focused applications with no installation required for tools that meet a focused need. The applications are configured for the following functionality:
    1. Signs and work orders
    2. Pavement
    3. Parks & Rec (largely playground assets)
    - Web-based apps
    - Mobile collection module for field collection
    - Unlimited users
2. **Cartegraph Essentials:**
   Cartegraph Essentials is a product developed for small agencies.
    - Cloud-based
    - Mobile applications for field collection
    - Asset inventory and inspections
    - Work management
    - Resource management
    - Dashboard and reports
    - Embedded maps
    - Esri integration
    - Cartegraph will discount the above services fees: 2-5 customers receive 50% discount on Implementation Services costs; 5+ customers receive 75% discount on Implementation Services costs. Discount requires group of customers to sign agreements with Cartegraph within 30 days of each other and adhere to a similar implementation schedule.
    - Contact: Kent Hartsfield
      Cartegraph
      kent.hartsfield@cartegraph.com
      Phone: 630-935-8288

Figure 5.2. Cartegraph Mobile Asset Management Interfaces

CARTEGRAPH FOCUSED APPS

- Sign and Work Order Management

Population	Cost
0-10,000	$1,500
10,001 – 24,999	$2,500
25,000 – 49,999	$5,000
50,000+	TBD

- Pavement and Work Order Management

Population	Cost
0-10,000	$2,500
10,001 – 24,999	$4,500
25,000 – 49,999	$7,500
50,000+	TBD

- Parks and Recreation

Population	Cost
0-10,000	$1,500
10,001 – 24,999	$2,500
25,000 – 49,999	$5,000
50,000+	TBD

CARTEGRAPH ESSENTIALS

$7,500 for software installation
Software cost based on population size

Population	Annual Cost
0 – 5,000	$2,920
5,001 – 9,999	$3,512
10,000 – 14,999	$4,760
15,000 – 24,999	$7,520
25,000 – 39,999	$9,450

Figure 5.3. Costs for Cartegraph Focused Apps and Essentials

Elements XS

Novotx works with the customer and customizes Elements XS to fit the organization size and workflows. Elements XS is a scalable enterprise software system.

The software is not modular based; the software is for the entire agency. Licensing available for a county and the cities within the county. Unlimited users.

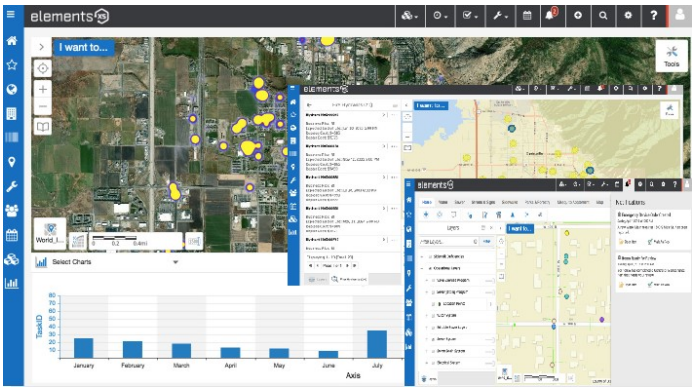

Figure 5.4. Elements XS Work Order, Reporting and Field Interfaces

Functions include: inventory management, routine maintenance, service requests and work orders, fleet management, facilities maintenance, permits, licenses, inspections, citizen requests, mobile interfaces for tablets and phones, real-time utility billing integration, GIS-centric, notifications and triggers for admin and field staff, auto-generated service orders, maintenance scheduling, analysis of user-defined datasets, automated job routing, real-time (not a nightly batch update), and user-defined data collection forms.

Designed for:

- Streets, traffic and public works
- Water, sewer and storm utilities
- Gas and electric utilities
- Planning and zoning
- Parks and recreation

- System functionality is the same regardless of whether hosted or on-premise. Data is stored in a central repository. Configured so users only see information applicable to their role for user-defined tools.
- Built-in data models or develop custom with agency.

Will consider discount cost for cooperative purchases from multiple agencies

- Contact: Ken Peterson
  Novotx
  kpeterson@novotx.com
  Phone: 402-309-5701

COST:

ELEMENTS XS

Annual license fees based on population. Three-year maintenance agreement. First year includes annual fee plus cost for:

- Installation
- Data migration
- Integration with third-party applications
- Training

Population	Annual Cost
0 – 25,000	$15,000
25,001 – 50,000	$25,000
50,000 – 100,000	$50,000

Example cost for a large city could be $80,000 to $110,000 depending on integration with other software and systems, and data migration, if required.

Figure 5.5. Costs for Elements XS

Esri Bundled Modules

Esri products are the most widely used mobile technology for field data collection and maintenance by 41.4% of survey respondents, and the Esri Collector application is used by all case study participants.

- Esri modules can be bundled to address mobile technology needs scalable to fit an agency's specific needs.
- Applications and tools can be developed for an individual agency or as a collaborative user group. Collaborative development is accomplished through shared templates for the group or as needed by individual agency. Out-of-box applications, tools and reporting can be configured by the agency (staff skilled in configuration) or consultant.
- Esri bundles include modules for field collection/inventory, work orders, inspections, citizen engagement, reporting/analysis dashboards, and advanced data management. Tech support is also available. Bundled products may include Collector, Explorer, Workforce and Survey123 applications.
- Applications can be accessed in the cloud eliminating the need for IT maintenance or data storage and applications can be integrated with an agency's on-premise enterprise system.
- Esri provides data models for transportation, local government, energy and water utilities, and telecommunications. Esri data models are customizable to fit agency needs.
- Advanced data management module will require a Pro annual Esri license of $700/year or $2,750/year depending on needs.
- Contact: Kendis Scharenbroich
  Pro-West & Associates
  kscharen@prowestgis.com
  Phone: 320-207-6861

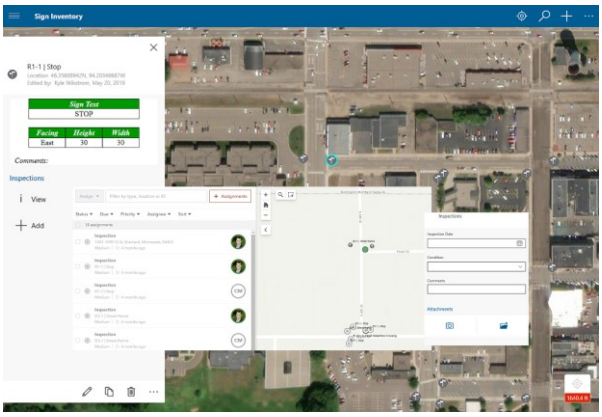

Figure 5.6. Esri Collection/Inventory with Work Order Modules

COST:

ESRI MODULE BUNDLE

$1,200 per module

- Collection/Inventory
- Work orders
- Inspections
- Citizen engagement
- Reporting/Analysis dashboards
- Advanced data management

- **Maintenance $500 annually per module.**
- Esri ArcGIS Online Creator license $500 and ArcGIS Online Field Worker license $350 may be required. Licensing is needed only if the agency does not have named users. If an agency uses Esri products in Public Works or other departments, they likely have named users.
- A free dashboard module will be included in the asset management bundle when 5 or more agencies develop modules collaboratively.

Figure 5.7. Costs for Esri Module Bundle

GRIT

Web map-based roadway inventory application with cloud server database and customizable ArcGIS online viewers and applications. This tool works on any web-enabled device in the office or field. Model and application are beginning-to-end workflow from field data capture to interactive web maps.

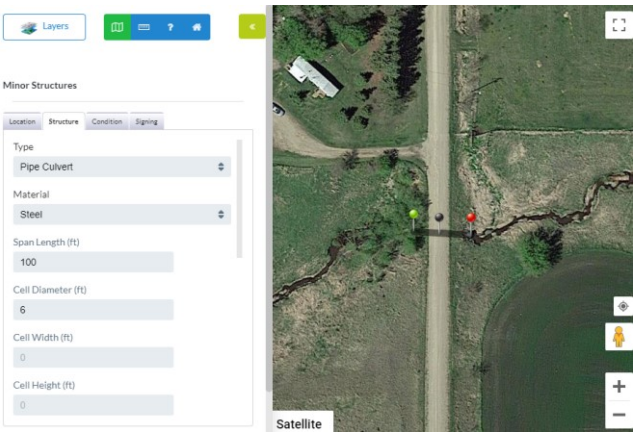

Figure 5.8. GRIT Example Work Order Interface

- Database model developed by county engineers.
- Focused on features within the right of way.
- One version for all users.
- Easy-to-use web map-based application and cloud-based database for decision makers and public use. GRIT has a common set of tools that can be enhanced to include additional functionality as requested. Future collaboration is required to detail and fund the enhancements. Upper Great Plains Transportation Institute (UGPTI) will work with agencies to enhance or customize the software collaboratively.
    - Work orders can be added to GRIT if there is strong demand from the user community.
    - Example Work Order Interface: A work order tab would only be added to layers, such as the existing minor structure layer shown above. Could be used on smartphone, tablet or laptop/PC. Would include drop-down menus, assigned staff email/text notifications, work completion notifications, and web map work order status.
    - Future layers are currently in consideration such as Signs and Spot Maintenance Repairs.

COST:

GRIT

$1,500 annually

Does not require IT or GIS expertise; data entry training requires one hour or less.

Figure 5.9. Cost for GRIT

- Contact: Brad Wentz, P.E.
  Upper Great Plains Transportation Institute
  bradley.wentz@ndsu.edu
  Phone: 701-231-7230
  Cell: 701-361-0742

ICON

ICON pavement analysis software for small agencies is used by Minnesota cities and counties for asset management collection, analysis and reporting.

- The software has a functionality level priced for small agencies.
- Modules:
    - Traffic sign
    - Pavement
    - Right of way
    - Universal asset management
    - Automated vehicle location (AVL)
    - Park assets
    - Sewer
- The software is more complex than simpler GRIT, Esri and Cartegraph focused applications, making it more difficult for staff to retain knowledge if an agency uses it occasionally, but provides more functionality than the focused solutions listed above.
- Some agencies contract with a consultant for ICON software use as needed.
- Cloud-based, mobile applications for field collection, dashboards and reports, integrates with the Esri platform.
- Software and data can be hosted.
- Built-in data models.
- Contact: Tony Kadlec
  GoodPointe Technology
  tkadlec@goodpointe.com
  Phone: 651-726-2555
  Cell: 651-271-0422

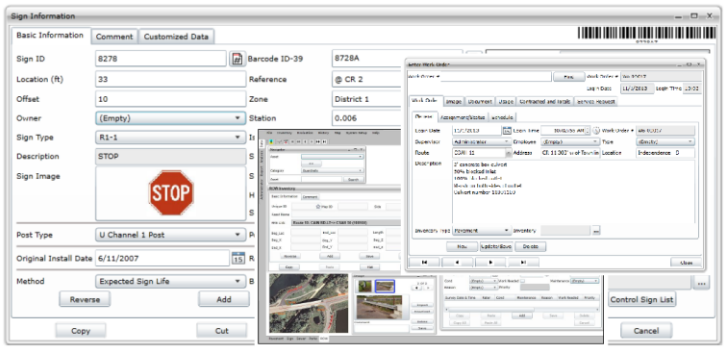

Figure 5.10. ICON ROW, Sign and Work Order Interfaces

COST:

ICON

Three levels:

- *Large cities and counties* (metropolitan area). Greater than $7,500 (5 client access licenses (CALS); one-time license.
- *Smaller county* (50,000 or less population). $2,500 to $7,500 (5 CALS); one-time license.
- *Smallest agency* (lowest for a homeowners' association, private community, township or small county). $750 annual single-user

Figure 5.11. Costs for Three Levels of ICON

5.1.2.2 If No Staff Available to Configure and Maintain Software

Select software to be configured, hosted and maintained by the vendor, such as GRIT, Esri bundled products, Cartegraph focused applications and ICON. The software listed above are scalable to fit various agency sizes and number of users.

5.1.2.3 If Staff Available to Configure and Maintain Software

Esri ArcGIS products can be configured and maintained in-house by skilled staff. Staff skills needed to configure and maintain applications and bundles such as ArcGIS Online, Collector, Survey123, Workforce and Web AppBuilder require the technical ability to configure and maintain the applications, and knowledge of database administration and maintenance to design databases that support the workflows unique to an asset. Staff need the creative ability to design, author and publish data as map services to support users well. Staff that configure and share web maps and apps also have the responsibility to manage user roles and privileges.

Time to configure Esri applications should be calculated into the cost of software. Time will vary dependent on the data and functions required. Below is a general rule of thumb per application:

- ArcGIS Online requires about 1-2 days to configure.
- Collector mobile application requires about 1-2 days to configure.
- Survey123 requires about 1-2 days to configure.

NOTE: More function and complexity in a software translates into more staff time to learn and implement, greater cost to purchase and maintain, and possibly additional data development to support. Consider the return on investment and long-term commitment when selecting the level of software.

5.1.3 Participating in the Development of Apps and Tools, or Software Purchase

Almost half of survey respondents (44.4%) expressed interest in collaborating with other local agencies on development of a suite of lightweight GIS apps for asset management. Slightly more than one-third of respondents (38.9%) would consider participating but have already invested in software.

5.1.3.1 Collaboration for Software Use is a Cost-Effective Approach for Agencies Getting Started in GIS for Asset Management

User Community Software Development: GRIT offers software use and development as a user community. GRIT users input requests for changes and enhancements to be considered by the user community. Approved changes and enhancements are scheduled based on priority. UGPTI manages the user community and software development.

Shared Templates and Collaborative Development: Application and tool templates can be shared from one agency to another and configured to the individual agency or as a user group. Pro-West, as an Esri Business Partner, can develop and share bundles of applications focused on asset management for data

field collection/inventory, work orders, inspections, citizen engagement and reporting/analysis dashboards (simple extracts to analysis dashboards), and advanced data management. Collaborative development and maintenance with partnering agencies is managed as a user group and/or individually.

- Jackson County has plans to migrate their current Ditch Work Order app to an Esri Web AppBuilder application. The work order application will have a common set of functions and various work order types that the County has offered to share as a template for collaborative development with other agencies.

Cooperative Purchase with Cost Discount: Cartegraph, Elements XS and ICON will work with agencies on a group discount for software purchase. Each software vendor will work with agencies individually to install and maintain software.

5.1.3.2 Software Development Considerations

- As use of GIS tools and applications matures to be accessed by more staff and requires increasing customization, the size and complexity of the system may outpace the agency's ability to cost-effectively support a number of applications and tools.
- A best practice for software development when getting started is to consider iterative development of applications, such as Esri products for specific tasks, GRIT enhancements or Cartegraph focused applications. Developing asset-focused applications by priority and over time allows an agency time to vet and become familiar with the function before developing the next application. Each enhancement or focused application creates buy-in from staff and administration based on end user success.
- Dashboards are an option for Esri Web AppBuilder and ArcGIS Online applications, and Cartegraph focused applications. GRIT is considering dashboard reporting as a possible future enhancement based on user requests. Dashboards provide map viewers and tools for administrators and engineering staff.

5.1.4 Staff Resources Required

The cost of staff collecting and digitizing assets will vary dependent on the level of field work required. As a rule, 25% to 50% for rural and small agencies and up to 1 FTE in some agencies is needed for GIS for asset management. The amount of time needed in the field to collect assets or in the office to digitize asset locations will vary dependent on whether data already exists and requires updating, or if data has never been created.

Training non-GIS staff and using interns and summer workers to collect data in the field was a game changer for Jackson County. Summer workers were the most successful when their education focused on GIS or engineering. Recent graduates were good candidates for summer employment. The most productive employment is from summer workers located in the Highway or Public Works Department to ensure dedication of their time and oversight by data authorities.

5.1.5 Funding for Getting Started and Mobile Technology

The follow-up survey responses indicate that **82.4% of agencies have no dedicated budget for GIS for asset management and/or mobile technology**. Examples of funding sources to support GIS for asset management are operating costs, IT Department budget, Public Works budget and countywide general fund.

GIS for Asset Management Costs Survey Responses: The follow-up survey asked respondents about initial cost and maintenance cost for mobile technology:

- Initial costs for mobile technology varied widely for agencies from $2,000 to $60,000 based on existing equipment and rollout of major implementations of technology (such as an enterprise software system).
- Maintenance costs for mobile technology varied from $100 to $30,000 annually. For many agencies, maintenance costs annually were 10% to 25% of initial costs for equipment and software.

5.1.5.1 How to Get Started or Grow with No Dedicated Budget

- Request funding for changing technology as a project rather than a program.
- Request funding for a shared position, software and equipment between departments.
- Take advantage of staff retirement or agency reorganization to hire staff or request dedicated time for GIS.

5.1.5.2 Return on Investment

Several research projects, reports and presentations demonstrate the return on investment (ROI) for developing GIS for asset management, including automated processes, shared information, cost-effective asset management and increased productivity. **Consider the cost of acting versus not acting.** Research on ROI reviewed for this project is available in Appendix A.

5.1.5.3 Benefits and Challenges of Mobile Technology

Benefits: Survey respondents highlighted the benefits of mobile technology used to complete work orders in the field, including the improved accuracy of agency records, and ready access to data in the field and in the office.

Challenges: Survey respondents indicated that challenges for mobile technology include funding the initial investment in GIS-related software and equipment, obtaining agency and user buy-in, training staff, and complicated processes or systems.

5.1.5.4 Lack of GIS for Asset Management Impact

Comments included in the project surveys point to the impact that lack of GIS for asset management or ineffective systems and processes can have, including the following:

- Technology changes quickly and that impact is worsened when there are issues with inspection standardization and data entry procedures.
- Historical data are lost when not recorded, or staff retire or leave the organization.
- Data collection or recording inconsistencies cause the inability to query data or use information effectively.
- Lack of GIS for asset management translates to lack of consistent support in-house for asset management.
- Difficulty in making mobile technology a regular part of field staff work causes low productivity and lack of consistency.
- Poor data currency and lack of maintenance creates an ineffective asset management system.
- Complicated asset management systems cannot be sustained due to need for consistent staff use and training to retain skills.

5.1.6 Equipment

Agencies are most often using tablets (78.8%) and GPS devices (72.7%) to capture field data. Other commonly used practices include the use of a cell phone (66.7%) and pencil and paper (48.5%). The most commonly used GPS devices are provided by Trimble; other vendors less frequently identified by respondents include Arrow, Bad Elf, Dual Electronics, Garmin and Leica.

- **Laptop computer** – approximately $1,500 to $2,300
- **Desktop computer** – approximately $1,200
- **Esri ArcGIS Server with workgroup license** – $100 per user/year, excluding server architecture
- **Tablet** – approximately $350 to $500

GPS Bluetooth receivers with Bluetooth connection to mobile devices:

- 2.5 meters accuracy — Approximately $300
- Meter accuracy — Approximately $2,500
- Sub-meter to centimeter accuracy — Approximately $12,000 to $14,000
- Within centimeters accuracy — Approximately $16,000 to $19,000

5.1.7 Training Available

The GIS process for asset management introduces different ways of carrying out staff work. Training and technical support prove crucial to staff adoption of technology. For more details and links to training, see Appendix G, Training Resources.

Success of GIS for asset management lies in continuous and tiered staff training for Carver County. Carver County intensively trains staff, starting with mid-level supervisors who are trained to be able to use the software effectively. Then crew leaders are trained, and they train technical and field staff. This method of training provides layer upon layer of technical support.

5.1.7.1 Connected Staff

Non-GIS staff trained by GIS staff: Training for lightweight, simple collection applications generally requires one to two hours per application.
Staff who work with the data are also those who are creating and collecting data and are most knowledgeable about data use. Roll out mobile technology as applications are being developed or data are ready to collect. As staff become familiar with mobile technology for one collection effort, they will adapt to the collection interface for additional collection efforts. In some cases, training is not needed for new applications due to skilled field crews using similar applications.

Training for non-GIS staff may need to be conducted numerous times for different seasons, updated software or changing agency needs, requiring time from dedicated GIS staff, supervisors or crew leaders.

- Create documentation (digital documents accessible for updating and sharing).
- Provide immediate field support to ensure buy-in for technology use.
- Hold on-site and online trainings with staff. Record training to be used as refreshers or for new staff.

Train the trainer. Supervisors train crew leaders who then train crew members, ensuring redundant support and knowledge transfer to more than one person.

5.1.7.2 User Groups

GIS User Groups are available in several areas of Minnesota or can be conducted by an agency. A listing of user groups is maintained by the Minnesota GIS/LIS Consortium; https://www.mngislis.org/page/user_groups.

5.1.7.3 Low-Cost GIS Training Options (see Appendix G, Training Resources, for complete training details)

Minnesota GIS/LIS Consortium; see https://www.mngislis.org/event/19-spring-tc. Workshops, presentations and conferences.

LinkedIn Learning (formerly Lynda.com);
https://www.linkedin.com/learning/search?keywords=GIS&trk=lynda_seo_learning.

Vendor training is specific to the software and can be tailored to the agency; costs vary. See Appendix H, Software Matrices.

Esri Academy; https://www.esri.com/training/unlimited-esri-training/.

Esri MOOCs (massive open online courses); see https://www.esri.com/training/mooc/.

5.2 SUMMARY OF GREAT SYSTEMS—GOING BEYOND WHAT AND WHERE

GIS provides tools that support asset collection and inventory, performing analysis to determine expected life, cost and maintenance requirements. Moving beyond "what and where" for asset management requires planning, development, testing and revising processes, often gained through trial and error. This summary of great GIS systems is built on the lessons learned and path paved by agencies moving their asset programs, staff and GIS processes to an enterprise system level.

Highlighted agencies have all advocated buy-in from administration and staff for organizational alignment, focused on organized data and effective software use, and empowered staff to author and maintain geospatial data.

5.2.1 Organizational Alignment

Enterprise level organizations understand that organizational alignment is key to support GIS for asset management at the enterprise level; staff require empowerment to define and execute the processes, becoming authoritative for their area of expertise.

- **Carver County**: Organizational preparation was key to GIS for enterprise asset management success. As a best practice, the County has implemented GIS and asset management in a cross-division arrangement which ensures data and processes are not siloed. In addition, developing GIS for asset management beyond knowing location for an asset requires knowing what is sustainable for an agency. While developing suites of lightweight applications may meet the needs of smaller agencies, sustainability of many applications may become an issue due to the resource skills and time needed to develop and maintain, or the growing demand for technical support that occurs as a GIS program grows.

  As an example, Carver County's asset management program wasn't built overnight but began showing worth incrementally. **Enterprise asset management software required two years to implement but it built upon eight years of GIS work in preparation.**

Research detailing organizational alignment as part of a transportation asset management plan is listed in Appendix A, Related Research, and specifically in the research documentation (AASHTO Transportation Asset Management Guide (Executive Summary), June 2013, available at https://www.fhwa.dot.gov/asset/pubs/hif13047.pdf; see Chapter C, Aligning the Organization, starting on page 8).

5.2.2 Data Development

At the enterprise level, GIS for asset management moves away from reactive data development (responding to needs as they occur) to creating and executing a priority plan for geospatial data with timelines for completion. A data plan includes migrating all location-based data out of spreadsheets and unstructured paper documents to structured geospatial databases, showcasing data quality and increased management capabilities.

A paradigm shift is needed for enterprise GIS for asset management from managing assets as issues occur to managing in a preventative manner. Efficiencies become evident due to standardized data collection leading to efficient mapping and work order completion, and effective communication between GIS, technical staff and engineers. Periodic updating of data (a preventative measure) collected by staff or a third party is required to ensure up-to-date and reliable data; data collection for an enterprise system is an ongoing process.

5.2.2.1 Data Requirements: Collaboration

- **Freeborn County** has proven success using a collaborative team approach for defining asset data to be collected, ensuring ownership of data and making decisions on what is relevant for each team's use of GIS asset data.

  The GIS and Public Works departments have been building applications to meeting the County's need for GIS for asset management. The development is conducted using a collaborative team approach, building teams for different asset management areas. GIS Coordinator Tim Fulton along with Engineering Tech II Dan Kenison work with GIS and Public Works staff to document the workflow and information needed. Historical information is not being input, but asset features are being built moving forward. Fulton sets up the server and Kenison configures the applications. The teams are:
  - *Gravel Road Improvement Program Team*. Information was transitioned from spreadsheets to an Esri ArcGIS Online application. Staff include six grader operators.
  - *Bridge Management Team*. The County integrates information from MnDOT's Bridge Replacement and Improvement Management tool and Structure Information Management System (SIMS) as layers in the GIS environment containing the bridge and bridge number.
  - *Construction Team*. The team relies on One Office from MnDOT that coordinates with RTVision software. ArcGIS is used to map the five-year plan, publish maps and data to the County website, and prepare maps for public meetings. Showing construction history has been helpful.
  - *Facilities and Equipment Team*. The team relies on an AVL system, which is currently using a Motorola product, and is trying to transition away from Street Trek into the Esri environment for work tickets and GPS tracking.
  - *Roadside Management Team*. Chemical use locations are mapped for weed control. Mowing, do not spray and do not mow areas are also mapped.
  - *Sign Management Team*. The County is transitioning away from ICON to Esri products.
  - *Pavement Maintenance/Winter Operations Team*. Plans are in the works to transition from ICON to the Esri suite.

5.2.2.2 Continuous Data Improvement

Enterprise data moves beyond static data to dynamic data for continuous data improvement. The best data continues to be the **most immediate data.** As an example, Highway Improvement Plan

lines and points can be based on the one- to five-year Highway Improvement Plan, which changes dependent on what construction and rehab has been completed in any given year and what is being planned for successive years. Dynamic data are not only relied on for Highway Improvement Plans but are also relied on continuously to create maps for projects, presentations as needed, and for County Board meetings. It is crucial to ensure data are dynamic to provide information for agency needs.

- **Carver County**, due to the pace of growth, has a process in place to **capture data as it is going to ground.** Annual updates as part of the as-built process; ensuring up-to-date asset features is critical.

  Data updates are scheduled for reliable, trusted information. Public Works has an extensive inventory of GIS asset datasets from over 20 years of digitizing and field collection, including signs, signals, pavement, culverts, lighting, and all other assets in county rights of way. The Public Works Division can now track the inspection, repair, replacement and maintenance of assets, calculating the total cost of an asset through its lifecycle.

  The importance of dates in asset data: The first challenge Carver County had to consider when creating data capable of forecasting and analysis was **resurrecting dates from historic information**. When was an asset installed? Recovering install dates needed to be done for every asset type, to move from "what and where" to budgeting and forecasting.

  Signal assets now have a five-year plan that relies heavily on multiple asset classes in an enterprise asset management system. As a result of the asset management efforts the Public Works Division has adopted a preventative replacement program for signals for the first time, moving from reactive to proactive. Previously, a lump sum budgeting process was performed and now the division can plan for replacement and anticipate costs.

- **Anoka County** has dealt with the issues that arise when data require frequent edits, but the department does not have its own GIS staff person, causing resource allocation constraints. Changes are discovered at the time maps are requested and GIS staff are not the subject matter experts to edit the data without input from Highway staff, causing the process to take additional time or not be as efficient as it could be.

5.2.2.3 Organize Data

Case study agencies have **data organization in common at the enterprise level.** After years of data development, data often are fragmented and in multiple locations and silos built by multiple staff and departments. Issues that must be tackled include:

Consolidating silos of data into a GIS repository. An enterprise database system like SQL Server or Oracle can be used to avoid data size issues. Take advantage of grouping data into logical feature datasets to enable efficient query and use of data. Organized, logical data are easier to maintain and administer, add transparency and build reporting capabilities.

Migrating all location-based data out of spreadsheets and unstructured paper documents to structured geospatial databases. Best migration practices include review of spreadsheet formatted data to ensure clean, single-row data with location coordinates (x, y). Unique identifiers are not necessary if the data integrity is maintained through automatically generating an object ID when data are migrated. Keep in mind that comments sections don't parse out to create individual attributes.

Databases should be developed with the ability to be expanded efficiently. Taking time to plan now will save money required to fix data issues down the road (pun intended).

- **Anoka County** organizes data being used at least annually or continually on an enterprise management site. Not all asset data are on the enterprise site; data that are not needed in an enterprise GIS are on accessible network drives, requiring further organization to easily access old projects and spreadsheets. Maintaining data within a designated management site has enabled mapping, maintenance routines and document linking to function seamlessly for efficient data management.

5.2.3 Software

Put software last! It is tempting to purchase software and make data collection, staffing, training and asset management fit the software. Instead, focus on planning, organizational alignment, staffing, and developing and maintaining quality data, then select software that answers the needs of the agency. Software is important but is not effective if staff don't use the software, data are not current or are not accurate or accessible. Software can't do everything.

5.2.3.1 What Systems Are Being Used by Agencies?

How are agencies using GIS-centric software for asset management? Survey respondents were asked if their agencies use separate systems for assets or asset types, or if the asset management system is consolidated. (Examples of consolidated systems include Cityworks and Cartegraph.) In the follow-up survey, five respondents indicated that their systems were both separate and consolidated. The remaining respondents were fairly evenly split, with 39.4% maintaining separate systems and 36.4% using a consolidated system. One-third of respondents reported using state systems such as SIMS, Minnesota Crash Mapping Analysis Tool (MnCMAT), PathWeb (pavement rating data) and HydInfra (culvert and storm drain inspection).

So, at what point does the need for applications and tools go beyond separate systems, such as simple configuration apps or collections of lightweight applications? As use of GIS tools and applications matures to be accessed by more staff and require increasing customization, the size and complexity of the system may outpace the agency's ability to cost effectively support a number of applications and tools. Performing an internal survey for software needs will uncover current needs and limitations and assist the agency in selecting a commercial off-the-shelf solution for GIS for asset management to provide greater support for staff and more advanced processes and analysis.

Five software systems used by survey respondents and case study participants are detailed in Appendix H, Software Matrices.

Additional enterprise level software was reviewed and detailed in Appendix A, Related Research. See in particular *Transportation Asset Management for Local Government Agencies: Threshold Levels and Best Practice Guide*, available at https://minds.wisconsin.edu/handle/1793/6962. Chapter 6, Review of Software Tools, starting on page 50 details eight enterprise software systems.

5.2.3.2 Internal Survey for Software Needs

The City of Rochester said it best in their presentation titled "Asset Management Systems: Build It and They will Come…Or Will They?" (See Appendix A, Related Research, for a link to this presentation.)

Choosing the appropriate GIS for an asset management system requires **conducting an internal survey of staff and reviewing all processes and data to document agency needs.** Due to increasing complexity, developing collections of applications and tools or purchasing a consolidated asset management software needs to be done in a sustainable manner that is unique to each agency. Below are examples of software selection for consolidated and separate systems.

5.2.3.3 Consolidated Enterprise Software Systems

- **Carver County** had several reasons for moving to an enterprise asset management system, including 1) being able to perform costing on the level of an asset, not limited to costing an entire road, and 2) before using Cartegraph to manage assets, there was an interim period when the County used ArcGIS Online for managing assets with GIS. There were numerous maps and applications built by the County, including a custom-developed workforce module containing a work order system using Esri GeoEvent Server. The shortcomings of this approach were that it did not include cost, and required extensive customization, complex related tables for visualization, and an inordinate amount of resource time and cost to build and maintain. The system was not sustainable for an enterprise, relying on one staff person to develop and maintain.

  Carver County Public Works Division asset management evolution is the result of top-level direction to elevate the practice of asset management and expand the use of asset management software. Public Works conducted a market study of enterprise asset management software vendors to ensure the transition from desktop-based to web-based software was successful.

  Since the planned expansion of asset management was going to be a significant change, including a major cultural shift, the Division performed a market evaluation in 2016 to determine if Cartegraph met the Division's expansion needs or if the Division should select a different software. Fourteen systems were reviewed. Major considerations included cost and functionality. Because the Division intended to mobilize all of their workers, the final selection of Cartegraph was based heavily on end user experience.

It is important to note that the move to enterprise asset management does not mean that Public Works has stopped using ArcGIS Online and other GIS applications; they are still heavily invested in Esri GIS and view the two technologies as complementary. Asset data in Esri ArcGIS shares a bi-directional integration with Cartegraph.

Challenges: Carver County discovered that the collection of applications developed over several years no longer met the needs of the County for functionality and cost-effective support, prompting implementation of Cartegraph enterprise-level software. The complexity of the many relationships involved in enterprise asset management became unmanageable without commercial software. Migration from multiple ArcGIS applications to Cartegraph happened simultaneously with the build-out of many asset classes over the course of 1.5 years. The level of support for asset management changed from one staff person to a significant portion of three staff members' time.

Successes: Once labor, equipment and materials were being tracked on an asset, asset management was at a critical turning point. Prior to the Cartegraph enterprise implementation, the Public Works Division only had generalized costing for each County State Aid Highway (CSAH) in the state system. Being able to accurately analyze cost and the impacts of treatments, and predict future needs is the power behind the Division's enterprise system.

- **City of Rochester** implemented GIS for asset management due to the need for knowledge transfer prior to retirement of staff, and to leverage functionality provided by GIS. The City had a lot of Microsoft Access databases and macros that were too complicated to manage. A requirement in the search for an enterprise system was one platform that could handle all asset management needs. The unwritten processes needed to be input into the system to provide onboarding and training to existing and new staff. The City needed to move asset management from an unstructured to a structured process.

  The City implemented an Elements XS (GIS-centric) asset management system, supplemented by configurable lightweight applications to meet the asset management needs of the City in 2013. At that time, the Sign Division had been using Cartegraph software for 10 years; the Sign Division decided to migrate to Elements XS. Reporting metrics are key indicators of the success of the migration and use of the new asset management systems.

  Challenges: The original implementation timeline for Elements XS was doubled from what was planned. The City decided to implement a pilot data process and staff time to develop for each group adopting the software. The process required staff time to develop, monitor and assist each group with review. A timeline that is adequate to fit each groups implementation timeline is required.

  Successes: It is crucial that systems can share information. The City of Rochester is well on its way of getting people out of data silos, sharing information and processes between departments and groups.

Some staff were reluctant to provide critical and essential feedback needed for software testing and use. Staff just want to know when it is done. Engagement meetings with the divisions were conducted to support loading useful information, soliciting feedback and triage for issues that arise. The City dedicated a full-time person to meet with groups from the seven or eight divisions participating in the pilot.

5.2.3.4 Connecting Separate Systems and Bundling Applications

- **St. Louis County** is in the process of connecting systems for greatest productivity**.** The County has experienced a software learning curve that started with a traffic signs inventory more than 20 years ago. A Microsoft Access database was developed in-house then migrated to SimpleSigns from 2002 to 2009. To approach sign inventory in a proactive, preventative manner, the County undertook migration in 2009 to RoadSoft. RoadSoft was used for sign inventory for seven years.

  Like many Minnesota counties, the proven inventory of signs led to other asset inventory apps. The County migrated signs to an Esri Collector for ArcGIS application in 2016 and has since developed six additional asset applications. The County is in the process of configuring a Collector application for municipal separate storm sewer system (MS4) inspections. Survey123 has been implemented for service requests.

  Matching labor time to equipment time: The County is in the planning stages of an innovative **"checkout" approach** to match labor time to equipment time. The approach is necessitated by Federal Emergency Management Agency's (FEMA's) requirement to track time for reporting damage, but it is difficult to match time sheets to equipment use. The checkout approach requires equipment operators to scan badges when they get in the truck or equipment to more accurately track maintenance cost by route. Other GIS applications are being considered such as tracking mowing of slopes in the summer to map where mowing has been completed and work remaining.

  Tracking plows: Esri's GeoEvent Server is configured and ready to go for use with plow trucks. A dashboard is being envisioned for future development to display different elements of real-time data during a weather event. These elements could include snowplow location and speed, plow and spreader operations, and truck telematics. These would all come from the AVL data through GeoEvent Server.

  Chemical application: Currently, the County is tracking chemical application by truck (salt, sand and brine) along the road linear feature. Plow trucks are equipped with Wi-Fi software and an antenna to allow download and syncing of plow truck data when the truck returns to the garage. All trucks have a GPS AVL system that records speed and route, and application of material on a route. The concept is to combine the chemical application by route data, Roadway Weather Information System (RWIS) data and NOAA weather data. Correlating the different data streams would allow the County to associate storm intensity with chemical usage and roadway surface recovery time. Combining all of these elements into one (or possibly two) dashboards will allow

the County to evaluate the current application rates, operator productivity and safety, along with chemical usage, to achieve the optimum level of service for snow maintenance on roadways.

Challenges: The County has seen an explosion of information collection and use in the last three years since implementing mobile technology for asset management. Each time the County has tried a process for collecting data in the field, the process has slowly built on itself. The process choices made to date were based on resource availability, both interns and county staff.

As Collector applications are being configured and loaded onto tablets, the need for internal support has increased. Tablets don't work all the time, and staff need to become acclimated to the new ways of collecting and using data. It was crucial to have immediate support in place to support users.

Successes: The use of mobile technology applications and tools in St. Louis County has had proven benefits**.** The County is large geographically. The use of lightweight Collector for ArcGIS apps allows for data and image collection of multiple crews of staff. Sign crews are now dependent on the application and process after using it for two years.

- **Anoka County has configured multiple applications and tools using Esri products**, such as the **Public Notification** application, an MXD (Map Exchange Document) template that automates the notification letter and map process for the department. The template contains predefined map and letter templates that users can change easily for dates and overall appearance of the documents. Staff use the application for public hearing and other presentation needs. Other applications include:
    - **The Construction Finder** created in-house to select road segments and input dates to the roadway feature class instantly online. Viewing and editing road data can be performed by non-GIS staff. **Sign and signal inventory applications** are next to be developed.
    - **Municipal separate storm sewer system (MS4) reporting for culverts**, outfalls and ponds. Interns and summer workers perform the data collection. The application automates extracting the data to a spreadsheet, and then populates the formatted MS4 reports.
    - **Park assets:** A University of Wisconsin–Eau Claire GIS intern collected 3,300 points in one season. Park assets such as memorial benches, picnic tables, firepits and structures were collected. A data dictionary was created with input from department subject matter experts prior to collecting park assets to ensure the department had considered all assets that could be collected and information to include before beginning the project. The data dictionary guided the intern to collect not only points but information about the asset such as maintenance condition and features of the asset.

Challenges: Three years ago, the technical staff person in Public Works with the greatest knowledge of GIS asset data left employment with the County, migrating the work to the GIS

Department. GIS staff do not have Public Works business knowledge and rely on Public Works for subject matter expert assistance to update data. The GIS Department supports Public Works with approximately .25 to 1 FTE, varying by season, but the result is GIS staff who are not as knowledgeable about asset data and do not fully understand the Highway Department business, requiring more time to dive in and figure out projects than previously.

Working on communication lines between the GIS and the Highway departments is crucial to successful development of applications, analysis and data that are unique to Highway. Different business units in the Highway Department increases the complexity of the communication with the units and specific experts within the units.

Successes: The County is growing the applications needed for asset management and feels they have not yet exceeded the out-of-the-box configurable applications. GIS staff fit application development into their schedules and plan to do more customized development in the future.

5.2.3.5 Software Considerations

Below are software considerations for agencies considering purchase of an enterprise asset management system, hosting data and software on agency servers, or collaboration with other agencies. See Appendix H, Software Matrices, for additional software specifications.

Agencies in the market for enterprise asset management software should perform a market survey to determine the best software to meet the agency's needs.

- Ensure software are capable of integration with other agency software and systems. Example: Enterprise asset management software should be able to integrate with lightweight applications, such as Cartegraph or ICON software integration with Esri software, Microsoft or Oracle.
- Ensure an adequate server infrastructure and space to house software. Not all components of cloud-hosted software reside in the cloud.
- Ensure software are scalable as all staff and departments won't need the same level of functionality. If sharing software or systems with other agencies, the software must be able to meet the lowest-level function, such as Carver County sharing applications with the small cities that meet the less advanced needs of the cities.

All applications and tools have costs beyond the initial cost of the software.

- Factor in the cost to migrate data and processes from previous software or from an unstructured system of data and applications. Some software subscription prices are based on population ranging from $7,500 to $50,000, plus cost of data migration, installation, training and support.
- Plan for adequate time to migrate from one system (or no system) to another system. Carver County required 1.5 years to migrate from multiple ArcGIS applications to Cartegraph.

- Expect to use lighter-weight applications when requiring quick stand-up for data collection or visualization. Example: FEMA events, short-term temporary data collection, simple data collection and use for nontechnical staff.
- Collaborative efforts for licensing bring down the cost of software, such as Esri Enterprise License Agreements (ELAs) for a county and cities within the county, or regional purchase of software for similar agencies (example: rural counties within the NW region of Minnesota).
    - Cartegraph, Elements XS (Novotx) and ICON (Goodpointe) will all consider discount pricing for cooperative purchases.
- **Carver County** was able to share an ArcGIS Online Organization registration with cities within the County to provide advanced functionality at a level the cities would not have been able to afford individually. The County and cities saved money.

  Carver County Public Works is also a member of a cooperative for cloud-hosted Fleet Management software, AssetWorks.

  Challenges: Drawbacks include limits to customization and expansion when configuration is coordinated for all member agencies, and agencies with technological abilities don't gain the same level of in-house expertise when one agency does the system management.

  Successes: Benefits of collaboration are realized for agencies that don't have the technical ability to implement a fleet management system due to available staff time or skills.

5.2.4 Staff

Time management is an issue for all agencies, regardless of the percentage of staff time or dedicated asset management staff. Departments are being required to do more with less. Using GIS for assets collected in the field allows departments and staff to edit their own files and maps, sharing the time required to collect and update data. At the same time, as applications and tools are being developed or configured and loaded onto tablets and editing abilities grow, the need for internal support increases.

- **Carver County Public Works** started with one staff person that was reallocated from other duties to support GIS for asset management and over many years took advantage of reorganizing opportunities to build up the Asset and Performance Management Department. The capability was built slowly over time and grew as demand grew. Getting buy-in for building up GIS for asset management in the Public Works Division was key to success. There had to be the right people with the right environment at the right time.

  Organizational alignment from the top down contributed to the success of asset management within the Division by empowering employees to shape an efficient and effective program. An important point of note is that in Public Works asset management touches all staff, from data maintenance to subject matter experts; it is a unified effort.

  Challenges: If only one person is being relied on to create data and that person leaves the agency, the data can become out of date unless there is redundancy of GIS skills.

Successes: The Carver County Information Technology Department and the IT GIS staff play a significant role in the success of GIS and asset management implementations in Public Works. IT GIS has supported Public Works throughout their journey, manages GIS servers, administers ArcGIS Online, and provides advanced functions such as pulling and pushing data through the Cartegraph API. Public Works has also greatly benefited from the County having an Esri ELA. Carver County as a whole has always been an organization that rewards innovation and supports the use of technology to better serve citizens.

- **St. Louis County:** The Public Works Department has two GIS specialists. Both GIS specialists are dedicated 100% to the Public Works Department. The Enterprise GIS Division within the Planning Department manages desktop GIS software, servers and data, and exchanges information and processes

  Mini-trainings on how to use dashboards and reporting are conducted for non-GIS staff to become familiar with the technology. Rolling out a new app doesn't always mean the staff need training since the interfaces and functions are similar, so staff are familiar with the operation.

  Challenges: Ensuring connected and trained staff over a large geographical area requires the GIS Specialist to conduct in-house trainings when new applications are rolled out. To accommodate staff in other areas, trainings are held in different locations since the County has offices in Duluth and off-site, such as Virginia.

  Successes: Countywide support for Public Works staff is provided by the Enterprise GIS Division by conducting a monthly GIS Infrastructure meeting in the downtown Enterprise office to discuss software states, issues, discoveries in the past month, benefits to all departments, and technical support. The County also staffs GIS specialists in six other departments.

The amount of staff time required will vary. Support staff knowledge and skills increase and become more specialized as data processes, number of end users and software functionality grow and evolve. Survey respondents indicated that most required more than 1 FTE for an agency with enterprise level GIS functionality, and larger agencies employed 3 to 4 FTE to meet the needs of Public Works. Plan for enhancing support staff expertise or hiring expert support staff as your GIS for asset management program grows.

As with agencies just getting started, training non-GIS staff and using interns and summer workers to collect data in the field makes an impact. Summer workers were the most successful when their education focused on GIS or engineering. Recent graduates were good candidates for summer employment. The most productive employment was from summer workers located in the Highway or Public Works department to ensure dedication of their time and oversight by data authorities.

Retirements provided an opportunity to hire staff with technical skills not currently available in an agency's department. Using GIS technology helped with knowledge transfer, taking information out of someone's head and into an organized format.

Non-technical staff may not be comfortable with technology. Simple tools that automate their work will have the greatest return on investment. In addition, a key to success echoed by more than one agency was to continuously train in-house.

- **The City of Rochester:** The three City GIS staff serve all departments within the City. One of the challenges of the GIS staff is not data, but the cultural side of assisting people to move from one system to another. Many staff are accustomed to seeing all the data on a clipboard, and now they need to view a map and trust that the information is easily viewable via a click and report. The GIS staff must ensure all the data is available and staff questions are answered as they arise.

5.2.5 Funding

5.2.5.1 Metrics

Return on investment will not be immediate. Some processes may take longer due to transitioning to new systems and tools, training staff and building a technology culture within an agency. The ability to store and use data efficiently, provide transparency, and enable reporting and analysis capabilities far outweighs the negatives.

- **The City of Rochester** has developed GIS for asset management to the point where their next step will include analysis of how to do their jobs better. They are developing data that can be analyzed for time, cost, equipment and materials. They now have baselines to figure out what is expected and the areas for focus. Now the City is focusing on getting numbers to understand how much work can be done in a year and developing data that provides repeatable consistent results. The power behind an enterprise system is being able to analyze what an asset actually costs.
- **Carver County Public Works** implemented GIS for the Division prior to integrating GIS into asset management with very little expenditure. The years of focused GIS implementation contributed to successful integration of GIS for asset management.

  Support for funding took time to build, demonstrating worth of the system, people and process. Today the Public Works Division has an Asset and Performance Management Department with its own dedicated budget.

Some costs are a one-time cost, and other costs are ongoing. GIS for asset management is an ongoing need for an agency that requires funding and support. Asset management changes, technology changes, and the level of support and funding change through time.

5.2.6 Equipment

Equipment costs are addressed in a previous section of this chapter. Additional considerations are outlined below for an agency's IT infrastructure.

- **Carver County:** Departments share equipment. The equipment is maintained by the department that purchased the equipment and access is allowed to other departments. Signs staff carry a GPS receiver with them at all times in the field because signs have a higher frequency of being added or removed.

5.2.6.1 Development and Production

- Developing a DTP (Develop/Test/Production) tiered environment for development of solutions is a practical idea for larger agencies developing their own applications and tools. DTP requires the setup of servers to run schema changes, test functions and implement new versions.
- Agencies have implemented VMware (Virtual Machine Ware) to address the need to spin up machines for GIS use as asset management grows through an organization. Resources can be added to machines and virtual machines are easier for IT departments to manage.
- Cloud-hosted software, applications, tools and data can reduce the need for IT infrastructure as asset management grows.
- Leverage sharing software and mobile technology collaboratively with other agencies and departments.
- Agencies have implemented drone use to enhance asset data collection and maintenance.
- Leverage sharing software and mobile technology collaboratively with other agencies and departments.
- Work to ensure up-time for asset management software. Server down time causes problems for non-GIS technical staff work.

TRAINING

All agencies experience success through intensively training staff, regardless of the size of the agency. Start with training mid-level supervisors to be able to use the software effectively. Then train your crew leaders, who will train technical and field staff. This method of training provides layer upon layer of technical support.

In addition, make use of professional development opportunities beyond GIS. As an example, professional development is provided by the Institute of Asset Management (IAM) conferences and trainings. Attending the 2019 conference exposed Carver County staff to expert speakers and formal asset management processes and organization on all levels, including federal or nationwide organizations. IAM is focused on providing leadership, innovation and advancement for asset management professionals through trainings and courses.

See Appendix G, Training Resources, for further details of the training opportunities available.

CHAPTER 6: SUMMARY AND CONCLUSIONS

Key findings and results from each phase of this study are summarized below. Each phase of the study gathered information to address **three critical questions**:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond "what and where"?

6.1 SURVEYS OF PRACTICE

6.1.1 Current State of the Practice with Regard to GIS

A preliminary survey identified categories of practice regarding the use of GIS and mobile technology for asset management among Minnesota's cities and counties. Respondents were organized into one of five categories:

- Group 1: Fully integrated users of GIS for asset management
- Group 2: Using GIS for asset management without full integration
- Group 3: Using GIS for asset management for three years or less
- Group 4: Nonusers interested in using GIS to manage assets
- Group 5: Nonusers uninterested in using GIS to manage assets

As Figure 13 indicates, survey respondents are most likely to use GIS without full integration, and almost 28% are nonusers of GIS. Only 16.5% of the 79 respondents consider their agencies to be fully integrated users of GIS.

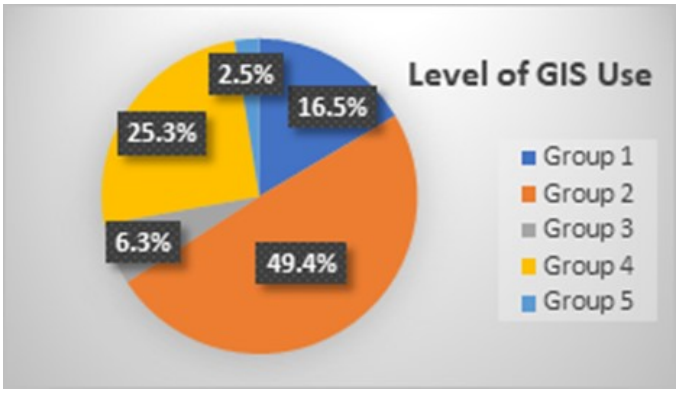

Figure 6.1. Categorizing Respondents Based on the Use of GIS in Managing Assets

Further categorizing respondents, just over 6% of all respondents have used GIS for three years or less. Only two respondents have been using mobile technology to track assets in the field for more than 10 years.

6.1.2 Details of Local Agency Experience with GIS

A follow-up survey distributed to agencies indicating experience with GIS in the preliminary survey probed for details of agency tools and practices. Almost three-quarters of the 33 respondents use Esri products; almost all of these agencies use ArcGIS Desktop. Most agencies are supplementing the use of GIS tools with other methods and systems, most often with spreadsheets. Agencies most often use tablets and GPS devices to capture field data.

More than half of respondents are not using state-provided data. Those that do use it are most likely to use LiDAR or aerial imagery. Almost all agencies store asset data in more than one data format; respondents are most likely to store data as shapefiles. Respondents are most likely to have dedicated GIS staff within various departments. The most typical staffing level among respondents is one or more FTE staff member.

6.1.3 Key Takeaways: Impacts Associated with the Lack of GIS

Survey findings pointed to the impacts associated with the lack of GIS for asset management or ineffective systems and processes:

- Technology changes quickly and that impact is worsened when there are issues with inspection standardization and data entry procedures.
- Historical data is lost when not recorded, or staff retire or leave the organization.
- Data collection or recording inconsistencies cause the inability to query data or use information effectively.
- Lack of GIS for asset management translates to lack of consistent support in-house for asset management.
- Difficulty in making mobile technology a regular part of field staff work causes low productivity and lack of consistency.
- Poor data currency and lack of maintenance creates an ineffective asset management system.
- Complicated asset management systems cannot be sustained due to need for consistent staff use and training to retain skills.

Details of the surveys are presented in the following appendix items:

- Appendix C: Surveys of Practice: Survey Questions
- Appendix D: Surveys of Practice: Preliminary Survey Summary
- Appendix E: Surveys of Practice: Follow-Up Survey Summary

6.2 REVIEWING MOBILE TECHNOLOGY

An online webinar showcased a range of mobile technologies used in asset management by local agencies. The demonstration included five presenters who described the software they used in various functions of asset management, the assets collected and managed using GIS mobile technology, and the

specific tasks and functionality the technology provided in connection with an agency's asset management practices.

The research team supplemented this demonstration with independent research about five of the software products often used by Minnesota local agencies. Detailed information about these software products appears in Appendix H.

6.3 DEVELOPING THE CASE STUDIES

All the information gathered for this implementation project informed the development of three case studies that include recommendations for agencies at different stages in the use of GIS for asset management:

- Case Study 1: Getting Started
- Case Study 2: Utilizing Mobile Technology for Asset Management
- Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting

Each case study includes a series of recommendations in six key areas:

- Data development and management
- Software
- Staff
- Funding
- Equipment
- Training

A Lessons Learned section is included at the end of each case study.

Recommendations are designed to be scalable for agencies with the greatest need to agencies that want to expand use of GIS for asset management. Table 3 summarizes the critical takeaways of the three case studies organized according to the key six agency needs described throughout this report.

Table 3. Critical Takeaways of the Case Studies

Key Agency Needs	Case Study 1: Getting Started	Case Study 2: Utilizing Mobile Technology	Case Study 3: Moving Beyond "What and Where"
Data Development and Management	• Start simple • Use a data plan and data model; adopt a neighbor agency's plan and model • Begin migrating asset information from spreadsheets and other formats to geospatial databases	• Create asset teams • Adapt a borrowed data schema for field data collection • Develop field data in a pilot project; revise process as necessary and follow priorities within data plan for continued field collection	• Move away from reactive data development; create and execute a data plan with timelines • Migrate all asset information from unstructured paper and spreadsheets to geospatial databases

Key Agency Needs	Case Study 1: Getting Started	Case Study 2: Utilizing Mobile Technology	Case Study 3: Moving Beyond "What and Where"
	• Explore publicly available imagery, base data, LiDAR		
Software	• Purchase scalable software and only what you need • Consider cloud-hosting and cost-sharing software (web-based) • Have vendor maintain the software if your staff can't • Options: GRIT collaboration, Esri products (including templates and collaboration with other agencies to develop common tools), Cartegraph focused applications and ICON	• Identify software capable of collecting assets in the field • Conduct a survey to identify department needs *before* vendor demos • More is not necessarily better • Options: GRIT collaboration, Esri products (including Jackson County work orders template and collaboration with other agencies to develop common tools), Cartegraph focused applications	• Perform a market survey for an enterprise management system • Move to an enterprise asset management system; custom developed apps and tools may become unsustainable • Consider cooperative purchases
Staff	• 25% to 50% dedicated GIS staff • Outsource GIS when cost-effective • Engage non-GIS staff or interns to collect data • Consider GIS shared position with multiple departments	• 25% to 50% dedicated GIS staff for rural and small agencies; up to 1 FTE in some agencies • Collect data once and use it many times to increase staff efficiencies • Look for summer workers with GIS or engineering education	• 25% to 3 FTE are reported by surveyed agencies • Need for staff with advanced skills and experience • Need for internal support increases as apps and tools are developed and configured • Essential to have staff engagement during software testing
Funding	• Request dedicated GIS staff time when staff retire • Consider costs for computers, GPS receivers	• Initial cost less than $10,000 • Maintenance cost less than $10,000	• Understand the costs and benefits • Take advantage of retirements and reorganization to build skills and gain organizational alignment
Equipment	• Purchase hosted software so no internal hardware or software needed • Use tablets (iPads most often used by agencies) in the field; laptops, GPS receivers	• Purchase hosted software so no internal hardware or software needed • Use tablets (iPads most often used by agencies) in the field; laptops, GPS receivers	• Use cloud-hosted software to reduce need for IT infrastructure • Leverage shared software and collaborate with other agencies and departments

Key Agency Needs	Case Study 1: Getting Started	Case Study 2: Utilizing Mobile Technology	Case Study 3: Moving Beyond "What and Where"
Training	• Train key users and ask for feedback before expanding the training program • Train the trainer; have GIS staff train non-GIS staff • Encourage participation in user groups • Make use of low-cost or free training options	• Training and technical support prove crucial to staff adoption of technology • Train the trainer; have GIS staff train non-GIS staff • Roll out mobile technology as apps are developed or data are ready to collect; training takes 1-2 hours per app	• Training and technical support prove crucial to staff adoption of technology • Intensively train staff, starting with mid-level supervisors, then crew leaders and field staff • Make use of professional development opportunities

6.3.1 Lessons Learned from the Case Studies

Each of three case studies includes a series of lessons learned gleaned from the survey findings and follow-up interviews. Table 4 organizes these lessons learned by key agency needs and identifies the case study from which each lesson is taken.

Table 4. Case Study Lessons Learned

Key Agency Needs	Lesson Learned	Case Study
Data Development and Management	Create new data schemas and configure applications in a way that supports collection needs; don't include legacy attributes	2
	Understand how data are intended to be used before publishing on a mobile device	2
	Be prepared to identify fragmented data in multiple locations and data developed in silos as new data are developed	3
	Start with a simple asset class	3
	Take care with migrating legacy data; move the data in as few shots as possible	3
Software	Keep it simple	1, 2
	Allow staff the time needed to develop data, train and test software	1, 3
	Don't look to the software to do everything; focus on functionality in the field, system availability and accuracy	3
	Put software last! Focus on planning, organizational alignment, developing and maintaining quality data	3
	Start with an enterprise software pilot and test in multiple departments—no enterprise program is turnkey	3
	Work to ensure up-time for asset management software; server downtime causes problems for non-GIS technical staff work	3

Key Agency Needs	Lesson Learned	Case Study
Staff	Remember that data will need periodic updates; ensure redundancy of GIS skills	1
	Supervising summer workers can be challenging	1, 2
	Expanding GIS can create a backlog of requests; prepare accordingly with available staff	1, 2, 3
	Hire GIS staff based on expert skills beyond data collection	1, 2, 3
	Time management of all staff is required	1, 2, 3
	Develop effective communication lines between GIS and the Highway Department; this communication is crucial to successful application development	3
	Ensure that technical staff with the greatest knowledge of GIS asset data are involved in the GIS process	3
	Incremental use of software by staff may be best, depending on staff skill and organizational alignment	3
Training	Training online or on-site is required for staff to configure Esri products in-house	1
	Be prepared to train non-GIS staff on multiple occasions	1, 2
	Plan for enhancing support staff skills or hiring expert support staff	3

A narrative for each case study that reflects the results of extensive interviews conducted with selected survey respondents appears in Appendix F. Detailed descriptions of selected GIS-related software appear in Appendix H.

6.4 MAPPING ASSETS IN MINNESOTA

Both the surveys and software demonstrations provided direction for conducting more than 26 interviews with local government and state agencies, and vendors to develop case studies. The culmination of TAP input, surveys, demonstrations and case studies is presented in Chapter 5 in a format that can be excerpted from the report and used as a summary of project findings. In this chapter, results from each facet of this research effort are gathered and presented to address **three critical questions**:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond “what and where”?

6.5 REPORT APPENDICES

Appendices to this report offer significant detail for agencies wishing to delve more deeply into the recommendations this project has developed for a broad spectrum of local agencies. In addition to the appendices previously cited, Appendix I, Quick Start Guide, presents a concise summary of project findings that offers guidance for both new users of GIS and mobile technology and agencies with mature programs seeking to expand and enhance current GIS and mobile technology practices.

APPENDIX A
RELATED RESEARCH

Related Research

The research team examined recent publications addressing asset management in Minnesota and nationally. These publications, highlighted below, informed the case studies and recommendations appearing in this report.

Transportation Asset Management Plan, Minnesota Department of Transportation, June 2019.
https://www.dot.state.mn.us/assetmanagement/pdf/tamp/tamp.pdf

Minnesota Local Agency Asset Management Peer Exchange, Minnesota Department of Transportation, May 2017.
https://www.dot.state.mn.us/stateaid/projectdelivery/pdp/pavement/peer-exchange-report.pdf

MN2050 State of the Infrastructure, Minnesota Department of Transportation, June 2016.
https://www.wilder.org/wilder-research/research-library/mn2050-state-infrastructure

Consolidated Asset Management for Minnesota Local Agencies, Transportation Research Synthesis, TRS1603, Minnesota Department of Transportation, 2016.
https://lrrb.org/media/reports/TRS1603.pdf

Transportation Asset Management for Local Government Agencies: Threshold Levels and Best Practice Guide, Project 05-01, Midwest Regional University Transportation Center, May 2006.
https://minds.wisconsin.edu/handle/1793/6962

AASHTO Transportation Asset Management Guide (Executive Summary), June 2013.
https://www.fhwa.dot.gov/asset/pubs/hif13047.pdf

Best Practices in Transportation Asset Management: U.S. Experience, Louisiana Transportation Engineering Conference, February 2007.
http://www.ltrc.lsu.edu/tec_07/presentations/Best%20Practices%20in%20Transportation%20Asset%20Management%20-%20US%20Experience.pdf

Esri Smart Communities: The Benefits of GIS for All, Carver County, Minnesota, July 2016
https://www.esri.com/library/casestudies/carver-county-minnesota.pdf

Asset Management Systems: Build It and They Will Come…Or Will They? Southeast Minnesota GIS User's Group Winter 2019 Meeting at Rochester Public Utilities, April 2019
http://semngis.weebly.com/current.html (select the Past Meeting download)

APPENDIX B
PUBLICLY AVAILABLE DATA AND DATA MODELS

Publicly Available Data and Data Models

DATA MODELS

- The **most common data models** used in Minnesota include:
  - Agency-developed data model based on user requirements
  - Esri data model https://support.esri.com/en/technical-article/000011644
  - Metro GIS stormwater is in review and test phase. A pilot dataset is being developed that will be published in the future for agencies to adapt. https://www.metrogis.org/projects/stormsewers.aspx
  - Simple asset management standards from the U.S. Environmental Protection Agency (EPA) http://simple.werf.org/Books/Contents/Interactive-Training/EPA-Asset-Management-Training-Material

DATA FOR DOWNLOAD AND/OR PURCHASE

- Publicly available data are significant for GIS for asset management as a base map source for digitizing, mapping and viewing.
- **MnDOT applications, imagery and data**
  - **Pathway Services video log** data is available in spreadsheet format that can be uploaded to applications or software. Example: ICON software has an uploading utility for MnDOT video log information.
    - Video logs are generated by MnDOT only for County State Aid Highways (CSAH) within each county. There is an additional cost for video logs on roads other than CSAHs.
  - **MnCMAT 2** (State Aid version) crash application focused on counties is currently in development and will be released in February 2020. Counties will be allowed to download up to 5,000 crashes at a time. The data update cycle has not yet been defined but may be monthly or quarterly. Data can be downloaded as an Esri format shapefile.
- **Publicly available imagery**
  - **MnGeo** (Minnesota Geospatial Information Office) will be publishing imagery flown in 2019. The publication timeline is planned for December 2019 or January 2020. The imagery does not require a server or storage on-premise and can be used as a map service hosted by MnGeo. Agencies can also choose to **"buy up"** higher resolution imagery prior to the next flight.
  - **Esri Living Atlas of the World** contains 1-meter or better resolution aerial and satellite imagery of the world with political boundaries and place names. Collection of content curated by Esri from third-party sources, with imagery of varying quality and currency.
  - **Google** offers a collection of 2D and 3D imagery (of varying resolution and currency, some historical) that can be used as reference imagery for viewing. The Google Map API (application programming interface) provides access to the imagery as a background map and enables creating a point that can be stored as a database x,y location.

- **Publicly available base data**
    - **Esri base maps** are authored using data from third-party sources. Imagery and road-related data could be from various data sources. Base maps are used as a canvas for operational layers.
    - MnGeo **Geospatial Data Commons** of MNIT hosts and maintains or contains links to publicly available geospatial data for Minnesota. Geospatial data such as traffic volume, road centerlines, county and municipality maps, reference posts and topographic maps (digital raster graphs (DRG)) at varied scales are available for viewing and download.
- **Publicly available LiDAR**
    - A link to MnTOPO (Minnesota's elevation portal), a Minnesota Department of Natural Resources (MnDNR) web application for viewing, printing and downloading high-resolution elevation data, is available from the MnGeo site or through a MnDNR launch page.
    - The State is in the process of writing a Statewide LiDAR Acquisition Plan. The 3D Geomatics Committee of the Minnesota Geospatial Advisory Council is working on cost-share opportunities for state and local government agencies, private business and academia as part of the Statewide LiDAR Acquisition Plan. The standard set of by-products will likely be included in the LiDAR capture. The Committee is compiling a minimum set of specifications that will be available by the end of September 2019. This opportunity is relevant for agencies using LiDAR for asset management to provide input on what is needed and how it will be used.
- **Purchase imagery collaboratively**
    - The State of Minnesota has a master contract with select imagery vendors for use by local government.
        - Benefits of using the master contract:
            - Partnering with other agencies provides cost savings when coverage area is increased under the same contract
            - Lower contracting overhead with one Request for Proposal (RFP) and one contract
        - Possible collaborative master contract issues:
            - Contracting and deliverable complexity increases when involving multiple agencies
            - Increased flight areas require more time to complete, which could create an issue during shortened seasonal time frames
            - Longer flight lines could result in an inconsistent imagery product
    - If the vendor offers hosted imagery, no server is required. Some vendors, such as EagleView with Pictometry imagery, have a widget that can be purchased to display oblique imagery inside an Esri Web AppBuilder application.

APPENDIX C
SURVEYS OF PRACTICE: SURVEY QUESTIONS

Surveys of Practice – Survey Questions

Survey questions for the two surveys conducted for this study are presented below.

Preliminary Survey: LRRB Survey of Local Agency Use of GIS to Manage Agency Assets

Agency Needs and Interests

1. How would you characterize your agency's current practices with regard to the use of GIS in managing your agency's assets?
    - We don't use GIS to manage assets and have no interest in doing so.
        - Please indicate why your agency has no interest in using GIS to manage assets.
    - We don't use GIS to manage assets but are interested in doing so.
        - What would be needed for your agency to begin using GIS?
        - Are there plans within the next year to implement GIS for asset management?
    - Our agency has been using GIS for asset management for three years or less.
    - Our agency uses GIS for asset management, but GIS is not fully integrated with other systems.
        - How many years has your agency used GIS?
    - Our agency is a fully integrated user of GIS for asset management.
        - How many years has your agency used GIS in asset management?
2. How would you characterize your agency's current use of GIS asset management mobile technology?
    - We use GIS but are not using mobile technology to track assets in the field.
        - Why is your agency not using GIS mobile technology to track assets in the field?
        - Are there plans within the next year to implement GIS mobile technology for asset management collection and maintenance?
    - We use GIS, including the use of mobile technology to track assets in the field.
        - How many years has your agency used mobile technology?
3. Please identify your agency's greatest GIS needs related to asset management by ranking the items below, with **1** being **most important** and **8** being **least important**.
   How to rank your choices: You can click into the number field and type in your rankings, use your mouse to drag-and-drop your choices, or make a selection using the drop-down menu.
    - Asset inventory
    - Assign risk/criticality
    - Condition assessment
    - Determine appropriate Capital Improvement Plan
    - Determine appropriate maintenance
    - Determine replacement cost and date (life cycle costing)
    - Determine residual life
    - Set target level of service
4. Please rate the importance of each of the following elements of a GIS-based asset management program using the rating scale of 1 = not at all important to 5 = extremely important.

- **Asset Inventory**
    - Asset history/changes to asset
    - Field collection accuracy
    - Simple to use for field staff
- **Assign Risk/Criticality**
    - Automated/repeatable
    - Mapping and reporting
- **Condition Assessment**
    - Condition rating
- **Determine Appropriate Capital Improvement Plan**
    - Construction costs
    - Construction planning
- **Determine Appropriate Maintenance**
    - Automated/repeatable
    - Labor tracking
    - Maintenance
    - Maintenance costs
    - Maintenance work/activities and history
    - Operations
    - Repairs
- **Determine Replacement Cost and Date (Life Cycle Costing)**
    - Cost of assets
    - Installation cost
    - Life cycle costing
    - Phases of an asset life cycle
- **Determine Residual Life**
    - Expected life
    - Rehabilitation
- **Set Target Level of Service**
    - AADT
    - Identify levels of service per asset
    - Performance forecasting
    - Scenario analysis

Asset Management Practices, Plans and Interests

1. Is your agency planning some type of asset management data initiative in the next three years?
    - No, we have no plans or interest
    - No, but we are interested in reviewing options and cost
    - Yes, we do have plans. (Please describe your agency's plans below).

2. Does your agency have a dedicated budget for asset management data collection and maintenance?
    - No (please skip to **Question 3**)
    - Yes (please respond to **Question 2A**)

2A. What is your agency's annual budget allocation for GIS-related asset management activities?

3. If a suite of lightweight GIS apps for asset management were developed or further customized for future use, please indicate below how you feel your agency would participate.
    - Collaborate with other local agencies on development
    - Prefer an individualized approach to development
    - Would consider but we've already invested in software
    - Would not participate

Wrap-Up

1. Please provide contact information for other staff members in your agency with information about your agency's use of GIS and mobile technology.
2. Please use this space to provide any comments or additional information about your previous responses.

Follow-Up LRRB Survey of Local Agency Use of GIS to Manage Agency Assets

GIS Tools

1. What GIS-related software for asset management does your agency use? Select all that apply.
    - AssetWorks
    - Cartegraph
    - Cityworks
    - Esri products (please respond to **Question 1A** below)
    - Geographic Roadway Inventory Tool (GRIT)
    - GeoMoose
    - Icon
    - Lucity
    - SimpleSigns
    - Other (please describe)

1A. Which Esri product(s) does your agency use? Select all that apply.
    - ArcGIS Desktop (ArcCatalog, ArcMap)
    - ArcGIS Online
    - ArcGIS Pro
    - ArcGIS Server
    - ArcView
    - CityEngine
    - Collector for ArcGIS
    - Portal for ArcGIS
    - Survey123
    - Other (please describe)

2. What other methods or systems are being used for asset management? Select all that apply.
    - Spreadsheets
    - Pdf maps that link to other systems
    - Other (please describe)

3. What type(s) of mobile devices does your agency use to capture field data? Select all that apply.
    - Cell phone
    - GPS devices (please respond to **Question 2A** below)
    - Laptop
    - Pencil/paper
    - Tablet
    - Other (please describe)

3A. Please provide the name(s) of the GPS devices your agency uses.

4. Please identify the GIS-related system functions **your agency uses** for asset management. Select all that apply.
    - Analysis
    - Asset history
    - Asset inventory
    - Cost of assets
    - Disconnected editing
    - Expected life
    - Field data entry
    - Installation
    - Integration with mobile devices
    - Maintenance
    - Multiple queries
    - Querying of assets at any age
    - Work order generation
    - Desktop mapping
    - Print reporting
    - Web-based mapping
    - Dashboard reporting
    - Other (please describe)

5. What functions **does your agency desire** but the current GIS-related systems do not offer the capability? Select all that apply.
    - Analysis
    - Asset history
    - Asset inventory
    - Cost of assets
    - Disconnected editing
    - Expected life
    - Field data entry
    - Installation
    - Integration with mobile devices
    - Maintenance
    - Multiple queries
    - Querying of assets at any age

- Work order generation
- Desktop mapping
- Print reporting
- Web-based mapping
- Dashboard reporting
- Other (please describe)

Mobile Technology

1. How much was your agency's initial GIS investment for mobile technology (not including staff)?
2. How much does it cost to maintain the mobile technology (not including staff)?
3. What percent of your agency's asset management annual budget is allocated to mobile technology?
4. Please identify the assets your agency has collected data ~~for~~ using mobile technology. Select all that apply.
    - ADA features
    - Bridges
    - Electrical
    - Facilities
    - Fiber
    - Fleet and equipment
    - Guardrails
    - High-mast light tower structures
    - Highway culverts
    - ITS elements (vehicle detection stations, ramp meters, variable message signs)
    - Maintenance features (potholes, shoulders, flood damage)
    - Parks and recreation features
    - Pavement
    - Pavement markings
    - Roadside features
    - Signalized intersection assets
    - Signs
    - Wastewater (sanitary)
    - Wastewater (storm)
    - Water
    - Other (please describe)
5. Please describe your agency's mobile collection practices.
    - Disconnected
    - Connected
    - Disconnected and connected
6. What data accuracy standard does your agency use for collecting assets? Select all that apply.
    - Recreational grade (30 to 100 ft)
    - Map grade (low-end unit; 3 to 5 meters (9 to 16 ft))
    - Map grade (high-end unit; .5 to 2 meters (1.5 to 5 ft))

- Survey grade (low-end unit; 1 meter (3 ft))
- Survey grade (30 cm (sub foot))
- Survey grade (within 1 decimeter (4 inches))

Asset Management System Integration

1. Does your agency use separate systems for assets or asset types, or is the asset management system consolidated? Select all that apply.
    - Separate systems are used for each asset or asset type (example: one app or tool for signs, a different app or tool for pavement)
    - Agency consolidated system(s) (example: Cityworks, Cartegraph)
    - State systems (example: SIMS, MnCMAT, PathWeb, HydInfra)
2. Does your agency's mobile data technology for asset management integrate with other local government processes (GPS, AVL) and/or systems? Select all that apply.
    - No, there is no integration.
    - Yes, it integrates with GIS mapping.
    - Yes, it integrates with a separate asset management program.
    - Yes, it integrates with public web mapping (511, road closures).

Data

1. Is your agency using statewide-provided GIS data for asset management, such as imagery or LiDAR?
    - No
    - Yes (please list the datasets your agency is using and how often the data is updated)
2. Please identify the frequency with which your agency collects geospatial asset data for each asset listed below by selecting from the following frequencies:
    - Continual
    - Monthly
    - Quarterly
    - Annually
    - As needed
    - No set schedule

    Please select all that apply. If your agency does not collect data for an asset, please skip that asset.
    - ADA features
    - Bridges
    - Electrical
    - Facilities
    - Fiber
    - Fleet and equipment
    - Guardrails
    - High-mast light tower structures
    - Highway culverts
    - ITS elements (vehicle detection stations, ramp meters, variable message signs)
    - Maintenance features (potholes, shoulders, flood damage)
    - Parks and recreation features
    - Pavement

- Pavement markings
- Roadside features
- Signalized intersection assets
- Signs
- Wastewater (sanitary)
- Wastewater (storm)
- Water
- Other (please describe)

3. In what data format(s) are your agency's assets stored? Select all that apply.
    - CAD files
    - Cloud-hosted data
    - Enterprise or workgroup geodatabase
    - File geodatabase (.gdb)
    - Hosted data in ArcGIS Online
    - Personal geodatabase (.mdb)
    - Shapefile
    - Other (please describe)
4. Does your agency use established data models or standards for collecting asset data?
    - Yes, we use an agency-designed data model.
    - Yes, we use a data model or standard developed by another agency, software vendor or organization (for example, an Esri local government model or another local agency's model).
    - No, we don't use a data model or standard for collecting data.

Other Technologies

1. Please describe your agency's IT infrastructure that supports GIS data collection, storage, use and maintenance. Select all that apply.
    - Data is not stored on-premise
    - File server
    - Oracle
    - Postgresql
    - SQL Server/SQL Server Express
    - Other (please describe)
2. Does your agency use imagery for asset data digitization?
    - No, and we have no plans to do so.
    - No, but we do have plans to use agency funds to purchase imagery (no cost share).
    - No, but we do have plans to share the cost of imagery with another agency.
        - Yes, we use imagery. (Please respond to **Questions 2A** and **2B** below.)

2A. Please describe the source of your agency's imagery.

- We use publicly available imagery
- We purchase imagery

2B. Please describe your agency's maintenance plans for the imagery-digitized asset data.

3. Does your agency use LiDAR for data collection?
    - No, and we have no plans to do so.

- No, but we do have plans to use agency funds to purchase LiDAR (no cost share).
- No, but we do have plans to share the cost of LiDAR with another agency.
- Yes, we use LiDAR. (Please respond to **Questions 3A** and **3B** below.)

3A. Please describe the source of your agency's LiDAR.

- We use publicly available LiDAR
- We purchase LiDAR

3B. Please describe your agency's maintenance plans for the LiDAR-derived asset data.

4. Does your agency use drones for asset data collection?
    - No
    - Yes (please respond to **Question 4A** below)

4A. Who is responsible for collecting drone data?

- In-house staff
- Contractors
- Both in-house staff and contractors

Staffing and Training

1. Please describe the current staffing allocated to your agency's GIS activities.
    - We have a GIS department.
    - We have dedicated GIS staff within various departments.
    - We do not have dedicated GIS staff, but some of our staff members use GIS.
    - We do not have any staff members who know GIS.
2. Please describe the staffing levels planned for the next three years to address GIS activities in your agency.
    - We plan to hire our agency's first GIS-dedicated staff.
    - We plan to hire additional GIS staff.
    - We plan to train staff in GIS (not dedicated GIS staff).
    - We do not plan to hire or train any GIS staff.
3. Has your staff received any formal asset management training in software use or field data collection?
    - No
    - Yes (please describe the training received)

Wrap-Up

1. Please describe the successes associated with your agency's current use of mobile technology for asset management.
2. Please describe the challenges associated with your agency's current use of mobile technology for asset management.
3. If available, please provide links to documentation related to your agency's use of mobile technology for asset management. Send any files not available online to cmorris@prowestgis.com.
4. Please use this space to provide any comments or additional information about your previous responses.

APPENDIX D
SURVEYS OF PRACTICE: PRELIMINARY SURVEY SUMMARY

Surveys of Practice - Preliminary Survey Summary

SURVEY RESPONDENTS

The preliminary survey received 79 responses from 75 cities and counties (four agencies provided two responses). Tables 5 and 6 identify the Minnesota counties and cities responding to the survey.

Table 5. Minnesota Counties Responding to the Preliminary Survey

Anoka	Itasca	Pope
Becker	Jackson	Ramsey
Benton	Kandiyohi	Redwood
Carver	Lac qui Parle	Rock
Cass	Lake	Roseau
Clearwater	Lake of the Woods	Scott
Cook	Lincoln	Sherburne
Cottonwood	Meeker	Sibley
Dakota	Mille Lacs	St. Louis
Dodge	Morrison	Steele
Douglas	Mower	Todd
Faribault	Nicollet	Wadena
Fillmore	Nobles	Washington
Freeborn	Olmsted	Wilkin
Grant	Pennington	Winona
Hennepin	Pipestone	Wright
Isanti	Polk	

Table 6. Minnesota Cities Responding to the Preliminary Survey

Albert Lea	Dayton	Plymouth
Austin	Duluth	Ramsey
Bloomington	Fairmont	Rochester
Burnsville	Golden Valley*	Roseville
Chanhassen	Hutchinson	St. Louis Park
Chisholm	Minneapolis*	St. Michael*
Coon Rapids*	Monticello	Waseca
Cottage Grove	Orono	Woodbury
Crystal		

* Agency responded twice.

SIGNIFICANCE OF SURVEY FINDINGS

The preliminary survey results provide a clear picture of the case study audience:

- Agencies need a quick start-up to develop GIS for asset management that provides cost savings and builds collaborative relationships with other organizations for data, process and possibly application sharing.
- Cost-effective and scalable mobile technology development.
- Options for agencies needing to take asset management beyond "what and where."

ASSESSING NEEDS AND INTERESTS

Respondents were asked to rank eight general functions associated with the use of GIS for asset management, with 1 being most important and 8 being least important. Averages of respondents' rankings are reflected below, in order from most to least important:

- Asset inventory = 1.81
- Condition assessment = 2.91
- Determine appropriate maintenance = 3.87
- Determine appropriate Capital Improvement Plan = 4.51
- Assign risk/criticality = 5.06
- Determine replacement cost and date (life cycle costing) = 5.11
- Determine residual life = 6.28
- Set target level of service = 6.30

After ranking the general functions of a GIS-based asset management program, respondents rated specific features of those functions using the rating scale of 1 = not at all important to 5 = extremely important. The highest- and lowest-rated GIS features are reflected in Tables 7 and 8 below.

Table 7. Highest-Rated Features of a GIS-Based Asset Management Program

General Function/GIS Feature	Weighted Average
Asset Inventory: Simple to use for field staff	4.60
Asset Inventory: Asset history/changes to asset	4.30
Asset Inventory: Field collection accuracy	4.24
Determine Appropriate Maintenance: Maintenance work/activities and history	4.06
Condition Assessment: Condition rating	4.05
Assign Risk/Criticality: Mapping and reporting	4.02

Table 8. Lowest-Rated Features of a GIS-Based Asset Management Program

GIS General Function/GIS Feature	Weighted Average
Determine Appropriate Maintenance: Labor tracking	2.84
Set Target Level of Service: Scenario analysis	3.04
Set Target Level of Service: Annual average daily traffic (AADT)	3.06
Determine Residual Life: Rehabilitation	3.08
Set Target Level of Service: Performance forecasting	3.08

Table 9 provides the weighted averages of all survey responses.

Table 9. Respondents' Ratings of Features of a GIS-Based Asset Management Program

GIS General Function	GIS Feature	Weighted Average
Asset Inventory	Asset history/changes to asset	4.30
	Field collection accuracy	4.24
	Simple to use for field staff	4.60
Assign Risk/Criticality	Automated/repeatable	3.54
	Mapping and reporting	4.02
Condition Assessment	Condition rating	4.05
Determine Appropriate Capital Improvement Plan	Construction costs	3.37
	Construction planning	3.53
Determine Appropriate Maintenance	Automated/repeatable	3.69
	Labor tracking	2.84
	Maintenance	3.63
	Maintenance costs	3.19
	Maintenance work/activities and history	4.06
	Operations	3.49
	Repairs	3.79
Determine Replacement Cost and Date	Cost of assets	3.31
	Installation cost	3.17
	Life cycle costing	3.25
	Phases of an asset life cycle	3.15
Determine Residual Life	Expected life	3.25
	Rehabilitation	3.08

GIS General Function	GIS Feature	Weighted Average
Set Target Level of Service	AADT	3.06
	Identify levels of service per asset	3.12
	Performance forecasting	3.08
	Scenario analysis	3.04

Respondents indicated no consensus in practice when asked about the data accuracy standards they employ. The data accuracy **least likely** to be employed by respondents: recreational grade (30 to 100 ft). Low-end map grade and low-end survey grade units were reported **most frequently** by respondents. Table 10 summarizes survey responses.

Table 10. Respondents' Data Accuracy Standards

Accuracy Standard	% of Respondents
Map grade (low-end unit; 3 to 5 meters (9 to 16 ft))	39.4
Survey grade (low-end unit; 1 meter (3 ft))	39.4
Map grade (high-end unit; .5 to 2 meters (1.5 to 5 ft))	36.4
Survey grade (30 cm (sub foot))	36.4
Survey grade (within 1 decimeter (4 inches))	30.3
Recreational grade (30 to 100 ft)	21.2

APPENDIX E
SURVEYS OF PRACTICE: FOLLOW-UP SURVEY SUMMARY

Surveys of Practice – Follow-Up Survey Summary

SURVEY RESPONDENTS

The follow-up survey received 33 responses from 32 cities and counties (one agency provided two responses). Respondents can be categorized into one of the three groups identified in the preliminary survey as reflected in Tables 11 through 13 below.

Table 11. Group 1: Fully Integrated Users of GIS for Asset Management

Counties	Cities
Carver	Burnsville
St. Louis	Golden Valley
	Minneapolis*
	Orono
	Roseville
	St. Louis Park
	Woodbury

*Agency responded twice.

Table 12. Group 2: Using GIS for Asset Management Without Full Integration

Counties	Cities
Clearwater	Albert Lea
Freeborn	Austin
Hennepin	Chisholm
Itasca	Coon Rapids
Jackson	Crystal
Lac qui Parle	Plymouth
McLeod	Rochester
Morrison	Waseca
Pennington	
Pope	
Sibley	
Washington	
Wright	

Table 13. Using GIS for Asset Management for Three Years or Less

Counties
Benton
Nobles

AGENCY USE OF GIS TOOLS

Respondents were asked about the GIS tools in current use and any other methods or systems used for asset management. Responses are summarized below in five categories:

- Software
- Other methods and tools
- Mobile devices
- GIS system functions used
- GIS system functions desired

GIS SYSTEM FUNCTIONS USED

Respondents were asked to identify the GIS-related system functions their agencies use for asset management. Table 14 summarizes survey responses, in order of greatest to least use.

Table 14. GIS Functions Used by Respondents

GIS Function	% of Respondents
Asset inventory	87.9
Maintenance	87.9
Field data entry	78.8
Asset history	75.8
Desktop mapping	75.8
Web-based mapping	66.7
Integration with mobile devices	57.6
Analysis	54.5
Work order generation	54.5
Querying of assets at any age	51.5
Print reporting	51.5
Multiple queries	48.5
Installation	42.4
Dashboard reporting	42.4
Expected life	33.3
Cost of assets	24.2
Disconnected editing	24.2
Work route planning	24.2

GIS SYSTEM FUNCTIONS DESIRED

Respondents also reported on the GIS functions their agencies desire but do not have access to with their current tools and systems. Table 15 summarizes survey responses, in order of greatest to least interest.

Table 15. GIS Functions Desired by Respondents

GIS Function	% of Respondents
Expected life	21.21
Integration with mobile devices	21.21
Asset history	18.18
Cost of assets	18.18
Field data entry	18.18
Maintenance	18.18
Work order generation	18.18
Analysis	15.15
Asset inventory	15.15
Desktop mapping	15.15
Print reporting	15.15
Querying of assets at any age	15.15
Web-based mapping	15.15
Multiple queries	12.12
Dashboard reporting	9.09
Installation	9.09
Work route planning	9.09
Disconnected editing	6.06

AGENCY USE OF MOBILE TECHNOLOGY

To gain a better sense of how respondents are using mobile technology, the survey asked about the type of asset data collected and how frequently it is collected, whether mobile collection is connected or disconnected, and the data accuracy standards most typically used.

Only two respondents have used mobile technology for more than 10 years. The remaining respondents were evenly split, with 18 respondents having one to 4 years of experience with mobile technology, and another 18 respondents reporting five to 10 years of experience.

Table 16 provides the reasons respondents cited for not using mobile technology to track assets in the field[3]. The right column of the table indicates whether the responding agency has plans within the next year to implement GIS mobile technology for asset management collection and maintenance.

Table 16. Reasons for Not Using Mobile Technology to Track Assets in the Field

Category	Reason for Lack of Use
Accuracy Concerns	GIS not integrated into asset management system; agency gets better accuracy using a Trimble unit.
Adding Mobile Technology	Currently working on adding a mobile solution for sign management.
	Migrating to a new asset management system that will have mobile capabilities (phone and tablet apps); new system will integrate with the agency's GIS system.
	Purchasing GIS enterprise January 2020 and will begin using GIS mobile technology to track assets in the field.
Decision in Process	Agency "in the middle of the process to better utilize mobile technology."
Lack of Resources	Insufficient resources.
	Lack of equipment and training.
	Lack smartphones to use the technology.
	Lack the technology to do so.
	Requires data subscription.
Multiple Areas of Concern	Costs, time constraints, lack of expertise/experience in users, lack of expertise/experience in technical staff to design, set up and manage a fully integrated system.
	Not found an easy, inexpensive, user-friendly option yet.
Staffing-Related Concerns	Lack staff experienced in GIS.
	Learning curve.
	Starting but progress is slow due to lack of IT staff to get it going and user knowledge.
Technology-Related Concerns	Need to update tablets with GPS.
	Technology does not give the same capability.
Technology Not Needed	Not needed at this time.

[3] Use of mobile technology by agencies in Group 1: Fully integrated users of GIS for asset management, and Group 2: Using GIS for asset management without full integration, along with mobile needs and reasons for lack of use informed development of Case Study 2: Utilizing Mobile Technology for Asset Management.

ASSET DATA COLLECTION

There is no consensus among respondents with regard to the type of data collected or when it is collected. The asset data **most frequently collected**, in descending order, includes:

- Americans with Disabilities Act (ADA) features
- Bridges
- Highway culverts
- Pavement
- Pavement markings
- Signs
- Wastewater (storm)

The asset data collected **least often** by respondents includes facilities, ITS elements and high-mast light tower structures. Respondents are most likely to collect data as needed or continually. Table 17 summarizes survey responses.

Table 17. Type and Frequency of Asset Data Collection

ADA features				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
2	0	0	4	19
Bridges				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
2	0	1	4	14
Electrical				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
2	0	0	1	11
Facilities				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
2	0	0	0	11
Fiber				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
4	0	0	3	10
Fleet and equipment				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
8	1	0	0	6

Guardrails				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
4	0	0	1	11
High-mast light tower structures				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
5	0	0	0	6
Highway culverts				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
9	0	1	2	10
ITS elements (vehicle detection, ramp meters, variable message signs)				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
3	0	0	0	9
Maintenance features (potholes, shoulders, flood damage)				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
8	0	0	0	11
Parks and recreation features				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
5	1	0	0	12
Pavement				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
6	0	0	6	9
Pavement markings				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
4	0	0	9	7
Roadside features				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
3	0	0	2	9
Signalized intersection assets				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
5	0	0	1	10
Signs				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
14	1	0	4	13

Wastewater (sanitary)				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
9	0	0	1	7
Wastewater (storm)				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
9	0	0	3	9
Water				
Continual	Monthly	Quarterly	Annually	As Needed/No Set Schedule
9	0	0	2	6

MOBILE COLLECTION PRACTICES

More than 40% of respondents employ connected mobile collection practices, while a relatively small percentage of respondents (15.2%) operate in a disconnected manner. Slightly more than one-third (36.4%) employ both connected and disconnected mobile collection practices.

DATA ACCURACY STANDARDS

Respondents indicated no consensus in practice when asked about the data accuracy standards they employ. The data accuracy **least likely** to be employed by respondents: recreational grade (30 to 100 ft). Low-end map grade and low-end survey grade units were reported **most frequently** by respondents. Table 18 summarizes survey responses.

Table 18. Respondents' Data Accuracy Standards

Accuracy Standard	% of Respondents
Map grade (low-end unit; 3 to 5 meters (9 to 16 ft))	39.4
Survey grade (low-end unit; 1 meter (3 ft))	39.4
Map grade (high-end unit; .5 to 2 meters (1.5 to 5 ft))	36.4
Survey grade (30 cm (sub foot))	36.4
Survey grade (within 1 decimeter (4 inches))	30.3
Recreational grade (30 to 100 ft)	21.2

ASSET MANAGEMENT SYSTEM INTEGRATION

Local agencies can use stand-alone systems to manage individual agency assets, or these agencies can integrate asset data, GIS files and other asset management-related tools and programs to provide seamless access to and management of asset data.

SYSTEM TYPES

Respondents were asked if their agencies use separate systems for assets or asset types, or if the asset management system is consolidated. (Examples of consolidated systems include Cityworks and Cartegraph.) Five respondents indicated that their systems were both separate and consolidated. The remaining respondents were fairly evenly split, with 39.4% maintaining separate systems and 36.4% using a consolidated system. One-third of respondents reported using state systems such as Structure Information Management System (SIMS), Minnesota Crash Mapping Analysis Tool (MnCMAT), PathWeb (pavement rating data) and HydInfra (culvert and storm drain inspection).

Almost three-quarters of the 33 respondents (72.7%) use Esri products, with Cartegraph the next most often used commercial product (27.3%). Icon and SimpleSigns are each used by 18.2% of respondents.

Twenty-nine of the 33 respondents (87.9%) reported using ArcGIS Desktop. Other Esri products used by more than half of the respondents include:

- ArcGIS Online (75.8%)
- Collector for ArcGIS (63.6%)
- ArcGIS Server (51.5%)

INTEGRATION WITH OTHER LOCAL GOVERNMENT PROCESSES

Most of the responding agencies integrate mobile data technology for asset management with other local government processes such as GPS (Global Positioning System) and AVL (Automated Vehicle Location), or with other local systems. Integration with GIS mapping was reported by 69.7% of respondents. Slightly less than one-quarter (24.2%) of the respondents reported maintaining mobile data that integrates with a separate asset management system. One respondent's mobile data integrates with public web mapping (511 systems that report on road closures). Only four respondents reported no integration of mobile asset data with any other systems.

DATA

State-Provided Data

Respondents were asked if their agencies are using state-provided GIS data for asset management. As Figure 14 indicates, more than half of respondents are not using state-provided data.

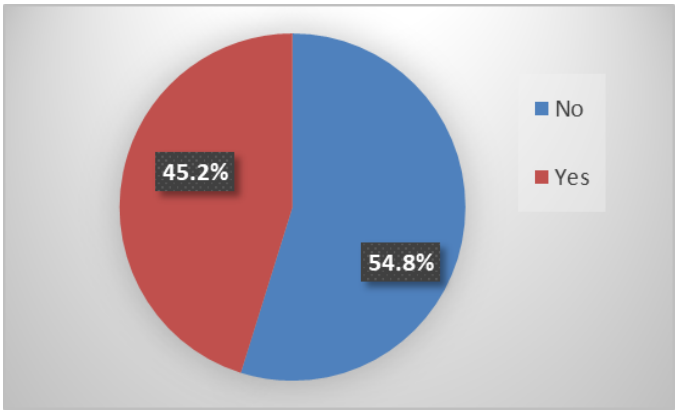

Figure E.1. Respondents' Use of Statewide-Provided GIS Data for Asset Management

The respondents using state-provided data are most likely to use LiDAR (mentioned by eight respondents) or aerial imagery (mentioned by five respondents). Other respondents reported using MnDOT's crash and traffic volume data or mapping.

Data Formats

Almost all the local agencies responding to the survey store asset data in more than one data format. Respondents were **most likely** to store data as shapefiles (50%), followed by enterprise or workgroup geodatabase (46.9%). The data formats **least likely** to be used by respondents: cloud-hosted data and a personal geodatabase .mdb file. Table 19 summarizes survey responses.

Table 19. Respondents' Use of Data Formats

Data Format	% of Respondents
Shapefile	50.0
Enterprise or workgroup geodatabase	46.9
CAD files	43.8
Hosted data in ArcGIS Online	31.3
File geodatabase (.gdb)	28.1
Cloud-hosted data	21.9
Personal geodatabase (.mdb)	18.8

Data Models

Almost 60% of respondents use some type of data model for collecting asset data. Of these, 61.1% use a data model or standard developed by another agency, software vendor or other organization. The remaining respondents using a model (38.9%) use an agency-designed model.

OTHER TECHNOLOGIES

Information Technology Infrastructure

Almost two-thirds of respondents (65.6%) use SQL Server or SQL Server Express to support their agencies' GIS data collection, storage, use and maintenance. Almost half of respondents (46.9%) reported maintaining this data on an unspecified file server. For one-quarter of respondents, GIS data is not stored on-premise.

Imagery Used for Asset Data Digitization

Most respondents (87.1%) use imagery for asset data digitization. Of those using imagery for this purpose, almost two-thirds purchase imagery. The frequency of update varies, with some agencies gathering selected new imagery every two years, while others collect aerial photogrammetry every three to four years. For another respondent, the city and county split the costs for imagery and updated data is gathered every three to five years.

LiDAR Used for Data Collection

Half of the respondents use LiDAR for data collection. Of those using LiDAR for this purpose, 70.6% use publicly available LiDAR. The remaining LiDAR users purchase it.

Drone Use

Only five responding agencies use drones for asset data collection. Two of the agencies use contractors to collect drone data, one uses in-house staff, and the remaining two respondents use both in-house staff and contractors for data collection.

STAFFING AND TRAINING

Current Staffing

Respondents are most likely to have dedicated GIS staff within various departments (45.2%). Only one respondent indicated that his or her agency does not have any staff members who know GIS. Figure 15 summarizes survey responses.

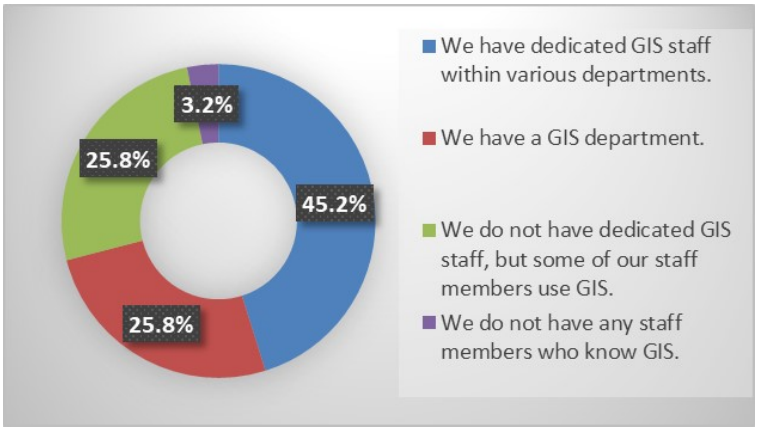

Figure E.2. Respondents' Current GIS Staffing

Staff Dedicated to GIS Asset Management

Respondents were asked to provide further details of GIS staffing levels by estimating the percentage of a full-time equivalent (FTE) staff person their agencies employed in a position dedicated to GIS asset management. Staffing levels ranged from less than 10% of 1 FTE to more than 1 FTE, with one or more FTEs being most typical among respondents (53.4%). Agencies employing more than 1 FTE reported a range of 1.75 to 4 FTE. One agency employs 2 FTE to support all county departments. Table 20 summarizes survey responses.

Table 20. Percentage of FTE Dedicated to GIS Asset Management

Percentage of FTE	%of Respondents
Less than 10% of 1 FTE	13.3
10% to 25% of 1 FTE	16.7
26% to 50% of 1 FTE	6.7
51% to 75% of 1 FTE	3.3
76% to 99% of 1 FTE	6.7
1 FTE	26.7
More than 1 FTE	26.7

Near-Term Staffing Plans

More than two-thirds of respondents (71%) plan to hire additional GIS staff (25.8%) or train staff in GIS (45.2%) in the next three years.

Training

Slightly more than 58% of respondents reported that their staff members have received formal asset management training in software use or field data collection. Most respondents reported on training provided by consulting firms and vendors. Vendor training can occur when software packages are purchased or on a periodic basis.

APPENDIX F
INTERVIEW NARRATIVES FOR THE CASE STUDIES

Interview Narratives for the Case Studies

Case Study 1: Getting Started

Agencies That Informed the Case Study

Telephone interviews were conducted based on responses to survey questions from one type of agency:

Agencies That informed the Case Study	
Group 2: Using GIS for Asset Management Without Full Integration	Becker County Beltrami County Jackson County McLeod County Pope County St. Louis County Washington County

Interviews for Case Study 1 were focused on the six key agency needs and informed by responses of each individual agency to the project surveys. In particular, questions were asked to discover why the needs existed and what the impact was for each agency.

Becker County

Interviewed: Jim Olson, County Engineer, Becker County Highway Department

Becker County does not have GIS-focused staff in the Highway Department. GIS is served for the County from the Information Technology Department and the Highway Department receives services as needed. Becker County uses pavement data provided by MnDOT along with the Geographic Roadway Inventory Tool (GRIT) from the Upper Great Plains Transportation Institute (UGPTI). The County uses GRIT software with AcquiSign to meet the needs for asset management and mapping.

DATA DEVELOPMENT AND MANAGEMENT

Sign inventory data has been collected using two iPads and AcquiSign software. Sign age is tracked on a time schedule more than actual condition. Retroreflectivity is not currently measured and may be done in the future.

In addition, Americans with Disabilities Act (ADA) deficiency data and a sidewalk inventory have been collected. Priorities for additional data collection include culverts and maintenance work.

Road plan data is in CAD format, and spreadsheets are used to track maintenance work (example: crack fill, seal coat, gravel road maintenance).

Hosted condition surveys from MnDOT are imported into GRIT each time there is a new project. AASHTO formulas are used to calculate future conditions.

Becker County GIS Department shares 2-foot contour data derived from LiDAR through the County's online mapping. The County's online web mapping application is used by the Highway Department for determining ownership and calculating value of land for right of way acquisition and conveyances.

SOFTWARE

In the past, the County has used ICON but the learning curve was extensive for their small agency. UGPTI's GRIT has been used for about a year. The software is very simple and intuitive and doesn't require much training. GRIT does the analysis for the roadway assets. It would be useful for GRIT to expand functionality to include something more GIS-oriented for gravel roads. A total of four people use GRIT in Olson's department; engineer, two technicians and construction manager.

Esri ArcGIS applications have not been developed for Olson's department but are used in other areas of the County. With the staff size of the Highway Department, the simpler the better. There is a need to get the information quickly.

Desired functionality for future asset management includes planning and budget management, and work orders. As existing asset management systems for certain utilities and roadways are modified or replaced, new systems may be applied.

AcquiSign purchase price $1,500 included an iPad, app software (license fee), setup, about an hour's worth of training, and the annual maintenance fee, which is $500.

STAFF

The Highway Department does not have dedicated GIS staff. The County is considering the addition of GIS staff to share between the departments. For a smaller-staff county with a certain number of miles to maintain, it is hard to have a dedicated staff who use software often enough to retain knowledge and use the software to the fullest.

For future consideration, since all construction projects have a data sheet that is pavement-related, and information is recorded in a database, it would be useful to have someone with GIS experience to extract the data and create geospatial features to be used in GIS software.

FUNDING

No dedicated budget for GIS in the Highway Department. The County is moving to bring on more staff to serve the departments.

EQUIPMENT

The Highway Department has two iPads used in the field. A Bluetooth Bad Elf GNSS receiver is used to provide 1-meter accuracy.

Beltrami County

Interviewed: Bruce Hasbargen, County Engineer

Beltrami County is testing GRIT software for simple data entry and use by staff and has also implemented ICON software for performance forecasting and reporting capabilities. The Highway Department receives GIS services from the GIS and Environmental Services Departments as needed and uses summer workers for data entry.

DATA DEVELOPMENT AND MANAGEMENT

Beltrami County began data development in the Highway Department with the collection of road signs. Location data are collected by staff starting with laptops, and now using tablets as well. Spreadsheets store unique IDs and sign attributes. In the future, staff will be using GPS units (Trimble) to collect condition data.

Asset data are being managed in spreadsheets and mapped in the office by segment of road for the following:

- Dust control status
- Striping
- Weed control

Ditch inspections are performed on an Esri Collector application configured for Ditch Inspections. Inspections are conducted by the Highway Department and Environmental Services Department staff. Staff are using tablets in the field to collect data and using GIS functions to create ditch buffers.

SOFTWARE

The County is testing GRIT software. The software has been a benefit to the department because it is simple to use for staff that need to pick it up and put it down without a significant time investment to learn or retain knowledge. GRIT meets the County's need for functionality, however more output as reports and greater ability to extract information for use in other GIS applications are requests for enhancement of the software.

Beltrami County uses summer GIS intern staff to collect attributes on roads, including year built, width, depth and construction history, as needed for GRIT use. Construction program features are also input to the data and utilized by the software. GRIT has not yet been linked to the County's website for public viewing of construction project status.

GRIT is being evaluated for forecasting the condition of roads. The County has also been using ICON for some roadway analysis during the past seven years. As an example, GRIT calculated the performance curve for pavement using a standard curve, while ICON contains a pavement deterioration curve that is customizable developed from factors based on the last three ratings for pavement. The pavement deterioration curve can be done for any type of pavement improvement, such as thin overlay, full-depth reclamation (FDR), and stabilized FDR, new construction and thick overlay.

Although ICON is favored for some analysis, the software is complicated for staff. A consultant runs the software as needed for the County, and the County uses ICON technical support when updates to the data are required.

The County would be interested in further collaborative development of GRIT for functions not currently in the program such as reporting and budget forecasting. ICON, like GRIT, is hosted with a minimal county cost.

STAFF

The Beltrami County Highway Department does not have dedicated GIS staff, and doesn't have a percentage of staff dedicated from the GIS or Environmental Services Department. The department receives GIS services as needed.

FUNDING

No dedicated funding.

EQUIPMENT

The department is using drones to capture images of construction projects.

Jackson County

Jackson County's use of GIS for asset management has been significant considering the County has a one-person GIS Department with 25% of staff time dedicated to the Public Works Department. Public Works is in the process of implementing Phase 2 of sign collection, which will include reporting and is focused on developing an Operations Dashboard to enable greater asset management reporting and function.

Interviewed: Jared Baloun, GIS Technician

DATA DEVELOPMENT AND MANAGEMENT

The County has focused on collecting asset features over the past 15 years, making the most of summer workers, tablets and the Esri Collector application:

- Signs – over 5,000 signs
- Pavement striping

- Facilities data
- Maintenance features (potholes, shoulders, flood damage)
- Parks and recreation features (such as electric pedestals, roads, camping pads) collected by a summer worker using a configured simple Collector for ArcGIS app. Due to the upper-story trees, GNSS GPS to the tablets was not feasible. Staff used laser-guided positioning with a Trimble Total Station to acquire positions.
- Pavement
- Roadside features
- Water
- Ditches

The County migrated from SimpleSigns to Esri Collector for ArcGIS and also migrated the data model for a related table with full history of each sign. Other standards for data were developed with input from the County Engineer and Public Works staff.

In addition to geospatial asset data in an enterprise geodatabase format, the County uses spreadsheets and pdf maps.

Future asset data development includes ADA data using MnDOT's Collector application for ADA features. In addition, culverts and guardrails are priorities for future data collection. The GIS Department's staff will be collecting the data.

Publicly available LiDAR by-products for contours are part of the base map for visualization.

EagleView imagery was first flown in 2017, then again in 2018 due to product needs. Imagery plans are for every three years with the next flight scheduled for 2021. The County has not collaborated with other agencies for the flights.

SOFTWARE

Jackson County does not currently have an Enterprise License Agreement (ELA) with Esri for software and other service offerings but has seven Desktop licenses and leverages Workgroup geodatabase licensing.

The GIS Department uses the software capabilities to their full capacity by developing viewing applications, Collector applications, and is planning for Operations Dashboard development.

Asset management began with collecting the first asset—signs—using SimpleSigns. Eventually, SimpleSigns was replaced with the Collector application two years ago for the GPS Bluetooth ability for collecting pavement striping.

Collector is used because it is simple, easy to configure for data collection and attribute domains could be transferred easily from SimpleSigns to the Collector signs application. Configuring the Collector application for asset data collection has required a GIS person knowledgeable about GIS software and

data, and skills in configuring applications. Time to configure was about one day and learning to configure and transfer domains was off and on over a month's time.

Plans are to configure the Collector application to collect more asset data and use a work order system developed for the County to process work orders. A citizen engagement application has been configured for highway maintenance that allows staff to display information within 5 minutes that used to require 45 minutes to find and show residents at the department's counter.

Six years ago, Pro-West & Associates built a Ditch Work Order application on Esri technology. The Ditch Work Order application is in the process of being updated to a set of ArcGIS Online templates: public facing solution, internal editing solution to manage requests and an internal viewer for searching/querying/dashboards. The templates will be integrated with the County's on-premise enterprise system. The updated Work Order application will allow Jackson County to add requests on a map and manage the requests. The application is not a full work order assignment solution but could be used to configure and streamline a common set of work orders for any small agency to use.

The updated system will include signs and highway maintenance in addition to ditches.

Jackson County is interested in assisting with configuration or development of GIS products for asset management and working collaboratively with other agencies to create applications and tools.

STAFF

GIS staff capabilities are supplemented by employing summer workers to collect asset features. GIS staff time of 25% of the 1 FTE is dedicated to Public Works, but help is needed to collect data during the summer season. Training requires a day in the field, then the GIS Technician reviews the data when returned to the office.

GIS staff are aligned with the goals of the agency and departments, building trust over almost 10 years. There were struggles in the beginning because previous GIS Technicians did not have GIS knowledge, education or degree. As a result, processes and data were not developed for best use and had to be recreated.

It is helpful that the GIS Technician position is within the Public Works Department.

FUNDING

There is no dedicated budget for GIS for asset management. The GIS Technician requests what is needed for assets.

EQUIPMENT

Currently, the GIS Technician supports field collection software use for cell phones (Federal Emergency Management Agency (FEMA) data collection) tablets and GPS. The Information Technology Department sets up and supports the servers.

Successes:

- Collecting signs using a more accurate Collector application so all signs are within a 3-foot accuracy.
- The GIS Technician has transitioned from being the only person with knowledge of GIS for assets to employing summer workers and teaching Public Works staff to use GIS. Trust in GIS as a tool for asset management was built through demonstration of the benefits and functions. Now a priority list exists for continued data and application development.

Challenges:

- Time management. Finding enough time to complete the priorities.
- Being able to hire engineering and parks and recreation interns to work in a rural area. The County has attracted local people with a wide range of degrees that are not traditional engineering or GIS.

Lessons learned:

- For rural agencies, it works to start simple and build a program. Teaching non-GIS staff to run GIS applications for asset management "has been a game changer."

McLeod County

Local government agencies that do not currently use GIS for asset management or want to be more effective by expanding the use of GIS expressed an interest, through the project preliminary survey, in user-friendly software and data processes for non-GIS users. McLeod County uses an open source web-based mapping application for countywide GIS, along with configurable Esri ArcGIS Online applications, and is currently testing GRIT for GIS use for asset management.

Interviewed:

John Brunkhorst, County Engineer
Jesse Dehn, Assistant County Engineer
Christy Christenson, GIS Director
Joel Crawford, GIS Specialist

DATA DEVELOPMENT AND MANAGEMENT

The County has collected culverts (3-foot accuracy), ditches and tiles, and 911 sign management using tablets. Pavement management information is stored in a spreadsheet with a unique identifier GPS location.

Public Works has 746 records of road segments identified by mile point, latitude/longitude from the MnDOT PathView video log that could be used to link to spreadsheet information for future mapping.

Standards have been developed through the NG911 standards and built using other county data models for reference. (NG911 is described as "a nationwide, standards-based, all-I[nternet]P[rotocol]

emergency communications infrastructure enabling voice and multimedia communications between a 9-1-1 caller and a 911 center, and on to responders in the field.")

Publicly available statewide low-resolution aerial imagery has been used along with County-purchased 4-inch resolution imagery. In 2007, the County "bought-up" to higher resolution through MnGeo. Since that time, imagery is flown every four years. The County partners with other agencies to reduce the cost.

LiDAR has been collected to attain a 1-foot contour by-product.

SOFTWARE

GeoMoose: McLeod County has been linking documents to asset map features in GeoMoose for about 20 years. The information is not used for costing but allows users to know what is located where and all the documents associated with an asset can be viewed, such as construction plans, tax sheets and Assessor Department photos. The cost of GeoMoose is $100/month for about 60 layers of information.

In addition, the County has pavement quality as a condition of the road as captured in the MnDOT video log and extracted to an Excel spreadsheet. There is no x,y for the features, but information is stored by county road segment. The County could create a pavement quality index that could be brought into GeoMoose for viewing.

The county's permitting system is RTVision, which is scripted to share data with GeoMoose. An asset management system that replaces GeoMoose would require the ability to push data to other apps, not require replicating the data.

Mobile connectivity is an issue since County staff would like to see GeoMoose available on their phones, although performance, user friendliness and speed of loading is poor on a small mobile device. The County wants to take GeoMoose to the next level since they have invested in the use of the application throughout the County.

SimpleSigns: McLeod County uses SimpleSigns, a database front-end for Microsoft Access. The GIS Department imports the location information into ArcView for mapping and presentations. At this time, the goal is to use SimpleSigns more in depth, since collecting information is a higher priority than redeveloping tools and information they currently use.

GRIT is being tested. There are overlaps in functionality with GeoMoose, but GRIT provides a pavement management system and the software is being enhanced as requested by the users. The County would be interested in exploring a collaboration effort by users to expand the current functions of GRIT to work with Esri Collector for ArcGIS applications. A simple, lightweight mobile application would fit their needs for GIS asset management. GRIT would be a good solution for an agency without GIS. Data migration and development is required for data to support the functions of GRIT.

The County has investigated mobile application technology in other states and hasn't found a mapping solution to address their needs. GeoMoose, at present, is providing the functionality needed at a

reasonable price without concerns for credit consumption as is needed for a Collector app. Staff would, however, find a dashboard to be useful.

The software choice for the future would need to handle the many gigabytes of GIS data needed by the users in an effective environment at a reasonable cost. The interviewees' choice would be a one-stop-shop of information with folders of content for different County uses.

Esri Collector applications: NG911 signs are being collected using the Collector application on a Samsung tablet. Other data being collected with the Collector application configured by the County GIS:

- Culvert inspections are collected with a tablet and inspection comments are added. Points were added initially and are being maintained.
- Weed inspections using tablet collection of weed location.
- Quick lightweight data collection for other GPS points used for the Highway Department. The Collector application can be configured to provide quick collection needs.

The County has a five-year plan in spreadsheet form for upcoming expenditures and would like to display location information for planned construction and maintenance. Justification for the cost of the software is needed.

Future options for software functionality include work orders for marking location of roadkill deer.

Precise system: McLeod County Public Works is located in the Tri-Agency Building (housing the City of Hutchinson, the State of Minnesota and McLeod County offices) and is involved in sharing the sand and salt used for road treatment. Precise software tracks chemical application of salt and sand using GPS on the trucks and sensors that detect the amount of material used.

STAFF

GIS Department provides services to the County's Public Works Department, and non-GIS staff are trained in the use of GIS data collection and software use.

GIS staff are located in the Public Works Department. GIS support to the County is provided by 2.5 staff, including land records, NG911 and other support. The time of 1 FTE is dedicated to public works.

FUNDING

No dedicated GIS for asset management budget. The GIS Department provides services to the Highway Department as needed.

EQUIPMENT

The County has equipment to support data collection and the use of Collector Applications:

- Samsung tablets. The tablets don't provide a live cell connection so are synced at the office at the end of the day. The cost is $300 per tablet. Ideally, the County would like to use smartphones for field work such as work orders or viewing maps.

TRAINING

GIS for asset management training is conducted using the "train the trainer" model. Key staff are trained in the use of new processes, software and equipment, then train others.

The County would be interested in training at the regional or district level.

Pope County

Pope County was a pilot county for the use of GRIT in Minnesota. The County is interested in expanding the use of GRIT as a solution for management of roadway assets.

Interviewed: Brian Giese, County Engineer

SOFTWARE

Pope County has been using GRIT for approximately 2.5 years. The County considers GRIT an easy-to-use and effective communication tool. Giese has used GRIT to display information focused on roads and as a communication tool to the County Board and the public. GRIT has provided transparency.

Some of the challenges of using GRIT:

- Staff need time to enter the data to meet the functionality of the application.
- Staff use GRIT software weekly or monthly for most of the year and daily at other times, and also use paper and interactive mapping as a reference, which is duplicative.
- GRIT is not used in the field.

Efficiencies realized through using GRIT:

- Data entry with GRIT began with entering roadway assets (age of pavement, surface year, shoulder width, lane width, shoulder type, construction date, base thickness, ROW width), then the county chose to expand data entry iteratively, adding traffic, pavement condition and maintenance.
- The select and query functionality is useful for extracting information.
- The software is used for planning and construction planning.
- Data are simple to enter manually. It took more time to gather the information from project files than the amount of time required to enter the information into the software.
- GRIT has a schema that fits the purposes of Pope County roadway data, providing a base to develop the feature.

GRIT was selected for use because the County wanted a simple solution that was plug-and-play, requiring little IT involvement, and without a major investment to get started. The County wants to extend the asset management program in the future to share more information with the public.

In addition, staff in the Land and Resource Management Department use Collector for ArcGIS for capturing feedlot areas and summary information on mobile devices in the field with the ability to work without an internet connection. They also have Survey123 for ArcGIS to allow for the capturing and recording of subsurface sewage treatment systems sites and components using a mobile device.

TRAINING

GRIT use is intuitive for highway staff. Giese and staff were trained to develop and edit data within GRIT. The training required approximately one hour.

St. Louis County

St. Louis County applies equipment asset principles to the roadway when using GIS for asset management. Treating roadway assets in the same preventative and proactive manner as equipment assets has changed the paradigm for asset management in the County.

Interviewed:

Vic Lund, Traffic Engineer
Matt Hemmila, Deputy Public Works Director, Engineering Division
Stephanie Boyum, GIS Specialist

Paradigm shift: Borrowing the principles of equipment management and applying them to asset management, the County applies proactive and preventative measures, such as replacing luminaires at a location every five years instead of waiting for something to break. Instead of doing maintenance and recognizing a total cost for all maintenance, the County looks at features and the target life cycle, and asset performance. Thinking about asset management in this way was a paradigm shift for the County.

DATA DEVELOPMENT AND MANAGEMENT

Incremental approach: The incremental approach to data collection and development has worked well for the County. It is important to collect data that is useful and falls in a sweet spot of effectiveness—not too much and not too little information. The County develops data models based on staff and department knowledge and as few iterations as are useful to avoid changes when deep into collecting the data. Each time changes to the data model are added, this question arises: What is the return on investment?

As an example, when preparing to collect ADA inventory, staff asked questions of the data to determine if data would be collected to meet the County's ADA needs. Brainstorming was conducted to define the data fields, and collection was performed on a trial basis with review to tweak the data as needed. The County was careful about borrowing the MnDOT data model for a transition plan because complexity of the data was more than was needed by the County.

Each time the County has tried a process for collecting data in the field, the process has slowly built on itself. The choices made to date were based on resource availability, both interns and county staff. The incremental approach to developing data has allowed the County to lay out a path for priorities and application development.

The Enterprise GIS Department manages the enterprise GIS system and data to support other departments. Public Works is in the process of moving data to the County's portal.

STAFF

The Public Works Department has two GIS specialists. Both GIS specialists are dedicated 100% to the Public Works Department. The Enterprise GIS Division within the Planning Department manages desktop GIS software, servers, data, and exchanges information and processes with the Public Works Department.

TRAINING

The Public Works Department rolls out new applications and the GIS Specialist conducts training in-house. The training is held in different locations since the County has offices in Duluth and off-site, such as Virginia.

Mini-trainings on how to use dashboards and reporting are conducted for non-GIS staff to become familiar with the technology. Rolling out a new app doesn't always mean the staff need training since the interfaces and functions are similar, so staff are familiar with the operation.

The Enterprise GIS Division conducts a monthly GIS Infrastructure meeting in the downtown Enterprise office to discuss:

- Software states
- Issues
- Discoveries in the past month
- Benefits to all departments
    - GeoEvent Server for use by other departments
- Countywide support

There are also GIS specialists in other departments:

- Sheriff (E911)
- Land and Minerals
- Assessor
- Auditor
- Planning and Community Development
- Public Works

Washington County

Washington County Public Works Department started using GIS for asset management by creating a geospatial culvert inventory as the pilot data digitization project, then incrementally migrated other data from georeferenced road plan sheets linked to information stored in spreadsheets. Other datasets have been created using similar methods.

Interviewed: Charlie Parent, Engineering Technician, GIS

At the time Parent started at the County in 2014, the County had already digitized the culvert inventory from aerial photos. GIS use for culvert inventory was the County's trial run. All other assets were in spreadsheet format or located in road plans. Parent began to georeference road plan sheets in GIS for finding culvert locations, and digital point data was then created overlaying the plan sheets. The CAD format data was not readily available for migration to GIS, but the georeferenced pdfs could be used to digitize assets. ROW, cadastral and other boundaries were visible in the road plans for georeferenced points.

Asset attribute information, based on unique IDs listed in the spreadsheets, was added to the geospatial data. At times, unique IDs were created to join the spreadsheet information to the asset feature. Asset data creation has evolved from creating lines and points by digitizing road plans to using the Esri Collector for ArcGIS app and creating ArcGIS Online apps for collecting data in the field.

DATA DEVELOPMENT AND MANAGEMENT

The County is currently using GIS to track roadway assets, continuing to refine the asset datasets. Now that assets have been collected, GIS development for asset management has changed to collecting and updating asset information as construction projects happen. Currently, Parent is reviewing all 2018 plans and CAD data to update assets.

Culvert data digitizing provided an example of data development and use in a GIS format. The County now has collected all highway assets using ArcGIS Online, including:

- Guardrail
- Signs
- Signalized system
- Culverts
- Noxious weeds were collected in 2019. Mapping information is collected at the same time the weeds are being identified and treated by field crews.
- Playground inspections are being collected for two playgrounds by the Parks Department through the use of a Collector app. The county plans to add other playgrounds to this system in the future.
- Storm sewers will be georeferenced in the near future. Almost every spreadsheet has been converted to GIS data.

- Road plans containing project/year/limits have been hyperlinked to geospatial data. The limits of every project have been mapped. Workers can open a GIS map, select an area of interest, and find out what projects have historically been constructed there and where to find the plans.

The County is using an agency-designed data model, with data hosted in ArcGIS Online, providing web access. SQL Server databases are managed at the County for:

- Roadway centerlines
- Cadastral and boundaries
- Parks data
- Highway Data

In addition, County engineers work with PathView data produced by MnDOT video logs. Access to PathView and spreadsheet data is shared for use in GIS.

Imagery is flown every two to three years, sometimes as part of a collaborative effort with other agencies in the region. There are no plans for a LiDAR initiative; however, the state-provided by-product shaded relief is used as base data for mapping and layouts.

SOFTWARE

Washington County relies on Esri products, ICON software and spreadsheets to conduct asset management. Parent maintains the Esri applications.

The Public Works Department uses dashboards and web map viewers to display and analyze the data that are created using ESRI's Web AppBuilder and ArcGIS Online. The platform primarily is used to share information with engineering staff and administrators, such as scanned plans associated with a segment of road. All engineering staff have ArcGIS Online accounts. The information has been set up as view-only web applications.

Survey123 is used for signal work orders, the first use of Survey123 in the Public Works Department. In the past, the signal work order system was a paper sheet that was filled out with a description of the work performed and parts needed. The paper was routed to accounting for billing purposes.

The paper signal work order has been converted to Survey123. Now orders are entered into a digital form on an iPad and stored in ArcGIS Online. Work order information is exported as an Excel spreadsheet and forwarded to the accounting unit for billing. The signal work order application will likely expand to other uses. The process is being tested for monthly park maintenance inspections.

The use of ArcGIS Online streamlines the use of GIS for asset management since all data is in the same location, and the dashboard and applications all look and function the same. This also allows the use of apps to be simple and user friendly.

ICON software is used for Pavement Condition Index (PCI) rating and pavement data. Data is acquired from MnDOT for the video log and input into ICON. The County is able to analyze the degradation of PCI

ratings over time. The data in ICON is extracted to merge with centerline features to make maps in ArcGIS.

STAFF

The County Public Works Department has 1 FTE GIS-dedicated staff for engineering and parks using GIS for asset management. There are also dedicated GIS staff in other departments who manage other datasets within the County.

Data collection was initially conducted by the GIS staff using ArcGIS Online and the Collector application. Now, sign shop technicians update the data with the Collector application when the sign is replaced or maintained. Signal techs do the update mapping without assistance from GIS staff.

Development of asset databases was a coordinated effort between GIS and maintenance workers, signal techs and engineers to create a process based on the workflow of the specific staff. Occasionally, a field is added to the data. The technical staff who work with the asset data are the staff who helped develop the data model and ensure data relevancy. There is ownership in the data. Staff want effective, efficient data because they need to work with the data for their daily jobs.

The workload for the dedicated staff varies depending on the projects for the year. Time management is a challenge. In addition to annual updates, Parent's position includes training and support for non-GIS staff, and maintaining GIS-related applications and tools. Part of the success of GIS for asset management is the result of training non-GIS staff to assist with updating asset inventories through the use of mobile technology in the field.

FUNDING

GIS for asset management has no dedicated budget, other than 1 FTE Engineering Technician focused on GIS.

EQUIPMENT

Within the Parks and Highway Departments there are approximately 20 tablets. iPads are used for data collection using the Collector application and Bluetooth connected to a Trimble R1 for sub-meter accuracy. The Trimble R1 receiver is shared by Parks and Highway.

TRAINING

Non-GIS staff are trained as needed in the use of applications by the Engineering Technician. The Engineering Technician receives training for technology advances through online courses, in addition to the college degree in Geographic Information Systems. The success of GIS for asset management is in training non-GIS staff to collect and update asset data so it's not just the "GIS guy."

Case Study 2: Utilizing Mobile Technology for Asset Management

A key requirement for the project was to survey the use of mobile technology for asset management. TAP members expressed the need for scalable cost-effective mobile technology to be used by non-GIS staff in the field. Case Study 2 includes agencies that have implemented mobile technology on a small agency scale and larger agencies that have developed customized queries, filters and automated options for work orders and administrative oversight.

All of the case studies are examples of the use of mobile technology as a "birth to death" process:

- Develop data models with the staff who will use the data
- Configure applications based on workflow and data use
- Collect data in the field
- Use GIS asset data for daily workflow needs
- Use data for tracking, planning and reporting needs
- Update data to keep current

Agencies That Informed the Case Study

Telephone interviews were conducted based on responses to survey questions from one type of agency:

Agencies That informed the Case Study	
Group 2: Using GIS for Asset Management Without Full Integration	Freeborn County Jackson County St. Louis County

Freeborn County

Freeborn County has identified an approach to mobile technology for asset management that has worked well for the County, researching and implementing what is successful at other agencies, and using a collaborative team approach for data modeling, application development and data collection.

Interviewed:

Susan Miller, Director of Public Works
Tim Fulton, GIS Coordinator

Initially, the County used mobile technology to capture FEMA events that occur every two years, up to possibly two events each year. Geographic location is tied to damage and repairs. The FEMA process has informed the use of mobile technology for other nonemergency events and features in the County.

SOFTWARE

Freeborn County has purchased an ELA with Esri for the use of Esri products. The ELA provides the County with the ability to use and configure anything they need for GIS for asset management. The County has its own ELA and is not a partner in a regional or county/city ELA.

The County feels it is not using Esri product to the full potential, and there is more that can be done to develop and configure applications that can serve the County. As of January 2020, the County plans to transition all location technology needs to the Esri environment. Some of the "low-hanging fruit" that will be transitioned to Esri products include:

- Job order database. Currently, a job order database is used to track job order complaints such as dead deer or hole on the edge of the road. The database doesn't track these incidents well.
- Analyze all the mail boxes hit when snowplowing
- Plan for road construction
- Record vegetation management complaints

The GIS Department (Tim Fulton) along with Dan Kenison (Engineering Tech II) have been building applications to meeting the County's need for GIS in Public Works. The development is conducted using a collaborative team approach, building teams for different asset management areas. Team members work with Fulton and Kenison to document the workflow and information needed. Historical information is not being input, but asset features are being built moving forward. Fulton sets up the server and Kenison configures the applications. The teams are:

- *Bridge Management Team*. The county integrates information from MnDOT's Bridge Replacement and Improvement Management tool and SIMS as layers in the GIS environment containing the bridge and bridge number.
- *Construction Team*. The team relies on One Office from MnDOT that coordinates with RTVision software. ArcGIS is used to map the five-year plan, publish maps and data to the County website, and prepare maps for public meetings. Showing construction history has been helpful.
- *Facilities and Equipment Team*. The team relies on an AVL system, which is currently using a Motorola product, and is trying to transition away from Street Trek into the Esri environment for work tickets and GPS tracking.
- *Gravel Road Improvement Program Team*. Information was transitioned from spreadsheets to an Esri ArcGIS Online application. Staff include six grader operators.
- *Roadside Management Team*. Chemical use locations are mapped for weed control. Mowing, do not spray, and do not mow areas are also mapped.
- *Pavement Maintenance/Winter Operations Team*. Plans are in the works to transition from ICON to the Esri suite.
- *Sign Management Team*. The County is transitioning away from ICON to Esri products.

An asset management suite of applications and tools has been configured using Esri Survey123, Collector and Operations Dashboard. Staff access information using the dashboard, fill out information

using Survey123 and field staff use Collector to collect information and close out a job. Administration is able to view the status of a request, export the information to a CSV file and use in the office.

STAFF

Non-GIS staff are being trained as needed. Training is a time issue when trying to set up a meeting with 20 staff in a room to train on iPads. The best training experience is when there is collaboration among the whole group for field collection equipment. Training has been all in-house for the applications.

There are several staff members close to retirement, and some are not comfortable with technology, so the next few years may provide an opportunity to use more mobile technology in the field. In addition, the use of technology is helping with knowledge transfer of information from seasoned staff.

Every department has permissions and responsibility for collecting its own data and editing files and maps.

EQUIPMENT

Maintenance staff all use iPads. Material safety data sheets are on iPads, and the iPads are used for purposes other than maintenance. Each department has its own equipment. Ditch data are collected and updated using a hand-held robotic total station.

Accuracy is ensured for data collection by using Bluetooth to connect the Trimble R2 and Trimble R10 to data collection devices. For collection that relies on cell service, if the device is offline, information will be submitted as soon as cell service resumes. If staff members know they will be conducting field work in an area with poor or no cell service, data can be downloaded to applications on the iPads, or staff can use the MyFi in the trucks to connect without returning to the office.

Jackson County

Jackson County has been successful with mobile technology for asset management by employing summer workers (GIS, engineering and other college students) and configuring lightweight applications that require minimal training and supervision to operate.

Interviewed: Jared Baloun, GIS Technician

DATA DEVELOPMENT AND MANAGEMENT

The County has focused on collecting asset features over the past 15 years, making the most of summer workers, tablets and the Esri Collector for ArcGIS application.

Signs data: Collecting signs data throughout the County required one summer worker and two seasons. A student was hired to input data into a configured Collector application for 5,000 signs. The Collector application was configured by the GIS Department and has since been configured to collect other assets. Signs data was input into a tablet connected by Bluetooth to a Trimble GPS with accuracy of less than 3

feet. The GPS unit was tied to the MnDOT Continuous Operating Reference Station (CORS) network. The cost for the tablets and student worker to collect sign data was less than $3,000.

Pavement striping data: An engineering student summer worker traversed 370 miles of roads using a survey-grade Trimble R10 to return no passing zone data within a few centimeters' accuracy. The GPS unit was mounted to a truck back rack, and the interface was configured with quick buttons to operate the collection of directional data.

Data collection has been completed for the following:

- Facilities data
- Maintenance features (potholes, shoulders, flood damage)
- Parks and recreation features (such as electric pedestals, roads, camping pads) collected by a summer worker using a configured simple Collector app. Due to the upper-story trees, GPS Bluetooth to the tablets was not feasible. Staff used laser-guided position with a Trimble total station to acquire positions.
- Pavement
- Roadside features
- Water
- Ditches

Data are stored in a Spatial Database Engine (SDE) geodatabase.

Data to be collected: Jackson County plans to use MnDOT's Collector application for ADA features. The GIS Department's staff will be collecting the data. Other data planned for collection includes culverts and guardrails.

SOFTWARE

As Phase 2 of the sign collection initiative, a report will be created to annually review sign status meeting the County's sign reflectivity policy. Currently, a date is being placed on the back of the sign.

The County is interested in developing an Operations Dashboard that will enable data display and querying for the County Engineer. Future desired software use includes Workforce for ArcGIS for work order submission by maintenance staff.

STAFF

Predominantly, summer workers have been used to collect asset features, supplementing collection performed by the GIS Technician. Training requires a day in the field to start, then review of the data by the GIS Technician when the worker returns to the office.

EQUIPMENT

Currently, the GIS Technician supports field collection software use for cell phones (FEMA data collection), tablets and GPS. The Information Technology Department sets up and supports the servers. The initial investment for one summer worker to collect is $2,500 and $150 for maintenance.

St. Louis County

St. Louis County works to ensure smart collection and use of information through an incremental approach to GIS asset data collection that includes conducting brainstorming attributes, conducting pilots and asking questions of the data related to user needs.

Interviewed:

Vic Lund, Traffic Engineer
Matt Hemmila, Deputy Public Works Director, Engineering Division
Stephanie Boyum, GIS Specialist

DATA DEVELOPMENT AND MANAGEMENT (AND SOFTWARE)

Software learning curve: St. Louis County's history with asset management started with the traffic signs inventory more than 20 years ago. A Microsoft Access database was developed in-house to track sign age, replacement schedule and other sign attributes. The Access database was migrated to SimpleSigns (also an Access database app) and used from 2002 to 2009.

A second major effort was undertaken in 2008/2009 to approach sign inventory in a proactive, preventative manner. The County decided to use RoadSoft, Michigan Technological University's Center for Technology and Training application. RoadSoft could only be used for signs since pavement management in Minnesota uses a different approach than that used in Michigan. RoadSoft was used for sign inventory for seven years.

In 2015/2016, the County decided to create its own Collector for ArcGIS sign inventory application. Through the years, the databases from various software had been added to and merged, corrupting the information. The database was archived, and sign attribute fields were created based on the County's needs for sign inventory. By 2017 the County was collecting information using a tablet with Bluetooth GPS support. When it was proven that the sign inventory application configuration and collection was successful, other asset data was collected, including:

- Culverts
- Erosion
- Potholes
- Guardrails
- ADA inventory
- Pavement markings inventory

The County is on the process of configuring a Collector application for municipal separate storm sewer system (MS4) inspections. Survey123 has been implemented for service requests.

The County has seen an explosion of information collection and use in the last three years since implementing mobile technology for asset management.

GeoEvent Server is configured and ready to go for use with plow trucks.

Currently, the County is tracking chemical application by truck (salt, sand and brine) along the road linear feature. Plow trucks are equipped with WiFi software and an antenna to allow download and syncing of plow truck data when the truck returns to the garage. All trucks have a GPS AVL system that records speed and route, and application of material on a route. The concept is to combine the chemical application by route data, Roadway Weather Information System (RWIS) data and NOAA weather data. Correlating the different data streams would allow the County to associate storm intensity with chemical usage and roadway surface recovery time. Combining all of these elements into one (or possibly two) dashboards will allow the County to evaluate the current application rates, operator productivity and safety, along with chemical usage, to achieve the optimum level of service for snow maintenance on roadways.

A dashboard is being envisioned for future development to display different elements of real-time data during a weather event. These elements could include snowplow location and speed, plow and spreader operations, and truck telematics. These would all come from the AVL data through a GeoEvent Server.

St. Louis County is in the planning stages of an innovative “checkout” approach to match labor time to equipment time. The approach is necessitated by FEMA’s requirement to track time for reporting damage, but it is difficult to match time sheets to equipment use. The plan is to have equipment operators scan their badges when they get in the truck or equipment to more accurately track maintenance cost by route.

Other GIS applications are being considered, such as tracking mowing of slopes in the summer to map where mowing has been completed and work remaining.

Each time the County has tried a process for collecting data in the field, the process has slowly built on itself. The choices made to date were based on resource availability, both interns and county staff.

Challenges: As Collector applications are being configured and loaded onto tablets, the need for internal support has increased. Tablets don’t work all the time, and staff need to become acclimated to the new ways of collecting and using data. During the first few months of implementing mobile technology there were hiccups; staff complained that the technology was a “piece of junk” that “didn’t work.” It was crucial to have immediate support in place to support users.

Successes: The use of mobile technology in St. Louis County has had proven benefits. The County is large geographically with more than 40,000 signs. Collector fit the sign collection needs for two crews of staff each collecting up to 100 signs a day and taking up to 100 pictures. The sign crews are now dependent on the application and process after using it for two years. They even like it!

FUNDING

Less than 25% of the County's asset management budget is dedicated to mobile technology.

EQUIPMENT

In the field, staff are using cell phones, laptops, tablets and GPS (Bad Elf and Garmin) units for mobile data collection. Public Works owns and maintains its own GIS related equipment.

Initial cost: Less than $10,000 (cost of mobile devices only, server infrastructure already existed).

Maintenance cost: Less than $10,000 (cost of mobile devices only, server infrastructure already existed).

The Information Technology Department maintains a file server and SQL Server for data storage and access.

TRAINING

The Public Works Department rolls out new Collector applications and the GIS Specialist conducts training in-house. The training is held in different locations since the County has offices in Duluth and off-site, such as Virginia.

Mini-trainings on how to use dashboards and reporting are conducted for non-GIS staff to become familiar with the technology. Rolling out a new Collector apps doesn't always mean the staff need training since the interfaces and functions are similar, so staff are familiar with the operation.

For new staff, a meeting will be set up to review the application, such as Survey123 Service Request Application. The training requires a one- to two-hour meeting. Documentation is provided and the GIS Specialist provides field support as needed. Most staff develop the skill set when out in the field working with others familiar with the applications.

Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting

Agencies That Informed the Case Study

Moving an asset management program from the "what and where" phase to full integration requires planning and testing, sometimes attained through trial and error. Each of the agencies presented in this case study have worked to develop GIS for asset management through a succession of processes and software, providing lessons learned for other agencies wanting to move their programs to an enterprise system level.

Agencies That informed the Case Study	
Group 1: Fully Integrated Users of GIS for Asset Management	Carver County Public Works Carver County GIS
Group 2: Using GIS for Asset Management Without Full Integration	Anoka County City of Rochester

Carver County Public Works

The efforts of the Carver County Public Works Division is significant for several reasons related to GIS for asset management: the Division informs the case study through experience having started with configurable apps and tools and migrated to an enterprise asset management system; experience using asset management software for 20+ years, mobile technology for over 15 years; and scalable and progressive GIS growth.

Public Works considers organizational preparation to be key to GIS for asset management success. GIS and asset management were implemented in a cross-division arrangement which ensured data was not siloed as GIS for asset management was implemented. A solid GIS base for data development and exposure to web applications and mobile applications was in place before asset management was integrated. In addition, organizational alignment was key to support; staff were empowered to define and execute the process, becoming authoritative for their area of expertise. The asset management program wasn't built overnight but began showing worth incrementally. Enterprise asset management software required two years to implement but it built upon eight years of GIS work in preparation.

Interviewed: Perry Clark, Asset Manager

DATA DEVELOPMENT AND MANAGEMENT

Public Works has an extensive inventory of GIS asset datasets from over 20 years of digitizing and field collection, including signs, signals, pavement, culverts, lighting, and all other assets in county rights-of-way. The Division can now track the inspection, repair, replacement and maintenance of assets, calculating the total cost of an asset through its lifecycle.

Signs: A study was conducted by the Public Works Division to determine sign placement and to identify unnecessary curve signs. As a result, many signs were removed, and significant savings were realized. The Division used maps and mobile applications to contract with a sign installer to replace 1,200 signs throughout the County. The application allowed the Division to track work progress, inspect the work and ensure post installation maintenance.[4]

[4] **Esri Smart Communities: The Benefits of GIS for All**, Carver County, Minnesota, Esri, July 2016.

The importance of dates in asset data: The first challenge to consider when creating data capable of forecasting and analysis was **resurrecting dates from historic information**. When was an asset installed? Recovering install dates needed to be done for every asset type, to move from "what and where" to budgeting and forecasting.

Signal assets now have a five-year plan that relies heavily on multiple asset classes in an enterprise asset management system. As a result of the asset management efforts the Division has adopted a preventative replacement program for signals for the first time, moving from reactive to proactive. Previously, a lump sum budgeting process was performed and now the Division can plan for replacement and anticipate costs.

Public Works employs **standards** for data from several sources dependent on the capability of the standard to fit the Division's requirements. Various databases reference attribute domains from the Esri Local Government Information Model, Federal Highway Administration documentation, MnDOT, Cartegraph data models, or developed in-house by staff.

Up-to-date mobile data collection: Public Works has a process in place to capture asset data as it is installed or replaced. Annual updates need to occur as part of the as-built process, and ensuring up-to-date asset features is critical.

SOFTWARE

Carver County Public Works moved from "what and where" to analysis, budgeting and forecasting as the result of top-level direction to elevate the practice of asset management and expand the use of asset management software. Public Works conducted a market study of enterprise asset management software vendors to ensure the transition from desktop-based to web-based software was successful.

Enterprise Asset Management System (Cartegraph): Public Works grew GIS for asset management starting with Cartegraph desktop software use in the sign shop. Over time, the Division added some additional asset classes, functionality and recently carried out expansion as needed to upgrade to an enterprise web-based system with a mobile component.

Prior to advancing Cartegraph to an enterprise implementation, Public Works used ArcGIS Online for managing assets with GIS. Through this period, numerous maps and applications were built by Public Works and County IT GIS staff, including a custom-developed work management system using Esri GeoEvent Server. The suite of applications and tools met the needs at the time but did not track labor, equipment and materials on the asset and required resource time to build and maintain.

Since the planned expansion of asset management was going to be a significant change, including a major cultural shift, the Division performed a market evaluation in 2016 to determine if Cartegraph met

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https://www.esri.com/library/casestudies/carver-county-minnesota.pdf

the Division's expansion needs or if the Division should select a different software. Fourteen systems were reviewed. Major considerations included cost and functionality. Because the Division intended to mobilize all of their workers, the final selection of Cartegraph was based heavily on end user experience.

As the asset management practice matured in this metropolitan area county, relying solely on the ArcGIS suite of applications for work management was not sustainable. The complexity of the many relationships involved in enterprise asset management became unmanageable without commercial software. Migration from multiple ArcGIS applications to Cartegraph happened simultaneously with the build-out of many asset classes over the course of 1.5 years. The level of support for asset management changed from one staff person to a significant portion of three staff members' time.

It is important to note that the move to enterprise asset management does not mean that Public Works has stopped using ArcGIS Online and other GIS applications; they are still heavily invested in Esri GIS and view the two technologies as complementary.

The power of an enterprise asset Management System: Once labor, equipment and materials are being tracked on an asset, asset management is at a critical turning point. Prior to the Cartegraph enterprise implementation, the Division only had generalized costing for each County State Aid Highway (CSAH) in the state system. Being able to accurately analyze cost and the impacts of treatments, and predict future needs is the power behind the Division's enterprise system.

Carver County Public Works is also a member of a cooperative for cloud hosted **fleet management software,** AssetWorks. Benefits of collaboration are realized for agencies that don't have the technical ability to implement a fleet management system due to available staff time or skills. Drawbacks include limits to customization and expansion when configuration is coordinated for all member agencies, and agencies with technological abilities don't gain the same level of in-house expertise when one agency does the system management.

STAFF

Carver County Public Works started with one staff person that was reallocated from other duties to support GIS for asset management and over many years took advantage of reorganizing opportunities to build up the Asset and Performance Management Department. The capability was built slowly over time and grew as demand grew. Getting buy-in for building up GIS for asset management in the Public Works Department was key to success. There had to be the right people with the right environment at the right time.

Organizational alignment from the top down contributed to the success of asset management within the Division by empowering employees to shape an efficient and effective program. An important point of note is that in Public Works asset management touches all staff, from data maintenance to subject matter experts; it is a unified effort.

The Carver County Information Technology Department and the IT GIS staff play a significant role in the success of GIS and asset management implementations in Public Works. IT GIS has supported Public Works throughout their journey, manages GIS servers, administers ArcGIS Online, and provides

advanced functions such as pulling and pushing data through the Cartegraph API. Public Works has also greatly benefited from the County having an Esri ELA. Carver County as a whole has always been an organization that rewards innovation and supports the use technology to better serve citizens.

FUNDING

Carver County Public Works implemented GIS for the Division prior to integrating GIS into asset management with very little expenditure. The years of focused GIS implementation contributed to successful integration of GIS for asset management.

Support for funding took time to build, demonstrating worth of the system, people and process. Today the Public Works Division has an Asset and Performance Management Department with its own dedicated budget.

EQUIPMENT

Drones: The Public Works Department Division is beginning to use drones to collect data. Drones provide expansive options for data collection. The Division intends to use drone data part of their as-built process. The Division is working to ensure drone use is carried out correctly since the technology has a steep learning curve, high public visibility and expansive options for data collection. The Division is in the process of undertaking cross-division staffing and developing a drone policy.

GPS receiver accuracy: Carver County Public Works was an early adopter for using Esri Collector for ArcGIS apps in the field. At that time a sub-foot GIS grade GPS receiver was used to collect data, resulting in lower accuracy asset data, in many cases unusable for elevations. More recent construction projects included the purchase of survey grade equipment, which increased the number of survey grade GPS units that Public Works owns, and these units have become more available for asset data collection. Collecting survey grade data today requires effectively the same amount of time to collect as using a lower accuracy receiver previously, but the resultant data are higher accuracy. Higher accuracy collection when possible will help ensure that the data is ready for unforeseen future uses.

Public Works departments share equipment. The equipment is maintained by the department that purchased the equipment and access is allowed to other departments. Signs staff carry a GPS receiver with them at all times in the field because signs have a higher frequency of being added or removed.

TRAINING

Tiered training: The success of GIS for asset management lies in continuous tiered training. The Division executed a tiered roll-out of Cartegraph software and intensively trained staff. Mid-level Operations Department supervisors were trained to be able to use the software effectively. They then trained crew leaders, who in turn trained technical and field staff. This method of training provided layer upon layer of technical support.

Professional development by participating in local chapter meetings and attending the Institute of Asset Management (IAM) conference exposed Public Works staff to expert speakers and formal asset

management processes and organization on all levels, including federal or nationwide private sector organizations. IAM is focused on providing leadership, innovation and advancement for asset management professionals through trainings and courses. Public Works staff also stay current with Esri GIS training, GIS/LIS conferences, and Cartegraph-led training.

LESSONS LEARNED

Put software last! Focus on planning, organizational alignment, staffing, and developing and maintaining quality data.

Begin with easy wins and showcase excellence and capabilities with a simple asset class.

Everyone's GIS and asset management journeys are different; only you know what will work at your organization.

There is no division between GIS and asset management; they are the same. Both use data and maps to identify patterns, perform analysis and solve problems.

Public Works has implemented an enterprise system that involves all staff, creating a demand for exceptional up-time, data accuracy/currency, and continuous expansion of capabilities. Time and resources are required to ensure the system meets the growing demand.

Carver County GIS

Carver County works collaboratively with the cities within the County to implement GIS in general, and GIS for asset management. The arrangement allows cost sharing of license costs, application development and staff time.

Interviewed:

Peter Henschel, Chief Information Officer
Allison Kampbell, IT City GIS Analyst

DATA DEVELOPMENT AND MANAGEMENT

Collaboration between agencies: Carver County and the cities of Chaska, Waconia, Victoria and Norwood Young America have a cost sharing arrangement to implement GIS for the cities. Vital to the working arrangement is cost sharing for software licenses and dedicated staff time.

The County has evolved the use of GIS over the years from the "what and where" of assets to a fully integrated system of GIS for analysis, setting target levels of service and assigning risk, among other functions. Some of the cities' most cost-effective asset budget and project priority planning methods are still performed using spreadsheets, which is the most efficient method for the small agencies. However, the chief concern of the cities has been ensuring accurate, complete geospatial inventories as a backbone for asset management, requiring knowing the "what and where" of assets.

Moving from paper to productive: The cities took the first step of moving from paper maps to digital data by the County producing map books (Esri ArcGIS derived product) to emulate paper maps and provide easier and more functional use. Initially, the cities didn't have mobile devices, yet were able to

update the information and view maps as needed with map book technology on desktop computers. Development of geospatial data for asset management at the city level started with collaboration with the Planning and Utilities departments.

The first data development project the cities undertook was an inventory of city utility data. The cities also edit address points that are being maintained in GIS at the County. The County found that data accuracy improved through the collaborative effort of both the County and the cities collecting and sharing the data. The cities are beginning to migrate inspections and maintenance functions to GIS and manage asset data using GIS.

Data models for asset data: All four cities are using Esri's data models, driving the organization of data and focusing data collection: water, sanitary, stormwater, transportation (pavement management) and signs.

Collecting GIS asset data using mobile technology: The cities began using mobile technology to maintain utility datasets such as water, sewer and storm. Now, much asset information that would have been entered into a spreadsheet for asset management is now entered into a geospatial database. Most of the cities conduct data collection, while others contract data collection data collection through a third-party engineering firm, as needed or on a project basis.

SOFTWARE

County/city collaboration: Carver County develops applications in a cost share contracting arrangement with the cities of Chaska, Waconia, Victoria, and Norwood Young America. The County creates applications specific to each city, however, county data models and county base data such as parks, trails and stormwater may be used for reference. The IT City GIS Analyst, Allison Kampbell, configures the applications and provides maintenance to the cities. The County also works with the cities of Watertown, Mayer and Cologne on a project-by-project basis and partners with the City of Chanhassen to share GIS software and data.

Esri Web AppBuilder platform is a template being used for configuring the cities' applications managed by the County, in addition to ArcGIS Online, Collector, Explorer and Survey123. The cities use Collector for inspections and Explorer on cell phones and tablets to view all utilities in the field. In addition to Esri products, the cities of Waconia and Chanhassen use Cartegraph for asset management.

Licensing Esri software: The license is supported through an ELA that includes the County and participating cities and paid for by the County and cities. At first there were challenges with licensing among the agencies, which became the key to success over time; the County and cities saved money and gained GIS functionality, and the County was able to share an ArcGIS Online Organization registration that provided advanced functionality at a level the cities would not have been able to afford individually.

The ELA enabled the County to extend their Esri license to include 250 ArcGIS Online accounts for County and city staff access to Esri software products.[5]

STAFF

Staffing support for the cities: Growing use of GIS has led to increased demand for GIS support to the cities which eventually couldn't be supported by the County, so the four cities agreed to fund most of a shared position as a cost share, billed on a quarterly basis, to meet their needs.

The shared position staff, Allison Kampbell, works directly with the cities, spending time at the cities, interacting with city engineers and public works staff. Key to the success of providing staff to the cities has been to find the right person. Staff must work beyond the tenets of GIS technology to create relationships and assist with planning for various cities. Experience and skills for the full scope of GIS services are required.

Challenges when providing support to multiple cities: Since there is one staff person to provide services and support, that staff must be good at time management. Requests are tracked to ensure priorities are met for daily requests. At times, it may take a little longer for the cities to get a product since each city has a total of eight hours of services and support in a week. Early on, the County worked with the cities to define expectations.

FUNDING

Shared cost: Developing a cost-share position provided GIS capabilities to both the County and cities initially, adapting to near full-time support for the four cities as the work load increased. The cities cover the cost of support.

Notable successes: The collaboration between the County and four cities has allowed cost share for software and contracting the collection of Pictometry aerial imagery reduced the cost to all agencies.

EQUIPMENT

Hosted data: The County maintains a web server specifically for the cities' use for data access. The cities also use a SQL Server database housed at the County. The web server is set up the same for all the cities and accessed through web services.

GPS Receivers: Three of the cities purchased a Trimble GPS receiver to collect asset locations.

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[5] **Esri Smart Communities: The Benefits of GIS for All**, Carver County, Minnesota, Esri, July 2016. https://www.esri.com/library/casestudies/carver-county-minnesota.pdf

TRAINING

The cities have the same challenges that all agencies face when implementing GIS for asset management—the GIS process introduces different ways of carrying out staff work. Training and technical support have been crucial to the adoption of technology.

Kampbell maintains a work space at each City Hall where she is available for staff with questions, data and application needs. She also has trained and continues to support city staff in the use of GPS Receivers.

In addition, Kampbell conducts GIS User Group meetings with the cities about three times per year. The user group began with a few city staff and now has grown to include the Public Works Directors. Different topics are covered during the user group meetings, including sharing what is being done with the agencies and information gained from workshops, conferences and trainings.

Anoka County

Anoka County is an example of a local government agency that has fully implemented GIS for asset management, migrating asset data to geodatabase format, and developed a linear referencing system (LRS) to reference data features along a measured linear feature. The LRS has allowed the county to link multiple sets of attributes to each feature, streamlining data maintenance.

Interviewed:

Joe MacPherson, Assistant County Engineer
John Slusarczyk, GIS Coordinator

DATA DEVELOPMENT AND MANAGEMENT

The Highway Department collects asset management features when in the field in the winter, then updates the data in the winter off-season. The work is performed by a GIS Technician/Survey CAD technician. The GIS Department and Highway Department are within the same Transportation Division, although Highway does not have GIS staff within the department.

Enterprise asset data management: Anoka County's asset management moved from the "what and where" stage to an organized, referenced data enterprise system during the past three to five years when the Highway Department realized the strengths of maintaining data in GIS versus maintaining that information in spreadsheets. Today, all asset-related GIS data is maintained in an enterprise asset management site on the County's server infrastructure. Maintaining the data within a designated management site has enabled mapping, maintenance routines and document linking to function seamlessly for efficient data management.

Linear referenced data: The County created its LRS and converted 15 layers of data, including plow routes, to the LRS. When data are collected or edited, points and lines are now referenced to the roadway. The LRS allows maintenance of multiple tables of information separately, streamlining the data maintenance process.

The Highway enterprise geodatabase contains department-specific feature classes and tables updated to reference as events on the County infrastructure LRS. Among several datasets such as plow routes, advisory curves, bridges, crack sealing, traffic count locations, overlays, rehab, reconstruction, right of way, signals, speed zones and stormwater ponds, and structures such as outfalls and culverts, the County also maintains:

- Life cycle costs that are updated as new numbers are received.
- Road restrictions that are used to publish maps on the County web site, updated about a half-dozen times a year.
- Segment project history to indicate the county network broken into segments, each with a unique identifier. Roadway information contains 30 to 40 fields of data.
- Highway Improvement Plan lines and points are based on the one- and five-year highway improvement plan. The data changes continually, dependent on what has been completed in any given year, and what is being planning for successive years. The dynamic data are used to create maps as needed and for County Board meetings.

An issue arises when data require frequent edits, but the department does not have its own GIS person; changes are discovered at the time maps are requested and GIS staff are not the subject matter experts to edit the data without input from Highway staff, causing the process to take additional time or not be as efficient as it could be. Highway collaboratively updates data with GIS by sending maps back and forth to ensure accuracy. Construction work in the County affects the layers on a continual basis, so data are sometimes edited to make current when mapping is requested.

Data management: Due to the loss of key personnel, some of the GIS asset data is out of date. There are multiple versions of the same data that are being reviewed and organized by the Highway Department to ensure the most current data are accessible.

Data that are being used at least annually or continually are organized on the enterprise management site, but not all data are on the enterprise management site. Data that are not in enterprise GIS are on accessible network drives, requiring further organization to easily access old projects and spreadsheets.

Standards: Anoka County uses the MetroGIS standards as much as possible to align with work being done by other metro counties. MetroGIS has provided an ETL (Extract, Transform, Load) tool to translate data to the standards. Reporting standards to MnDOT have been incorporated into the transportation related GIS data. No customized models have been created for Highway.

NG911 data development: Many agencies are experiencing an issue with data development time management due to an increase in NG911 data development staff needs. Other GIS data development is considered lower priority for the initial development of centerline/address data and the dataset requires continual ongoing maintenance. Data are loaded manually in the county's computer-aided dispatch system.

SOFTWARE

Anoka County has created applications as repeatable templates to automate processes within the County.

The Public Notification application is an MXD (Map Exchange Document) template that automates the notification letter and map process for the department. The template contains predefined map and letter templates that users can change easily for dates and overall appearance of the documents. Staff use the application for public hearing and other presentation needs.

The Construction Finder app is an Esri Web AppBuilder application created in-house to select road segments and input dates to update the roadway feature class instantly online. Viewing and editing road data can be performed by non-GIS staff.

Linear referencing system: Roadway data is referenced using a linear referencing widget built by Houston Engineering. The widget allows scrolling along a roadway feature to view attributes and measure distance. The Web AppBuilder widget allows business units to maintain the linear reference data themselves. The use of this simple-to-use tool takes work off the plate of GIS staff and allows the staff who are experts on the asset work with the data. The widget is yet to be fully implemented.

Esri ArcGIS licenses: The County uses concurrent licenses of ArcGIS desktop software, allowing staff to use ArcMap to visualize, edit and publish data as maps. Recently, the highway asset map has been reformatted to be more user friendly for staff use. The GIS Department has used Esri products to configure multiple applications and tools for Public Works. Examples of other applications are listed below.

Collector for ArcGIS applications have included **MS4 reporting for culverts**, outfalls and ponds. Interns and summer workers performed the data collection. The application automates extracting the data from the application to a spreadsheet and then populates the formatted MS4 reports.

The County Parks Department uses a **Collector application configured to collect all assets** within the County's parks. In one season, a University of Wisconsin–Eau Claire GIS intern collected 3,300 points such as memorial benches, picnic tables, firepits and structures. A data dictionary, with input from department subject matter experts, was created prior to collecting park assets to ensure the department had considered all assets that could be collected and information to include before beginning the project. The data dictionary guided the intern to collect not only points but information about the asset such as maintenance condition and features of the asset. The intern had skills to also conduct post-processing and mapping work when back in the office.

Sign and signal inventory applications are next to be developed. The County is growing the applications needed for asset management and feels they have not yet exceeded the out-of-the-box configurable applications. GIS staff fit application development into their schedules, and plan to do more customized development in the future.

Flood zone delineation application: In response to FEMA, the County is publishing new maps to replace maps that were not developed based on the most recent 2011 LiDAR data, which created inaccurate flood zones. Financial businesses sent out letters alerting residents to their flood zone status that was incorrect. Anoka County developed a Web AppBuilder application to delineate flood zones based on the 2011 LiDAR data and shared the corrected data with the public.

The application displays the FEMA data and provides steps to fill out the LOMA (Letter of Map Amendment) application. Users can view contours, plats and half sections, and proximity of the flood zone to property and structures. The County sent out 11,000 letters to residents to inform them of the new flood zone delineation application. The Highway Department has also used the application to analyze floodplains for bridge projects.

Atlas 14: A software used for rainfall density and rainfall curves for density provides updated flood zone information based on current rainfalls.

STAFF

The Highway Department uses staff in the summer season to collect asset data.

25% of 1 FTE staff is dedicated to Highway. The use of the staff fluctuates through the year as requested. GIS staff include application development and configuration into their schedules, so no additional funds are required to develop applications for the County at this time.

FUNDING

No dedicated budget.

The GIS Department functions like a focused IT resource for the County. Set amounts of their support time is not allocated for departments unless a large project is requested, requiring billing back for hourly time.

EQUIPMENT

Data collection is accomplished by using tablets with cellular service. Some staff have application loaded on their phones. Anoka County has spent time with Washington County to review their use of GIS for asset management, equipment and processes.

Purchase of a Bluetooth GPS to share with the Parks Department is being considered.

Public Works maintains their own server that links to documents and other Public Works information. Data were nested historically but have since be reorganized to be accessible from one location.

Applications using ArcGIS Server are stored on an application server.

TRAINING

Public Works staff have received Pictometry training for the use of viewing imagery.

Since there are concurrent licenses of ArcGIS, GIS can do show-and-tell trainings with ArcMap for Public Works users. There are no power users, so training is minimal.

Training is conducted for the Collector applications as needed.

LESSONS LEARNED

Three years ago, the technical staff person in Public Works with the greatest knowledge of GIS asset data left employment with the County, migrating the work to the GIS Department. GIS staff do not have Public Works business knowledge and rely on Public Works for subject matter expert assistance to update data. The result is GIS staff who are not as knowledgeable about asset data and do not fully understand the Highway Department business needs taking more time to dive in and figure out projects.

Working on communication lines between GIS and the Highway departments is crucial to successful development of applications, analysis and data that are unique to Highway. Different business units in the Highway Department increases the complexity of the communication with the units and specific experts within the units.

City of Rochester

The City of Rochester implemented GIS for asset management due to the need for knowledge transfer prior to retirement of staff, and to leverage functionality provided by GIS. The City implemented an enterprise asset management system, supplemented by configurable lightweight applications to meet the asset management needs of the City. Reporting metrics are key indicators of the success of the migration and use of the new asset management systems.

Interviewed:

Kevin Morrissey, GIS Coordinator, Public Works Department
Christy Shostal, GIS Coordinator, Public Works Department
Kelsey Budahn, GIS Technician, Public Works Department

Until 2013, the City of Rochester Public Works and Parks and Recreation Departments were managing asset data through individual efforts. At that time, the Sign Division had been using Cartegraph software for 10 years. Due to upcoming retirements and concern for the loss of undocumented processes and workflows, and the ability of GIS technology to map and manage asset data, the Public Works Department began a search for asset management software.

DATA DEVELOPMENT AND MANAGEMENT

Elements XS: The City chose Elements XS software from Novotx for asset management. Implementing the software required migration of extensive formatted data from miscellaneous databases, Cartegraph software, spreadsheets and paper. Each work process and dataset had its own system.

The City reviewed the data to be migrated to determine a justification for backloading data from prior years. Based on a review, some data started at the recent date while other processes required history that required migration. Data were migrated from the structured databases and software, and also from unstructured paper documents and spreadsheet comments. The amount and type of data varied by the Public Works group submitting the data.

Public Works staff input the data into the system from other formats and summer interns collected data in the field. Subdrains, as an example, did not have historical inspection information migrated to the Elements XS system, but the information remained accessible if needed. Data were located in 450 separate Excel spreadsheets, requiring an inordinate amount of time to transfer. As an alternative cost-effective solution, locations for the subdrains were located with GPS units and loaded into Elements XS software. Annual field inspections were conducted by a consultant using the location information going forward. Initially, the consultant asked for some historical subdrain information, but the City has benefitted greatly from data moving from unstructured comments in spreadsheet format to structured data that can be easily located, queried and shared with outside contractors.

The City still has asset data to be migrated to the Elements XS system. The process has been approached incrementally as an ongoing effort. Entering information into an asset management system has allowed the Parks Department's Forestry Division to hire interns to collect the tree inventory. Information that didn’t exist, like specific tree treatments, prior to starting asset management are now entered into the system. The software tools allow flexibility and responsiveness. Groups within Public Works are finding processes needing capture and documentation that they didn’t know about previously.

Rochester is a growing community. The City required a method to measure the amount of time required to perform maintenance work so future planning could be calculated for expansion of the City. Entering assets and tracking Public Works tasks has provided a baseline to understand future expectations and to focus staff and other resources in the most efficient and cost-effective manner. Metrics provided through asset management provide consistent numbers and repeatable results, applicable to multiple processes.

The Forestry Division has been collecting metrics about the Emerald Ash Borer for the past three years, and have made adjustments to the City’s five- and 10-year plans to account for control mechanisms. Forestry Division staff have presented findings to other forestry groups and at the state level.

The first data to be collected using mobile technology was sanitary, storm and water service connection inspections. Today, every truck has a tablet with the ability to collect data, but the first step was creating and making GIS asset data accessible so staff could take their laptops into the field.

SOFTWARE

The City had a lot of Microsoft Access databases and macros that were too complicated to manage. A requirement in the search for an enterprise system was one platform that could handle all asset management needs. The unwritten processes needed to be input into the system to provide onboarding

and training to existing and new staff. The City needed to move asset management from an unstructured to a structured process.

MS4Front permitting software from Houston Engineering was the first effort by the City to develop a consistent, centralized system. The City was considering Cartegraph for asset management, but before the City decided on a software a survey was conducted to understand what was needed. As a result, the City purchased Elements XS and the Sign Division decided to change from Cartegraph to Elements XS. Data is not interoperable between MS4Front and Elements XS at this time, but rewrites are being programmed into MS4Front that will make sharing data possible in the future.

Cautions when moving into an enterprise asset management software:

- Staff wanted Elements XS to do everything. The software does not track time or integrate laser fiche, although integration with other systems is possible.
- The best data is the most immediate data. When using technology in the field, the data requirement is up-to-date and accessible. Analysis tools and processes are not quite ready. The City is building the foundation of useful data and documented processes as a foundation for analysis use.
- No program is turnkey. The software is a toolbox. The best way to approach implementing an asset management program, regardless of software, is incrementally starting with a pilot. Each group needs a pilot data process and staff time to develop, monitor and assist the group with review. A timeline that is adequate to fit the need is required. The City of Rochester doubled the timeline originally planned.
- Engagement meetings with the divisions support loading useful information, soliciting feedback and triage for issues that arise. The City dedicated a full-time person to meet with groups from the seven or eight divisions participating in the pilot.

Some groups and satellite offices have not migrated to Elements XS yet due to needed support. The offices with structured data (databases and digital spreadsheets) are easier to incorporate into an asset management system. Bringing unstructured data (paper documents, post-it notes, information in someone's memory) into the system also means that the documents have likely not been documented and more work is required to migrate information to a system workflow.

Migrating data to a GIS-centric system was an opportunity to register datasets by identifying the REST *(*Representational State Transfer) endpoints and primary keys that provided the relationships to the separate SQL Server database. Much of the migration process was customized. It was also an opportunity to introduce industry best practices to unique workflows using standardized toolboxes and standards. The City is building standards as data are reviewed and migrated based on several industry models. These include the NASSCO pipeline inspections, such as PACP (Pipeline Assessment and Certification Program), MACP (Manhole Assessment and Certification Program) and LACP (Lateral Assessment and Certification Program) to support certification attained by City sewer operators.

In addition to Elements XS, the City uses Esri products for public-facing applications and applications that need quick configuration and cloud hosting. There are barriers to serving public applications from

the City's network, which limits on-premise applications and makes cloud-hosted data and applications useful.

The first Esri ArcGIS Online public-facing application was focused on volunteer litter cleanup ("Our Neighbors," launched in spring 2019). A second Capital Improvement Plan map was shared with the public to display where the main construction projects are located in the City. Residents can click to view a summary report. Successive public applications such as the Flood Event site are pulling information from the National Weather Service and required quick configuration and accessibility. The Rochester Fire Department has an Esri Survey123 application that coordinates search and rescue based on a template from FEMA. The City built a dashboard using ArcGIS QuickCapture for mobile workers that don't have time to fill in information about an assignment. With the dashboard, users can create work assignments with one tap in the application.

Successes: It is crucial that systems can share information. The City of Rochester is well on its way of getting people out of data silos, sharing information and processes between departments and groups.

STAFF

The three City GIS staff serve all departments within the City. One of the challenges of the GIS staff is not data, but the cultural side of assisting people to move from one system to another. Many staff are accustomed to seeing all the data on a clipboard, and now they need to view a map and trust that the information is easily viewable via a click and report. The GIS staff must ensure all the data is available and staff questions are answered as they arise.

EQUIPMENT

In approximately 2013/2014, mobile technology became a priority. The challenge was connecting mobile equipment to internal systems, ensuring an internet or cell phone connection, or method for syncing when disconnected. Equipment is shared between departments, and each department has its own equipment. The GPS devices used include Trimble Geo7x and Trimble R2.

APPENDIX G
TRAINING RESOURCES

Training Resources

The GIS process for asset management introduces different ways of carrying out staff work. Training and technical support prove crucial to staff adoption of technology.

INITIAL STAKEHOLDER TRAINING (INTERNAL)

Prior to training for a wider audience within an agency or department, an initial review and training is suggested for key users to provide feedback and test data and applications that have been developed.

USER GROUPS AND CONNECTED STAFF

- **GIS User Groups** are available in several areas of Minnesota or can be conducted by an agency. Generally, user groups meet two to four times per year. A listing of user groups is maintained by the Minnesota GIS/LIS Consortium; see https://www.mngislis.org/page/user_groups.
- **Non-GIS staff trained by GIS staff**. Staff who work with the data are also those who are creating the data and collecting data and are most knowledgeable about data use.

LOW-COST GIS TRAINING OPTIONS

Minnesota GIS/LIS Consortium; see https://www.mngislis.org/event/19-spring-tc.

2019 MN GIS/LIS Consortium Spring and Fall Workshops are usually held at the University of Minnesota Minneapolis Campus. Half-day workshops run about three hours in the morning/afternoon and cost $100. An example of workshops being held in 2019: *Web AppBuilder: Knowing Your Options, Getting Started with Story Maps, Preparing and Collecting Data with ESRI's Collector for ArcGIS*.

Minnesota GIS/LIS Consortium Conference and Workshops is held annually in October. The conference features regionally and nationally known keynote speakers, instructor-led workshops, technical sessions, panel discussions, technology demonstrations and networking opportunities. In addition to instructor-led workshops, the conference hosts an ESRI Hands-On Learning Lab (HOLL). The HOLL is a training resource provided and developed by ESRI Training Services. The lab is an excellent way to introduce ArcGIS software users to a variety of ESRI solutions and training opportunities while learning to use ESRI software.

LinkedIn Learning (formerly Lynda.com); see https://www.linkedin.com/learning/search?keywords=GIS&trk=lynda_seo_learning. The online learning option LinkedIn Learning (formerly Lynda.com) offers some GIS-related courses taught by private instructors. These previously recorded lessons are subscription-based; costs range from $29.99 per month to $19.99 per month if paid annually.

BY VENDOR

Training is specific and tailored to agency; costs vary. See Appendix H, Software Matrices.

Esri Academy; see https://www.esri.com/training/unlimited-esri-training/. Agencies purchasing an Esri qualifying product (ArcGIS Online Organizational Subscription, Esri Small Enterprise and Enterprise Agreements) have unlimited access to Esri's entire e-Learning collection. Web courses, seminars and videos provide a low-cost option to gain specific knowledge for GIS activities.

Esri MOOCs (massive open online courses); see https://www.esri.com/training/mooc/. These free online classes offer a convenient, effective and fun way to keep up with the fast-paced developments in geospatial technology. Classes are four to six weeks long and participants can study whenever they have spare time. A certificate is available upon completion.

APPENDIX H
SOFTWARE MATRICES

Software Matrices: Introduction

The software matrices that follow include:

- Cartegraph
- Elements XS
- Esri
- GRIT
- Icon

Each matrix offers high-level information in the following categories:

- Product description
- Products for small or rural agencies
- Field collection on mobile devices
- Data schema
- Installation
- Configuration
- Training
- Pricing (initial)
- Pricing (maintenance)

Appendix F provides more detailed information about specific agency use of all five software packages and a few other products mentioned in this report:

Case Study 1: Getting Started

- Becker County – GRIT, ICON
- Beltrami County – GRIT, ICON
- Jackson County – Esri
- McLeod County – Esri, SimpleSigns, GeoMoose, GRIT (test mode)
- Pope County – GRIT (pilot county)
- Washington County – Esri, ICON

Case Study 2: Utilizing Mobile Technology for Asset Management

- Freeborn County – Esri (Enterprise License Agreement)
- Jackson County – Esri
- St. Louis County – Esri (migrated from SimpleSigns and RoadSoft)

Case Study 3: Moving Beyond "What and Where" to Analysis and Forecasting

- Carver County – Cartegraph (migrated from Esri)
- Carver County/multiple city collaboration – Esri
- Anoka County – Esri
- City of Rochester – Elements XS (migrated from Cartegraph), Esri (public-facing, cloud-hosted, quick configuration)

Software Matrices: Cartegraph

Feature or Function	Description
Product Description	Small focused apps for smaller agencies (see products row below) new to Cartegraph products, and varied levels of Cartegraph full software for larger agencies. Cartegraph Essentials/Pro/Plus/Premium - Varied level of function and cost - Focused applications for smaller agencies are detailed below Essential functions: - Cloud-based - Mobile applications for field collection - Asset inventory and inspections - Work management - Resource management - Dashboard and reports - Embedded maps - Esri integration Pro additional functions: - Request management - Report designer - Preventative maintenance Plus additional functions: - Fleet management - Advanced inspections - Workflow automation Premium additional functions: - Material management - Asset builder - Proactive work plans
Products for Small or Rural Agencies	Yes – Unlimited users for focused apps **Focused apps** - **Sign app and work order management** o Web-based app o Mobile collection module for field collection o Recognizes signs for collection automatically - **Pavement management** o Web-based app o Mobile collection module for field collection

Software Matrices: Cartegraph

<table>
<tr><th>Feature or Function</th><th>Description</th></tr>
<tr><td>Products for Small or Rural Agencies (continued)</td><td>- Parks and recreation
  o Web-based app
  o Mobile collection module for field collection
- Playground equipment</td></tr>
<tr><td>Field Collection on Mobile Devices</td><td>Yes</td></tr>
<tr><td>Data Schema</td><td>Built-in data models or develop custom with agency.</td></tr>
<tr><td>Installation</td><td><table><tr><td>Essentials</td><td>Pro</td><td>Plus</td><td>Premium</td></tr><tr><td>$7,500</td><td>$10,000</td><td>$12,500</td><td>$15,000</td></tr></table>The scalable web server components are built using Microsoft’s ASP.NET MVC Framework and renders cross-browser compliant HTML, Javascript, and Cascading Style Sheets (CSS) to the client’s web browser. HTML 5, Javascript, JQuery, CSS3, and AJAX. The back-end business logic and data access layers driving the application are written in C#.</td></tr>
<tr><td>Configuration</td><td>System functionality is the same regardless of whether hosted or on-premise. Data is stored in a central repository. Configured so users only see information applicable to their role for user-defined tools.
Configured using Esri Base Map and feature functionality.</td></tr>
<tr><td>Training</td><td>Remote training cost included in installation cost. On-site training cost additional.
- Remote train-the-trainer training for overall system navigation – up to 4 hours
- Remote train-the trainer training for Cartegraph OMS & Esri – up to 2 hours
- Remote train-the-trainer training for overall system navigation – amount of time TBD with project manager
- Remote training for Cartegraph for iPad and Cartegraph One – amount of time TBD
- Remote reporting functionality – up to 6 hours
- Remote administration training – amount of time TBD</td></tr>
<tr><td>Pricing (Initial)</td><td>- Focused applications – unlimited users
- Sign and Work Order Management<table><tr><td>Population</td><td>Cost</td></tr><tr><td>0-10,000</td><td>$1,500</td></tr><tr><td>10,001 – 24,999</td><td>$2,500</td></tr><tr><td>25,000 – 49,999</td><td>$5,000</td></tr><tr><td>50,000+</td><td>TBD</td></tr></table>- Pavement and Work Order Management<table><tr><td>Population</td><td>Cost</td></tr><tr><td>0-10,000</td><td>$2,500</td></tr><tr><td>10,001 – 24,999</td><td>$4,500</td></tr><tr><td>25,000 – 49,999</td><td>$7,500</td></tr><tr><td>50,000+</td><td>TBD</td></tr></table></td></tr>
</table>

Software Matrices: Cartegraph

<table>
<tr><th>Feature or Function</th><th>Description</th></tr>
<tr><td>Pricing (Initial) (continued)</td><td>
- Parks and Recreation
<table>
<tr><td>Population</td><td>Cost</td></tr>
<tr><td>0-10,000</td><td>$1,500</td></tr>
<tr><td>10,001 – 24,999</td><td>$2,500</td></tr>
<tr><td>25,000 – 49,999</td><td>$5,000</td></tr>
<tr><td>50,000+</td><td>TBD</td></tr>
</table>
If organizations wish to collaborate on implementation and adhere to a similar timeline, Cartegraph will discount the above services fees as such: 2-5 customers, all customers receive 50% discount on Implementation Services costs; 5+ customers, all customers receive 75% discount on Implementation Services costs. This discount requires this group of customers to sign agreements with Cartegraph within 30 days of each other and adhere to a similar implementation schedule.

Initial cost for Cartegraph Essentials/Pro/Plus/Premium software:
<table>
<tr><td>Population</td><td>Essentials</td><td>Pro</td><td>Plus</td><td>Premium</td><td>Users</td></tr>
<tr><td>0-5,000</td><td>$2,920</td><td>$4,380</td><td>$5,840</td><td>$7,300</td><td>5</td></tr>
<tr><td>5,001-9,999</td><td>$3,512</td><td>$5,268</td><td>$7,024</td><td>$8,780</td><td>5</td></tr>
<tr><td>10,000-14,999</td><td>$4,760</td><td>$7,140</td><td>$9,520</td><td>$11,900</td><td>10</td></tr>
<tr><td>15,000-24,999</td><td>$7,520</td><td>$11,280</td><td>$15,040</td><td>$18,800</td><td>20</td></tr>
<tr><td>25,000-39,999</td><td>$9,450</td><td>$14,560</td><td>$18,220</td><td>$21,500</td><td>25</td></tr>
</table>
</td></tr>
<tr><td>Pricing (Maintenance)</td><td>- Same price annually as initial cost, without installation costs for Cartegraph Essentials/Pro/Plus/Premium software</td></tr>
</table>

Software Matrices: Elements XS

Feature or Function	Description
Product Description	Designed for: - Streets, traffic and public works - Water, sewer and storm utilities - Gas and electric utilities - Planning and zoning - Parks and recreation Functions: - Inventory management - Routine maintenance - Service requests and work orders - Fleet management - Facilities maintenance - Permits, licenses, inspections - Citizen requests - Mobile interfaces for tablets and phones - Real-time utility billing integration - GIS-centric - Notifications and triggers for admin and field staff - Auto-generated service orders - Maintenance scheduling - Analysis of user-defined datasets - Automated job routing - Real-time – not a nightly batch update - User defined data collection forms Web-based
Products for Small or Rural Agencies	Yes - Licensing available for a county and the cities within the county - Not modular based; the software is for the entire agency - Unlimited users
Field Collection on Mobile Devices	Yes
Data Schema	Built-in data models or develop custom with agency.
Installation	Works with the customer and customizes to fit the organization size and workflows.
Configuration	Out-of-the-box reports and workflows dependent on size of the agency. Example of deployment: Migrate from another system and running in 4-5 months. Quicker configuration and ready to use if not migrating from another system
Training	All employees using the system are trained; “train the trainer” support is provided for the agency to train future employees.

Software Matrices: Elements XS

<table>
<tr><th>Feature or Function</th><th>Description</th></tr>
<tr><td>Pricing (Initial)</td><td>Annual license fees based on population. Three-year maintenance agreement. First year includes annual fee plus cost for:
Installation
Data migration
Integration with third-party applications
Training
Cooperative pricing will be considered for group purchasing<table><tr><td>0 – 25,000</td><td>$15,000</td></tr><tr><td>25,001 – 50,000</td><td>$25,000</td></tr><tr><td>50,000 – 100,000</td><td>$50,000</td></tr></table></td></tr>
<tr><td>Pricing (Maintenance)</td><td>Three-year maintenance agreement.<table><tr><td>0 – 25,000</td><td>$15,000</td></tr><tr><td>25,001 – 50,000</td><td>$25000</td></tr><tr><td>50,000 – 100,000</td><td>$50,000</td></tr></table>An estimated example cost for a large city could be $80,000 to $110,000 in total depending on integrations with other software and systems, and data migration if required.</td></tr>
</table>

Software Matrices: Esri

Feature or Function	Description
Product Description	If an agency opts to configure applications, Esri applications include the following: **Explorer and Collector** - Viewing, collection and editing in the field; can be used offline - Maintain inventory and related info that occurs on more than one occasion such as related tables **Survey123** (form-centric application) - Collect and edit assets for points, polygons and lines - Collect spatial features and records in a table; logic in the form to provide input options to fit the asset **Navigator (**premium Esri app) - Routing of published network routes; pay credits if using Esri routing network **Workforce mobile application** (receive work order notifications in the field) - Track work order from assignment to completion - Search maintenance records **Pro-West & Associates will provide bundled applications of modules to include:** Collection/Inventory Work orders Inspections Citizen engagement Reporting/Analysis dashboards Advanced data management A free dashboard module will be included in the asset management bundle when 5 or more agencies develop modules collaboratively.
Products for Small or Rural Agencies	Yes. Same product for all agencies. - Host data and applications in ArcGIS Online - Don't need Server or enterprise GDB at the entry level - Can host data on-premise if desired
Field Collection on Mobile Devices	Yes
Data Schema	Yes. Asset management-related data models include: - Energy utilities - Telecommunications - Transportation - Water utilities - Local government information Each agency can use custom data models to fit their organization, if desired. Esri data models are customizable.

Software Matrices: Esri

Feature or Function	Description
Installation	Hosted data and solutions in ArcGIS Online or on-premise by agency with GIS staff or from a consultant.
Configuration	Out-of-box applications, tools and reporting can be configured by the agency or consultant.
Training	Online or on-site from Esri.com. Third-party training from consultants.

Pricing (Initial)	Cost per module configure by Pro-West: $1,200
	• Esri ArcGIS Online Creator license $500 and ArcGIS Online Field Worker license $350 may be required. Licensing is needed only if the agency does not have named users. If an agency uses Esri products in Public Works or other departments, they likely have named users.
	  ○ A minimum of 1 license is needed. An agency can choose license levels based on needs.
	  ○ Advanced data management module will require a Pro annual Esri license of $700/year or $2750/year depending on needs.
	Pro-West will consult with agency to determine license requirements
	Collaborative development by a group of agencies with Pro-West: A free dashboard module will be included in the asset management bundle when 5 or more agencies develop modules collaboratively.

Pricing (Maintenance)	Cost per module maintained by Pro-West $500 annually.

Software Matrices: GRIT

Feature or Function	Description
Product Description	Web map-based roadway inventory application with cloud server database and customizable ArcGIS online viewers and applications, this tool works on any web-enabled device in the office or field. Model and application are beginning to end workflow from field data capture to interactive web maps. Functions: - Viewing: Attributes available as map layers with Google Map background; also, all attributes available for ArcGIS online web map applications. - Data collection in field or office with Google Maps and aerial photos as reference. Data connection is required for field data collection. Cloud-based SQL Server database with normalized related tables for all layers. - Query and display - Reports: System pavement condition graphs available. Other reports may be made available as requested. - 20-year future pavement condition forecasting and interactive condition maps - Routing available within Google Maps API - All the online maps are live data; example: when construction planning is updated with road closure all web-maps are updated real time. - Notifications or triggers could be added; requires request - Work orders could be added; requires request - No feature tracing
Products for Small or Rural Agencies	Yes. Same product for all agencies. Unlimited users; software and data are hosted. No agency IT or GIS support required. Currently being used by 11 counties in Minnesota.
Field Collection on Mobile Devices	Yes
Data Schema	GRIT data schema: Database model developed by county engineers to capture paved or gravel roadway attributes for decision making for construction history, construction planning, minor structures and load restrictions
Installation	Setup requires county to contact UPGTI to receive a user name and password for web application access.
Configuration	- No configuration required - Use website app to enter data the first time - Enhancement requests sent to UGPTI - One version for all users - Enhancement process: UGPTI reviews and discusses major enhancement requests with counties in ND and MN to determine interest, feasibility and benefits. Minor enhancements or requests will be implemented by UGPTI as time allows. May need funding for students to do enhancement work as a research project.

Software Matrices: GRIT

Feature or Function	Description
Training	- Advisory committee in ND, not in MN at this time - Periodic webinars as needed when major enhancements are released - Training per agency; less than an hour via online videos - Training videos on the UGPTI home page
Pricing (Initial)	$1,500 to purchase
Pricing (Maintenance)	$1,500 annually

Other Services	- No GIS person required to install and configure, but technical staff are needed to enter data into the software.
	- Any asset that can be tied to the roadway can be used.
	- Progressive web application development dependent on user requests; possible future enhancements:
	  ○ Sign inventory
	  ○ Link to online construction plan PDF files
	  ○ Work orders
	  ○ Metadata
	  ○ Citizen engagement

Software Matrices: ICON

Feature or Function	Description
Product Description	Modules (all GIS-centric): - Traffic sign - Pavement - Right of way - Universal asset management (doesn't need to be in the ROW) - Work management module (handles service requests and work orders) - AVL (vehicle tracking) - Park assets - Sewer (sanitary and storm) Other features: - Cloud-based - Mobile applications for field collection - Dashboard and reports - Integrates with Esri platform
Products for Small or Rural Agencies	Small agencies use the same product used by large cities. Features benefitting small or rural agencies: - Can streamline interface for less complicated use. - Software can be hosted. - Data can be hosted.
Field Collection on Mobile Devices	Yes
Data Schema	Offers built-in data models or can develop custom models with the agency.
Installation	- Amazon-hosted or on-premise for the same pricing as hosted; price-neutral. - Set up for the agency to test and deploy additional cost.
Configuration	- Adapted system to work with the MnDOT pavement management methodology. - MnDOT video van spreadsheet imported into the agency's system.
Training	- On-site training after installation or web-based (WebEx) training. - Offers training the trainer. - Unlimited tech support. - Regional user meetings or online meetings are used to conduct high-level training and cover specific issues.
Pricing (Initial)	Three levels: - *Large cities and counties* (metropolitan area). Greater than $7,500 (5 client access licenses (CALS); one-time license. - *Smaller county* (50,000 or less population). $2,500 to $7,500 (5 CALS); one-time license. - *Smallest agency* (lowest for a homeowners' association, private community, township or small county). $750 annual single-user subscription license. Cooperative pricing will be considered for group purchasing

Software Matrices: ICON

Feature or Function	Description
Pricing (Maintenance)	Three levels: - *Large cities and counties* (metropolitan area). $4,000 and up. - *Smaller county* (50,000 or less population). $500 to $1,750 depending on module and database platform. - *Smallest agency* (lowest for a homeowners' association, private community, township or small county). Tech support provided.

Other Services	- Offer manual data collection with a fleet of vans.
	- Train agencies to collect data.
	- Turnkey data collection service.
	- Cost plus $125/hour if the work is charged by the hour. Packages of hours can be purchased at the prices below:
	  ○ 10 hours at $99/hour
	  ○ 20 hours at $86/hour
	  ○ 40 hours at $68/hour
	  ○ 80 hours at $49/hour
	Typical service would include:
	  - Data entry.
	  - Roadway inventory integration with GIS.
	  - Link a centerline map with a database.
	  - Generate maps for presentations.
	  - Maintenance in a given season (can create data from hard copy).

APPENDIX I
QUICK START GUIDE

Quick Start: GIS Tools and Apps—Integration with Asset Management

Project Overview

Asset management is critical for local and state governments to track assets and plan for maintenance of assets that will provide the greatest return on investment (ROI) for the agency. The use of geographic information system (GIS) applications, tools and geospatial data can provide agencies with the most accurate inventory of assets, a basis to determine and maintain condition, cost-effective mobile tracking and maintenance of assets such as signs, culverts, roads and bridges, and reporting tools to justify asset expenditures. However, challenges such as agency size and location, access to accurate and timely geospatial data, and lack of information about the best data processes, applications and tools to use limits local agency use of GIS for asset management.

This project examined current local agency practices and reviewed existing mobile technologies to recommend best practices for the efficient, cost-effective use of GIS mobile technology by different types of local agencies in Minnesota seeking to better manage agency assets. Following the summary of the current state of the practice in Minnesota, this *Quick Start Guide* offers brief synopses of the three case studies appearing this project's final report and highlights five software options used by Minnesota local agencies.

Current State of the Practice in Minnesota

DATA SOURCE

The data that follows was gathered using a preliminary survey that received 79 responses from 75 cities and counties; a follow-up survey of GIS users received 33 responses from 32 cities and counties.

GIS USE

- A quarter of respondents are currently nonusers of GIS but are interested in using GIS to manage assets.
- Almost half of respondents use GIS for asset management without full integration.
- Relatively few respondents consider themselves to be fully integrated users of GIS (only 16.5%).

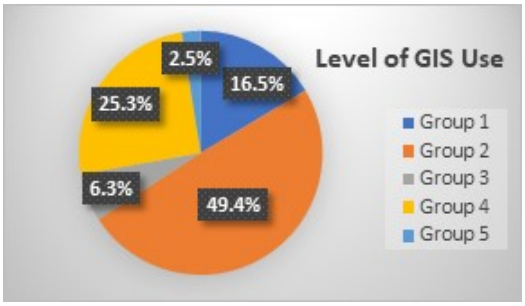
Group 1: Fully integrated users of GIS for asset management **(16.5%)**

Group 2: Using GIS for asset management without full integration **(49.4%)**

Group 3: Using GIS for asset management for three years or less **(6.3%)**

Group 4: Nonusers interested in using GIS to manage assets **(25.3%)**

Group 5: Nonusers uninterested in using GIS to manage assets **(2.5%)**



NEEDS, PLANS AND INTERESTS

- Respondents want a GIS tool that can be used for asset inventory, a tool that is simple to use for field staff, provides an asset history and allows for changes to assets in the field, and gathers accurate data in the field.
- Half of respondents have plans for some type of asset management data initiative in the next three years.
- Almost half of respondents expressed interest in collaborating with other local agencies on development of a suite of lightweight GIS apps for asset management.

GIS TOOL USE

- Almost three-quarters of respondents using GIS use Esri products; almost all use ArcGIS Desktop.
- Most agencies supplement GIS tools with other methods and systems, most often with spreadsheets.
- Agencies are most often using tablets and GPS devices to capture field data.
- More than 40% of respondents employ connected mobile collection practices.

STAFFING LEVELS

- One or more FTE is the most typical staffing level among all respondents.
- Respondents are most likely to have dedicated GIS staff within various departments.
- More than two-thirds of respondents plan to either hire or train GIS staff in the next three years.

Quick Start: GIS Tools and Apps—Integration with Asset Management

SUGGESTED AUDIENCE

Agencies just getting started with GIS for asset management and mobile technology. These agencies may have the beginnings of a GIS program or none at all and want to use a mobile GIS system for work orders, field inventory and data collection.

This Quick Start Guide is an appendix to the GIS Apps and Tools – Integration with Asset Management project report. The report documented county and city engineer surveys, GIS technology demonstrations, and case studies conducted during the Local Road Research Board (LRRB) project to answer the questions:

- What is out there for agencies to get started?
- What currently exists for mobile technology and what can be developed?
- How do agencies grow great asset management systems, moving beyond "what and where"?

Below is key information gleaned from the report to assist agencies just getting started with GIS for asset management to begin the process.

Data Development and Management	**Key Takeaway: START SIMPLE.**
	
	DATA COLLECTION
	• Plan data collection and development to set cost-effective priorities within your budget.
	• The most successful collection efforts have occurred when development is a coordinated effort between GIS and maintenance workers, technicians and engineers. Staff need ownership.
	• Start with easy-to-collect assets like signs and culverts. Use these simple data collection efforts as a test case to refine how you'll collect assets in the field for erosion, potholes, guardrails, ADA inventory, bridges, weeds, playground equipment, signalized systems or pavement markings.
	• Start simple and build a program. Teaching non-GIS staff to run GIS applications for asset management "has been a game changer" for some agencies. Use non-GIS staff and summer workers to collect and digitize data; consider consultants and vendors for data collection.
	• Invest in the highest level of GPS receiver as possible to support data collection. Collecting data using a higher accuracy receiver requires the same amount of time to collect as using a lower accuracy receiver, but higher accuracy collection will ensure the data is ready for unforeseen future uses.
	
	DATA MANAGEMENT
	• Use simple configurable applications like Esri's Collector for ArcGIS or GRIT to create data in the office or the field. GRIT has a user community to support software functions. Esri software templates can be developed as a user group of agencies and can be bundled to pick and choose needed functionality for individual agencies.
	• Begin migrating asset information from spreadsheets and other formats to geospatial databases. *Consider this critical question*: How much historical information is needed?
	  ○ Plan for cost-effective data migration. Some data are best managed using spreadsheets and migrating over time.
	  ○ Time to locate and organize information is a limiting factor for developing asset data. Plan for staff time.
	• Consider adopting the data model included with asset management software, or a neighbor agency's data model.
	• Begin to capture data as it goes to ground and schedule data updates.
	• As GIS use for asset management grows (application and tool use, data collection), the need for internal support increases. The rate of expansion can create a backlog due to requests for GIS asset data. The demand for location-based services can, at times, be greater than the availability of staff to provide services and security.

Quick Start: GIS Tools and Apps—Integration with Asset Management

Software

Key Takeaway: Purchase scalable software and only what you need.

- 72.2% of project survey respondents are using GIS for asset management.

Software may have additional specifications such as training limitations, user requirements, additional software needed, or population-based cost. Refer to Appendix H, Software Matrices for full details.

MANAGEMENT PRACTICES

- Agencies successful in the use of mobile technology for asset collection conducted a survey of department needs to ensure needs are met when selecting software.
- If you don't have staff or staff are not skilled or do not have time, use a vendor to maintain software.
- Purchase cloud-hosted solutions; all featured software offer cloud-hosting of software and data.
- Participate in collaborative development (GRIT, Esri bundles) or cooperative purchasing (Cartegraph, Elements XS, ICON) for cost-effective software.
- Iteratively develop functions and tools based on priority and over time to vet and become familiar with the function before developing the next application. Each iteration creates buy-in from staff and administration based on end user success. More is not necessarily better. Start simple with scalable software focused on small agencies.
- Roll out mobile technology as applications are being developed or data are ready to collect.

SUGGESTED SOFTWARE

- ***Cartegraph*.** Two Options: 1. Focused applications for signs and work orders, pavement and parks. **Cost for Focused Apps: $1,500 to $7,500 per application/$1,500 to $7,500 annual maintenance per application.** 2. Cartegraph Essentials – enterprise asset management software developed for small agencies. **Cost for Cartegraph Essentials: $10,500 to $15,000 dependent on population 2,500 to 20,000; $7,500 annual maintenance, plus installation fee.** Cartegraph will consider cooperative purchasing for group discount.

- ***Elements XS***. Enterprise software for the entire agency designed for public works, transportation, utilities, planning and zoning, parks and recreation. **Cost: $15,000 to $50,000 dependent on population from 25,000 to 100,000. Additional costs for implementation.** Novotx will consider cooperative purchasing for group discount.

- ***Esri Modules*.** 41.4% of survey respondents use Esri products for mobile technology. Pro-West will bundle modules for collection/inventory, work orders, inspections, citizen engagement, reporting/analysis dashboards, advanced data management. Agency selects desired modules. **Cost: $1,200 per module/$500 annual maintenance per module**. Esri licensing to be discussed with agency. Collaborative development of 5 agencies or more will include a free dashboard module.

- ***GRIT*.** Easy-to-use web- and map-based application focused on features within the right of way. **Cost: $1,500 annually.** One version for all users with a user group to set development priorities for functionality. UGPTI will work with agencies to enhance and customize the software collaboratively. Signs and work order functionality being considered for future development.

Software (continued)	• ***ICON*.** Functionality level priced for small agencies; more complex than simpler Cartegraph focused applications, Esri and GRIT. Software includes pavement analysis, asset management collection, analysis and reporting for signs, pavement, right of way, AVL, parks, sewer and universal asset management. **Cost: Small county 50,000 or less in population—$2,500 to $7,500 (5 users); large cities and counties—$7,500. Additional costs for implementation.** Goodpointe Technology will consider cooperative purchasing for group discount.
Staff	**Key Takeaway: Most agencies will require 25% to 50% dedicated GIS staff.** • **Getting started requires .25 to 1 FTE.** Need up to 1 FTE if using GIS staff to collect data in the field, configure apps, and do in-house data development and maintenance. • Hire for a GIS position based on skills to develop data, configure applications, train and supervise. To get the most productivity and greatest range of services, staff need GIS skills beyond collecting data. Staff need time to develop data, test software and train users on the software and equipment. • Outsource maintenance of applications (Cartegraph, Elements XS, Esri modules, GRIT, ICON) to limit staff engagement. More function and complexity in software translates to more staff time to learn and maintain. • Staff time dedicated to GIS for asset management is a limiting factor for data and application development and use; consider outsourcing data development to a vendor, if no staff available. • Engage non-GIS staff, summer workers or interns to collect data. • Data collected by staff or a third party will require periodic updating to ensure up-to-date and reliable data. If only one person is being relied on to create data and that person leaves the agency, the data can become out of date unless there is redundancy of GIS skills. • Consider a GIS shared position with other departments.
Funding	**Key Takeaway: Fund changing technology as a project rather than a program.** • 82.4% of agencies have no dedicated budget for GIS for asset management. Funding sources include operating costs, budget for IT or public works, and countywide general fund. • **Initial costs for mobile technology** varied widely for agencies from $2,000 to $60,000 based on existing equipment and rollout of major implementations of technology (such as an enterprise software system). • **Maintenance costs for mobile technology** varied from $100 to $30,000 annually. For many agencies, maintenance costs annually were 10% to 25% of initial costs for equipment and software. • Request dedicated GIS staff time when staff retire. • Consider costs for computers, GPS receivers. • Consider the cost of acting versus not acting. ROI and benefits include ability to complete work orders in the field, improved accuracy of agency records, and ready access to data in the field and in the office. • Lack of GIS for asset management impacts include issues with inspection standardization and data entry, lost historical data when staff retire or leave organization, data collection inconsistencies, and low productivity. • Lack of data currency and data maintenance creates an ineffective asset management program.

Quick Start: GIS Tools and Apps—Integration with Asset Management

Equipment	**Key Takeaway: Esri ArcGIS is the most often-used GIS editing software among survey respondents.** • A hosted software option requires no internal server equipment or software; a laptop or desktop computer is used to develop data and configure applications. • Agencies are most often using tablets (78.8%) and GPS devices (72.7%) to capture field data. Other commonly used practices include use of cell phone (66.7%) and pencil and paper (48.5%). **Costs** • Laptop computer – approximately $1,500 to $2,300. • Desktop computer – approximately $1,200. • Esri ArcGIS Server with workgroup license – $100 per user/year, excluding server architecture. • Tablet – approximately $350 to $500. • GPS Bluetooth receivers – $300 to almost $20,000 (based on accuracy).
Training	**Key Takeaway: Take advantage of low-cost or free training offered by vendors, user groups and others.** • Training for lightweight, simple collection applications generally requires one to two hours per application. Roll out mobile technology as applications are ready to collect. • Train the trainer; have GIS staff train non-GIS staff. Training non-GIS staff may need to be conducted numerous times for different seasons, updated software or changing agency needs. • Encourage participation in user groups. • Develop mini trainings for non-GIS staff on how to use dashboards and reporting to help them become familiar with the technology. • Bring together GIS-related staff monthly to discuss software, new discoveries and benefits that can be shared with other departments.

For More Information: Find the final report for this project, *GIS Tools and Apps—Integration with Asset Management*, on the MnDOT Office of Research and Innovation website at researchprojects.dot.state.mn.us/projectpages/pages/homepage.jsf.