



Greater Minnesota Public Transit Technology Plan

Final Draft

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PREPARED WITH SUPPORT FROM



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Acknowledgements

The Greater Minnesota Public Transit Technology Plan was developed in consultation with partners throughout Greater Minnesota. These organizations included:

- **Section 5307 providers:** Small urban transit systems are eligible to receive Federal Transit Administration (FTA) funding through Section 5307. Section 5307 funding is available for transit capital and operating assistance and for transportation related planning in urbanized areas (Census-designated areas with a population of 50,000 or more).
- **Section 5311 providers:** FTA Section 5311 funding provides capital, planning, and operating assistance to rural areas (populations less than 50,000) to support public transportation.
- **Tribal providers:** The FTA Tribal Transit Program funding provides capital, planning, and operating assistance to Federally recognized tribes in rural areas to meet the growing needs of rural tribal communities.
- **RTCCs:** Regional Transportation Coordinating Councils (RTCCs), developed by the Minnesota Departments of Transportation, in collaboration with Human Services and other state agencies, lead coordination efforts between transportation providers, service agents and the private sector to fill transportation gaps, streamline access to transportation and provide individuals more options of where and when to travel (source <https://www.dot.state.mn.us/transit/grants/RTCC/index.html>).

All these stakeholders were engaged as follows:

- Contacted at the beginning of the Plan-development process to inform them about the process, timeline, website, and opportunities to contribute
- Invited to participate in the summer 2020 virtual Technology Summit hosted by the National Center for Applied Transit Technology (N-CATT) and MnDOT
- Asked to complete a survey on their current technology uses (35 agencies participated)
- Invited to provide feedback on the draft set of statewide transit technology goals and key strategies

The Plan was actively supported by the **Steering Committee members** shown below. It is thanks to their tireless efforts and feedback throughout the planning process that this Plan addresses the issues and priorities of both MnDOT and Greater Minnesota transit agencies.

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1. Introduction

PURPOSE

The Greater Minnesota Public Transit Technology Plan (Plan) is designed to help the Minnesota Department of Transportation (MnDOT) and Greater Minnesota public transit agencies better use transit technology to improve operational efficiency, enhance the customer experience, and expand mobility options and access.

Technology in the transit industry is generally underutilized and there is significant potential to expand its use. The technology solutions most useful for public transit agencies have been around for some years and are well-tested, such as scheduling/dispatching and maintenance software. What is critical in advancing these solutions include:

- Widespread adoption of technology that has proven useful in similar contexts
- Solutions tailored to the variety of agencies and needs in Minnesota and elsewhere
- Shared specifications and ways for exchanging digital information between transit agencies
- Greater cohesive networks of services across Greater Minnesota so that transit agencies can readily connect and exchange digital information, and customers can access information using commonly employed mobility platforms

Collaboration between MnDOT and its partner public transit agencies is key to successfully transitioning to a future where transit technology significantly benefits service delivery. MnDOT can provide leadership and support to help transit agencies make informed technology decisions. As a key funder of transit technology investments, MnDOT can help public transit agencies secure cost-effective and robust technology solutions. Public transit agencies are most knowledgeable about where technology would be most valuable to them, and are responsible for selecting, purchasing, and installing most transit technology.

This Plan provides guidance on how MnDOT can support this technology transition and future.

For **public transit agencies**, the Plan provides guidance, resources, and tools to assess agency capacity and needs, determine an appropriate growth plan, make informed decisions, and implement sustainable and secure technology to improve operations and the customer experience.

For **MnDOT**, the Plan provides recommended actions to support public transit agency technology development, increasing agency capacity to use technology effectively and keep data secure.



PLAN DEVELOPMENT PROCESS

Plan development began in summer 2020 with a virtual Technology Summit hosted by the National Center for Applied Transit Technology (N-CATT). Sessions included technology function considerations, a structured approach to planning and deploying technology, and a summary session on key themes that emerged from the Summit; see Figure 1.1.

While hosting the transit technology summit, MnDOT embarked on a planning effort and established a Steering Committee and group of stakeholders to develop this Greater Minnesota Public Transit Technology Plan. The Steering Committee included representatives from public transit agencies, Tribal agencies, Regional Transportation Coordinating Councils (RTCCs), and MnDOT representatives. The Steering Committee served to provide guidance to the MnDOT project manager and consultant team, and to support stakeholder engagement and the plan-development process. Seven meetings were held with the Steering Committee over a 10-month period covering all aspects of plan development. In addition, workshops were held with a broader group of stakeholders including approximately 50 rural, Tribal, and small urban area public transit agencies, RTCCs, and MnDOT employees to introduce the planning process, develop goals and strategies, and present the final plan. Regular project updates were posted on the project website (<https://greatermntransitech.com/>; project information now located at <http://www.dot.state.mn.us/transit/reports/transitechplan.html>).

Key activities in the Plan-development process included:

- Survey of public transit agencies regarding their current technology uses
- Review of current transit agency plans and related MnDOT short and long-range plans
- Interviews with industry experts, representative state DOTs, and public transit agencies across the nation to understand what is being done in the field and identify current trends
- Identification of resources and tools needed to help agencies identify the appropriate technology for various service-delivery demands
- Development of goals and strategies
- Development of tools to help transit agencies assess system needs and develop growth plans, included as [Supplemental Materials](#).
- Development of recommended actions to support technology deployment and enhancement of technology use

Figure 1.1: N-CATT Technology Summit Themes

Non-prioritized Themes and Goals	
• Theme 1: Coordinated Back Offices	▪ Goal: Cross-Agency Demand-Response Booking
• Theme 2: Universal Trip Planner	▪ Goal: Create One-Stop-Shop for Passengers to Book Trips
• Theme 3: Mobility Management	▪ Goal: Direct Customers to the Rides that Best Fits Need
• Theme 4: Data Collection	▪ Goal: Seamless Collection and Reduced Silos
• Theme 5: Filling Coverage Gaps	▪ Goal: Eliminate Cell/Radio Coverage Gaps
• Theme 6: Statewide Program Management	▪ Goal: Coordinate Recommendations and Tools (includes asset management, eligibility processes, schedule and dispatch and route optimization tools, training)
• Theme 7: Group procurement.	▪ Goal: Develop Streamlined Procurement Tool

KEY CHALLENGES

Based on the activities conducted in development of this Plan, several key challenges in transit technology deployment and enhancement were identified:

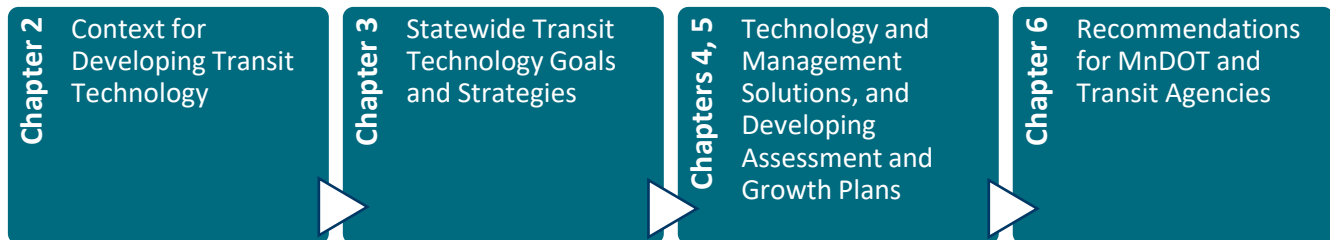
- Transit technology is rapidly evolving. While this Plan assesses the current state of Greater Minnesota transit technology, it will need to be updated within five years to reflect the continually changing state of the industry and the technical capacity of transit agencies.
- Larger public transit agencies have implemented a variety of technology systems, but smaller agencies operate with limited technology improvements. For these smaller agencies, the available technology improvements are not yet a routine part of how transit agencies plan, manage, and operate their services. It may be a 10 to 15-year process for them to adapt workflows and build technological capacity. This Plan supports building transit agency capacity to support this transition.
- Transit agencies and states are beginning to identify where specifications and standards are needed to support interoperability between transit agency services and their technology systems. This Plan identifies ways MnDOT and public transit agencies can support the use of specifications and interoperability.
- There is a national need to develop fundamental support for DOTs and transit agencies. Examples are:
 - Comprehensive transit technology training
 - Expanded specifications to support information exchange between transit agencies
 - Integration of different technology systems so transit agencies can tailor systems to their needs and to support a variety of platforms
- There is not yet a common and widely used framework for discussing transit technology. This Plan synthesizes information from several sources to reflect a framework organized to help agencies develop and manage their transit technology systems.

Some of these challenges suggest ways to support broader technology adoption among small and rural transit systems. Other challenges currently limit the choices available to MnDOT. Given these challenges, this Plan is both foundational and visionary in its goals and purposes. As such, the findings and recommendations in the Plan can serve to help shape transit technology development and should be viewed as a starting point for short and long-term advancements in transit technology.



PLAN CONTENTS

Following this introduction, Chapter 2 provides information on the technology development of public transit agencies in Greater Minnesota and interview results from industry experts and peer agencies. Chapter 3 summarizes the statewide transit technology goals and strategies developed for this Plan, showing how various strategies relate to each other and support the larger goals common to most transit agencies, such as community mobility or operating systems that are financially sustainable, effective, and efficient.



Supplemental Materials include:

- Glossary
- Goal-strategy-action details
- Resource Guides
- Transit Technology Flowcharts
- Transit Agency Assessments and Growth Plans (including samples and forms)

An important MnDOT objective is to provide public transit agencies with tools to assess their current technology and plan for technology system growth. Chapters 4 and 5 are oriented to transit agencies. Chapter 4 presents a variety of resources, including:

- Description of supports needed for successful technology implementation, such as system planning, training, and vendor support.
- A Baseline Technology Reference Chart, showing appropriate technology for transit agencies of various sizes and needs. These recommendations support equity among the public transit agencies and effective use of technology at different scales of public transit agency size and capacities.
- Flowcharts showing how technology systems serve key functions that transit agencies carry out and how the technology systems interconnect. The technology flowchart diagrams show how the technologies work together and create opportunities for future integration.

Chapter 5 describes how to complete a technology assessment and use those results to develop a technology growth plan. It also addresses the need for evaluating cybersecurity.

Chapter 6 is largely oriented to MnDOT and presents a series of recommendations on how to support the transition to technology among public transit agencies in Greater Minnesota. This includes establishing a Transit Technology Committee including MnDOT and transit agency representatives to



collaboratively guide decision making. The recommendations in Chapter 6 address the basic issues that emerged in the initial phase of this project, reflect the basic strategies from Chapter 3, and reflect the current state of the industry.

The [Supplemental Materials](#) at the end of the Plan provide tools for transit agencies to use in determining the technology tools appropriate for their size and type of transit services, assessing their technology needs, and developing growth plans. Additional reference materials are available on the project website at: <http://www.dot.state.mn.us/transit/reports/transitechplan.html>.

2. Context for Developing Transit Technology

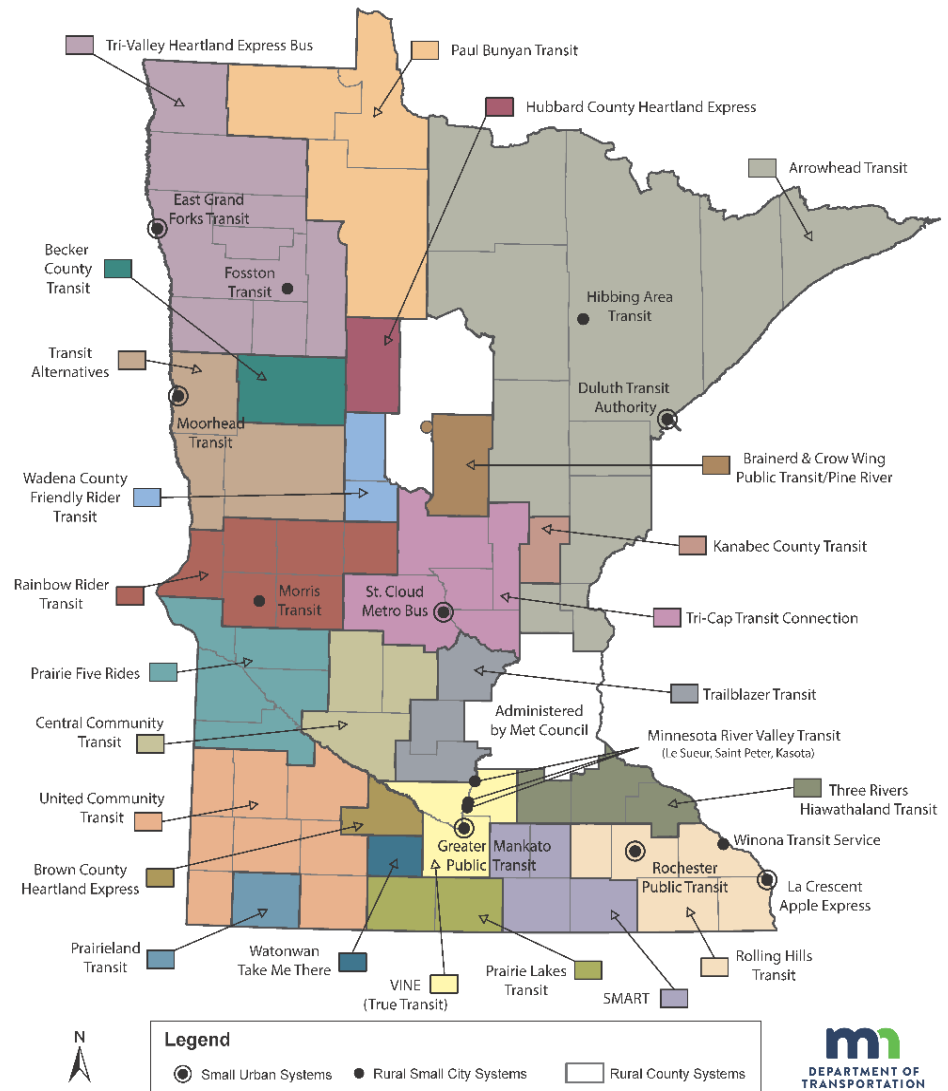
Establishing the local and national contexts for developing transit technology was an essential first step in identifying goals and strategies for this Plan and further detailing recommendations for MnDOT and transit agencies in the state. This chapter summarizes information from the initial Plan-development activities. These built on a Technology Summit put on by the National Center for Applied Transit Technology (N-CATT) and included an online survey to assess technology use and interest among transit agencies, a review of transit agency planning documents, and interviews with peer agencies and industry leaders. Combined, these activities helped to create a foundational understanding of critical issues to guide statewide goals and strategies for the Plan and a framework for transit agencies to build out their individual technology systems. A variety of terms are used throughout this report and are defined in a glossary included as part of the [Supplemental Materials](#).

GREATER MINNESOTA TRANSIT LANDSCAPE

Greater Minnesota has 39 public transit agencies serving a single small town or county, a small urban area, a Tribal community, or a region with multiple counties. Figure 2.1 is a map of the Greater Minnesota public transit agencies. These agencies provide demand response, fixed route, and/or route deviation services. Most operate as part of a multi-purpose agency such as a city, county, or community action agency with broad responsibilities. In many cases, this also includes responsibilities for managing and implementing information technology.

Information on the current state of transit technology among these agencies was gathered via an online survey; detailed results are available on the [project website](#) as part of the reference materials.

Figure 2.1: Map of Greater Minnesota Public Transit Agencies



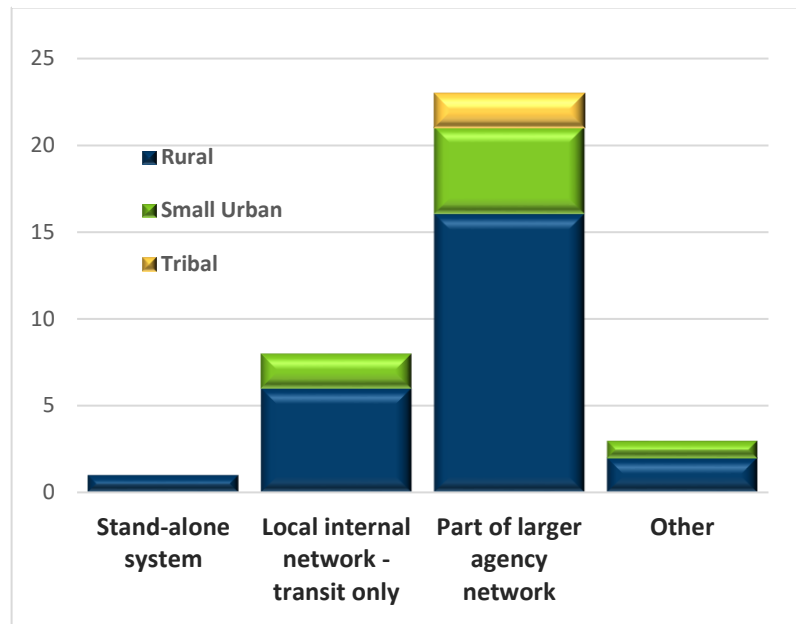
Map source: MnDOT

The majority of the public transit agencies in the state have an IT infrastructure in place to set them up for success (see Figure 2.2, Computer Networks by Type of Agency). Most have networked computer systems for easy file transfers and backup systems.

Agencies reported reliable internet, which is essential as most software systems rely on cloud-based storage solutions. Some agencies, however, reported difficulties with internet speed, particularly in rural areas.

Most transit agencies in the state have dedicated IT staff or IT contracts to help service computers, which is necessary for transit agencies to perform essential job functions without interruption. This infrastructure also supports the agencies in implementing technology solutions to improve system or staff efficiency and effectiveness.

Figure 2.2: Computer Networks by Type of Agency



We have been able to maintain a good cycle of replacing equipment as it ages, and in doing so we had very little issues with equipment failure and downtime. We also have a very reliable ISP which helps immensely with downtime. In recent years we have been able to digitalize our shop inventory and our timekeeping systems. This has helped in several ways for bus maintenance and optimization of workloads.

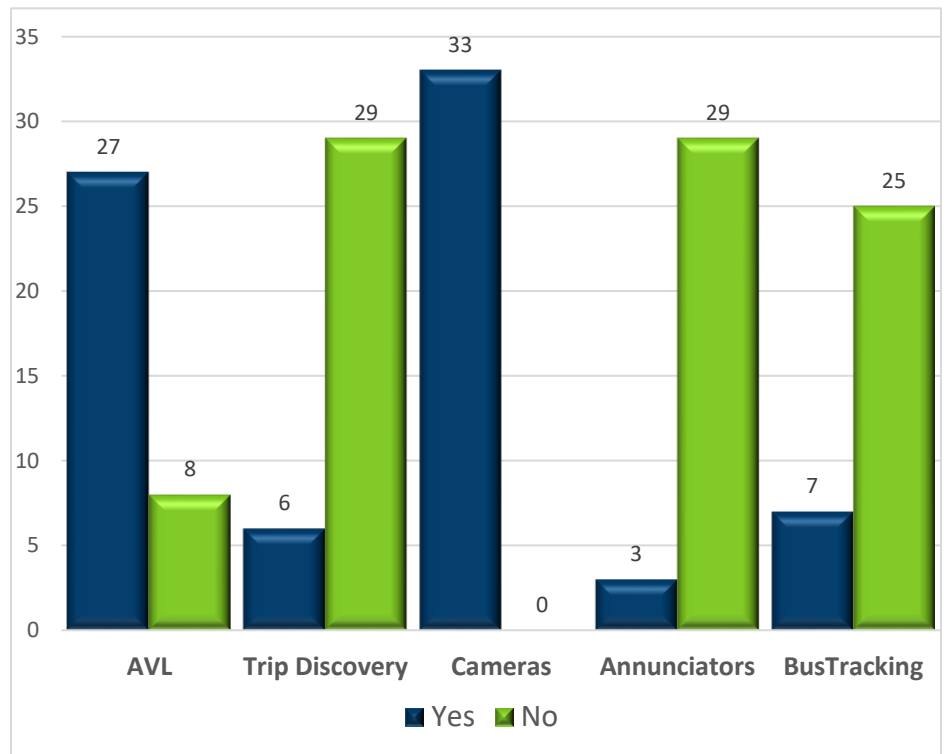
—Rainbow Rider Transit System



A variety of questions were asked regarding various technologies found in vehicles or that can assist with trips. These questions, shown in Figure 2.3, included if transit systems had cameras on vehicles, annunciators, AVL, etc. Some key findings include:

- Every transit agency that completed the survey has cameras on vehicles.
- 27 out of 35 respondents (77%) use automatic vehicle location (AVL), yet 78% of the providers answered that there is not a way for customers to know the location of the vehicle they are expecting. This is potentially an opportunity for some training to utilize the AVL feature either by the software vendor or a train-the-trainer type scenario.

Figure 2.3: Does your agency have...?



The parts of technology infrastructure that are the most challenging for your organization are...

Bad cell tower connections for communicating with bus tablets and AVLs.

-- Paul Bunyan Transit

Information from current plans, existing technologies, and initiatives indicates there is inconsistent technology use across regions and transit agencies. Some have robust technology systems, grant funding sufficient to meet most needs, and the organizational capacity to implement new technology solutions. Others are enmeshed in day-to-day issues and indicated less time available to learn about new technologies, apply for funding, or implement new technology. Lack of access to funding is a clear differentiator with technology and technology support. As this Plan is implemented, MnDOT will need to provide additional technical assistance to the latter group and ensure transit funding is equitably distributed.

The variation in agency knowledge about technology solutions presents a training challenge for MnDOT. How to use technology to improve operations or assess overall technology

Public transit agencies were surveyed to rank a list of 12 items on how helpful they would be to their organization.

The top six areas where assistance is needed, listed in order, are:

1. Technology procurement
2. How to use technology to improve operations/assessing overall technology needs
3. Website ideas, content, maintenance
4. Scheduling and management software
5. Helping customers plan across multiple providers
6. Customer information software options

needs was the second-highest need transit agencies identified (technology procurement assistance was the highest ranked need and is addressed in Chapter 6). To move forward with this Plan, the regions, transit agencies, RTCCs, and MnDOT need a shared language and understanding of technology.

There are no clear standards, consistent interfaces, or common tools utilized, making coordination and information gathering difficult. The need for coordination among transit agencies, human service agencies, RTCCs, and MnDOT was a recurring theme across local, state, and national plans, and will need to be prioritized and resourced. Additional needs include developing and adopting data standards and technology tools to support coordination, such as a state-wide trip planner, data exchange, or similar.

What we would like to see is greater interoperability between scheduling, payment, and reporting software. Not necessarily a single program but programs that meet a single data standard to enable communications between multiple providers and vendors.

-- Arrowhead Transit

The need for trip planning software (and, thus, General Transit Feed Specification [GTFS] and General OnDemand Feed Specification [GOFS] data collection) was a recurring theme and Plan priority. Transit agencies recognized this need in their ranking of helpful technology tools: A “Find my bus” application was the third-highest priority. Public comments from riders during local transit planning projects expressed similar desires, as well as trip planning, mobile booking, and e-fares.

Summary of Existing Plan Review

A review of current MnDOT and public transit agency plans provided an understanding of the needs and goals of Greater Minnesota transit agencies and state approaches to the development of alternate modes and technology. Plans were reviewed from MnDOT, Minnesota’s transit systems, Greater Minnesota regions, and other state and national plans including:

- Greater Minnesota Transit Investment Plan
- Transportation Development Plans (TDPs)
- Public Transit Coordinated Plans
- Minnesota GO
- Minnesota Safe Routes to School Strategic Plan
- MnDOT Transportation Systems Management and Operations (TSMO) Planning Documents
- Minnesota Statewide Regional ITS Architecture Plan

In addition, a variety of websites were reviewed from websites for transit agencies to websites about initiatives for broadband service in rural Minnesota.

There are recurring themes and goals among existing transportation plans around enhanced transit services, improved customer information, and the importance of coordination. Technology, at its best, supports key functionalities of transit agencies, such as providing customer information. State-level plans address the

importance of coordination more so than the plans of individual transit agencies. Again, this is an area that developing technologies can support, providing a viable path to improving coordination.

At the same time, generally the plans do not directly address questions of how to implement or achieve the desired outcomes. These plans are public or stakeholder-facing and the detail of how to achieve the goals is left to the implementation phase.

FOUNDATIONAL CONCEPTS

In addition to the transit agency survey and review of Minnesota regional and statewide plans, a national review of peer agencies and industry leaders was undertaken to understand different approaches to technology including challenges or barriers to implementation, prioritization and lessons learned. Three foundational concepts and needs arose from this analysis as key to successful technology development: lead with function, determine appropriate technology, and manage risk.

Lead with function. For transit agencies, technology is useful to the extent that it helps the agency meet its organizational functions and fulfill its mission and key objectives. This is foundational to technology development across the board.

Determine appropriate technology. Transit technology can make organizations more functional and efficient; strengths include:

- Handling large amounts of data, carrying out repetitive functions quickly and accurately
- Sharing information among interested parties, such as with customers and transit agency staff who can access routing, schedule, and on-time performance information
- Creatively using shared information, such as through mapping programs or other third-party apps



It is important to weigh the costs and benefits of procuring and utilizing technology. When assessing technology, agencies must consider the volume of data to be managed and how often data management tasks need to occur. For instance, a spreadsheet may be appropriate for a small system that schedules only 10 to 20 trips on an average day, but as the number of trips, vehicles, and drivers increases, a more complex scheduling system will need to be considered.

Similarly, it is important to compare benefits of any technology solution with the work of installing and maintaining it, risks, and costs. In some instances, a low-technology solution (e.g., telephone calls, maintaining a calendar, using a whiteboard, using a spreadsheet) may remain a viable option for meeting near-term transit agency needs.

Manage risk. There are risks throughout the lifecycle of employing a technology solution, including the following:

- Procurement can be very labor and time-intensive

- The time and effort for implementation and training are often greater than originally estimated; this is often the case with technology systems closely tied to organization workflows, such as scheduling
- More difficult to quantify is the risk that the system simply does not produce the desired results
- Toward the end of a technology system's useful life, a transit agency may find itself locked into using a particular brand of technology due to the length of a contract, the effort and training time to change systems, or because other systems are tied to a proprietary interface

One way to manage risk is to use technology systems with a single focus that connect to other systems through standardized interfaces. While interfaces can also become outdated, that approach allows parts of the system to be independently upgraded or replaced, which lowers risks and costs. This is a technology trend occurring across industries.

Small agencies can also lower risks through state support for basic technology purchase and implementation. This could include small-scale efforts such as coordinated training or software procurement, or larger efforts like implementing software systems (e.g., trip planners) that are available to all agencies.

FINDINGS FROM INDUSTRY AND PEER REVIEWS

While technology may be changing quickly, the industry experts and peer agencies interviewed identified similar approaches for state departments of transportation and transit agencies to introduce and maintain transit technology that follows the trajectory of other transportation assets: **Understand the asset, take care of its components, support it with training, and make plans to replace or upgrade it.** In other words, a program management approach where the hardware, software, and data are all component assets of the technology program. Key findings of the industry and peer reviews are described below.

Key Finding 1: Defining clear goals is a critical first step, and champions must communicate and advance those goals.

Multiple agencies noted that without a clear goal for what the technology brings to the organization, it is merely innovation for its own sake. It is critical to understand the technology or technology program and why it is needed. This understanding should exist at all levels, from senior leadership to transit system dispatchers, to asset management staff. Not everyone needs to be actively involved in implementation, but each agency needs a champion for mobility and technology who can communicate with key stakeholder groups.



Key Finding 2: After setting goals, regularly monitor performance measures and update work plans.

Goals, performance measures, and work plans will help an agency craft the right approach to procuring, implementing, upgrading, or retiring technology throughout its lifecycle.



Day-to-day software tools are most useful if there is a process in place to evaluate technology performance and adjust software program settings to meet evolving needs. Just as there needs to be a champion to communicate, there should be staff who understand the full capabilities of the tools in order to ensure they are being used to their full potential – meeting or exceeding the goals set prior to procurement.

Key Finding 3: Watch for coordination opportunities that align with agency/provider goals.

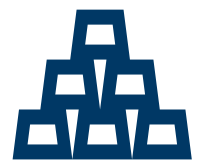
Transit is a complex program that could be an example for other modes and programs on how to use data well. Some state transportation agencies found it beneficial to work with other internal offices to capitalize on intelligent transportation systems, safety, or other programming. While such cross-functional collaboration is not a necessary element, keeping the broader DOT and transit agencies statewide informed can generate collaboration opportunities and improve appreciation for the value that organized data can bring to an agency.



Collaborating with other agencies, departments, or universities was not always a primary ingredient, but the relationship between the DOT and other agencies was a common component that peers noted as either a **success factor** in their project *or* as a **longer-term goal or outcome** of their technology undertaking. Collaborations can help build economies of scale that are important for transit service productivity. After setting goals and having performance measures in place, agencies could use those metrics and goals to have conversations around collaboration. There are several types of collaboration that we heard about: across geographies, among and within agencies, and finally with other groups like universities or regional hospital systems.

Key Finding 4: Technology is evolving quickly but getting fundamental building blocks in place – and maintaining them – is an ongoing activity.

Even as agencies are experimenting with new tools such as electronic fare payment, there are several “building blocks” that are ready enough for MnDOT to put in place for statewide benefit, including:



- **The family of GTFS data**, which is recognized as the standard in the United States for trip discovery or planning. This includes the static GTFS fixed route information, GTFS-realtime for arrival predictions, vehicle positions and service advisories, and GTFS-flex for demand response or flexible route services. While GTFS data is predominately used for trip planning, one DOT used GTFS data to alert transit agencies to construction projects impacting fixed route services.
- **Business rules** describe the agreed-upon definitions established when setting up technology systems and guide operations. Business rules identify training, insurance, eligibility, asset management procedures and background checks mandated by the FTA and other funding/governmental requirements.
- **Supports** include training, documentation, cybersecurity, system design and planning, vendor supports, and procurement. More information on supports is in Chapter 4.

Key Finding 5: The technology program must have a plan for sustaining data and covering ongoing costs.

Some worthy national pilot projects were cancelled because ultimately the cost of the service or the application was unsustainable. By contrast, one successful pilot (Rides to Wellness) was sustained, and the program managers credited having set a price that covered operating costs.

While new services or technology may cost more than existing programs, agencies that are successful have determined the program or technology cost-effectiveness as it relates to meeting clearly defined goals (key finding 1). The path to a sustainable cost model might include multiple funding sources, centralized leadership, strong coordination at the state or regional level, statewide procurement strategies, or cost-sharing / cost-allocation across a group of agencies.



Several state and transit agencies also had a full-time staff person devoted to data analysis for continuous improvement. Vendors noted that maintaining clean, accurate data is a time-consuming and important foundation for any technology program.

To succeed with more demanding technologies, we found multiple examples of DOTs helping smaller transit agencies address the challenges of deploying specialized transit technology. When DOTs support decision making and procurement, the barriers and risks are reduced for all public transit agencies, and especially benefit smaller ones.

TRENDS

Interviews with peer agencies and industry experts and the literature review addressed technology trends, opportunities, and how organizations and state DOTs are responding. The ways technology is affecting the transit industry fall into three categories:

Data and Technology Trends

- **Data management.** Data management becomes more important when agencies begin presenting internally generated data to the public. For example, agencies that implement integrated fare payment must ensure riders have the data quality and availability they need.
- **Open data and data standards.** Putting more transit data into the hands of the public can only be achieved at scale with standardized methods for getting transit agency service data into trip planners and mobile devices. There is a clear trend toward expanding the use of open data and data standards.
- **Limited integration between vendors despite broader technology trends.** Most technology is developed by private vendors without interoperability, and most vendors have been slow to transition their offerings and business models away from end-to-end offerings. By contrast, the broader technology industry is moving swiftly toward modular software that can communicate and work with other software or technology applications through documented system-to-system interfaces.
- **Software as a Service (SaaS) is now the predominant model for software.** The shift to hosted or cloud computing requires staff to understand security risks and how to mitigate them. It also means that the reliability and speed of a transit agency's internet connection is increasingly important.

Need for Support

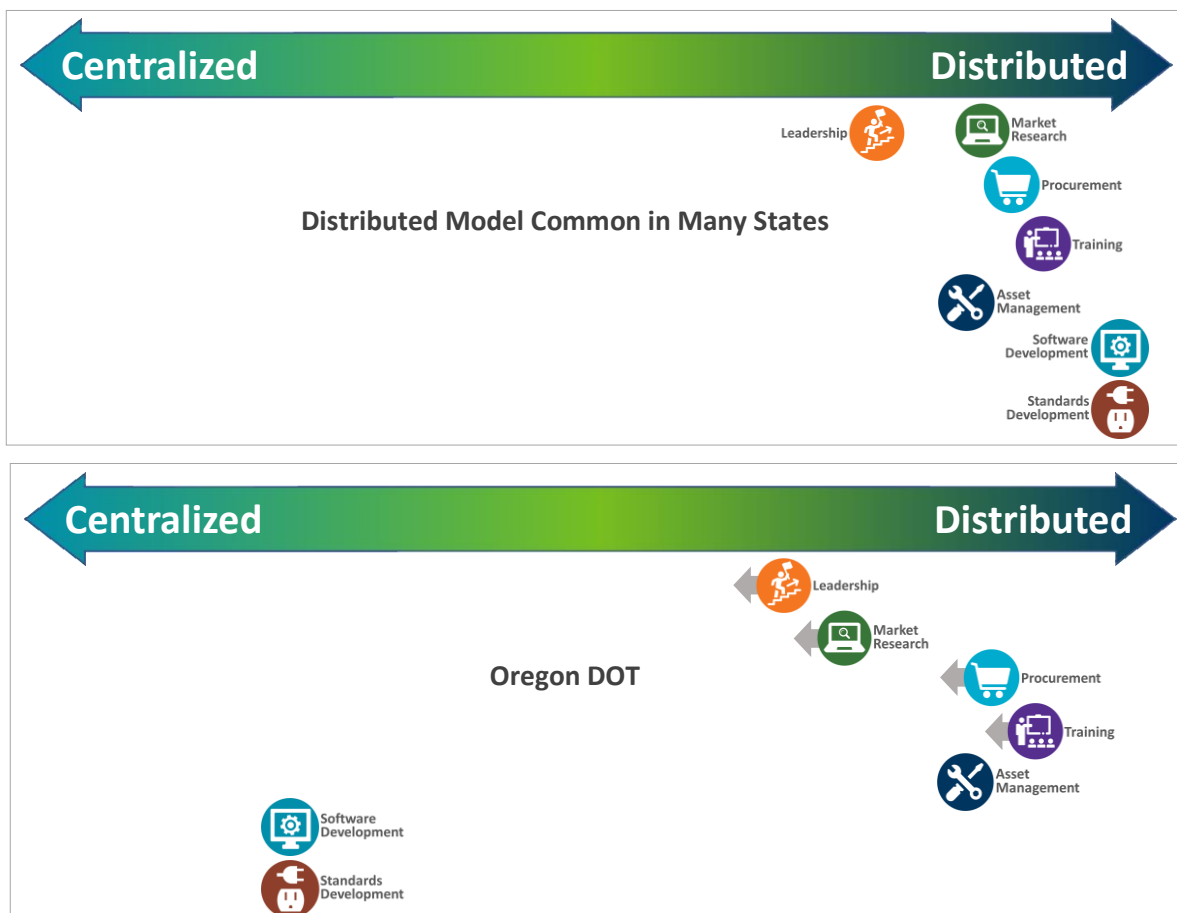
Interviewees consistently noted challenges around maintaining data, understanding technology, and organizational capacity.

- **Building organizational capacity for technology.** All interviewees described challenges with managing transit-specific technology and the new demands for managing data. These were most pronounced at DOTs, which have traditionally focused on grant management.
- **Onboard technology is expected but often poorly supported.** The prevalence of this technology masks a range of costs and challenges that may not be apparent to the agency until after it is procured. Connectivity issues, especially in rural areas, can significantly hinder the usefulness of onboard devices. The IT support services required to maintain such technology systems is often lacking, especially for smaller, rural agencies (e.g., updating the operating system to address a security vulnerability or supporting Android-based tablets in vehicles).

- **Centralization and contracting to manage complex technology.** Typically, state DOTs distribute responsibilities for technology functions to transit agencies. Transit technologies have specialized components, however, that require comparable knowledge throughout its life cycle, from procurement to implementation and on to maintenance. To succeed with more demanding technologies, several state DOTs are assuming a greater role in helping smaller transit agencies deploy specialized transit technology. Such centralization can lower the barriers that smaller transit agencies encounter when attempting to use sophisticated transit-specific technologies.

Examples of different state models based on the industry research are shown in Figure 2.4, one for a typical state and one for Oregon DOT, a state that is providing more leadership and research than most DOTs into what is available in the transit technology market. Oregon DOT has centralized work on software and standards development and is shifting to be more centralized for leadership, market research, procurement, and training. In these examples, “centralized” refers to state-level management and “distributed” indicates areas managed by each transit agency.

Figure 2.4: Models of Centralized versus Distributed Technology Functions



DOT Technology Program Definition

- Adaptation. DOTs wishing to encourage the development of transit technology among the transit agencies they fund are evaluating and modifying their programs in response to the needs they see.
- Some DOTs are serving as risk mitigators. Adopting technology, especially newer applications that reflect emerging trends, is inherently a risky venture. State-level support can provide a way for agencies to

responsibly manage risk while they explore new options.

- Program structures vary. There is no single approach to program structure. Institutional responses to the growing role of technology vary widely with local conditions and leadership.

CONCLUSIONS AND OPPORTUNITIES

The rapid ascendance of mobile computing and data-intensive business models means that transit agencies of all sizes have been called upon to build and enhance customer-facing technology, data management, and integration of disparate systems. Agencies need to have the organizational capabilities to select, implement, and maintain technology and effectively manage the data produced, even if this support resides with another entity, as with a software as a service (SaaS) model.

Large and medium-sized urban transit agencies are managing this shift but are often doing it without a well-defined framework. Barriers are markedly higher for Tribal, small urban, and rural agencies and the organizations that support them, requiring critical assistance for them to be successful. In response to these needs, several state DOTs are building capacities on behalf of the agencies they oversee. Each effort is unique, based on their particular leadership, resources, mix of transit systems, and priorities.

Below are key opportunities for DOTs to create a foundation and framework for transit agencies to build out their individual technology systems.

- Procurement, ranging from creating more functional processes to establishing functional standards and pre-qualifying vendors.
- Coordination and knowledge sharing, by providing venues for agencies to learn from each other's activities and build peer relationships.
- Creating and maintaining service-related data by creating GTFS feeds where they do not exist or are burdensome for the agency to produce.
- Providing easy access to technical assistance, from training to on-call support to consulting services.
- Centralizing highly specialized technology applications that can easily scale statewide. Examples include trip planners, one-call/one-click centers with websites, and systems that produce real-time arrival estimates.

The power of DOTs to facilitate coordination, provide technical assistance, manage risk, and establish technology expectations for the statewide transit network uniquely positions them to support successful technology for transit agencies that otherwise would be less able to provide valuable, reliable, and efficient services to their communities.



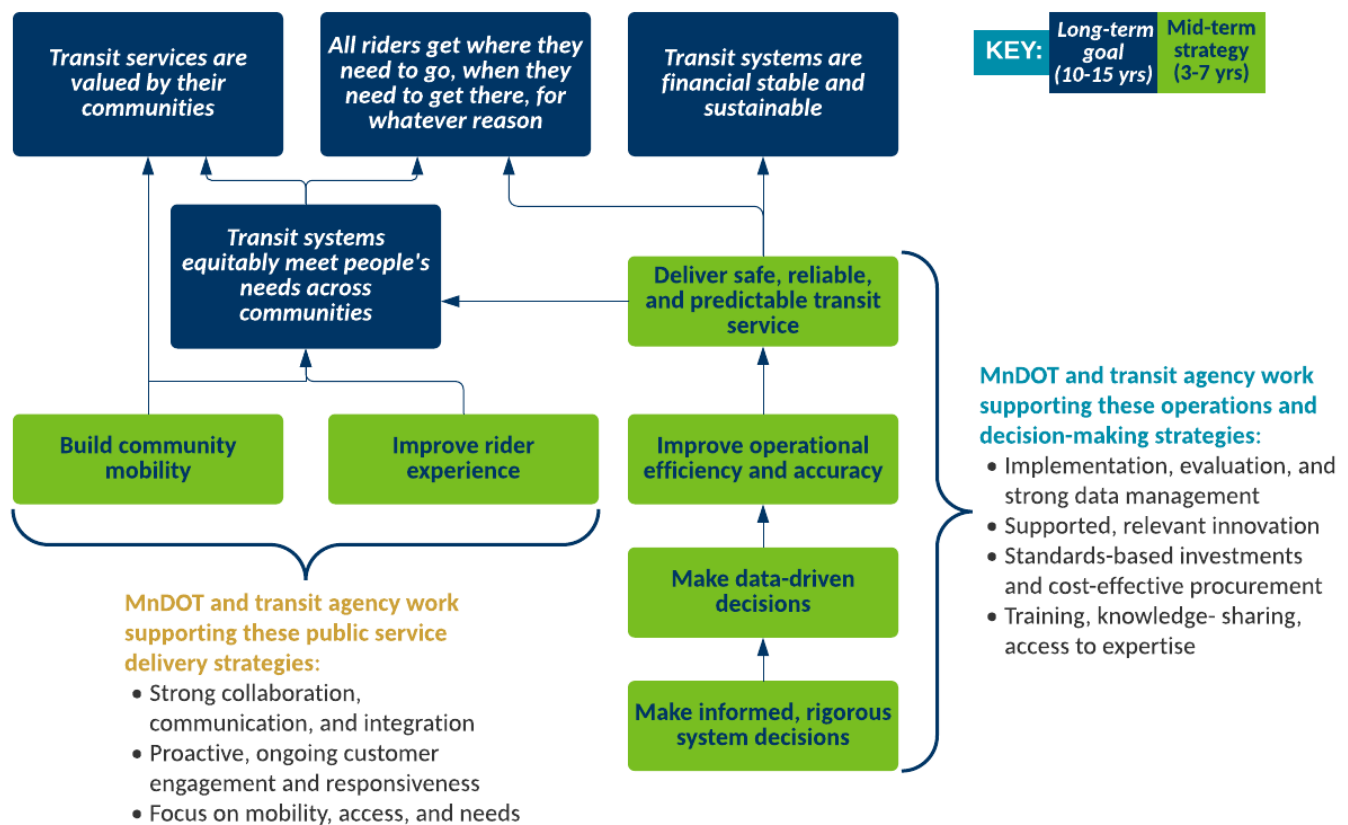
3. Goals and Strategies

The Greater Minnesota transit goals and strategies were collectively developed in a multi-step process by MnDOT and leaders from Greater Minnesota public transit agencies and RTCCs. While MnDOT has primary responsibility for implementing the Greater Minnesota Public Transit Technology Plan, the transit agencies will make decisions, purchase, and implement most of the technology systems. The statewide goals and strategies therefore must reflect and address the priorities of both MnDOT and transit agencies.

This Plan is intended as a working document for MnDOT and transit agencies to thoughtfully and efficiently integrate technology into transit planning, management, and operations, and the goals, key strategies, and detailed actions were developed accordingly. The goal and strategy effort was also intentionally scheduled following the initial analyses, so participants brought their own expertise plus familiarity with results from the transit agency surveys, industry trends and research, and best practices and lessons learned from interview with peer agencies and industry experts.

This inclusive, iterative process to draft and refine the goals and strategies helped ensure that the goals resonate well across all stakeholders and directly support the missions, primary functions, priorities, and roles of MnDOT and Greater Minnesota public transit agencies. The resulting goals and key strategies are shown in Figure 3.1. The goals (blue) look out 10-15 years and are framed as community outcomes. The mid-term key strategies (green) directly advance each other and the long-term goals and are expected to be completed over 3-7 years.

Figure 3.1: Statewide Transit Technology Long-term goals and Mid-term Strategies



The mid-term key strategies are further supported by dozens of short- to mid-term actions and processes organized into strategy clusters to guide the transition to digital operations. The primary clusters are Public Service Delivery, and Operations and Decision Making. These strategy clusters and actions are illustrated and described in the [Supplemental Materials](#). Many of these include efforts that are currently in place but will be refined as technology is introduced. For example, for one of the actions, “transit agencies provide riders with the information needed to plan and use transit,” technology can make it possible for riders to access real-time information on bus locations. Another example is that MnDOT currently makes decisions about how to invest funds for technology through grant applications and a technology assessment process. This will continue and be refined over time as recommendations from this plan are put in place and as both MnDOT and transit agencies work toward a systems approach to technology investments.

It will take time for transit agencies to adapt their systems and increase the rigor of the transit technology efforts, and the work should be regularly reviewed, updated, and refined to meet Greater Minnesota public transit needs. Further, adapting to technology will be iterative rather than a sequential, in part because transit technology is still actively developing.

Some actions can be most effectively implemented if MnDOT waits for the industry to evolve. For example, a few transit systems in other states are testing a specification for digital demand response service information called GTFS-flex, and MnDOT may wish to learn from these early adopters. For other efforts, there may be opportunities for MnDOT to lead through innovative projects, such as partnering with peers or national organizations to develop transit technology training.

FOCUS AREAS FOR THE TRANSIT TECHNOLOGY PLAN

Input received from technical analysis and these stakeholder outreach processes helped to define an array of needs to advance transit technology solutions at the state and transit agency level. Key needs identified from the combined outreach efforts and technical analysis included:

- Different agencies have differing needs for technology solutions based on their size, customer needs, and available internal capacity. Comprehensive guidance is needed to help agencies make decisions that are consistent and can be scaled to specific agency needs.
- Technical assistance and comprehensive technology assessment training is needed to build organizational capacity for many transit agencies who have less time and resources to assess, plan, and implement technologies in their organizations.
- To assess and plan for technology needs comprehensively, it is valuable to leverage and integrate different staff (operations, planning, financial/grant mgt, asset mgt/maintenance) and include a variety of perspectives within the transit agency.
- Internet speeds and connectivity currently limits service in some rural areas in state. This limits the ability to address current expectations for on-board technologies and larger trends towards software as a service. The statewide initiatives to make sure transit agencies and customers across the state have access to reliable and dependable high-speed internet access are critical.
- Clear standards, consistent interfaces, and common tools are essential to allow for greater integration and interoperability between technology systems and transit agencies. Centralization and greater standardization, such as GTFS feeds, are needed to provide and maintain consistent and interoperable service-related data.

- There is a high priority need and desire by transit agencies and the customers they serve in the state for trip planning software such as the one shown in Figure 3.2, "find my bus" applications, mobile booking, and e-fares. Centralization of trip planners, one-call or one-click centers, and real time information would assist in developing more integrated and useful technology systems.
- There needs to be better knowledge sharing between agencies implementing technology solutions and incentivization of coordination and communication across transit agencies and their technology systems.
- Vendors often offer a specific service and support with many different technology products in use. Ways to assist in contracting and vendor procurement (e.g., maintaining technology resources) and offering more centralized sources for technology decision-making are needed.
- As trends move towards Software as a Service (cloud-based services), there are cybersecurity risks that must be assessed. Many agencies do not have expertise and knowledge to make informed decisions on mitigating risks to their data and need additional organizational support and capacity to properly assess cybersecurity risks.
- Expertise is needed to support agencies in better developing and implementing comprehensive technology solutions.

Figure 3.2: Trip Planner
(credit: Duluth Transit Authority)

STARTING POINT

ADDRESS OR LANDMARK

USE YOUR LOCATION

DESTINATION

ADDRESS OR LANDMARK

DATES

05/27/2021

LEAVE NOW 11:00 PM

☒ SHOW ROUTES WITH LEAST WALKING FIRST.

Let's Go!

Implementing comprehensive solutions to address these needs is not an overnight process; it will be iterative and evolve over time, especially given that transit technology is itself still actively developing. To establish a manageable Plan development process with clear recommendations, needs were further refined into five major focus areas for this Plan:

1. Provide guidance to transit agencies about transitioning to transit technology and related management solutions according to transit agency size, capacity, and resources.
2. Provide guidance to transit agencies on how to develop Technology Growth Plans for their organization.
3. Foster and support greater collaborative decision-making regarding transit technology in the state
4. Provide transit agencies with greater organizational supports and assistance for technology implementation
5. Provide statewide support for transit agencies in creating standard specifications, acquiring transit technology, and integration of technologies within their organization.

Chapters 4 and 5 of this Plan address initial steps for the first two focus areas. Additional resources and tools are included in the Supplemental Materials to help transit agencies in assessing technologies and developing agency specific growth plans. These assessments and growth plans can then be further used at a state level as MnDOT evaluates needs and supports technology development at a transit agency level. This allows support to be

tailored to specific transit agency needs but that can also feed into a performance-based system for evaluating and prioritizing statewide investments in transit technology. Transit agencies will play an essential role in helping move state practices forward with regard to technology by developing baseline assessment data and growth plans for their specific transit agencies in the state.

Chapter 6 develops recommendations at the MnDOT level for focus areas three through five. These recommendations will provide foundational support for MnDOT staff in advancing transit technology across the state and inform process changes, funding support and prioritization of technology investments over time. These initial recommendations and outcomes of implementation can further be used in making updates to this Greater Minnesota Transit Technology Plan to address the evolving nature of the industry and to leverage lessons learned in initial implementation. As this working Plan evolves over time MnDOT and transit agencies will identify new short-term actions.



4. Technology and Management Solutions

This chapter provides both basic resources and tools to assist transit agencies in making decisions about transitioning to transit technology and related management solutions. These solutions consist of specific technology systems and the broader support systems needed to assure the technology meets expectations and is sustainable over time.

- Technology systems serve many functions including: providing information for customers, assisting in scheduling passenger trips, tracking vehicle maintenance, and enabling riders to purchase digital tickets.
- Support systems include training, cybersecurity, and the base connectivity needed for technology, including the reliability and speed of connections. Support also includes research on technology options, establishing standards to support interoperability, procurement assistance, and access to technical support.

These resources are designed to help transit agencies and MnDOT understand the range of transit technology available and to make decisions about when it is appropriate to consider using technology based on the agency's size, transit modes operated, and other characteristics. This chapter includes:

- Organizational support systems and processes that must be in place to ensure that the technology is effective and sustainable.
- Basic resources for key transit technologies, including [Resource Guides](#) that are part of the [Supplemental Materials](#).
- A Baseline Technology Reference Chart (Figure 4.3) to help agencies determine beneficial transit technology for systems of different sizes and modes. It identifies technologies that are considered important, those that are not a good fit, and the middle ground of those technologies that may be worth considering, depending on agency need, maturity, and coordination requirements.
- Flowcharts illustrating technology systems for key transit agency functions, how information flows between technology systems, and where interoperability may be important.

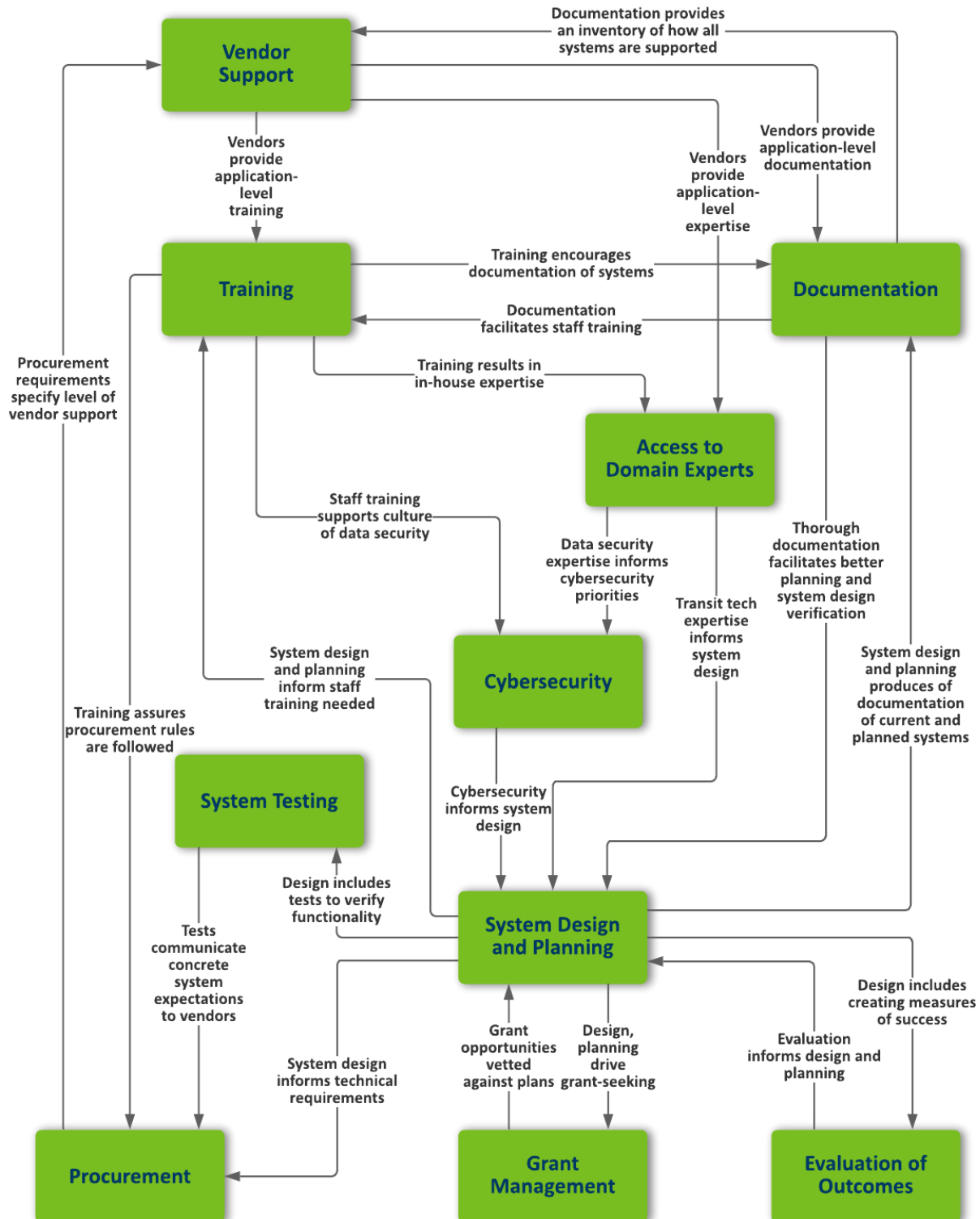
Key items to keep in mind when reading this chapter include:

- **Relationship to goals and strategies.** The information and decision tools in this chapter respond to three key strategies: ensuring cost-effective technology solutions, using decision-support tools to make the best technology decisions, and improving operational efficiency and accuracy.
- **A systems approach is recommended.** Transit agencies need to consider not just a specific technology system but also the relationships between technology systems and the supports that are needed to sustain the technology development.
- **There are many interrelated parts.** It will be useful to refer back and forth between sections. The relationship of the transit agency's institutional structure can impact both the technology supports available and the decision-making process. Ensuring strong organizational capacity is important to successful technology implementation.

ORGANIZATIONAL SUPPORTS FOR TECHNOLOGY

A variety of support systems are important to successfully transition to digital operations. Figure 4.1 illustrates key technology supports and their relationships to each other. It is important that some of these supports be provided within transit agencies, but many may also be provided by MnDOT to build the capacity of all transit agencies like Access to Domain Experts.

Figure 4.1: Relationships among Key Technology Supports



Depending on the technology planning process, one may start with Vendor Support and Training for the existing systems. If an agency is starting from scratch, start at System Design and Planning. These supports do not necessarily follow a linear process; the diagram is meant to illustrate not a sequence of activities but rather the relationships among the supports. In these diagrams, the ability for elements to function in the system is related to those supports. Some examples include:

- Documentation of Standard Operating Procedures for data governance is a major challenge for many state DOTs and agencies. To be able to share data among agencies, a consistent procedure and format for that data are important. Anywhere that data is used for back office or reporting, a common standard should be defined. This standard does not need to be complicated – defining the type and content of key variables for each report can simplify reporting.
- The technology systems an agency operates are also subject to cybersecurity best practices; agencies should maintain an inventory of physical and digital technology assets and who has access to them.
- Managing technology requires keeping up with training and market research. In the market, there are typically single-vendor solutions, which are large enterprise software systems that can perform a wide range of functions. With the growth of software-as-a-service (SaaS), more modular, custom-built applications have emerged. These custom applications tend to be purpose-built to perform specific tasks and generally utilize open standards or documented APIs that can be used to share information.

Vendor Support

Anticipate that technologies will experience failures and require vendor support as they are complex systems. Technology is only as useful as the systems and agreements in place to prevent failure or respond when problems occur.

Companies may list the types of features and modules their software can support, but not provide a high level of detail about how it is supported once in place. One example is the ties to interoperability and standards - is the vendor explicit about supporting GTFS by automatic export, or will agency staff have to initiate a support ticket and pay for additional time to have the GTFS data created each time the schedule is updated?

Across an organization's entire technology footprint, it is important to have a clear and detailed picture of how each system gets its support. This includes:

- An inventory of all vendor service level agreements, e.g., the vendor will respond by the end of the day, or within 48 hours of the request, and the number of hours of customer support available based on the size of the contract and user licenses, e.g., five licenses equal one three-hour training session and 50 hours of support over the year.
- If there are points of integration between systems from different vendors, written service level agreements (SLAs) clarify who will provide support, for what, and under what circumstances.
- Documentation for all systems or circumstances where the agency provides its own support, with a clear understanding of the internal resources dedicated to that support. For example, a vendor may provide ongoing support for in-vehicle tablets, but the agency may install the tablets through its fleet management department.
- For updates and upgrades, documentation can be a major undertaking for both vendor and agency. It is important to get a detailed understanding of the roles each vendor will play throughout the useful life of a technology solution.

When planning for technology, think carefully about not just whether a vendor supports certain features but how the vendor supports those features and whether it is included in the license cost. Vendor support reinforces two other supports:

- **Training:** Vendors provide application-level training and certification that allow agencies to easily determine whether the appropriate skills are in place to use a given system.
- **Documentation:** Vendors provide generalized documentation for their tools, which may need to be augmented by an agency's own documentation that describes how the tool fits in with its particular procedures.

QUESTIONS TO CONSIDER

- What are the time commitments for staff to participate in vendor support and training?
- Does a vendor's SLA match with the impact of a loss in functionality?
- Does the bundled vendor support include training new staff? If not, what are the budget or in-house training implications?

Training

Training is a crucial support to technology of any sophistication. Technology must be supported by initial and on-going training to ensure their proper use.

Technology training can be broken down into two broad categories: System-level training and application- or device-level training.

System-level training supports realistic thinking about how technology can effectively support transit operations. Examples include:

- How to design a collection of applications to work together and match an organization's needs
- How to collect, use, and maintain good quality data
- How to protect the organization's data and the privacy of their customers



This more generalized type of training provides technology life skills that can be applied to many applications and situations, even as the specific tools change over time.

Application- or device-level training enables staff to understand how to use a particular vendor solution. This category is usually provided directly by a vendor or an IT department and may be accompanied by certification to show that a specific set of skills has been acquired. This may include advanced spreadsheet training along with training for transit-specific technologies.

Training is often under-planned in technology deployments. Training of front-line staff, especially drivers who interact with customers and implement in-vehicle and fare payment technology, can take twice as long as anticipated. A primary reason for this is that a project may entail a thorough reworking of an organization's workflows and staff expectations are viewed as mere technology projects – as if a manual typewriter were being replaced with an electric one. However, in many cases, the “typewriter” is being replaced by a new approach to communications at the organizational level.

At the agency level, an effective training strategy reinforces other key supports described in this section:

- **Access to experts:** Training builds internal capacity and cultivates staff who are experts in both the specific technology in question and the inner workings of the agency applying it.
- **Procurement:** Training assures the appropriate requirements and language are included and that all procurement procedures are followed for complex technology investments.
- **Cybersecurity:** Training makes clear staff responsibility, identifies current risk areas, and supports an organization-wide culture of data security.
- **Documentation:** Documenting how systems are used in an organization varies widely and often is not a natural part of most employees' workflow. Training on how to document builds this skill and communicates its importance to staff. Written policies and procedures also ensure consistency and proper operations occur, thereby improving data and service quality.

QUESTIONS TO CONSIDER

- What minimum levels of vendor training should be required as part of procurements? Is initial and on-going training supported/included in technology solicitations? If not, what is some standardized text that can be included in all solicitations?
- What minimum level of internal/provided training should be standard for employees? How frequently are employees re-trained?
- Where training involves both technology and changes in organization workflows, how early can leadership engage all staff in planned changes so that as many people as possible are committed to the effort needed for success?

Documentation

Documentation is a tool used in many fields to clearly define processes and procedures. Clearly documented procedures ensure consistent execution of tasks to comply with best practices.

Technology vendors often provide manuals, guides, and training for their tool and potentially how it can be used in conjunction with other products. Comprehensively understanding how to operate the specific program or device is important to ensure it is meeting the objectives of its purchase. Technology documentation might include translating the software company's user guides for different tools into “how our agency uses these tools to perform functions.” Sometimes documentation is written with administrative personnel in mind, and at other times written with the end-user in mind. Other terms used to describe the documentation include standard operating procedures (SOPs), user guide, or user manual.

What aspects of the agency needs documentation? This could include everything from scheduling to billing/finance, to vehicle and equipment maintenance procedures. When initially developing procedures, allow

staff to set aside several hours a week to develop the documentation for any process or tool that is not yet documented. This is even a great task for an intern or new staff person who is learning the initial tool – as it trains them while allowing them to approach the task with a beginner’s mindset, which will document small details that more experienced staff have adopted as second nature. Step by step screen shots are particularly helpful as they reduce miscommunication. Next, conduct regular quality checks as staff are developing documents – for instance, by having other mid-level staff or senior leaders note where it could be improved.

Documentation is only as valuable as it is accurate. As such, all forms of documentation should be considered working documents, supported by an organizational culture that encourages all affected staff to participate in maintaining and improving it. These are practical barriers to managing changes over time. Once the documentation is established, set aside at least one hour a month for staff to review and update it. When updates occur, the version number of the documentation and date of the update can be noted at the beginning of the document.

The Federal Highway Administration and Transportation Research Board (TRB) offer several resources for documenting data governance¹ and data sharing² practices that would be relevant to MnDOT and public transit agencies.

Documentation reinforces vendor support when priority is given to explicitly mapping out how vendors support their solutions. Documentation also works in virtuous cycles in relation to two other key supports:

- **System design and planning:** Good documentation can make planning for future systems much easier by making the starting point more readily understandable, while the results of planning can become a key source of documentation for how systems fit into the whole organization. Documentation can also verify that the system is functioning as it was planned and designed to function.
- **Training:** Documentation is a central ingredient in training new employees or cross-training existing staff. One element of training can include an organization’s approach to documentation and affirm its importance in making the organization one that works smoothly.

QUESTIONS TO CONSIDER

- What are the systems and procedures that need to be in place so that responsibility and incentives for documentation are situated as close as possible to the most knowledgeable staff members? How can supervisors assist staff in finding time to create documentation?
- What tools are needed so that staff can easily update documentation and the affected staff members are updated appropriately?
- How is the process of documenting workflows working for agency staff? Is documentation being updated and reviewed monthly? If not, what are actions agency leadership can take to ensure processes are being documented carefully?

¹ NCHRP Synthesis 508: Data Management and Governance Practices, <http://www.trb.org/NCHRP/Blurbs/176005.aspx>

² TCRP Report 213: Data Sharing Guidance for Public Transit Agencies: Now and in the Future <https://www.nap.edu/catalog/25696/data-sharing-guidance-for-public-transit-agencies-now-and-in-the-future>

Access to Technology Domain Experts

Success will rely on access to experts in transit technology. Given the breadth of knowledge involved and turnover in technology tools, it is not feasible for leadership or operation-level staff to master all the topics needed to stay current.

While expertise can often be brought in-house through training or new hiring, sometimes the best option is securing it through contracting. Through a contract with a managed service provider, an agency can obtain both general IT skills and skills in specific transit technologies such as the integration of CAD/AVL systems with other transit technologies. Technical assistance programs, such as those funded by the FTA, may also be able to provide vital help.

For areas where the same knowledge is needed across many transit agencies or is difficult to access, it may be most effective to centralize access at the regional or state level. Some examples where centralized access would be useful include the following:

- Conducting market research to maintain current information on core technologies
- Research needs that apply to multiple agencies
- Developing minimum standards for key technologies, which would become core requirements in any solicitation (RFP or RFQ)

Gaining access to technology experts can reinforce other key supports described in this section:

- **Cybersecurity:** Threats to data security are complex and rapidly changing. Seeking outside knowledge can be key to keeping abreast, setting priorities, and adhering to data security requirements.
- **System design and planning:** One area where expertise is valuable is market research in preparation for new procurements. Technology companies introduce new features and software versions with some regularity, and competition in the market will drive customer expectations for what is standard. Having a good sense of minimum standards as well as additional enhancements is important to getting good tools – but it requires effort to stay current on the latest trends and capabilities of scheduling, fare payment, and in-vehicle technology.

QUESTIONS TO CONSIDER

- What are the everyday skills to which agency staff would like immediate and regular access? Agencies may already have these needs met by a help desk. If not, can these needs be met by IT staff within the agency?
- What are the help desk skills agency staff desires periodic access to, where staff could just call someone and get an answer or an on-site visit with a predictable turnaround time? This occasional assistance may be met by a managed service provider.
- What types of project assistance skills are accessed on a less frequent basis? Projects might include developing RFP requirements, specific software development, etc.

Cybersecurity

Having a well-considered cybersecurity plan is becoming critical to operating a public transportation service.

There are three key trends:

1. General public transit services are gradually acquiring personally identifiable information (PII) on riders through wayfinding and e-fare apps
2. Data security expectations for agencies providing demand-responsive transportation is growing more stringent as Health Insurance Portability and Accountability Act (HIPAA) and related laws are being applied to services that support the healthcare industry
3. The threats at large are growing and extending to more and more industries.

Having secure data and IT systems is an on-going process of: Examining risks to data, services, and hardware; developing processes to mitigate those risks; and ensuring those processes are being followed by internal and external parties.

Cybersecurity is a complex and intimidating topic that is constantly evolving – some statewide support to protect smaller agencies is important to ensure proper cybersecurity measures are in place.

Rather than a single training effort or problem relegated to the IT department, cybersecurity is a concern that touches nearly every staff member and aspect of an organization. Beyond training and IT, it can affect contracting, incident response and business continuity planning, physical safeguards, and most importantly, risk management and thoughtful cost-benefit analyses. Ideally, cybersecurity is fully integrated into an organization's larger culture of safety.

At the level of reinforcing other key supports described in this section, cybersecurity particularly impacts system design and planning by helping to ensure that technology investments are considered through a security lens.

QUESTIONS TO CONSIDER

- What data needs to be protected?
- Is management supporting developing cybersecurity risk mitigation procedures? If so, is there adequate funding budgeted to ensure for proper cybersecurity practices and training?
- What can be implemented without additional budget (e.g., playbooks for what to do if something is destroyed, documentation, etc.)? How can existing resources be used to mitigate the cyber risks?
- Who is going to be responsible for cybersecurity and make related decisions?
- What type of training is needed, and at what frequency?
- Can the agency involve partners to help identify the gaps in security?
- How well is the agency's equipment, including network and field equipment, documented? Who has access to the asset logs?
- Are there any policies/procedures (e.g., password requirements, etc.) and are they well communicated or enforced? Are the policies/procedures regularly updated?

System Design and Planning

The more thought that goes into an investment, the more likely a successful outcome will be. Intention, planning, and/or ongoing monitoring helps organizations acquire technology to best fit their needs.

Thorough planning can help avoid common pitfalls, such as failing to fully consider the resources needed for maintaining a system for its full useful life or evaluating how systems need to connect across vendors or organizational units. Informed by cybersecurity strategies and access to domain experts, design and planning provides a solid foundation for the development of successful procurement activities. It is also a critical element to multiple cycles involving other key supports:

- **Documentation:** The results of designs and plans serve as a blueprint for how systems are intended to work and fit together. As systems evolve in their use, documentation makes the generation of new plans easier because the current conditions are more readily understood.
- **Training and access to domain experts:** Planning should ideally include an assessment of what staff training is needed for a technology solution to be successful. The training cultivates in-house expertise, which in turn can be used to improve future designs and plans. In addition, the results of market research conducted with the aid of domain experts are key to developing designs and plans that reflect the applications and services available from vendors.
- **Evaluation:** planning and evaluation work together in a feedback loop in which plans remain grounded in measurable results.

QUESTIONS TO CONSIDER

- What are the values and core strategic plans that should be reflected in technology system design and planning?
- As designs and plans are developed, who should be kept informed and be able to provide input?
- What domain expertise is needed to help assure the success of the plans?
- When looking at the various technology solutions, what does the agency need versus what are desired functionalities?
- What are sources of capacity-building information that transit agencies and MnDOT can use to stay current on appropriate market research and trends?
- What are the opportunities to coordinate? Is a foundation of agreements in place to work with all partners? For example, have business agreements and standards been developed for fare sharing?



Grant Management

Grant funding requests are best supported by a technology growth plan focused on improving key agency functions and meeting the agency mission and goals.

A central element of technology investments is their funding. While grant opportunities can often drive what technologies are invested in and when, a lower-risk approach is to start with mission-driven plans that then drive grant-seeking efforts. A considered, prioritized technology growth plan positions a transit agency to access existing or new funding streams to finance these technology solutions.

While some projects require winning large and competitive grants, many technology investments can be broken down into smaller chunks that can be managed through more accessible funding streams. If an aligned grant opportunity arises, the existing project timeline can be accelerated. Coordinating and leveraging funding streams may enable an agency to fund a technology purchase that will benefit multiple types of clients (older adults, people with disabilities, Veterans). Coordinated approaches, such as through a regional project, may also provide opportunities to procure technology.

Projects that have most of their design take place in direct response to the announcement of a round of grants may not only have a lower likelihood of obtaining funding due to the tight time constraints, but they also have a higher risk of failure if the grants are won. The development of partnerships, organizational consensus on problems and their solutions, and other key supports to a project often cannot be put into place in the few weeks allotted to putting together a proposal.

QUESTIONS TO CONSIDER

- How do agency grant writers stay informed about the organization's technology needs?
- Many technology-related grant opportunities, while not identical, carry similar traits to one another. Based on past solicitations, how can agencies plan now for future ones?
- How are grant applications coordinated at the agency level, the regional level, and with MnDOT?
- How do grant funding cycles align with transit agency needs?
- How can transit agency technology needs be broken down into pieces that align with funding availability?

System Testing

Most transit technologies are complex and need significant setup and testing. Success depends on having a plan to validate that a new investment is performing as expected, along with staffing resources to execute that plan.

Testing has two major components. The first is the design of the tests, which to the degree possible should be carried out as part of the development of technical requirements. The second is the application of the tests once the system is up and running. While designing a set of tests can be challenging, it can reap tremendous benefits because they both communicate the measures of success to vendors and organize all parties on what is most crucially important in a project from a technical standpoint.

Carrying out the testing itself can also be time-consuming, especially if it involves validation of expectations for onboard technology across a range of scenarios. It may be necessary to run two systems in parallel to assure

that the new system is collecting data properly. Plan for testing regimens to take significant time and pull staff away from regular duties.

QUESTIONS TO CONSIDER

- What are the clearest and most quantifiable measures that can be included as requirements?
- What scenarios and results can be described that clearly convey what the desired system needs to do?
- How can staff time be dedicated to carry out testing?

Procurement

Technology is often the most important, yet difficult, type of procurement that agencies make. Besides needing to comply with a range of complex rules to ensure a fair and transparent process, a successful technology procurement needs to effectively communicate circumstances and objectives, all while attracting the right vendors to respond.

The resounding message from engagement with the Steering Committee for this Plan was that more support is needed in this area. This support could come in a variety of forms:

- Increased access to expertise and market research for the development of technical requirements, as described in the Access to Technology Domain Experts section above.
- State-level leadership via a committee that might pre-approve vendors while still allowing enough flexibility for agencies to procure their own solutions when it makes sense.
- MnDOT may leverage greater authority with vendors by selecting and managing who is permitted on an approved statewide vendor list. MnDOT would set the standard and secure commitment from vendors to perform to a certain level. To stay on the list, vendors would need to meet clear requirements.

In relation to other key supports, procurement has a direct impact on vendor support, which can be defined as part of the requirements in a request for proposals. Transit agencies can contact MnDOT as they consider the questions below to determine the amount of support that might be needed and what support is available through MnDOT's evolving procurement process.

QUESTIONS TO CONSIDER

- Is this situation unique, or might there be other agencies struggling with the same question, and would a group procurement work?
- Will an agency get better customer support, additional tools/modules and/or a better price from a vendor if they go through MnDOT?
- If an agency wants to procure something outside of MnDOT's approved vendor list, is there a template to use to find a local vendor?
- Does the RFP include language about the consumer price index to keep operating/maintenance fees consistent with inflation? Are there funds available to cover these on-going fees? Does the RFP include language about training and support?

Evaluation of Outcomes

A thoughtful evaluation framework allows agencies to increase their technology capabilities over time by encouraging organization- and system-level learning.

While it is common for agencies to evaluate the transportation services they provide to their communities, it is less so that agencies evaluate the tools they rely upon to deliver those services. This can lead to technology investments that miss the mark while having no mechanisms to identify problems or correct course.

Evaluation should be rooted in tracking whether a system succeeds at solving the problems it was designed to solve. Some measures may be easy to quantify, such as on-time performance for a CAD/ AVL system or how often vehicles are out of service for an asset management system. Others may be more difficult to assign objective values to, such as staff satisfaction with the user interface of an application. In these cases, approximate benchmarks or informative narratives may be possible to use in place of strictly objective measures.

However evaluation is handled, the key is to institute some method of looking back and glean lessons learned in support of future investments. Doing so avoids the pitfall of getting technology for technology's sake. Evaluation works with system design and planning as a means of continuous improvement, where evaluation design is part of the larger design work for an investment, and the results of evaluation inform the next related system design.

QUESTIONS TO CONSIDER

- How will an agency know if the system chosen does what we intended it to?
- What are the metrics used that are accurate, informative, and sustainable to collect? What frequency does this data need to be collected?



Other Supports

Many supports are needed for successful technology implementation. In addition to the supports described above, three other supports are needed:

- Standards and specifications
- Funding and budgeting to assure system continuity
- Connectivity

These other supports impact multiple areas in Figure 4.1, including Procurement, Systems Design and Planning, and Documentation, so these other supports are not shown on the diagram. The relationships depend on and impact other categories of supports differently depending on the situation. Rather than defining these other supports as single categories, it may be more useful to consider them at each of those steps. In other words, when agency staff or leadership are documenting existing workflows, planning or designing for new workflows and applications, or initiating a process to procure new applications – these other supports should be considered.

STANDARDS AND SPECIFICATIONS

Moving towards interoperability and integration may require a variety of supports including identification of standards and specifications. These requirements need to be built into the procurement process. As mentioned under Access to Technology Domain Experts, several resources for documenting data governance³ and data sharing⁴ practices are a good starting point for MnDOT and transit agencies to work toward developing/adopting shared standards and specifications.

FUNDING AND BUDGETING

Technology can change rapidly so planning for the full technology lifecycle too far in advance might result in outdated equipment standards or software versions by the time installation occurs.

The funding and budgeting process at both the state and local levels must assure continuity of systems, required supports, and routine maintenance and updates. Funding continuity and budgeting will occur at any levels where budget decisions are made. MnDOT can provide support by:

- Keeping agencies informed of funding timelines and grant opportunities
- Supporting agencies in understanding budget timelines and deadlines
- Developing budget/procurement timelines that make sense and allow for flexibility - evolving existing procedures if necessary – to accommodate need and system growth

CONNECTIVITY

Speed and reliability of internet and data connections are a critical consideration for technology adoption, especially given the trend of mission-critical applications being hosted in data centers. Without reliable, high-speed connections, agencies might limit their technology stack to systems that do not need a refresh more

³ NCHRP Synthesis 508: Data Management and Governance Practices, <http://www.trb.org/NCHRP/Blurbs/176005.aspx>

⁴ TCRP Report 213: Data Sharing Guidance for Public Transit Agencies: Now and in the Future, <https://www.nap.edu/catalog/25696/data-sharing-guidance-for-public-transit-agencies-now-and-in-the-future>

often than every hour, and sufficient backup systems (such as drivers checking in via radio with a dispatcher every so often) would be in place.

Access to universal broadband is covered under other statewide initiatives (including the Office of Broadband Development and the Broadband Task Force), but here are some things to consider:

- How often are agency staff reviewing service-level agreements with the internet service provider (ISP)? Does an agency's broadband get guaranteed throughput? What are the consequences for the ISP for downtime?
- How costly is a loss of connectivity? It may be worth it to get a backup connection in case the primary service goes down. In rural areas, cellular- or satellite-based services may provide stopgap connectivity.



BASIC RESOURCES

Technology System Resource Guides

The basic transit technology systems are listed below. The [Supplemental Materials](#) section contains [Resource Guides](#) for each of the technology systems summarized below. The Resource Guides contain information on the type of technologies available in each category, considerations for each, and some questions for transit agency staff to ask in determining whether the technology is a good fit for their system.

SCHEDULING/DISPATCH SOFTWARE AND RELATED MANAGEMENT SYSTEMS



There are a variety of tools for scheduling. Those focused on **demand response** services address how to efficiently schedule passenger trips, identifying for each day who will be transported by each vehicle. Scheduling systems for **fixed route** systems include scheduling vehicles so all trips are covered and cutting driver schedules from those vehicle schedules. Most scheduling software links driver availability, vehicle capacity, driver training and credentials, and recordkeeping functions.

CUSTOMER-FACING TRIP PLANNING



Trip planning tools enable customers to determine the available transit services and their schedules. Trip planning tools are widely available for fixed route services (bus or rail) based on General Transit Feed Specifications (GTFS) and GTFS-realtime data. Trip planning applications are often available on both mobile apps and web-based applications. Trip planning tools are now available for **demand response** and **route deviation** services through

GTFS-flex⁵.

COMMUNICATION WITH RIDERS AND THE PUBLIC



Communicating with riders and the public is a key responsibility for transit agencies. Transit agencies are adding websites, social media, and system-specific transit applications to the more traditional paper schedules and maps, telephone information, line, and posting notices on vehicles. These tools help transit agencies communicate information efficiently and accessibly to the public.

ASSET MANAGEMENT AND MAINTENANCE



Transit asset management (TAM) refers to tracking and maintaining a transit agency's capital assets. Transit assets include vehicles, bus shelters, and transit facilities, as well as an agency's technology systems and infrastructure. Asset management tools and procedures allow agencies to track the assets, the scheduled actions needed to maintain them over time (vehicle oil changes, shelter cleanings, etc.), and the unforeseen events that may affect their future service (collisions, vandalism, etc.).

⁵ GTFS-flex is not yet widely used but is in place for some transit systems. This is an area with significant developments occurring. There is an ongoing effort to develop General On-Demand Feed Specifications (GOFS) with a working group looking to expand data that can be shared, building on both the existing GTFS-flex data descriptors and work done on the Transactional Data Specifications (TDS) developed through the TCRP G-16 project.

IN-VEHICLE TECHNOLOGY



A variety of technology tools are vehicle-based, from Automated Voice Announcements (also known as annunciators) to cameras to automatic vehicle location devices. With most in-vehicle technology, the ability to integrate systems is an important consideration. On board technologies cover many features such as safety and security, communications, fare collection, scheduling, and core operations.

FARE PAYMENT



Fare collection can be a resource intensive process and the pandemic has resulted in increased interest in contactless fare systems. While cash, paper tickets, and other fare media like magnetic stripe cards are not touched by drivers, they place passengers in close proximity to drivers (closer than six feet). Contactless fare systems are generally used by larger transit agencies with enough revenue to warrant the costs of the technology.

SERVICE PLANNING



These tools are primarily for agencies charged with regional transportation planning in urban areas and/or for the larger fixed route systems. They include tools for planning of fixed-route services, equity analysis, and GIS mapping tools.

GRANT MANAGEMENT AND COMPLIANCE



Many state DOTs rely on some sort of management system that tracks a variety of federal and state compliance related information, including assets, fiscal activities, grant management and compliance. MnDOT uses BlackCat by Panther for grant management and compliance.

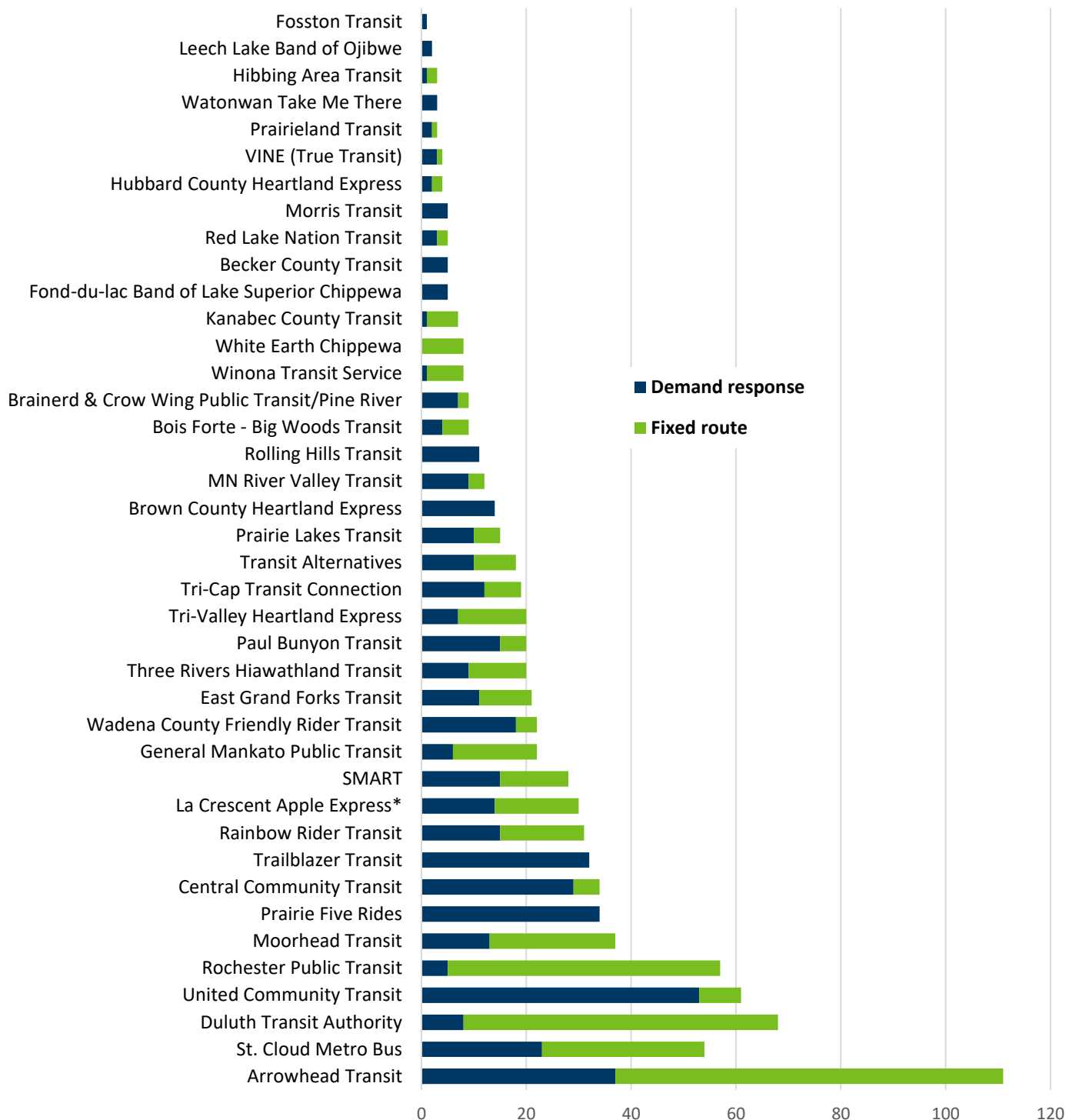
WHAT TECHNOLOGY IS A GOOD FIT FOR EACH TRANSIT AGENCY?

The modes a transit agency operates and its size, as measured by fleet size, are key variables in determining the transit technology that will be a good fit for the system. Starting with size and mode is useful, while recognizing there are other variables that need consideration. For example, important considerations are the institutional structure, number of jurisdictions served, or the balance between modes (e.g., is the service mostly demand response, mostly fixed-route, or a balance between the modes?).

Figure 4.2 illustrates the total vehicles by mode for transit agencies in the state, as reported in the 2019 National Transit Database. There are 15 systems with fewer than 10 vehicles. The smallest nine primarily operate demand response service while the next four have larger fixed-route fleets. There are 14 systems operating between 10 and 29 vehicles. These systems often are more balanced between the two modes and include two small urban areas. The remaining eleven systems operate between 30 and 100 vehicles, including some systems oriented to demand response services, some oriented to fixed-route services, and some balanced between the two modes.



Figure 4.2: Greater Minnesota Total Transit Vehicles by Mode, 2019 National Transit Database



*La Crescent Apple Express is part of the La Crosse Metropolitan Transit Utility. The fleet numbers here reflect the entire La Crosse MTU system, as technology decisions are based on total system size. Similarly, Moorhead Transit and East Grand forks Transit, each serving two states, show the total system fleet numbers.

Figure 4.3 lists the various transit technology systems and uses size categories of less than 10 vehicles, 10 to 29 vehicles, and over 30 vehicles. The chart identifies technology systems that have long-proven value for a specific size agency, those that are likely not appropriate, and those that warrant additional questions and perhaps consideration. There are some items that have a clear “yes” or “no,” but for many the chart indicates “maybe.” The many variations between systems means that it is necessary to carefully consider the characteristics of the service, daily ridership, and technology systems that may be available through the larger agency that is home to the transit operation (city, county, or community action program).

Due to the complexities of transit services, some agencies may not fit the size classifications when determining the best technology fit. For example, an agency with nine vehicles providing complex services may be more like the medium sized agencies in respect to technology needs. For agencies that offer both demand response and fixed route service, the appropriate technology solution is based on the size of each service. For example, if an agency has 45 fixed route vehicles and 9



demand response vehicles, they are a large system for their fixed route technology needs and a small system for their demand response needs. Agencies that offer demand response and fixed route services may also be able to use one technology system to serve multiple functions for their agency (i.e., personnel management or maintenance). Additionally, complimentary paratransit and deviated fixed route services technology needs are generally considered as demand response so only the demand response service columns are shown in the figure.

When there are no clear answers, it is important to think through the functional needs of the agency and potential benefits and costs of a particular technology solution. Factors to consider are the characteristics of each particular function within the agency, funding sources and program requirements for reporting or budgeting, or the level of support within the organization. For example:

- What functions, such as finance, human resources, or maintenance, are available within the organization and which are needed from transit-specific technology?
- What portion of fares comes in through fareboxes, through prepaid passes or tickets, and through agency billing?
- What is the reliability and speed of internet connections?
- What are the characteristics of the riders?

Figure 4.3: Baseline Technology Reference Chart

KEY:	FLEET SIZE					
	1 to 9 vehicles		10 to 29 vehicles		30+ vehicles	
	DR	FR	DR	FR	DR	FR
Scheduling/Dispatch Software and Related Management Systems						
Client mgmt and scheduling DR trips	●	NA	●	NA	●	NA
Scheduling FR vehicle runs	NA	●	NA	●	NA	●
Algorithm to optimize schedule	●	NA	●	NA	●	NA
Driver and vehicle scheduling and mgmt	●	●	●	●	●	●
Reporting	●	●	●	●	●	●
Interfaces and export/import ability	●	●	●	●	●	●
Driver manifests on tablets or MDTs	●	NA	●	NA	●	NA
Reminder calls	●	NA	●	NA	●	NA
Customer-Facing Trip Planning						
Trip planning for riders	●	●	●	●	●	●
GTFS	NA	●	NA	●	NA	●
GTFS-Realtime	NA	●	NA	●	NA	●
GTFS-Flex	●	NA	●	NA	●	NA
Communications with Riders and Public						
Web page	●	●	●	●	●	●
Social media	●	●	●	●	●	●
Business telephone systems	●	●	●	●	●	●
Asset Management						
Vehicle maintenance	●	●	●	●	●	●
Facility maintenance/other	●	●	●	●	●	●
Pre-trip inspections	●	●	●	●	●	●
In-Vehicle Technology						
Automated voice announcements	NA	●	NA	●	NA	●
Cameras	●	●	●	●	●	●
Automatic vehicle location or GPS	●	●	●	●	●	●
Automated passenger counters	NA	○	NA	●	NA	●
Collision avoidance systems	●	●	●	●	●	●
Mobile data terminal/computer	●	●	●	●	●	●

Continued on next page

Figure 4.3: Baseline Technology Reference Chart, continued

KEY:	FLEET SIZE					
	1 to 9 vehicles		10 to 29 vehicles		30+ vehicles	
	DR	FR	DR	FR	DR	FR
Fare Payment						
Farebox	●	●	●	●	●	●
Electronic fare reader/validator	●	●	●	●	●	●
Account-based (contactless)	●	●	●	●	●	●
Reporting/interface with financial software	●	●	●	●	●	●
Ticketing vendor or other points of sale	●	●	●	●	●	●
Service Planning (may be conducted by City/County or MPO)						
GIS tools	○	●	●	●	●	●
Spreadsheets for demand analysis or fixed route runs	●	●	●	●	●	●
Demand analysis models with MPO	○	●	●	●	●	●
Fixed route planning software	NA	●	NA	●	NA	●
Integrated service planning tools	○	●	●	●	●	●

TRANSIT TECHNOLOGY FLOWCHART

Introduction

Another resource to assist transit agencies in designing effective technology systems is the transit technology flowchart. These flowcharts, also known as transit stacks, illustrate the technology tools and processes used by transit agencies. These diagrams show the relationship of different transit technologies to each other and show the dependencies between them, illustrating what can be free-standing (such as on-vehicle cameras) and what may require foundational technologies to be in place. For example, Automatic Vehicle Location (AVL) is needed for several technologies. These dependencies can assist in identifying where it will be useful to integrate two or more systems.

This section presents an overview of the transit technology flowcharts, illustrating a flowchart for a large agency (30 or more vehicles). The [Supplemental Materials](#) section contains a more detailed description and sample flowcharts for small and medium transit agencies. The small agency flowchart is intended for agencies with fewer than ten vehicles in their fleet. Automated processes or software may not provide enough benefit to these agencies for the implementation of many transit technology systems. They can, however, use a mix of spreadsheets and lightweight technology with thoughtful integrations. The flowchart for medium-sized agencies, or those with 10 to 29 vehicles, offers some guidance on optional components to consider if an agency has the capacity to maintain the additional technology.

These typical flowcharts are intended to guide transit agencies. The reader is cautioned to keep in mind the diversity that exists between transit agencies. Even within a given size category, two agencies will have different technology need and make very different technology decisions. An agency with three vehicles will look quite different than an agency with nine and, therefore, have different technology needs.

Large Agency Technology Flowchart

The comprehensive transit technology flowchart for large agencies shown in Figure 4.4 is used as an example for this section. Arrows traveling into and out of the various technology systems show the flow of information and how it might be used by another application. The information may be generated by a technology system, equipment, or staff. It may be transmitted manually (such as through a report) or electronically, such as AVL information that flows automatically to one or more technology systems.

Following the flowchart is a description of the legend and then a description of sample components as they may apply to small and medium transit agencies.

Figure 4.4: Large Agency Technology Flowchart

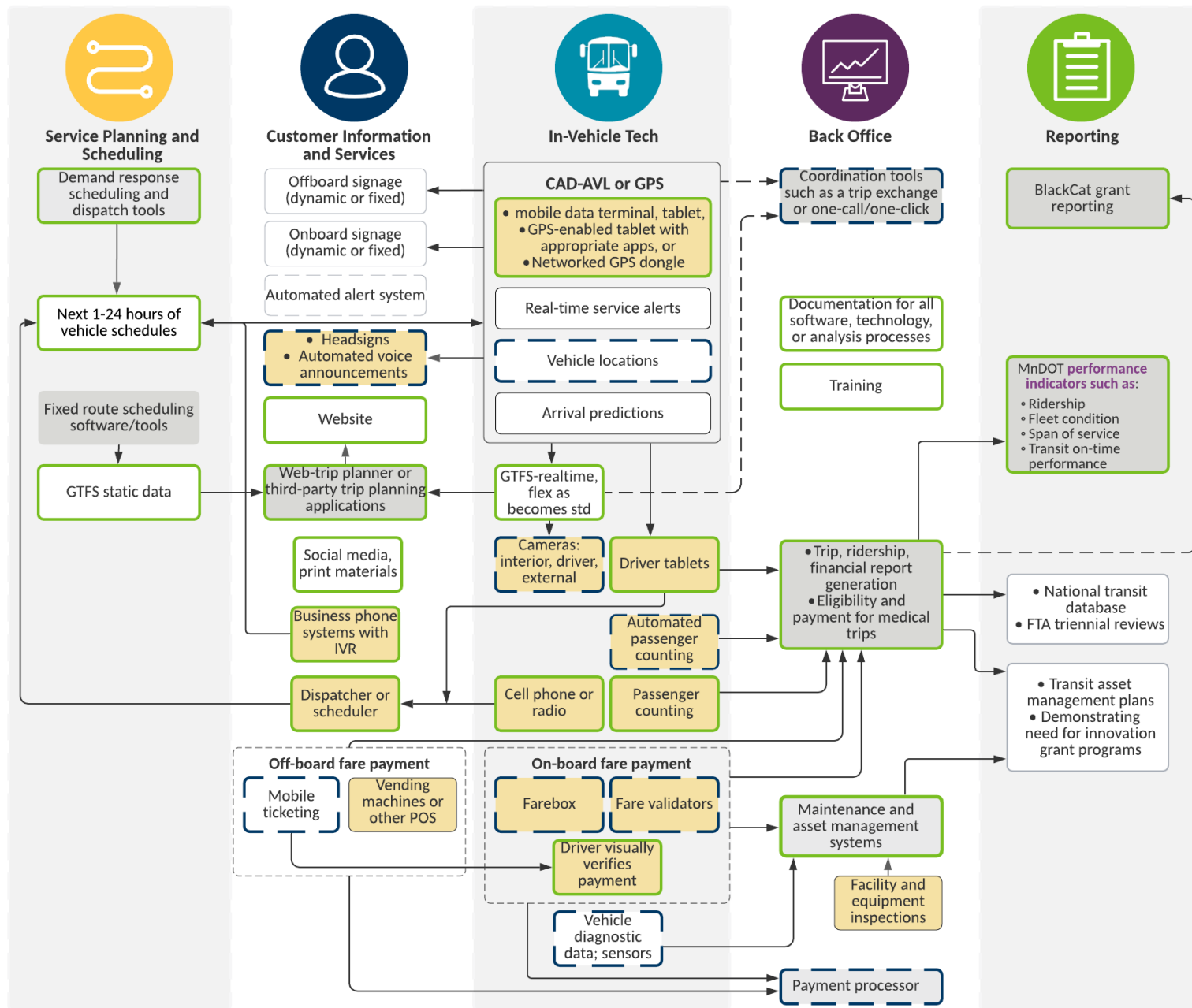
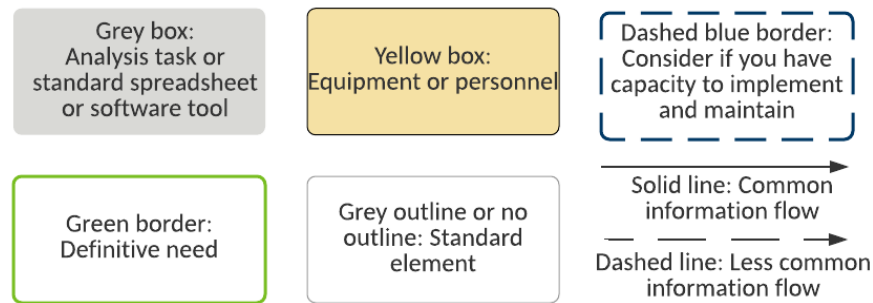


Figure 4.5 is a legend for the Transit Technology Flowchart. The standard spreadsheets or software tools that are used in functional or analysis tasks (represented by grey boxes) might include spreadsheets, software systems used for scheduling demand response trips, or trip planners that may be a mobile app or web based. The yellow boxes represent equipment (many of which are technology systems) or personnel. The on-vehicle technology column contains many devices such as cameras, tablet, cell phones or radios, and fareboxes. A yellow box under Customer Information and Service lists dispatchers/schedulers who act on information received (via telephones, radios, AVL) to adjust or refine vehicle deployments to keep the systems running efficiently.

Figure 4.5: Transit Technology Flowchart Legend



The comprehensive, large agency technology flowchart illustrated in Figure 4.4 contains a wide variety of ways in which technology can support the daily functions carried out by a large and complex transit system. “Customer Information and Services” is the point where scheduling and service planning intersect with operations. On the diagram, this is illustrated by lines between the columns. For example, drivers generally use cell phones, tablets, or radios to communicate with dispatch in order to report/ receive emergency information, schedule changes, and other relevant information. A radio, tablet, or cell phone connection to the dispatcher may also be the means by which dispatchers update customers on their vehicle’s arrival time.

Looking at the large-agency Transit Technology Flowchart, one finds that AVL systems are integral to a transit agency’s technology systems. For the smallest of systems this may be a simple dongle or an AVL system integrated into a single technology application (illustrated in Figure 4.6). For larger systems, it is useful to consider integrated CAD/AVL systems that are used for multiple technology systems. Figure 4.6 shows the technology flowchart components for small and medium transit agencies.

Information from many systems feed into the Back Office and Reporting columns. For many of these information flows there are likely already processes in place to, for example, translate trip, ridership, and financial reports into MnDOT’s performance metrics and metrics for the National Transit Database (NTD) reports.

Other connections are generally less established in the industry and are indicated with the dashed line. These include:

- Coordination tools, while increasing in number, are not widespread. These tools enable planning by using GTFS or other map data. Sometimes they allow booking/re-booking or cancellation. For booking or cancellation, these tools need real-time information about available provider capacity and potentially be able to send and receive information from driver tablets/manifests in order to modify trip schedules.
- In Minnesota, transit agencies are able to upload ridership performance metrics by uploading comma-separated values (csv) files into BlackCat. However, at present, transit agencies are not able to upload csv files for financial reporting into BlackCat, necessitating manual entry for each line item.

Thinking about all the ways in which a transit agency uses technology fosters a system approach to technology development. This includes making decisions about how to develop the overall system as well as what needs to be interconnected and what can be free-standing. A system approach also helps agencies build a strong development strategy, a capital plan for replacement and new technology, and a maintenance plan for technology, feeding into both operating and capital budgeting processes.

Figure 4.6: Sample Technology Flowchart Components for Small and Medium Transit Agencies

Functional Area	Small Transit Agencies	Medium Transit Agencies
 Service Planning and Scheduling	• Demand-response scheduling • GTFS static data for fixed route services	• Demand response scheduling • Fixed route scheduling tools • GTFS data, with GTFS-realtime
 Customer Information and Service	• Website, augmented by social media and print materials • Business telephone systems with IVR and SMS capabilities	• Website, augmented by social media and print materials • Trip planners • Business telephone systems with IVR and SMS capabilities • Automated Vehicle Announcements
 In-Vehicle Technology	• Fareboxes • AVL – from simple dongles to CAD/AVL as part of scheduling system • Cameras • Driver tablets for DR scheduling • Radios and cell phones • Headsigns for fixed route buses	• Fareboxes • Electronic fare payment options • CAD/AVL, including integrated AVL for multiple systems using a mobile data terminal • Cameras • Driver tablets for DR scheduling • Radios and cell phones • Headsigns for fixed route buses • Automatic passenger counters • Vehicle diagnostics
 Back-Office	• Trip, ridership, and financial reports • Eligibility and payment processes for specific programs • Maintenance systems	• Trip, ridership, and financial reports • Eligibility and payment processes for specific programs • Maintenance and asset management systems
 Reporting	• BlackCat reporting to MnDOT • Performance measures and metrics • NTD reporting	• BlackCat reporting to MnDOT • Performance measures and metrics • NTD reporting

CONCLUSION

This chapter describes a variety of tools to assist agencies in understanding the technology system resources appropriate for a particular transit agency. A challenge for the entire transit industry, and one that transit agencies beginning to integrate technology into their operations are likely to experience, is that the language of technology is not yet built into the functionalities and workflows of most transit agencies. The tools in this chapter are geared toward building an understanding of:

- The importance of having organizational supports (training, documentation, vendor supports, access to domain experts, etc.) in place
- The types of technology systems that support the many functions in which transit agencies engage (customer communications, scheduling passenger trips and vehicles efficiently, maintaining assets, etc.)
- The importance of taking a broad view to understand how technology systems can be linked together as well as the importance of building a strong foundation for technology

The Baseline Technology Reference Chart will assist in identifying technologies that may be appropriate for an agency or are worthy of further consideration. This tool can also assist in identifying where technology will not improve efficiencies. The transit technology flowcharts show the relationships between technology systems and assist in illustrating the foundational components that an agency may wish to obtain early on.

Key points to remember are:

- The organizational supports needed for technology are as important as the technology systems.
- An agency's goals serve as a foundation to making technology choices. One agency may have improvements to customer communications as a key goal. The technology for that will be quite different than for an agency that is seeking improvements to maintenance systems or scheduling efficiencies.
- These tools are a guide. Each transit agency is unique and will need to tailor technology systems to meet the needs of their organization.
- How technology systems are used within each agency requires in-depth knowledge of the transit agency and careful consideration of the capacity of the organization to sustain the technology. Sometimes it makes sense to keep systems simple, but that does not mean the transit agency cannot benefit from some technology.

The Resource Guides and transit technology flowcharts are described in more detail in the [Supplemental Resources](#) at the end of this Plan.

Chapter 5: Developing Assessments and Growth Plans shows how to apply these tools to assess what is in place and where updates or improvements would be beneficial. It also describes using this assessment to develop a growth plan for a transit agency's technology systems.



5. Developing Transit Agency Technology Assessments and Growth Plans

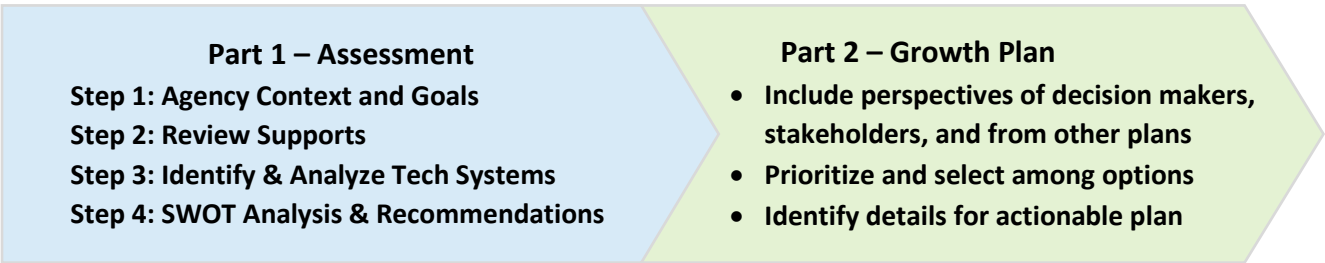
An important objective of MnDOT is to provide transit agencies with the tools to assess their current technology and plan for growth in their technology systems. This chapter illustrates how transit agencies can use the tools and resources presented in Chapter 4 to complete a technology assessment and then use those results in developing a growth plan. Templates for creating a technology assessment and growth plan, including examples of each, are contained in the [Supplemental Materials](#).

ASSESSMENT AND GROWTH PLAN DEVELOPMENT PROCESS

As with other significant investments transit agencies make, the likelihood of technology investments succeeding increases significantly with thoughtful planning. While there are many instances across the industry of technology being successfully applied, within the United States there are no generally agreed-upon processes between agencies and state-level funders to ensure successful technology deployments. The objective of the recommended growth plan development process is to apply a replicable, lightweight, and systematic approach to technology planning, one that increases agency capacity to implement appropriate technology tools, reduces risk, and ultimately expands mobility options for the general public.

The development of growth plans is a two-part process: the first part is a technology systems assessment; the second is the growth plan itself. The basic steps of each part are shown in Figure 5.1.

Figure 5.1: Assessment and Growth Plan Development



A technology systems assessment is an important foundation for transit agencies to make wise investments. The focus of technology systems assessment is to gather and present all the key facts needed to inform a growth plan. It is largely technical in nature, though it also includes analysis of non-technical supports that are vital to a technology project’s success.

While the assessment focus areas may be informed by an agency's priorities and key challenges, the scope is agency-wide and expressly broader than any one problem or current project. As such, it should in some form include all the major systems where technology is being used or considered. While the primary audience for this assessment is the agency itself, it should provide enough contextual information so that it can be readily understood by staff at other agencies, by MnDOT, and with the passage of time. The purpose of the assessment is to serve as a snapshot of the agency’s reality as it relates to technology.

A technology assessment also serves a broader organizational purpose by helping the agency better understand and leverage its operations, opportunities, and strengths. It provides an opportunity for agency staff to look across systems and consider all the various technologies, align available technology solutions with the transit

system services and operations, the integration between technology systems, and the supporting resources needed to maintain them. This assessment provides opportunities to bring the people together who work in different areas of the organization to identify opportunities for greater efficiency and effectiveness in achieving agency goals.

TIMING

As the transit technology field is in a period of rapid change, it is important that assessments be made or updated prior to making a major technology investment (cost exceeds \$25,000) and at least every five years. A model for assessing transit systems follows:

- For all agencies, conduct an initial assessment and growth plan independent of any particular project. These documents may serve as the basis for updates for up to five years.
- For small urban and large rural transit agencies, an updated technology assessment is recommended prior to major technology purchases, or as part of annual budgeting, grant application, and capital planning cycles. A more thorough re-assessment should be done as part of a three or five-year planning process.
- For small and medium-sized rural, and Tribal transit agencies, an updated technology assessment is recommended prior to major technology purchases, or every five years as part of the planning process (whichever comes soonest).



DEVELOPING ASSESSMENTS AND GROWTH PLANS

Assessments and Growth Plans are typically developed internally by a team of people that may include the transit operations manager, IT staff, potentially someone from the finance department, and the people who use the technology systems regularly (i.e., scheduler, dispatcher, driver). Small urban and large transit agencies often have the capacity to develop assessments and growth plans internally.

For medium-sized rural agencies, the ability to perform a technology assessment internally will depend on staff expertise. If there is an employee with technology expertise, the agency may be able to complete the technology assessment on its own. If those skills are lacking, these medium-sized transit systems can be included with the smaller agencies that are supported by MnDOT.

For small rural and Tribal agencies, MnDOT will provide support in completing an initial technology assessment and provide follow up assistance as needed.

In all cases, it may be beneficial to obtain the support of outside expertise because it can be challenging to assess one's own organization.

Key Steps for Assessing Technology

STEP 1: DESCRIBE AGENCY CONTEXT AND DEFINE GOALS

The assessment should begin with a brief description of the agency's general context. This may include demographic and geographic facts related to the service area, current services, annual ridership, fleet size, staffing levels, annual budget and funding sources, growth patterns, and any other additional information that allows the reader to better understand the environment where technology investments would be made. Since technology is not an end in itself, but rather a means to achieve broader agency goals, the assessment should identify where technology may help and the goals of the technology improvements. To the extent that these goals are explicit, prioritized, measurable, and rooted in the mission of the agency, the task of selecting which systems are in the greatest need for evaluation becomes much easier. Example goals may include:

- Increasing service reliability
- Improving rider access to real-time service information
- Reducing manual effort involved in tracking preventive fleet maintenance
- Meeting increased service demand (due to population growth, service area growth or increase usage)

Importantly, technologies themselves should not be listed as goals. Technology solutions come in step 3 below.

The process for transit agencies begins with a systemwide technology assessment. When a current system-wide assessment is in place, a more targeted assessment can be carried out as an annual update or to address a specific issue, such as updating a scheduling software system or addressing how to integrate various automatic vehicle location (AVL) systems. Following is a description of the system-wide assessment. For updates, only those items that are being considered for change need to be updated.

STEP 2: REVIEW ORGANIZATIONAL SUPPORTS FOR TECHNOLOGY

The exploration of supports is valuable because it may reveal critical underlying infrastructure that, once in place, may significantly reduce the risk associated with a technology project.

The section on organizational supports for technology in Chapter 4 is the basis of this step. Start from the system view and consider each support area. Figure 4.1 illustrates the relationships between each type of support. Is the support in place? Does it effectively feed into other supports? Would either the support system or its connections benefit from strengthening? If one area is weak, it is likely that those "downstream" are affected by that weakness.

Remember too, the "other supports" that do not fit neatly on the chart:

- Standards and specifications
- Funding and budgeting to assure system continuity
- Connectivity

These other supports impact multiple areas, including Procurement, Systems Design and Planning, and Documentation. In other words, when agency staff or leadership are documenting existing workflows, planning or designing for new workflows and applications, or initiating a process to procure new applications – these other supports should be considered. How will the availability or lack of specifications affect the technology

systems? Is there adequate funding to assure that the system can be maintained over time? Will internet speeds affect the functionality of the technology being considered?

Cybersecurity is a special case and may require outside expertise to gain a comprehensive understanding of the strengths and weaknesses of existing systems and procedures. A cybersecurity risk assessment is valuable in identifying both specific risks and the culture around keeping technology systems safe. A data security professional will be valuable in identifying cybersecurity risks and possible solutions. Separately, this report contains a recommendation for MnDOT (Recommendation 2.4) to develop a cybersecurity assessment tool for agencies to use. This tool, once developed, can be used in system-wide assessments.

STEP 3: IDENTIFY AND ANALYZE TECHNOLOGY SYSTEMS

Start with the tools from Chapter 4: [Baseline Transit Technology Reference Chart](#), [Large Agency Technology Flowchart](#), and [Resource Guides](#). Account for the transit modes operated, size of the vehicle fleet, and other system characteristics to identify the category that is the best fit.

Some key questions are:

- Is there any technology system identified as appropriate for the agency that is not in place?
- Are the technology systems working as desired?
- Are there technology systems in place that would function more effectively if integrated?
- Have there been any changes in the transit technology landscape that call for a new analysis of costs and benefits?

What are the secondary implications of a considered change in the system? What other systems or supports would need to be updated or improved as a result of a given technology project?

Figure 5.3: Sample Transit Technology Flowchart

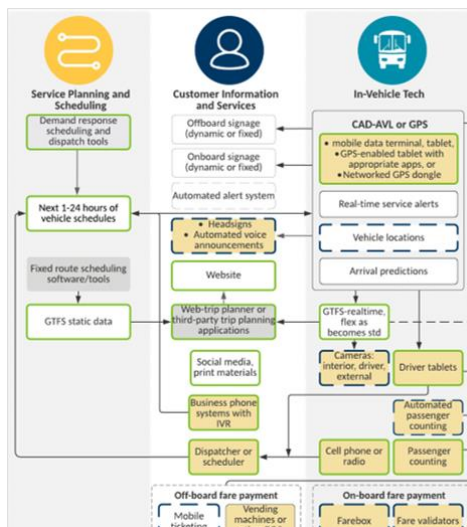


Figure 5.2 Baseline Transit Technology Reference Chart

KEY: ● = NO ● = MAYBE ● = YES NA = Not applicable	FLEET SIZE					
	1 to 9 vehicles		10 to 29 vehicles		30+ vehicles	
	DR	FR	DR	FR	DR	FR
Scheduling/Dispatch Software and Related Management Systems						
Client mgmt and scheduling DR trips	●	NA	●	NA	●	NA
Scheduling FR vehicle runs	NA	●	NA	●	NA	●
Algorithm to optimize schedule	●	NA	●	NA	●	NA
Driver and vehicle scheduling and mgmt	●	●	●	●	●	●
Reporting	●	●	●	●	●	●
Interfaces and export/import ability	●	●	●	●	●	●
Driver manifests on tablets or MDTs	●	NA	●	NA	●	NA
Reminder calls	●	NA	●	NA	●	NA
Customer-Facing Trip Planning						
Trip planning for riders	●	●	●	●	●	●
GTFS	NA	●	●	NA	NA	●
GTFS-Realtime	NA	●	NA	●	NA	●
GTFS-Flex	●	NA	●	NA	●	NA
Communications with Riders and Public						
Web page	●	●	●	●	●	●
Social media	●	●	●	●	●	●
Business telephone systems	●	●	●	●	●	●
Asset Management						
Vehicle maintenance	●	●	●	●	●	●
Facility maintenance/other	●	●	●	●	●	●
Pre-trip inspections	●	●	●	●	●	●
In-Vehicle Technology						
Automated voice announcements	NA	●	NA	●	NA	●
Cameras	●	●	●	●	●	●
Automatic vehicle location or GPS	●	●	●	●	●	●
Automated passenger counters	NA	●	NA	●	NA	●
Collision avoidance systems	●	●	●	●	●	●
Mobile data terminal/computer	●	●	●	●	●	●

Considering system characteristics (the modes operated, size of the vehicle fleet for each mode, ridership levels by mode, and other system characteristics), use the [Baseline Technology Reference Chart](#) and the relevant transit flowchart to identify those technology systems that are considered as a baseline and those that might be desirable. Which are in place and which are needed?

Three sample transit technology flowcharts are available in the [Supplemental Materials](#). Transit agencies may use these as a guide or modify the templates for to fit the needs of their agency. The base charts may be modified to reflect the configuration of a specific system, with the ability to delete flows that are not relevant or highlighting systems or connections that are needed. For example, a

system that only operates demand response services would delete flows that pertain to fixed route or deviated fixed-route services.

For technology systems that are needed, or for which upgrades are being considered, review the [Resource Guides](#) in the Supplemental Materials. Pay attention to the features that would best meet the functional needs of the agency. Consider the workflows and modifications that might be needed. Documentation of existing technology and workflows will aid in this review. Also, be sure to review the questions at the end of the Resource Guide for the specific technology being considered to help guide the decision-making process.

STEP 4: IDENTIFY STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS (SWOT) AND TECHNOLOGY RECOMMENDATIONS

The conclusion of the technology assessment is a set of the most salient facts, arrived at based on the prior sections of the assessment: agency current conditions, agency goals, the review of agency supports, and prospective technology systems. These key takeaways should ideally be presented in a SWOT format. Each area should consist of a list of easy-to-understand statements, roughly ranked by importance.

At this final assessment step, technology recommendations may be made based on the identified strengths, weaknesses, opportunities, and threats. For example, if a weakness is an aging on-premises phone system and an opportunity is the lowering costs of cloud-based phone systems, there may be a recommendation to replace the land-line phone system with a cloud-based one.

If an IT professional has not already been involved, this is the point where such knowledge will be crucial to determining what is possible, to identify where systems need to be integrated, what to ask for in procurements to achieve the desired outcomes, and what likely will need to wait for other developments to achieve desired outcomes. Other consideration include:

- What support systems would need to be strengthened?
- What features are necessary and what are desired if budget allows?
- What would have the most benefits for customers? What would have the most benefit for organizational efficiency?
- How would implementation affect agency workflows? For drivers? For schedulers or dispatchers? For maintenance and other staff?
- What connections to other systems are crucial? What would be nice to have?
- What cybersecurity upgrades or procedures are needed to protect the system and customer data?

A cost/benefit analysis is an important part of developing recommendations and priorities. Where will the agency find the most value for its technology investments? It is important to consider the full costs, including additional or upgraded equipment that may be required, annual fees, training, and the staff time required to implement the system. On the benefit side of the equation, there may be value created for the customer that cannot be measured financially. Once implemented, how much time will be saved? Will the transit service be more effective as a result of the improvement? This might be measured by fewer vehicle miles and more riders on each vehicle. Will the improvement result in improved customer service? Agencies are encouraged to make reasonable assumptions and document the assumptions.

From a system perspective, consider how best to implement improvements to the agency's technology systems. Possible actions may be a combination of investments in support systems, in new or improved technologies, or in the integration of existing technologies. Broadly speaking, the recommendations should be based on technical reasoning while presenting that reasoning in a manner that can readily be understood by non-experts. Recommendations may also include an array of technically viable options that all solve the same problem.

The conclusions, from the SWOT analysis and the resulting recommendations, become a key source for the growth plan described below. A sample technology assessment is included in the [Supplemental Materials](#).

Developing a Growth Plan

A growth plan is a three to five-year plan to implement the recommendations from the technology assessment, including those specific to cybersecurity. The growth plan takes all the facts and conclusions from the technology systems assessment and considers:

- Non-technical perspectives
- Evaluation and selection of options
- Recommendation prioritization

Developing a growth plan for a specific agency will include a broader group of stakeholders than the technical assessment and will follow the agency's process for making decisions and programming projects. MnDOT will work with individual transit agencies to develop growth plans. It is important that various departments within the agency have a chance to bring their expertise and competing needs to the table and that the resulting plan has the support of decision-makers. The decision-makers will weigh all agency priorities, with regional/state-wide plans and efforts and stakeholder feedback, to prioritize the items in the technology assessment. The growth plan should be shared agency-wide so staff is aware of the priorities and can plan and budget accordingly.



From this merging of technical and non-technical elements should come a plan that is technically feasible, inclusive of the values and priorities of the agency and its stakeholders and is operationally manageable. At this point, the growth plan will recommend projects or actions to undertake.

The growth plan also needs to detail high-level action steps and sequencing for each prioritized activity, with detail sufficient for concrete actions to take place. For example, identify how it will fit into the agency budget cycle and the MnDOT grant cycle. Allow time for the procurement process (starting with identifying choices, developing technical specifications, conducting an independent cost analysis, and procuring the system), and staffing considerations.

While there is much to consider, the growth plan will remain at a high level. Remember that much can change between the development of a growth plan and implementation of the projects. Depending on the timing, there may be changes in transit technology that bear consideration. Final project planning, once funding is obtained, will address any changes in the options available for addressing the problem. It will also cover the procurement process, impacts on the agency's workflow, roles and responsibilities of team members, and agreements that

will be needed or policies that need to be adopted or updated. For example, the implementation of an electronic fare payment system would impact agency workflows, require policies to address how the personally identifiable information will be secured, and require agreements with payment processors. The exact details will become clear once decisions are made on the exact technology option that will be procured.

Growth Plan Considerations

The recommended growth plan builds on the assessment but takes the priorities to the next level, providing information that may be needed by the decision-making team. This section presents three key areas to consider: agency objectives, resources, and implementation timeframe. Figure 5.4 illustrates a range of items to consider in developing growth plans.

Begin with the priorities from the initial technical assessment, including support systems, benefits, and costs. Prior to presenting these to a wider range of colleagues and decision-makers, think a bit more about the items that seem to reasonably fit into a three to five-year growth plan. This will aid in refining priorities and planning for those priorities that can get implemented over a three to five-year period.

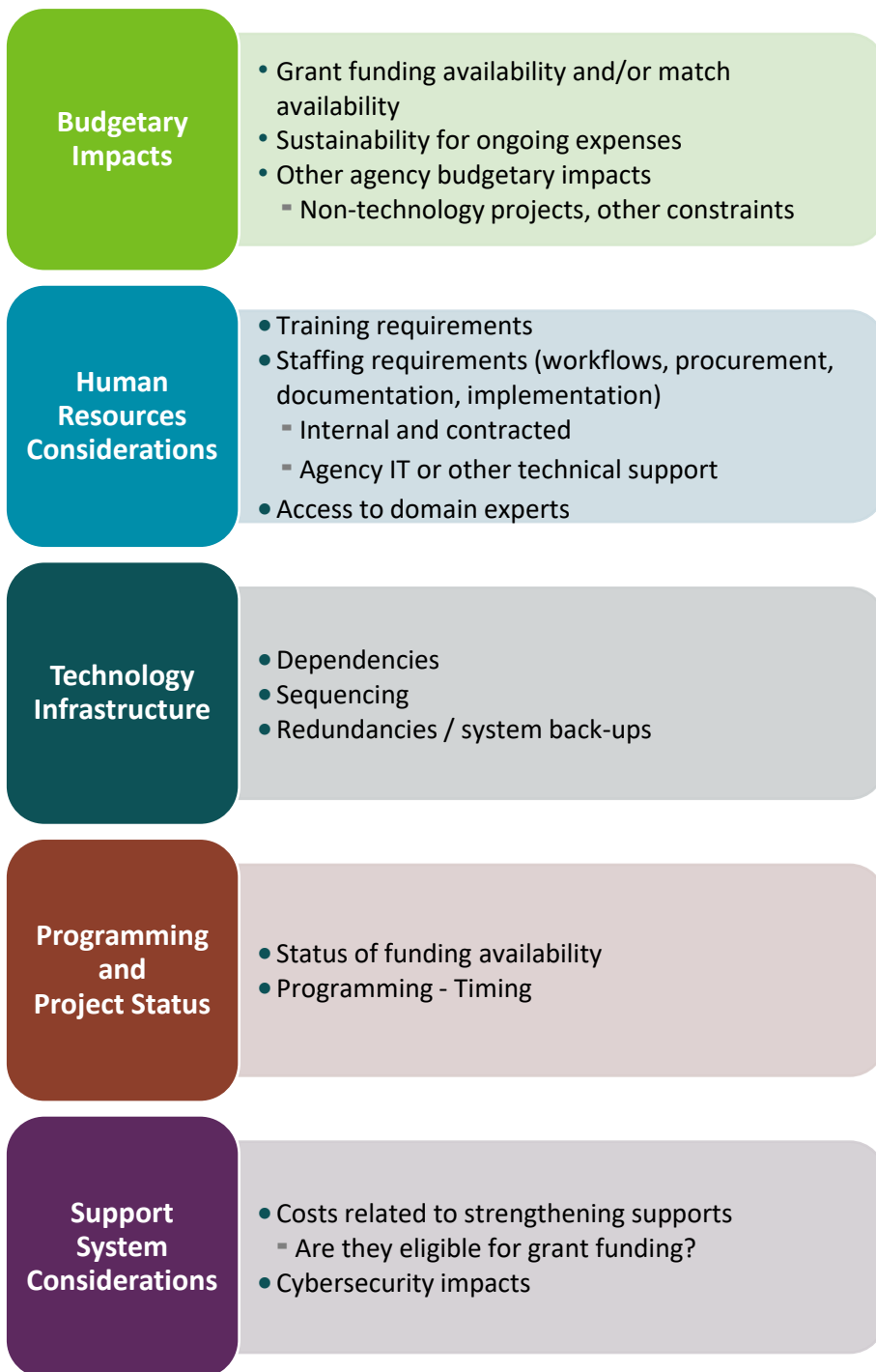
AGENCY OBJECTIVES

For each priority, describe briefly what the project includes, its relationship to other activities, and how it will help the agency achieve its goals and the Greater Minnesota Public Transit Technology Plan goals and key strategies.

RESOURCES

Consider agency impacts and the resources required to implement the project and develop reasonable estimations for the items shown.

Figure 5.4: Growth Plan Considerations



Estimations are meant to be reasonable, at a fairly high level, and consistent across all the technology priorities. It may be useful to talk with colleagues from other systems that have implemented the technology to learn about their experience with installing the technology. One of the recommendations in the following section is for MnDOT to provide resources in a resource library in order to facilitate this Growth Plan development process.

IMPLEMENTATION TIMEFRAME

Identify the time needed to go through the process, from start to finish. This includes:

- Initial research including potential costs and vendors
- Applying for funding
- Grant award and contracting
- Procurement process (research, preparing specifications, independent cost estimate, procuring technology)
- Implementing the project:
 - Adjustments to workflows
 - Impacts on other systems
 - Data transfer/cleanse, deployment, testing, and training
 - Documentation, re-training

If a priority action has to do with establishing or strengthening a support system (e.g., acquire additional training or establish documentation of tech systems/related workflows) the considerations will revolve more around internal resources and time frames for accomplishing the activity.

This step will help build a more complete understanding of each potential project and inform any revision to the priorities. Even though more detailed background information has been identified, the growth plan priorities remain at a fairly general or high level.

When discussing priorities with others within the agency and going through an internal decision-making process, this additional information will allow final priorities to be established, along with the desired year to implement. The timing will be informed by staff resources, other agency activities, the logical sequence of projects, and funding availability.

Growth Plan

The growth plan will reflect the final agency priorities for technology development and will present the planned projects by year and summary level information on the individual projects. It will be a result of the agency decision-making process.

Narrative description. Briefly describe the growth plan and key details regarding the sequence of events or what activities are dependent upon.

Summary of priorities. Below is a sample table. Identify the most salient information to use in a summary table. The information for this summary will come from the background work and be reflected in the individual project descriptions that follow. The following is an example template; agencies can add more columns if it is useful.

Prioritized Activities	Year to Implement	Initial Capital Cost	Ongoing Operating Costs	Internal/External Staff Support Required
1.				
2.				
3.				

Description of each project. For each priority, provide the following summary level information:

Project summary. Describe the project briefly but be specific. Include any major project components. Identify the agency objectives or key functions the project will support and anticipated benefits.

Cost and staff resources

- Initial budgeted cost. Ongoing impact on operating budget. These costs may come from discussion with vendors, a general review of the market, discussions with other agencies, or any independent cost estimate data MnDOT has collected. Cost ranges may be appropriate, especially when there significantly different options to be considered.
- Staffing requirements for the period required to research current options, procure, and fully implement. If outside expertise will be required, describe the services that will be procured.

Sequence and timing

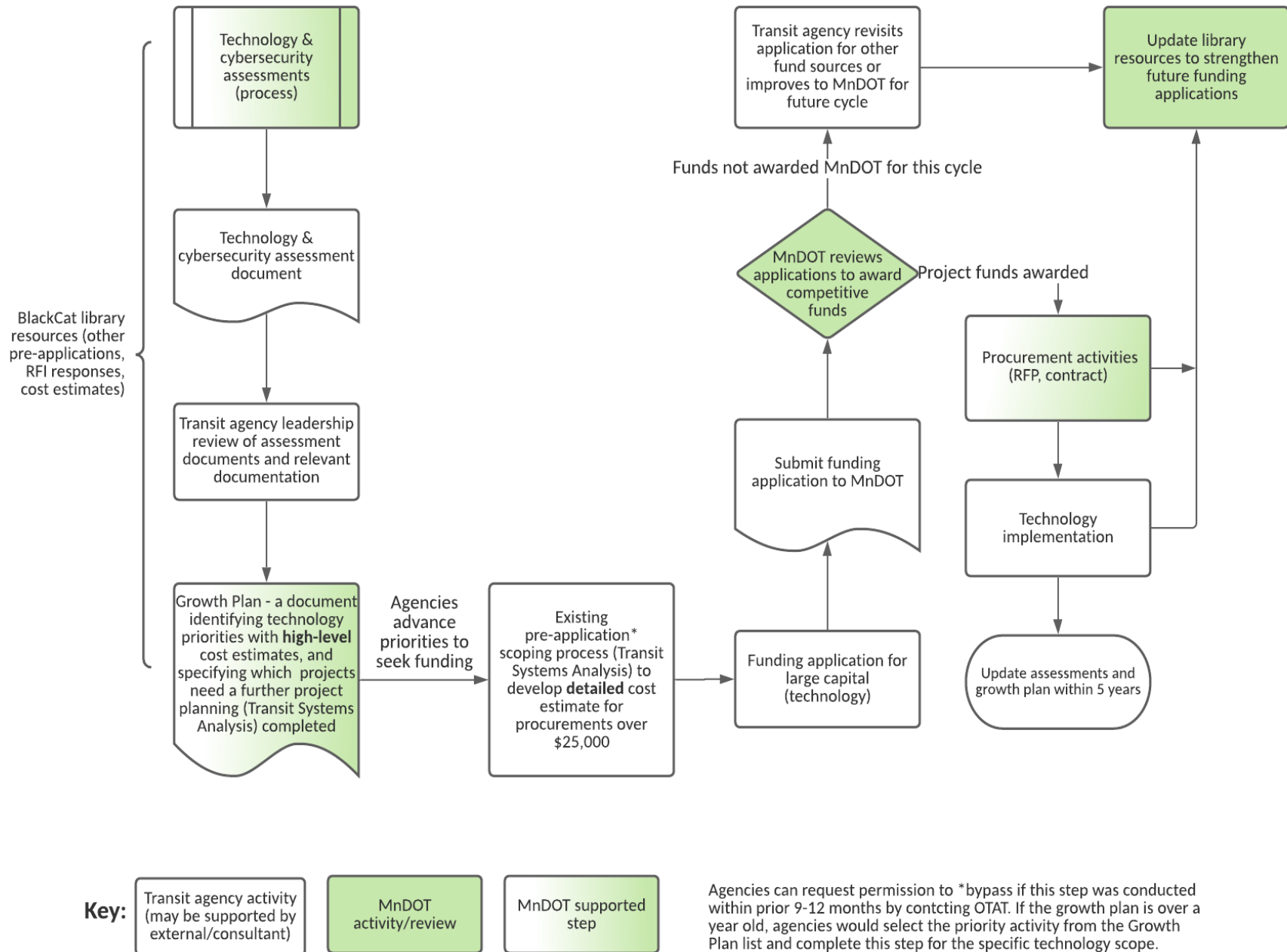
- Identify any key dependencies or timing issues.
- List the months required to procure and to implement the project.
- Based on desired implementation date, identify when the agency will:
 - Request grant funding
 - Budget internal funds
 - Procure the technology system
 - Implement

Remember that the resulting growth plan is a planning and budgeting document. It remains at a fairly high level and there is every expectation that activities may shift a year either direction or priorities may be adjusted. Implementation of each project will depend on the availability of staffing and financial resources. In the year prior to implementation, more detailed project planning will occur. A sample Growth Plan is provided in the [Supplemental Materials](#) with the prioritized activities listed on the first page.

MnDOT Funding Processes

Agencies would select projects based on the priorities in the Growth Plan to carry forward through further scoping and developing a funding application for MnDOT. Figure 5.5 describes the process from the initial technology assessment through the funding process.

Figure 5.5: Recommended Assessment and Growth Plan Process for MnDOT Funding Applications



The column on the left illustrates the development of the Growth Plan, with top priority project then advanced for funding consideration. More detailed project planning, using the MnDOT Transit Systems Analysis format, is required as part of the funding application.

The right half of the diagram describes the MnDOT funding process. If projects are selected by MnDOT for competitive funding, then agencies can proceed with procurement. For projects that are not selected via MnDOT's funds, the growth plan will provide information that agencies can use to pursue other funds through FTA or local opportunities. Having a growth plan from which to choose prioritized activities will give agencies a "head start" when surprise funding opportunities with short response windows are released.

A sample growth plan technology assessment and related forms are included in the [Supplemental Materials](#).



6. Recommendations for MnDOT and Transit Agencies

While there are some recommendations for transit agencies, Chapter 6 is mostly oriented to MnDOT and presents a series of recommendations on how MnDOT can support the transition to technology among public transit agencies in Greater Minnesota.

FOCUS AREAS

Based on the planning efforts, particularly the goals and strategies, five broad focus areas emerged as listed below. The first is addressed in Chapter 4 of this Plan; the second is addressed in Chapter 5. The remaining three focus areas are addressed through the recommendations in this chapter.

1. **Tools for Determining Transit Technology Options:** Provide guidance to transit agencies on transitioning to transit technology and related management solutions according to transit agency size, capacity and resources
2. **Guidance on Developing Growth Plans:** Provide guidance to transit agencies on how to further develop Technology Growth Plans for the organization
3. **Collaborative Decision Making:** Foster and support greater collaborative decision-making regarding transit technology in the state
4. **Organizational Supports:** Provide transit agencies with greater organizational supports and assistance for technology implementation
5. **Specifications, Acquisition, and Integration:** Provide statewide support for transit agencies in creating standard specifications, acquiring transit technology, and integration of technologies within their organization

Many of the strategies that emerged from engagement with MnDOT, the Steering Committee, and stakeholders focus on decision making, including items such as selecting appropriate technologies based on agency size/need and creating and adopting specifications. The Steering Committee and stakeholders expressed a desire for more collaborative decision making to reduce risk and ensure consistency among agencies, resulting in strong MnDOT and public transit agency collaboration. Collaborative decision making is the foundation for many of the recommendations for MnDOT and public transit agencies. While the public transit agencies will be heavily involved in the decision making, MnDOT Office of Transit and Active Transportation (OTAT) will have the “heavy lift” and will likely need additional staff to carry out the efforts required of this Plan’s recommendations, as discussed in detail in this chapter.

The second focus area, organizational supports, arose from both the industry and peer reviews and the goal and strategy mapping process. In particular, the stakeholders expressed a strong desire for training and access to resources (i.e., independent cost estimates, RFPs, etc.). Ensure comprehensive technology training was a foundational strategy in the goal/strategy map that underpinned many other strategies. The technology maturity assessment results suggested that many public transit agencies lack the organizational supports necessary to successfully implement technology solutions. The deficient areas included access to technology domain experts, system planning and design and thorough documentation.

Lastly, the specifications, acquisition, and integration focus area is tied to numerous technology acquisition and use strategies. MnDOT and its transit agency partners currently make decisions based on individual priorities and capabilities. Transit technology is generally promoted by staff champions; beyond the champions there is not a broad understanding of the benefits nor how the project relates to other agencies. These siloed decisions

result in many different technology solutions, various vendor selections, and inconsistent use. Each agency uses their own technology in their own way without coordinating with other agencies (including MnDOT). A shift to a more collaborative and standardized approach with common priorities, and an understanding and recognition of the value and benefits of improved transit technology, is needed to implement the recommendations of this Plan. Creating functional requirements, specifications, and supporting technology integration will support the implementation of consistently high-quality technology projects.

Most of these recommendations reflect areas where MnDOT can act independently to accomplish the plan goals and strategies, along with opportunities to build partnerships. In some cases, actions depend on available opportunities such as a Federal funding or partnerships. Many of the focus areas tie to each other and depend on coordinated efforts to occur. These connections are described toward the end of this chapter.

Some of the individual recommendations consider the maturity of transit technology maturity. The Plan also recognizes that national initiatives may be important prior to fully implementing some recommendations. Areas where national initiatives are needed include:

- Comprehensive transit technology training
- Expanded specifications to support the information exchange
- Better integrated technology systems, which support more modular solutions and allow public transit agencies to better meet their unique needs

MnDOT and public transit agencies are encouraged to participate in and advocate for national and state DOT efforts to address the above industry-wide initiatives. While MnDOT can take some actions to create/refine system specifications, require system integration and work toward better standardization, some initiatives must occur at a national level. Moving the transit technology industry forward through standards and training will require the concerted effort of many people and many states.

Thirteen recommendations have been identified, grouped into the three focus areas of Collaborative Decision-Making, Organizational Supports, and Specifications, Acquisition, and Integration. They are presented on the following pages.



1. COLLABORATIVE DECISION MAKING RECOMMENDATIONS

MnDOT, Greater Minnesota public transit agencies and other transportation partners bring valuable knowledge and perspective as Minnesota and the overall transit industry transition to broader use of transit technology. All perspectives are critical to ensure appropriate transit technology systems effectively support improved operational efficiencies and increased communication.

Substantive, ongoing collaboration between MnDOT and public transit agencies is essential to the successful development and implementation of transit technology. The recommendations reach beyond this focus area to underpin all the other recommendations. They address a collaborative decision-making process, a robust communication plan, and refine the processes for investing in transit technology including supporting innovation.

MnDOT and the public transit agencies will need to build capacity and adapt their planning and management processes to move from individual, ad hoc decisions and processes to those that reinforce each other's work toward common goals.

Figure 6.1 shows a recommended timeframe for the efforts of this focus area. The intensity of the shading signifies the level of effort involved, with darker shading reflecting a greater level of effort required and lighter shading reflecting less effort.

Figure 6.1: Timeline for Collaborative Decision-Making Activities

	CY 2021	CY 2022	CY 2023	CY 2024
1.1 Establish a Transit Technology Committee	Establish	Develop Workplan	Implement	Update annually; implement
1.2 Establish ongoing communications	Develop Workplan	Implement communications plan		Update annually; implement
1.3 Refine technology investment process		Develop, establish, communicate process		Update annually; implement
1.4 Develop new approach to technology innovation		Develop, establish, communicate process		Update annually; implement

To successfully implement the four recommendations in this Focus Area, it is anticipated that additional staff support will be necessary. This is especially true for staffing the Transit Technology Committee as MnDOT staff will be responsible for the majority of the research and preparation of reports to support the decision-making process.

Recommendation 1.1: Establish a Transit Technology Committee (TTC)

Ensuring inclusive, collaborative technology planning and decision-making processes was identified as foundational in the goal and strategy mapping process.

STRATEGIC ACTIONS

- MnDOT should establish a committee charged with collaboratively making decisions on technology issues critical to Greater Minnesota transit. MnDOT will lead the committee and provide technical and administrative support; members will include MnDOT and public transit agency staff. The Transit Technology Committee will work together to fully define the charge, structure, roles and responsibilities, membership, processes and procedures, and meeting frequency. It is expected that members will prepare for meetings, discuss and deliberate key issues, and make decisions. Subcommittees could address essential topics such as data and interoperability, training, transit technology recommendations, investment process and funding criteria, and similar; such subgroups could also include non-committee members with special knowledge or expertise.
- The committee will develop an initial workplan that includes developing appropriate performance measures and targets; annually update.
- The committee will hold regular meetings with agendas and meeting notes; share with all stakeholders to support timely progress on priority issues. A committee chair and a committee secretary should be selected by a vote of committee members to coordinate between MnDOT and the committee.

Timing: Early in year 1

Sequence: Foundational action item

Staffing: Moderate year 1, low afterwards

Relative costs: Low

Benefits resulting from this recommendation include:

- Collaboratively determined priorities, programs, and projects address key priorities and have the support necessary for successful implementation.
- Increased understanding among MnDOT and transit agency staff about the constraints other stakeholders face and the opportunities to build toward common objectives.

Recommendation 1.2: Establish Ongoing Communications

Effective and substantive communications about technology activities are essential among MnDOT, public transit agencies, other stakeholders (RTCCs, MPOs, counties, etc.), and vendors to inform and build understanding of key technology issues, challenges, opportunities, and actions. This recommendation directly advances two foundational strategies, to: incentivize coordination and communications across systems and to ensure knowledge-sharing between agencies.

Timing: Roundtables and e-news in year 1; remaining actions later

Sequence: Can occur any time but early action recommended

Staffing: Low

Relative costs: Low

STRATEGIC ACTIONS

Establish regular opportunities to communicate transit technology information and the approach being taken in Minnesota. Examples include the following:

- **Information exchanges (Transit Roundtables):** MnDOT hosts regular roundtables, with content determined primarily by the public transit agencies. Both agency and MnDOT staff would likely participate. Topics may include sharing best practices, transit technology, effective customer communications, funding opportunities, etc. The roundtables provide networking and information exchange.
- **Build stakeholder awareness:**
 - MnDOT and public transit agencies organize presentations on transit technology issues that reach a wide range of stakeholders. These could include virtual sessions or presentations at conferences for groups such as city and county officials, RTCCs, or human service agencies.
 - MnDOT prepares and distributes a periodic transit technology electronic communication to help build an “ecosystem” of people working toward common objectives. Recipients (and contributors) would include MnDOT and transit agency staff, as well as supporting stakeholders such as IT staff from cities or counties that operate public transit agencies, related MnDOT staff, third-party contractors, vendors, and others. Topics would evolve over time and might include information about the Transit Technology Committee and its work, upcoming roundtables and other learning opportunities, peer agency spotlights, and progress toward specifications, interoperability, and transit technology system integration. This would likely require some support from the MnDOT communications department.
- **Structured learning, teaching opportunities:**
 - MnDOT and/or the Transit Technology Committee organizes presentations by technology domain experts on topics that address needs and interests identified by public transit agencies; examples include on-vehicle technologies, fare payment options, and others.
 - MnDOT presents at or jointly hosts information exchanges with related MnDOT groups. Sample topics include the recommendations from this plan, FTA grant efforts, and general issues such as cybersecurity or quality data streams.

Benefits resulting from this recommendation include building an understanding of MnDOT’s transit technology program and supporting transparent and inclusive processes. The recommended actions allow for two-way communication, making it more likely that decisions will reflect agency priorities and result in improved and more rigorous decision-making processes.

Recommendation 1.3: Refine Technology Investment Process

Improved processes around technology investment requirements, funding, and timing were identified as key issues needing timely attention.

STRATEGIC ACTIONS

In collaboration with the Transit Technology Committee and key stakeholders, MNDOT will review and refine the processes for technology investments, including funding criteria, budgeting, grant funding, and procurement so they are responsive to public transit system needs and market realities. Key considerations and tasks include the following:

- Maintain a five-year vision for planning and budgeting purposes, while providing flexibility for agencies to respond within one or two years to improvements in transit technology, opportunities for grant funding, and changing operational characteristics.
- Assess current funding criteria and budgeting, funding, and procurement processes to identify issues that create barriers for public transit agencies without improving results. Identify, evaluate, and implement streamlined processes for both agencies and MnDOT that increase opportunities for agencies to make informed, timely investments that meet their short- and long-term needs. Incorporate revisions into the State Management Plan and grant application processes.
- Ensure that refined processes differentiate between expansions, ongoing funding for existing technologies, and the need to re-evaluate existing technology solutions on a regular basis to account for changes in system needs and technology options.
- Require agency requests for MnDOT technology funding be accompanied by a technology and cybersecurity assessment using the tools in this plan. (See recommendation 2.4). These assessments will inform improvements to technology systems, support a systems approach, and long-range budgeting for capital projects and ongoing operations.

Benefits resulting from this recommendation include transit technology investments that better meet agency and MnDOT priorities, address equitable fund distribution, are more cost-effective, and build toward sustainable public transit agencies and services.

Timing: Year 1

Sequence: After recommendation 2.3 assessments are underway

Staffing: Moderate years 1-2, then low

Relative costs: Low

Recommendation 1.4: Develop New Approach to Technology Innovation

This recommendation reflects high-priority strategies around innovation and is anticipated to result in improved technology solutions. This also aligns with Recommendation 1.3, a refined technology investment process.

The ability to fund innovation projects will be largely based on funding opportunities. MnDOT can increase the chances of obtaining outside funding by working with public transit agencies to determine areas of interest, define potential projects, and identify lead agencies, interested participants, and sources of local matching funds. Starting these relationships early gives MnDOT and public transit agencies an advantage over other applicants.

Timing: Years 2-3

Sequence: After recommendation 1.4 investment approach, and 2.3 assessments are underway

Staffing: Low

Relative costs: Low

STRATEGIC ACTIONS

Through the Transit Technology Committee, identify an approach to supporting and funding transit technology innovation. Key tasks for the Committee include the following:

- Jointly identify areas where innovation may offer critical benefits, are most needed, and will have high impact; examples are specifications, interoperability, training, testing, automated driver assistance systems, etc.
- Develop a process to determine funding priorities and the nature of MnDOT support (such as a letter of support, matching funds, or both).
- Identify funding and partnership opportunities.
- Identify public transit agencies interested in taking a leadership role on various innovation projects.
- Agree on how to share results from innovation projects for the broadest benefit (including relevance, scalability, etc.).

Benefits resulting from this recommendation include formally and actively supporting transit technology innovation efforts and directly tying the results of these efforts to better and more cost-effective procurement, efficient solutions, and more informed system decisions. This will also improve the chances of obtaining grant funding for key priorities.

2. ORGANIZATIONAL SUPPORTS RECOMMENDATIONS

The recommendations in this focus area build agency capacity to make informed decisions on appropriate technology solutions and reflect the strategies that enable public transit agencies to effectively select and use technology, and manage data. They are:

- Ensure comprehensive training
- Ensure knowledge-sharing among agencies
- Provide access to transit technology domain experts

Procuring transit technology requires technical expertise that is difficult for individual transit systems to muster, especially for smaller and Tribal systems that do not have a designated IT staff person. Some state DOTs or regional transportation coordination agencies procure software on behalf of public transit agencies within their states or regions. Even so, what is available for purchase is typically driven by what vendors have to sell rather than what public transit agencies would like to purchase or are technology systems that are built to provide a single solution. It is common for public transit agencies to get locked into a single vendor.

Training is a critical strategy, but no comprehensive transit technology training program currently exists in Minnesota or at a national level. There are options to help close this gap. MnDOT can work with public transit agencies and training providers to establish training based on currently available courses (e.g., advanced spreadsheet training or cybersecurity training). MnDOT could partner with others to develop and perhaps pilot training programs. Examples of partners include a university or college or even a national organization such as National RTAP. Those partnerships are essential because MnDOT does not control the training development process or the speed with which it develops.

The recommendations include projects and processes, and each assumes some level of contracting for support services. They also assume implementation activities will be tailored, especially around training and access to technology domain experts. Progress in this focus area will be supported by work in other focus areas to build agency capacity.

Figure 6.2 shows a recommended timeframe for the efforts of this focus area. The intensity of the shading signifies the level of effort involved, with darker shading reflecting a greater level of effort required and lighter shading reflecting less effort.

Figure 6.2: Timeline for Organizational Supports Activities

	CY 2021	CY 2022	CY 2023	CY 2024
2.1 Provide comprehensive technology training		Assess resources, needs	Seek partnerships, opportunities	Update annually; implement
2.2 Increase access to domain experts	Assess resources	Workplan	Implement	Update annually; implement
2.3 Create a resource library		Workplan	Establish on BlackCat	Gather, update resources
2.4 Technology and cybersecurity assessments	Define project; procure contractor	Carry-out pilots	Evaluate; implement	Update annually; implement
2.5 Leverage state role	Collaborate w/TTC on innovation, investment processes	Work-plan	Implement	Update annually; implement

Recommendation 2.1: Provide Comprehensive Technology Training

Comprehensive, differentiated training is essential for staff at all levels of public transit agencies until the use of technology simply becomes the way public transit agencies conduct business. In an environment changing as quickly as transit technology, the initial lift may take 5-10 years and the supporting training must be ongoing to address evolving needs, requirements, and staff turnover.

Much current training is specific to technology systems and provided by vendors. There are general technology training courses available – such as an insurance company that provides cybersecurity training or a community college course in advanced Excel – but these lack the specifics that are particularly important in the transit industry. An important resource is National RTAP, which often hosts training on GTFS at conferences.

Timing: Initiate in year 1; most activities will occur in later years

Sequence: Can begin any time

Staffing: Moderate; depends on amount of contracting

Relative costs: Low; depends on amount of contracting

STRATEGIC ACTIONS

Two parallel paths are recommended: One starts with what is available and builds a training program for Minnesota public transit agencies; the other partners with a national organization to address additional training needs.

- **Inventory, assess, and support existing offerings:** With a statewide purview and national contacts, MnDOT should pursue the following, potentially with assistance from a third-party contractor.
 - Inventory available transit technology training.
 - Concurrently, work with public transit agencies to assess short- and long-term training needs.
 - Identify gaps in training offerings, and also note existing training that could be tailored to the transit industry; an example might be customizing a general cybersecurity class to include securing personally identifiable information (PII) or securely collecting privacy-protected information through electronic fare payment applications.
 - Based on the findings, host or pay for transit agency staff to attend training that will meet agencies' transit technology needs.
- **Partner to expand offerings, close gaps:** Once gaps have been identified, MnDOT can develop partnerships with respected national organizations to fund the rapid development of modular training curricula to meet the needs of rural and small urban public transit agencies. Potential partners with access to training funds through the FTA include National RTAP, N-CATT, CTAA, and AASHTO. Further, MnDOT could collaborate to improve the content and gain early access for its public transit agencies by volunteering to test or pilot the training during the development phase.

Benefits resulting from this recommendation include expediting and deepening agencies' technology decision-making and implementation skills and learning how to use technology to improve operations and customer experience. Piloting offers opportunities for public transit agencies to shape relevant, quality training. Statewide trainings bring agencies together and open up critical opportunities to share knowledge and leverage integrated technologies.

Recommendation 2.2: Increase Access to Technology Domain Experts

MnDOT is in a unique position to increase public transit agency access to relevant transit technology experts. Public transit agencies identified this as a significant issue – not having access to expert resources to help with issues such as:

- Integration problems between technology systems, such as when one system has been updated and another no longer connects.
- Ensuring proper cybersecurity measures are in place to keep data and systems secure.
- Writing RFP requirements so that new technology will align with agency priorities and integrate with systems already in place.
- Getting maintenance for systems not covered by vendor agreements.

Timing: Years 1-2; begin procurement early so implementation is year 2

Sequence: Can begin anytime

Staffing: Low

Relative costs: Low to moderate, depending on contractor fees/ MnDOT's level of support

STRATEGIC ACTIONS

Working with public transit agencies to determine priorities and timing, MnDOT can pursue options including the following:

- Pilot direct MnDOT-level support to agencies for smaller, quick-turnaround issues on a range of technology and data-related challenges. This could be contracted to a technology domain expert or staffed by MnDOT. In addition to fielding direct calls from agencies, MnDOT staff could participate in roundtable discussions, trainings, and other forums where agencies may identify problems, and follow up with individualized support.
- Collaborate with larger public transit agencies, cities, or counties to inventory existing transit technology resources across the state. Many of these organizations have developed staff capacity to address technology issues that are not transit- or vendor-specific. Some may be willing to make their expertise available to public transit agencies based on geographical overlap, through intergovernmental agreements, or other mechanisms.
- Develop regional vendors as managed service providers, with options ranging from establishing a vendor list based on basic requirements, to various types of contracts or agreements that result in a wider range and more affordable services for agencies.

Benefits resulting from this recommendation include quickly and cost-effectively enabling transit agencies to make rigorous, data-driven decisions, and supporting development and access to localized expertise and resources as part of the ecosystem of transit technology expertise.

Recommendation 2.3: Create a Resource Library

Public transit agencies across the state would benefit from a central repository of transit technology resources to build local knowledge and support knowledge-sharing among agencies.

Timing: Year 1-2; ongoing

Sequence: Can be done any time

Staffing: Low

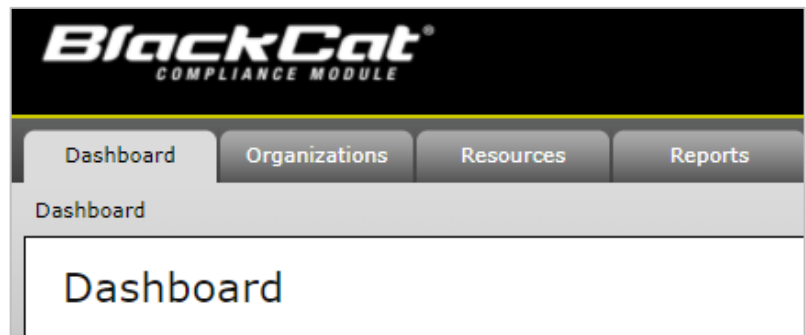
Relative costs: Low

STRATEGIC ACTIONS

MnDOT will lead a major push to launch the Resource Library and build it out over time with content relevant to users and organized in a way that is most helpful for them. Agencies would benefit from a range of information, such as the following:

- Information about technology systems, such as found in the [Resource Guides](#)
- RFPs and other procurement documents
- A list of technology systems by agency, as well as information on bids received, to be used in independent cost estimates
- Independent cost estimates and overall evaluations of proposals
- Systematically collected information about the quality of transit technology systems, what works well, and what does not
- Baseline Technology Reference chart and other materials from this Plan

Annual user evaluations and ongoing refinements will ensure the Resource Library delivers measurable value and benefits to agencies. One option to keep the information kept current and accessible is to use the BlackCat “Resources” tab to host this content, allowing user access and the ability to post content directly.



BlackCat screenshot

Benefits resulting from this recommendation include building local capacity, supporting knowledge sharing among agencies and MnDOT, and improving overall rigor and quality of technology decision making, implementation, and operations.

Recommendation 2.4: Technology and Cybersecurity Assessments

Rigorous technology and cybersecurity assessments provide crucial information for making technology investment decisions and are recommended for public transit agencies of all types and sizes.

STRATEGIC ACTIONS

- MnDOT clarifies expectations around the requirements for technology and cybersecurity assessments and supports initial and ongoing assessments to advance statewide strategic transit technology priorities.
 - Specify how these assessments can be conducted as part of five-year planning processes.
 - Note: Full system assessments should be carried out at all public transit agencies, with new assessments required at least every five years. Trigger events, such as a not-yet-assessed technology investment, may require an additional assessment. More limited annual assessments may be used to spot emerging issues and keep current. Transit technology assessments must address technology systems, system and module integration, technology supports, and cybersecurity risks.
- Identify how the growth plans created based on the assessments and system priorities will become a part of the funding requests and MnDOT project planning process as part of recommendation 1.3, refine technology investment process.
- While cybersecurity is one of the supports for technology systems, it is also a special case. Cybersecurity risk assessments require unique expertise and the assessment tools developed as part of this Transit Technology Plan are not intended to fully address those technical requirements. Such assessments should be part of systemwide technology assessments as both require knowledge of workflows and procedures. If conducting a more limited assessment for a new investment or annual update, cybersecurity will be covered but only as it relates to the proposed technology system within the scope of the limited assessment.
- Lead a project to develop the needed cybersecurity assessment tool and to support agencies without the resources to conduct their own initial assessments. This will likely require the services of an outside contractor.
 - Develop a cybersecurity assessment tool and test it at least three agencies of various sizes in conjunction with complete technology assessments for those agencies. Revise as needed.
 - Using the technology assessment tool in this plan and the newly developed cybersecurity risk assessment tool, pilot full assessments at up to six additional agencies that do not have the resources to conduct their own assessments.
 - Lay out the core processes and outputs for technology and cybersecurity assessments based on the findings of the pilot assessments.
 - To support statewide access, address issues common to many agencies, and build local capacity, a MnDOT staff person should be trained in this tool for conducting basic assessments so they can work

Timing: Launch in Year 1; ongoing

Sequence: Foundational action item

Staffing: Moderate

Estimated costs: \$120,000 total for cybersecurity assessment tool and initial piloting / assessments



directly with agencies to conduct them or help determine when additional or specific expertise is required.

Benefits resulting from this recommendation include preparing agencies to make informed and cost-effective technology procurement decisions and make rigorous system decisions. It will significantly reduce the risks associated with implementing and maintaining selected technology solutions. The cybersecurity assessment tool and implementation of full assessments will provide information for technology investment processes (recommendation 1.3). This recommendation also builds MnDOT capacity, targets MnDOT support to equitably meet needs, and builds local agency capacity for successful long-term technology implementation.

Recommendation 2.5: Leverage State Procurement Role

As a major funder of transit technology, MnDOT has leverage that individual public transit agencies do not. Agencies would benefit if MnDOT used this leverage to improve transit technology purchases. This speaks to the strategy of identifying and leveraging resources and economies of scale, resulting in informed and cost-effective technology investments.

Timing: Years 1-2; ongoing

Sequence: Any time

Staffing: Moderate

Relative costs: Low

STRATEGIC ACTIONS

With guidance from the Transit Technology Committee, there are a variety of ways MnDOT could exert leverage to benefit public transit agencies.

- Procure technology systems with a range of options from one or more vendors to meet the diverse needs of transit systems.
- Establish lists of pre-qualified vendors for various transit technology systems based on minimum functional requirements. This requires some level of verification to assure that claims match reality and to identify any limitations.
- Provide model RFP language to hold vendors accountable. For example, if requirements are not met, the RFP language and resulting contract language would specify that MnDOT is prepared to respond to agency requests to help resolve the issue, will consider disqualification for MnDOT funded contracts for some period of time, or may remove the vendor from any pre-qualified vendor lists.

Different actions may be appropriate for different circumstances or over time. For example, MnDOT may wish to leave the procurement of technology systems to individual transit systems but may either procure the services of domain experts or establish a list of pre-qualified domain experts across Greater Minnesota for their transit systems to call upon.

Benefits resulting from this recommendation include public transit agencies understanding they can depend on MnDOT for key supports; vendors knowing that MnDOT is providing oversight and consistency; improvements to technology system quality; and easier procurements for public transit agencies.



3. SPECIFICATIONS, ACQUISITION, AND INTEGRATION RECOMMENDATIONS

The recommendations in this section are geared towards enabling technology procurements that:

- Provide for activities at the state-level that need not be done by individual public transit agencies such as research into product development and support for solicitations,
- Use state leverage to encourage vendors to publish APIs and otherwise support the use of specifications and the integration of technology systems. (See Recommendation 2.5 for additional information), and
- Support procurements that result in technology systems that are the best fit for each agency, reflect current developments, and reduce agency risk by supporting modular systems.

These recommendations support the strategy of creating and supporting options to cost-effectively procure technology. In addition to improving the cost-effectiveness of delivering technology solutions, they will support public transit agencies in making rigorous system decisions.

Figure 6.3 shows a recommended timeframe for the efforts of this focus area. The intensity of the shading signifies the level of effort involved, with darker shading reflecting a greater level of effort required and lighter shading reflecting less effort.

Figure 6.3: Timeline for Specifications, Acquisition, and Integration Activities

	CY 2021	CY 2022	CY 2023	CY 2024
3.1 Establish functional requirements for key systems		Leverage current efforts, seek partnerships	Workplan	Implement; update annually
3.2 Support integrated technology systems		Add existing integrations to RFPs	Workplan; implementation	Monitor, update/refine; implement.
3.3 Support data specifications development	Continue, expand participation on committees		Workplan; implementation	Monitor, update/refine; implement.
3.4 Ensure high-quality, streamlined data collection and management		Assess data collection; identify solutions	Advocate for changes	Initiate changes to BlackCat

Recommendation 3.1: Establish Functional Requirements for Key Systems

Successful technology procurements require clearly specified functional and other requirements (i.e., training, customer service, etc.), and establishing these for technology systems is a foundational strategy. Rigorous specifications do not yet exist for all technology systems. Development is occurring agency-by-agency and state-by-state as RFPs are prepared to help agencies keep pace with rapidly changing technology.

Timing: Years 2-3

Sequence: Builds on other activities; would benefit from partners

Staffing - Moderate

Relative costs - Low

STRATEGIC ACTIONS

Ways to develop or strengthen detailed functional requirements include:

- MnDOT builds on and shares the work of public transit agencies in Minnesota and other states, such as by providing access to RFPs for each type of technology system (see recommendation 2.3).
- MnDOT monitors key technology systems and identifies changes relevant to transit systems. This can be done through networking (attending conferences and trade shows, participating on committees, etc.), and by scanning journals and blogs. MnDOT can also establish partnerships with other states to share work and exchange information. MnDOT and public transit agencies will also learn from domain experts or local agency experts who may emerge through roundtables (recommendation 1.2).
- Jointly establish acceptance test procedures for key technology systems and/or by randomly testing key features. For example, to check the quality of mapping, a transit agency can do a regular test to determine if the schedule and dispatch generates correct itineraries. Agency staff can score, document, and share the results of these tests.
- Establish procedures to update existing functional requirements that are not adequate to meet agency needs.

The timing of some activities will depend on the maturity of the industry and the ability to form partnerships with larger state DOTs and national organizations to collectively build a full set of functional requirements.

Benefits resulting from implementing this recommendation include improvements to technology system consistency, procurements driven by functionalities needed by public transit agencies, and easier procurements for public transit agencies.

Recommendation 3.2: Support Integrated Technology Systems

Integrating technology systems is essential to high-functioning technology and was identified as a key strategic priority. Efforts must focus on areas most important to public transit agencies, and vendors must be actively involved as they control integrations across current and future systems.

Timing: Begins Year 1; increasing activity over time

Sequence: Any time/order

Staffing: Low

Relative costs: Low

STRATEGIC ACTIONS

Working with the Transit Technology Committee, MnDOT can serve several roles. One is in requiring such integrations to:

- Identify specific scenarios where APIs are a priority (e.g., AVL equipment, GTFS-realtime, Transactional Data Specifications, etc.).
- Require vendors to publish APIs for the priority areas by specific dates. The requirements should include clear expectations with regard to the thoroughness of API documentation. For example, the documentation should list all the scenarios where the API is designed to be used, describe all the functions it provides, and describe in detail the API's call and response syntax.

Another role for MnDOT is to develop and distribute policy recommendations and RFP language to support data quality and integrations. MnDOT can also encourage and support agencies preparing RFPs to require respondents to provide information about how their system integrates with others and include that criterion in their scoring.

Benefits resulting from this recommendation include enabling public transit agencies to select the best technologies for their systems, supporting agencies to easily communicate with each other, and helping agencies select systems that can readily adapt to changing needs.



Recommendation 3.3: Support Data Specification Development

As current and future riders increasingly turn to digital means to understand and access their mobility options, it becomes more important for transit agencies to present themselves as a viable and preferred choice through a range of digital channels. This is only possible at scale through a range of robust data specifications. Agreeing upon such specifications is reflected on the strategy map.

For internal operations and on-vehicle systems, the proliferation of data-producing systems results in a similar need to standardize how data flows between vendors and systems. Such internal standards result in better system design, increased interoperability between vendors, and reduced risk of vendor lock-in.

Timing: Begins Year 1; major activities in years 3-4

Sequence: Policy depends on maturation of specifications

Staffing: Low

Relative costs: Low

STRATEGIC ACTIONS

- Participate in standards development efforts such as current working groups for Transactional Data Specifications and General On-demand Feed Specifications (GOFs). MnDOT staff currently participate in both of these and should also consider including a public transit agency representative. Financial support for the development of specifications is also important.
- Monitor development and changes in a range of specifications (GTFS-family, on-vehicle equipment, transactional, other), and proactively share relevant information with agencies.
- Articulate a broad vision for why, when, and how to embrace state-level specifications.
- When specifications have adequately matured, require software vendors to use current specifications and have a process in place for annual updates to reflect changes in specifications. Develop appropriate language for procurements.

Benefits resulting from this recommendation include greater agency flexibility to invest in integrated solutions and improved ability to coordinate trips and resources.

Recommendation 3.4: Ensure High-quality, Streamlined Data Collection and Management

High-quality data collection and management are foundational to accurate and effective transit technology systems.

STRATEGIC ACTIONS

MnDOT will work with the Transit Technology Committee (or subcommittee) and collaborate with public transit agencies on the activities listed below.

Timing: Year 2-3

Sequence: Any time/order

Staffing: Low-moderate

Relative costs: Low to moderate depending on any contracting costs

For data collection and reporting, jointly assess the current data collection requirements, processes, frequency, and use of that data; compare the value of the results to the cost of collection; and seek opportunities to streamline processes and increase value for local agencies, MnDOT, and regulatory entities.

- Advocate for changes in state legislative requirements to focus only on data that are being used and align collection frequency accordingly.
- Improve data collection processes by refining the format for uploading information into BlackCat. For example, work with BlackCat on system integration improvements so agencies can import monthly financial information rather than entering it manually.
- Update data collection instructions and associated training on specific workflows and processes for critical data areas.

For data streams: Prioritize the GTFS family of data streams, particularly for real-time data; other priorities can be identified by the Transit Technology Committee and might include:

- Assure accurate customer information.
- Support the efforts of [MobilityData](#) to develop data quality testing and validation tools for GTFS-related data.
- Identify testing protocols and share results.
- Support agencies to resolve data quality problems (see recommendation 2.2).
- Identify and share information on common issues such as slow Internet speeds, vendor accuracy problems, and similar.

Project recommendation: Fund a statewide GTFS data development project to support a statewide trip planner. MnDOT can develop an RFP to procure the services of a contractor to create GTFS data streams for every transit agency in Greater Minnesota. Steps to implement this project might include:

- Build upon the existing MnDOT AIM grant to extend the GTFS and GTFS-Flex data feeds for all Greater Minnesota public transit agencies. The AIM grant will implement GTFS and GTFS-flex for the participating agencies. If the proof of concept is successful, the results can form a foundation to extend GTFS and GTFS-flex to the rest of Greater Minnesota transit agencies.
- Work with those transit systems with existing GTFS and GTFS-realtime data feeds to align efforts to maintain a comprehensive set of data feeds providing consistent high-quality data and allowing urban areas to maintain integration of their on-board and customer information applications.

Benefits resulting from this recommendation include improving the quality and consistency of transit data to meet the needs of public transit agencies; enabling agencies to provide riders with accurate, timely, and valuable information; and supporting agencies to learn from each other. The statewide GTFS and trip planner project will demonstrate these benefits from quality service information to agencies, riders, and MnDOT.



SUMMARY OF RECOMMENDATIONS

Figure 6.4, on the following page is a summary chart showing each of the recommendations and the implementation timing. The intensity of the colors signifies the level of effort involved, with darker colors reflecting a greater level of effort required and lighter colors reflecting less effort.

This will result in a significant staff effort, especially in the first two years. It is likely that activities will need to be shared among several staff members in the MnDOT Office of Transit and Active Transportation.

Recommendation 1.1 is an early action item as the collaborative decision-making process underpins most of the other recommendations. Recommendation 2.4 is also an early action item as the results of the first round of assessments will provide important information into the development Recommendation 1.3, the technology investment process.

The recommendations reflect a significant shift for MnDOT that provides stronger support for public transit agencies and leadership in technology. Through the work of MnDOT and the Transit Technology Committee, transit agency technology decisions will be supported by access to domain experts and peer agencies, coordinated training, and leadership in standards enabling agencies.

Annual updates are recommended and are especially important as several activities will depend on partnerships and the maturation of the transit technology industry.



Figure 6.4: Timeline for Summary of Recommendations

1: COLLABORATIVE DECISION MAKING

	CY 2021	CY 2022	CY 2023	CY 2024
1.1 Establish a Transit Technology Committee	Establish	Develop Workplan	Implement	Update annually; implement
1.2 Establish ongoing communications	Develop Workplan	Implement communications plan		Update annually; implement
1.3 Refine technology investment process		Develop, establish, communicate process		Update annually; implement
1.4 Develop new approach to technology innovation		Develop, establish, communicate process		Update annually; implement

2: ORGANIZATIONAL SUPPORTS

	CY 2021	CY 2022	CY 2023	CY 2024
2.1 Provide comprehensive technology training	Assess resources, needs		Seek partnerships, opportunities	Update annually; implement
2.2 Increase access to domain experts	Assess resources	Workplan	Implement	Update annually; implement
2.3 Create a resource library		Workplan	Establish on BlackCat	Gather, update resources
2.4 Technology and cybersecurity assessments	Define project; procure contractor	Carry-out pilots	Evaluate; implement	Update annually; implement
2.5 Leverage state role	Collaborate w/TTC on innovation, investment processes	Work-plan	Implement	Update annually; implement

3: SPECIFICATIONS, ACQUISITION, AND INTEGRATION

	CY 2021	CY 2022	CY 2023	CY 2024
3.1 Establish functional requirements for key systems		Leverage current efforts, seek partnerships	Workplan	Implement; update annually
3.2 Support integrated technology systems		Add existing integrations to RFPs	Workplan; implementation	Monitor, update/refine; implement.
3.3 Support data specifications development	Continue, expand participation on committees		Workplan; implementation	Monitor, update/refine; implement.
3.4 Ensure high-quality, streamlined data collection and management		Assess data collection; identify solutions	Advocate for changes	Initiate changes to BlackCat

COORDINATION

Coordinating transportation resources is a common strategy across multiple MnDOT plans such as the Greater Minnesota Transit Investment Plan and through the Local Human Service-Public Transit Coordination plans, as well as through the activities of the Minnesota Council on Transportation Access (MCOTA) and the Regional Transportation Coordinating Councils (RTCCs). Coordination can identify cost effective solutions, spur innovation and enhance transit options for users. Transit technology can best support coordination as part of a comprehensive strategy that addresses key issues including eligibility by program and trip purpose, payment for services, and quality of service (i.e., driver training, vehicle requirements, etc.).

The focus areas described in this section relate to one another through coordination. Starting with collaborative decision making, the TTC will continue the efforts of this Plan, working together to tackle topics such as data and interoperability, training, transit technology recommendations, ways to support innovation and investment process and funding criteria.

Key MnDOT activities to support coordination include:

- Work toward interoperable technology systems. Examples include integration and procurement support activities requiring published APIs and use of data specifications (recommendations 3.1, 3.2, and 3.3).
- Support small, rural providers transition to digital operations appropriate to their needs.
 - Technology and cybersecurity assessments (recommendation 2.4) serve as a foundation for technology investment process (recommendation 1.3), helping to ensure successful technology implementation.
- Actively support comprehensive training (recommendation 2.1).
- Ensure access to domain experts (recommendation 2.2).
- Support high-quality data streams (recommendation 3.4). For example, after GTFS-flex has matured in three-to-five years, support implementation for rural systems and flex-routes in small urban areas.



PROJECTS

Most of the recommendations in this section are procedural; a relatively limited number of outside projects have been identified. Specific projects are listed in Figure 6.5. These are projects where MnDOT OTAT will take the lead.

It is, however, reasonable to expect that MnDOT OTAT would benefit from outside resources to accomplish the various process activities. For example, the MnDOT Office of Communications and Engagement might be a good resource for developing electronic communications with stakeholders. In many areas, the first step is to assess the issues and available resources and then develop a workplan. It is at the workplan stage that it will be possible to identify the specific resources that will support success. Because of the uncertainty that exists, the

plan recommends an annual assessment of progress and development of workplans for the upcoming year. Maintaining flexibility will be essential for success.

Figure 6.5: Recommended MnDOT Technology Projects

Project	Description	Year	Projected Cost
Cybersecurity assessment development and pilot	Develop cybersecurity assessment tool. Pilot cybersecurity tool, in conjunction with the technology assessment, at three varied agencies. Refine cybersecurity and assessment tools accordingly and distribute to all transit agencies.	2021-2022	\$50,000
Technology, cybersecurity assessments and growth plan support	Support a limited number of agencies in completing cybersecurity and technology assessments, and growth plans.	2022-2023	\$70,000
Technology training	Assess resources. Contract to have some tailored to transit agencies. Determine how to deliver and fund the delivery of basic tech training.	2022-2025	\$50,000
Domain experts	Assess resources and needs. Identify how to best develop managed service providers and domain experts for rural agencies. Implement.	2022-2023	\$50,000
Communications	Develop workplan, identify resources available within MnDOT and outside resources. Implement communications plan	2021	\$50,000
State-wide GTFS	Fund a statewide GTFS data development project.	2022	\$20,000

There are a variety of other projects that have been identified through the five-year planning process for each transit agency. For Section 5311 agencies, these are summarized in Figure 6.6. Similar projects are in place for agencies funded with Section 5307 funds. Many projects are to replace, add onto or otherwise upgrade existing IT systems. Projects to replace or upgrade existing systems are building on an existing foundation and reflect projects that have already been justified. For adding on components and otherwise expanding technology system, this plan recommends taking a system approach to determining how to best improve functionality. Most projects appear to fall within the baseline recommendations by system size.

It will take some time to transition to the new assessment process. It is anticipated that the new assessment process will be refined and phased in through the end of 2022. Some systems might start using the recommended assessment process sooner, either as part of a regularly scheduled transit plan update or as a pilot. However, it is recommended that MnDOT not require the new process until 2023. This allows time for pilots to take place and the Transit Technical Committee to identify any needed revisions prior to widespread

use. Once the assessment process is in place, a wider range of projects may be identified as valuable to improve the functioning of transit technology systems.

Completing a systemwide assessment process will enable transit agencies to build growth plans that identify projects to strengthen the overall technology system at any given agency. Starting the technology assessment and growth plan process in 2023, means that by 2024 to 2025 MnDOT will have comprehensive growth plans based on consistent technology assessments.

Figure 6.6: Transit Agency Projects

Project	Comments	Systems
Install or replace scheduling and dispatch systems		8 agencies
Add modules to existing scheduling and dispatch systems	AVL, mobile rider app, fleet, communications upgrades, maintenance, advance pick-up reminder, trip planning, and others	9 agencies with some identifying multiple modules
Rider app	Some may be free-standing and some an add-on to scheduling system	4 agencies
Electronic fare boxes		5 agencies
Electronic fare payment systems	Several agencies are participating in a pilot as a first step.	4 agencies
New computers		2 agencies
New cameras or upgraded camera/video systems	Variety of upgrades identified.	4 agencies
Upgraded communications	800 MHz systems or other systems	4 agencies
Online reservations and rider application		1 agency
Call recording system		1 agency

Source: MnDOT OTAT

CONCLUSION

The recommendations in this chapter are in response to four main items:

- MnDOT's desire to transition the public transit agencies it funds to digital operations
- Stakeholder and Steering Committee feedback about their technology needs
- The state of the transit technology industry
- Best practices in general information technology and specifically in transit technology

The recommendations represent a significant change for the Office of Transit and Active Transportation (OTAT) division of MnDOT, not unlike the type of shifts public transit agencies make when they transition to more digital operations. Overall, these recommendations result in MnDOT taking a stronger leadership role, especially in activities that can most effectively be carried out at a statewide level. Decisions on the technology that will be most effective in individual transit agencies remain the responsibility of each transit agency. Through these actions, MnDOT will be a national leader among DOTs in how it supports transit agencies throughout the state. The basic recommendations reflect fundamental actions that are needed, although the timing of activities may be uncertain. The transit technology industry is both evolving rapidly and under-developed in key areas. There are developments that are needed at the national level, or which will require more resources than appropriate for a state the size of Minnesota. In recent years, the Federal government has been more focused on innovation than on building a foundation.

As a result, a number of recommendations suggest monitoring activities of larger states and organizations that are leading new developments, building partnerships, or simply waiting until the industry matures. The timing of actions in these areas will depend on factors outside of MnDOT.

This plan identifies an approach and a variety of actions that will position MnDOT and its transit agency partners to embrace and benefit from advancements in transit technology. As reflected in the Gantt chart (Figure 6.5) illustrating activities from calendar year 2021 through Calendar year 2024, it will take three to five years to see significant results as the process evolves for agencies to make comprehensive technology choices. During this time, MnDOT and transit agencies will be building capacity and transitioning to a systems approach to technology that will result in stronger, safer, and more flexible technology systems at transit agencies.





Greater Minnesota

Public Transit

Technology Plan –

SUPPLEMENTAL

MATERIALS

Table of Contents

- [Glossary](#)
- [Resource Guides](#)
- [Goal-Strategy-Action Details](#)
- [Transit Technology Flowcharts](#)
- [Transit Agency Assessments and Growth Plans \(including samples and forms\)](#)

Glossary

APPLICATION PROGRAMMING INTERFACES (API) A set of protocols and tools for building scalable technology systems that define how various technology components can interact. Typically, well-documented APIs include information that describes an API “call”, that is the language that must be passed to the API in order to get an expected “response.” In a transit context, responses would include information such as an arrival time prediction or vehicle location. Using APIs, independent systems can transmit information based on a common standard or a standard specific to that API. Examples of standardized interfaces are GTFS and SAE Standard J1939. Also, see Standards and Specifications.

ANNUNCIATION SYSTEM or automated vehicle announcement system is a feature of onboard technology that can use vehicle location to announce upcoming stops or other important information to riders. While automated systems are not required under the Americans with Disabilities Act⁶, they ensure consistency in announcements and timing and remove the responsibility for calling out stops from the equipment operator.

AUTOMATED PASSENGER COUNTERS (APC) are an electronic way of counting passengers often through infrared lights mounted above the doors or cameras that count the number of passengers.

AUTOMATIC VEHICLE LOCATION (AVL) is a means for automatically determining and transmitting the geographic location of a vehicle. This vehicle location data, from one or more vehicles, may then be collected by a vehicle tracking system or scheduling/dispatching system. See global positioning system as this data is the foundation for the AVL system.

COMPUTER-AIDED DISPATCH systems with AVL (CAD/AVL) are common in public transit. Most commonly, the location is determined using GPS data with the longitude and latitude coordinates transmitted from the vehicle to a radio receiver.

CONNECTIVITY is a term that can be used in many ways. In the context of this report, it refers to the ability of an agency to connect to wireless broadband for internet service, mobile phones, and two-way radios. Agencies are generally concerned with the ability of the main office to obtain signal coverage and for vehicles in the field to connect to services. Dead zones, or areas where no service is available, are often caused by geographic features or tall buildings as many systems rely upon line-of-site radio waves.

- **Broadband** is a high-speed transmission link for internet connections. It has some basic forms: DSL (or Digital Subscriber Line), fiber-optic cable, and satellite.
 - DSL travels on existing copper telephone wires on a frequency range not used by voice communications such that the transmission of data causes no interruption to the telephone service. The speed of a DSL connection varies with one’s distance from the switching station.
 - Fiber-optic cables provide the fastest Internet connection however, service areas remain limited to areas where fiber-optic cable has been installed.
 - Satellite broadband service can replace dial-up connections for remote rural areas, but the installation costs are quite high.

⁶ 36 CFR 1192 <https://www.federalregister.gov/documents/2016/12/14/2016-28867/americans-with-disabilities-act-ada-accessibility-guidelines-for-transportation-vehicles#h-13>

- Wireless broadband⁷ services connect to an internet backbone (usually a fiber-optic trunk) using Wireless Fidelity (Wi-Fi) connections or radio waves instead of cables for the last mile.
- Wi-Fi (Wireless Fidelity) is a fixed, short-range technology that is often used in combination with DSL, fixed wireless, fiber, or cable modem service to connect devices within a home or business to the Internet using a radio link between the location and the service provider's facility. A Wi-Fi network uses radio waves, similar to two-way radio communications.

DATA is the basis of digital communications. A transit system has a trove of data, much of which is stored in spreadsheets. Most data remain internal to an agency and is used in operating and managing the system. Some is shared through regular reports with funding agencies, such as a ridership report to a City Council, National Transit Database reporting, or reports on grant expenditures or transit assets. Some are useful to riders, such as schedule, route, and fare information. Some common data terms are described below:

- Data feeds or data streams describe how data is shared (received or disseminated).
- Open data describes data that is freely available to use and republish (without copyright restrictions). Open data is used for open-source development.
- Static data is data that does not change after being recorded. Standard GTFS data for fixed-route services is static.
- Discovery data, also sometimes called trip planning data, is the information that helps customers plan their trips. This often includes information on the available services, hours of operation, how to schedule a trip, and perhaps information on fares and how to purchase a ticket. It may be found on a website, a mobile app, or through mapping software or a trip planner.
- Transactional data is the information that helps transit systems conduct their business. Having standardized ways to share information about passenger origin and destinations, time of trip, and mobility aids allows agencies to coordinate human service transportation. TCRP Report 210 defines initial transactional data specifications.

ELECTRONIC FARE PAYMENT. Fare payment technology includes card-based or account-based fare payment systems. These can be provided through partnerships with vendors or even developing fare payment in-house through services such as Square. One benefit of this transition is the reduced need for the transit agency to manage cash and fare media. Fare payment continues to be a rapidly evolving area; this description summarizes some key definitions.

- Contactless Payment Systems are credit and debit cards, key fobs, smart cards, or other devices, including smartphones and other mobile devices that use radio-frequency identification (RFID) or near field communication (NFC) for making secure payments. The embedded integrated circuit chip and antenna enable consumers to wave their device over a reader at the point of sale. Contactless payments are made in close physical proximity, unlike **mobile payments** which use broad-area cellular or Wi-Fi networks and do not involve close physical proximity.
- Digital Ticket is a virtual instance of a ticket that represents the digitization of rights to claim goods or services. In order to implement a digital ticket system, a combination of two paradigms can be used. The first is the *account-based system*, which relies on a central storage and network connections. The second is the *card-based system*, which uses decentralized storage to store and transfer the ticket.

⁷ Broadband and Wifi references: [Broadband Reference Guide](#), produced by the Center for Community Technology Solutions, UW Madison, January 2014

- **Mobile Fare Payment App** refers to a software application on a smartphone or other portable electronic device such as a tablet that allows transit riders to pay for and access public transit services. These software applications are typically downloaded onto the user's device.

GENERAL TRANSIT FEED SPECIFICATIONS (GTFS) AND GENERAL ON-DEMAND FEED SPECIFICATIONS (GOFS) See Standards and Specifications.

GLOBAL POSITIONING SYSTEM (GPS) is a satellite-based radio navigation system. It is one of the global navigation satellite systems that provide geolocation and time information to a GPS receiver anywhere there is an unobstructed line of sight to four or more GPS satellites. Obstacles such as mountains and buildings block the relatively weak GPS signals.

HARDWARE. Computer hardware is composed of the physical parts of a computer, such as the central processing unit (CPU), the monitor, mouse, computer data storage, sound card, and motherboard. Hardware is typically directed by the software to execute any command or instruction. A combination of hardware and software typically forms a usable computing system. In the context of transportation systems, hardware can also refer to other equipment such as GPS devices, passenger counters, sensors, electronic headsigns, automated stop announcements, and cameras.

INTEGRATED MOBILITY refers to the ability for people to move easily from place to place among various modes and according to their own needs. Public transit is a key component. Connecting many modes of travel, including active transportation and automobile travel, and providing a means to compare and use the means most appropriate for a specific trip is an objective of integrated mobility. Location data is also a key component, in particular, using a common map database or coordinate reference system are important.

INTEGRATION is making two or more systems work together through web APIs, physical connection, standard data definitions, or other means. See Application Programming Interfaces

MOBILITY MANAGEMENT is an approach for managing and delivering coordinated transportation services to customers. These customers include but are not limited to, the transportation disadvantaged such as seniors, individuals with disabilities, and individuals with lower incomes. Mobility management focuses on meeting individual customer needs through a wide range of transportation options and service providers. It also focuses on coordinating these services and providers in an effort to achieve a more efficient transportation delivery system.

MOBILITY AS A SERVICE (MaaS) (rhymes with sauce) maximizes personal mobility through the use of technology so it is possible to reduce reliance on a privately-owned vehicle. Successful MaaS implementation integrates available transportation options into a single platform with on-demand trip planning, real-time information, and payment for seamless end-to-end journeys.

ONE-CALL/ONE-CLICK is an *organization* that enables riders or their representatives to find out their transportation options by making a single call or going to a single website where the information is available. This is often a feature of mobility management programs. Sometimes, this concept goes beyond an organization and a tool may be offered to the public to reserve a ride with one-call or one-click. A good example of a tool is FindMyRidePA.com.

OPEN ARCHITECTURE refers to computer architecture or software architecture that is nonproprietary and uses open interfaces and standards to enable third-party components to interoperate. It is intended to make adding, swapping, and upgrading components easy. Some or all components of the architecture could be published to enable integration.

RULE OF SINGLE MENTION. Information should only be entered manually a maximum of one time. That is, if someone has entered information manually into a form or spreadsheet, a tool is needed to maintainance.

SOFTWARE is the set of instructions that can be stored and run by hardware, telling the computer how to work. Computer hardware and software require each another, and neither can be realistically used on its own. In computing, the combination of front-end tools and interfaces that customers interact with as well as the back-end tools that enable reporting and functions that comprise what software developers refer to as the software stack (see Transit Technology Flowcharts).

- Operating system software is necessary for basic hardware functionality, with complex systems used for devices from personal computers to smartphones. Much on-vehicle equipment such as electronic fare boxes or stop announcement systems (annunciators and signage) have operating system software that enables the hardware to function and allows for an interface with the transit system computer network.
- Application software is layered on top of operating system software. For transit operations, common application software includes scheduling and dispatch software, run-cutting software for fixed-route systems, inventory software, maintenance software, and the software that powers an agency's website. Application software is commonly referred to as an **app**, short for application, especially as downloaded by a user to a mobile device (Smartphone, tablet, or laptop).
- Open-source software is software in which source code is released under a license in which the copyright holder grants users the rights to use, study, change, and distribute the software to anyone and for any purpose. Open-source software may be developed in a collaborative public manner. Open-source software development can bring in diverse perspectives beyond those of a single company. Linux, the underlying operating system for Android, ChromeOS, and most data center servers is open source, as are the current versions of all major web browsers. In the transit world, OpenTripPlanner (OTP) is an open-source software application that powers regional and national journey planning services throughout the United States and Europe.
- With open-source software, the user is responsible for maintaining and upgrading the software, either directly or through a contract. Open-source software works best when there is a community of users who share these responsibilities. Open-source software code is often made available publicly through online services such as GitHub.com.
- Proprietary software, also known as closed-source software, is computer software for which the software's publisher or another person retains intellectual property rights – usually the copyright of the source code. The publisher licenses the software to users and is responsible for its security, and for maintaining and upgrading the software. Most of the application software used by transit agencies is proprietary. These commercial packages are sometimes referred to as commercial off-the-shelf (COTS) software.
- Software as a Service (SaaS), where applications are hosted in secure data centers and directly managed by the vendor developing the software. This SaaS (rhymes with grass) approach of deploying and managing applications can greatly ease the technology burden on smaller organizations and opens the door to faster and more manageable technology infrastructure.

STANDARDS AND SPECIFICATIONS describe an agreed-upon means of describing data so that the software systems are speaking the same language. Another benefit of these shared specifications is that databases stay clean. An example would be a shared client database that lists Mary Smith also as Mary A. Smith resulting in two entries for one client. Along with the shared standards and specifications, software needs a way to exchange this data. One of the most common ways to do that is through APIs. (See Application Programming Interfaces).

- Standards-based System or Design. Software systems in which the design and technology follow public, standards and specifications. Well-managed standards-based systems tend to have a high level of interoperability and have been independently tested to confirm compliance. Transit fare payment systems require the use of such specifications that have been established for the financial payments industry. The interfaces are successful because of the work on standards for all manufacturers. Unix/Linux operating system is an example of a public, non-proprietary standards-based system. Microsoft Windows is an example of a proprietary standards-based system.
- General Transit Feed Specifications (GTFS) is a family of specifications that describe the availability of transit services in a geographic area.
 - GTFS is a data specification that allows public transit agencies to publish their transit service data in a format that can be consumed by a wide variety of software applications. GTFS describes static schedule, fare, and geographic transit information.
 - GTFS-realtime is a component that contains arrival predictions, vehicle positions and service advisories.
 - GTFS-flex expands the specification to describe demand response or flexible route services. This is particularly relevant for transit providers in rural areas, or those that provide flexible or route deviation services. It is being tested in the State of Vermont and in Denver, CO. OpenTrip Planner has been modified to read GTFS data feeds, but Google Trip Planner has not been modified as of 2021.
 - GOFS (General On-Demand Feed Specifications) is a developing specification that is built upon and expands GTFS-flex and the Transactional Data Standards developed through Transit Cooperative Research Program Project G-16. GOFS is, in 2021, in a developmental stage.

TRANSIT TECHNOLOGY FLOWCHART OR TRANSIT STACK⁸ was coined to describe the combination of systems a transit agency may use in its operations. It is useful to think about the layers of software that create the stack as parts of a modular system. Some of these functions have standard interfaces so they work seamlessly together, such as GTFS-Realtime and GTFS. To the extent standard interfaces are developed, it will make systems more modular, increase agency options, is less costly in the long run, and less risky to implement. Within the transit stack some programs are able to share data with other programs but not all are connected with each other. An example of a foundational part of the technology stack is an automatic vehicle location (AVL) system.

⁸ Trillium Transit blog post. <https://trilliumtransit.com/2016/10/10/transit-stack-diagram/>

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TECHNOLOGY TOOLS

There are a variety of tools for scheduling, primarily focused on **demand response services**. With demand response services there is a need to schedule passenger trips, identifying for each day who will be transported by each vehicle. The characteristics of demand response services vary a lot, and the system characteristics will determine what tools are most appropriate. Generally, technology tools for demand response scheduling include:

SPREADSHEETS	A simple spreadsheet can be used to for some key functions: • To assign riders to vehicles, in the order they are picked up and dropped off. • Time blocks usually show how long a person will be on the vehicle and allow for time at stops. • To maintain client data, listing key information about each client (home address, phone, mobility needs, emergency contact) • expanded spreadsheets can be quite powerful, adding more functions (such as driver or vehicle information), and making it easier to link information across different pages or different spreadsheets.
USER-CUSTOMIZABLE DATABASE APPLICATIONS	A relational database program automatically links information in various tables, allowing one to readily access and link together detailed information. Microsoft Access and FileMaker Pro are two well-known examples. Information on riders, drivers, and vehicles may be maintained in tables and used to help schedule passenger trips.
COMMERCIAL OFF-THE-SHELF (COTS) SOFTWARE SYSTEMS	A variety of COTS systems are on the market. These typically have a core system and various modules that allow an agency to tailor the system to meet their needs. These systems generally feature a polished user interface, so the scheduler or dispatcher only sees pertinent information for the task they are completing while the rest of the system operates in the background. The core system typically includes: • Customer database • Scheduling that uses an algorithm to optimize the schedule • Configurable reports • Driver manifest on a tablet • Ability to assign costs and to track eligibility for fund sources Advanced features may include: • Computer-aided dispatch (CAD)/Automatic Vehicle Location (AVL) • Other functionalities may also be added on to or bundled with multi-function scheduling packages. Examples include pre- and post-trip inspection features for the vehicle on the tablet, the ability to track maintenance that has occurred, or fare features. These also may be purchased through separate apps

Scheduling systems for **fixed route service** include scheduling vehicles so all trips are covered and “cutting” driver schedules from those vehicle schedules. Small systems typically use a spreadsheet while larger systems can benefit from software designed to accommodate more complex schedules and specific work-rule requirements that exist in many union contracts. Fixed route schedules do not change on a daily basis – a particular schedule (with breakouts for weekdays, Saturdays, and Sundays/holidays) may stay in place during the school year, only changing significantly when service is shifted for the summer. However, drivers need to be assigned to cover shifts and respond to changes in schedules. A medium-sized agency might use a fixed route scheduling module that is available through the comprehensive demand response scheduling software systems. There are ~~also~~ dedicated software systems that focus on very large bus systems.

Route deviation or flex services share characteristics with both demand response and fixed route modes. The type of service operated and frequency of passenger trips that deviate should be considered when selecting a scheduling/dispatch system, so it supports the service types operated.

CONSIDERATIONS

What needs to be in place first?

This is a foundational software application. Using a simple spreadsheet or a database program does not necessarily require internet access, but the other options do. As more programs are cloud-hosted, reliable internet access should be considered a basic requirement.

What is appropriate for a transit agency?

The complexity of transit agency, the scale of services, and the type of services operated will determine what will be the best fit for transit agency. Consider:

- The numbers of riders scheduled daily, including:
 - Individually scheduled versus subscription trips
 - The number of day-of schedule changes needed (e.g., will-call and same day trip requests)
 - Trips scheduled on deviated route services
 - Extra load time for mobility needs
- The number of vehicles and drivers
- Complexity of funding sources and fare structures
- Ancillary management systems, such as for human resources, training, or maintenance, in place through the sponsoring agency

Capabilities

Review the chart below to identify which systems have the functionalities needed and desired. For simple spreadsheets, some program time may be required to achieve the desired functionalities. In COTS applications, remember that each vendor packages components differently. Consider if the system can be programmed to fit the workflows in the agency. Consider also what is included in the core system and what would be added on as an additional cost.

Function	Spreadsheet	Custom Database	COTS Software
Demand Response scheduling			
• Client database management	☑	☑	☑
• Basic scheduling	☑	☑	☑
• Complex scheduling (benefitting from algorithm)			☑
• Allocating trip costs and assigning eligibility by funding source			☑
Fixed route: Run cutting/driver scheduling	☑		☑
Drivers: Availability; tracking licenses, training			☑
Vehicles: Availability; mobility features such as ramps and lifts for trip scheduling			☑
Reporting: Ability to create reports	☑	☑	☑
Interfaces: Ability to send/receive information			☑
Common add-ons:			☑
• Driver manifests on tablets			☑
• CAD/AVL			☑
• Reminder calls			☑

Other key considerations include:

- Ongoing maintenance and upgrades
- Customer service
- Training
- What programs or systems will depend on information generated by this system? How will that occur?

Cost Considerations

For spreadsheets and database applications, the direct software cost is minimal. Generally, spreadsheets are available as part of a suite of office products while database systems may require an annual subscription fee. Google sheets is a part of Google Workspace, which is free to non-profits and \$6-18 per user per month to other organizations. In addition, a transit agency may wish to pay for an expert's time to assist in setting up the spreadsheet or to send staff to training to develop spreadsheet skills.

Purpose-built database programs, such as those geared towards volunteer driver programs, cost in the range of \$2,500 annually.

COTS scheduling and dispatch systems have a wide range of costs, and what an agency pays depends on what is included in the core system and the modules purchased in addition to the core system.

Generally, a key driver in decision-making is how much staff time an agency is likely to save and what improvement in vehicle productivity an agency is likely to see by automating the system, as well as how accuracy in reporting might improve. It is important to arrive at estimated savings not just from vendor

estimates, but also from conversations with similar organizations that have adopted the solution being considered. One rule of thumb for demand response agencies is that the cost of the scheduling system should not be greater than \$0.50 to \$1.50 per trip scheduled.

These systems come with implementation costs and annual fees. The cost to any system may depend on the number of vehicles, the number of user licenses, and/or the number of riders carried annually. spread the initial purchase and set-up fees over five years and then add in the annual fees to get at the total cost per year. The COTS systems typically become viable for systems carrying over 10,000-15,000 demand response riders annually although this will depend on the complexity of scheduling, size of the customer database, and other system functions.

QUESTIONS

Scheduling for demand response services generally drives the need for scheduling software.

- How many trips are provided on a typical day? of these, how many are subscription or standing orders? How often are “will call” trips provided? Translate this volume into staff time: how many hours of scheduling and dispatch time is needed to schedule and update trips and to deliver daily trips?
- How large is the client base? The greater the number of unduplicated riders served, the more value there will be in automation.
- How complicated are the scheduling decisions? an agency in a small town that has 3-4 vehicles operating in the same area goes through a more complex decision-making process than an agency with 3-4 vehicles, each of which operate on different highways and serve different towns. The key reason for using a COTS system is to gain efficiencies through being able to optimize the schedule.

What transit modes does the agency operate and which is the primary mode? Consider a software system tailored to the primary mode. Then identify additional features needed for the other mode and how particular COTS packages meet those needs. Note that some functionalities, such as CAD/AVL, operate differently for demand response and fixed route services.

Most transit agencies will benefit from a scheduling system that links driver availability, vehicle capacity, and recordkeeping functions. Some agencies rely on City or County systems for employee training records and licensing or for maintenance while other agencies would reap significant benefits from having these systems automated as part of a scheduling system.

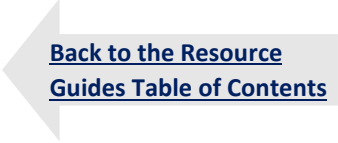
- What core functions are presently automated or covered by another system?
- What functions are needed to improve system efficiency?

How complex are the operations? This will help determine the functions a transit agency will need in a scheduling system.

- What modes does the transit agency operate? What types of demand response services are operated (standard, ADA Complementary Paratransit, taxi services, deviated routes, etc.)?
- Do rider trips need to be tracked by fund source?
- Is it easy to hire and train schedulers and dispatchers?

With what other software systems will an agency need to be able to share information?

- Based on frequency and complexity of data that needs to be shared, where will it be adequate to produce hard copy reports, where will machine readable files be needed, and where will true interoperability be needed?
 - An annual report with moderate detail might be a hard copy
 - Frequent transactions, such as with a contactless fare system, will require full interoperability



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TECHNOLOGY TOOLS

Trip planning tools enable customers to determine the available transit services and their schedules.

- Trip planning tools are widely available for **fixed route services** (bus or rail) based on General Transit feed specifications (GTFS) and GTFS-realtime data. This data can be consumed by Google maps and other similar services such as Bing, and a variety of trip planning applications (Transitapp, Rome2Rio, and others). Many fixed-route dispatch systems also provide trip planning public-facing planning tools (e.g., Transloc, ETA) for the agencies they serve. Trip planning applications are often available on both mobile apps and web-based applications. For more on system-specific apps, see the Communication with Riders and the Public Resource Guide.
 - Standard GTFS data tells one where fixed-route or rail service is available and the hours of operation.
 - GTFS-realtime, drawing data through Automatic Vehicle Location (AVL) hardware on vehicles, provides specific information on schedule adherence so one can identify when the next bus is arriving.
- Trip planning tools are now available for **demand response and route deviation services** through GTFS-flex. The state of Vermont has a trip planning implementation in place using GTFS-flex data. Other implementations, such as for Denver RTD, are in progress. The above trip planning tools are generally oriented to people who can use public transit, and not towards services for which program eligibility must be determined. Trip planning tools for human service programs often use some sort of filtering software that enables a rider to see what is available in their region for individuals who qualify (such as for older adults or a Veteran) and who require specific mobility services such as door-to-door pick-up or wheelchair accessibility. Information on available services is maintained in an online database or directory, including information on hours of operation, service area, rider costs, and similar details. Some of these programs include links to the provider or even the ability to request a trip and receive confirmation that the trip has been scheduled.

Many states have found success mapping the state-wide transit networks through the GTFS family. Since the majority of Greater Minnesota transit agencies operate demand-response service, GTFS-flex is a tool that may likely need to be considered at a later date when the technology has matured and can better serve Minnesota.

CONSIDERATIONS

Customer-facing trip planning

The customer sees the end product, through a trip planning application or simply by using a mapping program. It is important to understand the foundation that is required so these systems work.

General Transit Feed Specifications (GTFS)

Data on the transit agency's services are sent in either a static or real-time format so they can be used (or consumed) by third-party applications, including mapping software. The static feed must be updated only when the schedule changes, while real-time information will be continuously updated during all hours of service with data from on-board AVL equipment.

GTFS-flex data is similar to the GTFS static feed, but requires different information, such as the size of a service area or the area where a bus will deviate from a fixed route.

For both static and real-time data, data quality matters a great deal, both initially and over time as services change. Reliable feeds provide a valuable service amenity that increase the usefulness of a service, while unreliable data feeds risk losing the trust of riders. High quality feeds are best achieved through an ongoing investment in testing of a planner's results across many scenarios.

Mapping

Mapping programs must be configured to consume the data and respond to information requests. A variety of mapping programs are configured to read GTFS and GTFS-realtime data streams. Only open Trip Planner (based on the Open Streets map) is presently configured to read GTFS-flex data streams. It is important to clarify the mapping systems in use for the transit agency and for any third-party applications being considered.

Other considerations

Applications that use GTFS data may be specific to a single transit agency, cover multiple agencies, or be part of third-party applications that use the GTFS data stream.

- How easy is it for customers to use? Is it available on both mobile devices and stationary computers?
- What are the accessibility features for individuals with disabilities?
- What features and reports are available to the agency?
- How much flexibility is there in defining addresses or place names?

Cost Considerations

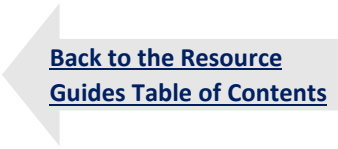
Many of the tools for riders such as websites and GTFS feeds are now mature and widely used, so the costs of deploying these tools in a minimal fashion are now low and easy to plan for. The costs that must be considered more strategically are those relating to user experience and data quality over time.

If a website or data feed is managed as a project, once the project is complete, there is significant risk that the site or data will degrade in relevance or accuracy over time. An inaccurate GTFS feed that riders cannot trust may pose a net negative to an agency.

More effective than a project-based approach may be to consider customer-facing information as an ongoing product for customer engagement that exists alongside the transportation services themselves and enjoys dedicated staff time for regular updating and attention to detail.

QUESTIONS

- What is the agency's overall strategy for customer engagement? How would the transit agency like technology tools to fit into that larger vision?
- What are the methods for gathering feedback about what kind of information customers are seeking from an agency about services?
- What are the methods for ensuring that the trip itineraries generated by GTFS feeds are accurate?



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TECHNOLOGY TOOLS

Communicating with riders and the public is a key responsibility for transit agencies. The traditional means of providing paper schedules and maps, providing a telephone line for customer information, and posting notices on vehicles and at bus stops remain a part of the toolkit for communicating with customers. Transit agencies are adding digital communications in order to meet the public in the ways the public most often uses and to communicate information efficiently. Key technology tools include:

- Social media
- Websites
- System-specific applications for transit information
- Business telephone system software to support tracking customer support metrics (such as average hold time)

Social media provides an opportunity to communicate rider information in real time and to get feedback. It is a great tool for communicating about delays or detours; it also is a means of sharing notices about public meetings or services changes. Information “ages” quickly on social media, so it is best used for timely updates such as special events or announcements. Information that does not change as frequently, such as quarterly route timetables, can be hosted on the main website.

Websites are vital for posting maps and schedules, hours of service, fares, and agency rules. The website is an important location for the agency trip planner, if there is one, and can provide links to other providers.

A key feature of websites and social media is a means to file complaints or compliments. This process should be easy for riders to find and use and monitored providing prompt responses to all comments. A challenge with social media is that it allows for upset customers to complain publicly. An agency policy that includes response timeframes, managing expectations, researching the situation, and following up with the customer is an important foundation for successful, consistent communication.

See the Customer-facing Trip Planning Tools Resource Guide for related information. This area also overlaps with in-vehicle technologies including:

- Automated Voice Announcements (AVAs) provide audio and visual announcements to on-board riders and those waiting to board. AVA systems typically have the capability of making time-based, location-based and vehicle operator-initiated announcements/displays. To ensure that next-stop announcements are made at the appropriate location, AVA systems interface with AVL systems.
- Dynamic message signs (DMs) - digital signs located at a bus stop, station platform, on-board the bus, common area that provide real time bus route information.
- Interactive Voice Recognition (IVR) - software that allows an automated computer system to interact with customers over the telephone. This can reduce workloads for schedulers/dispatchers as customers can cancel or modify their trips via an IVR system.

The costs for the on-vehicle technologies mean they are generally appropriate for larger agencies. Digital tools can increase access for people with disabilities. However, remember that they function alongside traditional systems so people without access to smartphones or a computer retain access to information.

CONSIDERATIONS

What needs to be in place first?

The foundation of digital communications is having adequate Internet services in terms of reliability and speed. Consider the redundancy that will be necessary to ensure reliability in a variety of conditions including emergencies.

A telephone network is another part of the foundation. Is the capacity of the line adequate for the desired communication systems implementation? Does the telephone software allow text messages to be sent or alerts to be pushed to the customer based on registered preferences?

Functional Considerations

Almost all Minnesota transit agencies have websites but there is a great deal of difference in the level of information on the sites. Transit agencies should consider if the agency website is meeting the customer needs. The basic customer information activities, such as maintaining route maps and schedules or maintaining a transit system map, still need to occur. It will continue to be necessary to post notices on vehicles and at stops in addition to sending out text alerts.

How often are there service changes? With what frequency are there rider alerts? How does the website and use of social media mesh with overall agency marketing? How do these tools improve customer service?

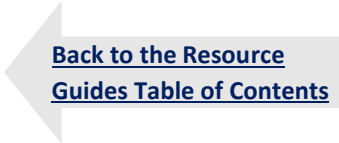
Cost Considerations

Maintaining a website and social media accounts are relatively low-cost ways to provide comprehensive information to customers. Labor is the main cost for maintaining a website and keeping communication channels current. Maps and schedules will be prepared in additional formats so they can be posted, so those costs may rise. The cost for printed materials and for staffing customer information calls will go down as riders can refer to the information online.

QUESTIONS

If the transit agency already has a website or uses social media, consider:

- What do they do well? What could be improved?
- Can the website be read easily on a mobile device?
- What website accessibility standards do the public-facing digital materials meet? How is accessibility tested or verified?
- Is the website limited because it is a small part of a larger organization's website?
- How much staff time is presently used to maintain the website and social media accounts? Are contracted services used for some or all of this work? How would this change if the website and social media accounts were upgraded?
- Is there a point person responsible? Is any training provided? Are expectations and procedures documented? If the transit agency does not have a website or use social media, consider:
 - What are the benefits (both current and future)?
 - What would it take to set one up and maintain it?



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TECHNOLOGY TOOLS

Transit asset management (TAM) is a process of operating and maintaining capital assets. Transit assets include vehicles, bus shelters, and transit facilities, as well as agency technology systems and infrastructure. Agencies use asset management to track the condition of assets (metrics include year purchased, performance measures, etc.), the scheduled actions needed to maintain them over time (vehicle oil changes, shelter cleanings, etc.), and the unforeseen events that may affect their future service (collisions, vandalism, etc.). A fleet maintenance program often forms the core of an asset management system. Most fleet maintenance programs now track basic metrics and can predict when maintenance is coming up.

For smaller transit agencies, assets can be capably tracked with basic spreadsheets, so long as all needed data is consistently entered. A combination of financial inventory management systems, fleet maintenance, and facility maintenance systems may form the basis of an asset management program. For larger agencies, commercial off-the-shelf (COTS) solutions can provide a comprehensive approach and additional tools such as tracking parts inventories.

In recent years asset management tools have advanced to include the ability to track rolling stock in real time through mobile device-based inspections and on-board systems connected to vehicle electronics (“telematics”). The benefits of these features include simplifying data entry for such things as odometer readings and reducing the time that a vehicle is out of service for repair.

Transit agencies may wish to consider maintenance or vehicle inspection modules that are part of a comprehensive scheduling and dispatch system. Alternately, there are mobile apps that provide logistical functionalities from inspections to fuel use and maintenance tracking. Several companies offer tools to streamline asset management through work order assignment and tracking as software as a service. The right choice for a transit agency will depend on the tools that are already available and in use, how workflow is divided between transit operations and maintenance functions, and the overall cost and functionality of available products.

CONSIDERATIONS

What needs to be in place first?

As with other applications described in these resource guides, the market for COTS asset management solutions is now dominated by hosted, web-based applications. Agencies using such systems should have reliable internet access.

Functional or Process Considerations

The value of an asset management system is only as good as the data entered into it. Policies and procedures for continuous entry of data and acting on the information provided are essential, so that (for example) the system has what it needs to show when oil change is due, and all relevant staff are alerted to make sure that the needed servicing happens in a timely fashion.

Assets need to be tracked for operational reasons as described above and also to comply with accounting requirements such as depreciation. Depending on circumstances, it may be easiest to have two systems, one for operations and one for financial tracking, with procedures in place to assure that each is in alignment with the

other. A review of the capacities of the organization's financial software will help inform the best course of action.

On-board equipment is an area where interoperability may provide significant cost savings. Some asset management systems will connect to most any vehicle hardware that offers an open interface. Thus, a vehicle AVL system could also provide data for asset management, or vice versa.

Cost Considerations

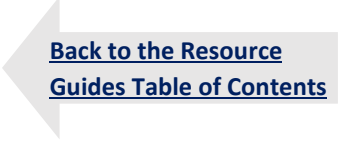
When considering investing in asset management technology tools, it is important to consider the types and number of assets involved. If an agency has a small number of vehicles and no other transit related assets, a spreadsheet tracking system is probably sufficient. The larger an agency's fleet, the more valuable connectivity to telematics would be to have a reliable and comprehensive picture of the state of the fleet.

If an agency is part of a larger organization like a city or county government, the transit agency may be able to make use of an overarching asset management solution software provided by the parent entity. Such a system could track both fixed assets (shelters, benches, and buildings) and mobile ones (buses and other mobile equipment like laptops or staff vehicles).

For other considerations, APTA has developed a comprehensive guide titled "Procuring Software to Support Transit Asset Management". As agencies execute the TAM plan mandate, APTA's guidance may provide a timely source of best practices for MnDOT and transit agencies.

QUESTIONS

- What are the existing processes for monitoring and maintaining assets?
- What are the strengths and weaknesses of these systems? Is the information generally accurate and consistent between systems?
- What connections would be valuable between these systems?
- Do these systems provide the information needed for budgeting, capital plans, and other management decisions?
- What are the relative costs and benefits of using a TAM module bundled with another solution (e.g., scheduling and dispatch system) compared with a dedicated TAM solution?
- In what ways can the existing on-vehicle hardware (e.g., GPS-enabled systems) be used to supply data to a TAM system?



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TECHNOLOGY TOOLS

A variety of technology tools are vehicle-based. Some overlap with other tools, such as electronic fareboxes that may have overlap with contactless fare payment tools. Others may stand alone, but with most in-vehicle technology, the ability to integrate systems such as AVL with scheduling systems or automated Voice announcements is an important consideration. On board technologies cover many features such as safety and security, communications, fare collection, scheduling, and core operations. Some key technologies are listed here.

AUTOMATED VOICE ANNOUNCEMENTS (AVA)	This is a communication system for on-board riders and those waiting to board through voice and visual announcements. AVA systems typically have the capability of making time-based, location-based and vehicle operator-initiated announcements/displays. In order to ensure that next-stop announcements are made at the appropriate location, many AVA systems rely on GPS data. Automated Voice announcements can help meet ADA compliance regulations of stop annunciation, as they automatically announce the next stop based on GPS location, thus the driver does not have to remember to announce each upcoming stop.
CAMERAS	On-board and exterior video surveillance can be used for the following purposes: • Crime deterrence and potential crime prevention • Identify criminal activity and perpetrator(s) • Identify proper/improper driver behavior, which can be used to support driver training and resolve issues • Incident/insurance investigation Camera technologies can also allow for authorized users, such as transit police, to access the cameras through Wi-fi while an incident is taking place
WI-FI AVAILABLE ON BUSES	Wi-fi can be provided as a hotspot through the cellular network.
AUTOMATIC VEHICLE LOCATION (AVL)	Automatic vehicle location (AVL) is a system to send real-time information on a vehicle's location from the vehicle to one or more central systems such as a dispatching system for operations management. AVL systems require an onboard mobile data computer or terminal (MDC/MDT or tablet) with integrated GPS (Global Positioning System) receiver and mobile data communications capability.

	AVL, combined with Computer-aided Dispatch (CAD) is important to maintaining schedule adherence and ability to apply real-time control methods to prevent/reduce the impact of schedule deviations. Some AVL related technology vendors, like Samsara and Transit App, also include other functionalities.
ELECTRONIC FARE BOXES AND FARE MEDIA READERS	Electronic fare boxes are installed on buses and accommodate cash and the fare technologies used by the transit service. Fare media readers may also be mounted separately from the fare box. Common types of electronic fare payment options include magnetic stripe cards, smart cards, and mobile devices. Smart cards refer to a card that has an integrated microchip that stores fare information. Electronic fare boxes also accommodate fare options used such as stored value, stored trip, various lengths of passes and capped-trip passes. The fare Collection Resource Guide has additional information.
AUTOMATED PASSENGER COUNTERS (APC)	Automated passenger counters (APC) are technologies that count the number of passengers that board and exit a vehicle. Data from the APCs can be stored and downloaded later or be transmitted to central dispatch by radio. The two most common types of APC technology are treadle mats and infrared technology.
COLLISION AVOIDANCE SYSTEMS (CAS)	Collision avoidance systems (CAS) refers to a range of technologies from providing a warning to taking control of a vehicle. CAS include: • Rear impact collision warning system • Side collision warning/object detection system • Frontal collision warning system • Intersection conflict warning system • Lane change/merge warning system • Pedestrian warning
MOBILE DATA TERMINAL/COMPUTER (MDT/MDC)	On-board system that is used for vehicle operator logon/logoff, sending vehicle location reports to dispatch, voice call management, data messaging, odometer readings, and display of schedule adherence and integration with other on-board equipment. For some systems, this is a tablet in the vehicle. For other systems, it is an actual MDT/MDC that integrates various on-vehicle technologies.

GPS RECEIVER / ANTENNA / DONGLE	Global Positioning System (GPS) technology reports date, time, latitude, longitude, speed, and direction of travel.
VEHICLE ASSIST AND AUTOMATION	These types of technologies automate the movement of buses to allow precise operations in extremely narrow lanes, stations, and maintenance facilities. They include: • Precision docking • Vehicle guidance • Vehicle platooning • Automated operations
VEHICLE COMPONENT MONITORING	This technology can be useful for an asset management system for rolling stock. A set of sensors monitors various components of the vehicle and reports on the component's performance. Engine, transmission, anti-lock brakes and various fluid levels are constantly monitored. Maintenance supervisors can use this information to perform preventative maintenance intervention before a minor problem becomes a costly major one.

CONSIDERATIONS

Dependencies and Interoperability

Many of the on-board technologies are dependent on each other to function. While some standards for interoperability between systems and vendors exist, they are far from the “plug and play” functionality that is now the norm in consumer technology. For this reason, integrations should be approached with a systems-engineering mindset, with planning, thoughtful design, and clear lines of responsibility for the agency and each vendor involved. The table below shows examples of the integration within a transit agency of various technologies.

Component	Integrated with Component
CAD/AVL	• Scheduling/Dispatch system • Automated voice announcements • GTFS-realtime data feed • Mobile data terminal • Cellular data networks • Asset management system

Mobile Data Terminal/Tablet	• Fareboxes • Headsigns • Odometer • Automated passenger counters • On-board cameras
Automated Voice Announcements	• CAD/AVL • Cellular data networks
Automated Passenger Counters	• CAD/AVL • Cellular data networks • Wheelchair lift sensors

Unlike software solutions like scheduling and dispatch systems which can be supported remotely, on-board technology requires local resources to maintain and replace equipment over time. The sophistication of the solution should be matched with the local capabilities.

In-vehicle technology may change over time. For more information, the us Department of Transportation (USDOT) Intelligent Transportation Systems Joint Program Office (ITS-JPO) offers fact sheets on transit technology.

Cost Considerations

Vehicles are a hostile environment for technology, and the logistics of fixing equipment failures can add unexpected costs to keeping an on-board system up and running. Similarly, driver-facing technologies such as tablets may require initial and ongoing training that also present logistical challenges that should be planned for, especially if drivers are uncomfortable with technology.

For those wishing to build out their on-board technology gradually, the most easy-to-implement is hardware that requires minimal integration with other on-board systems and little to no interaction with the vehicle operator. Examples include freestanding camera solutions and GPS dongles with their own integrated cellular connectivity.

Each of the technologies described above has their own cost/benefit analysis required. Decisions to procure them need to be based on agency size, scope of service and need.

QUESTIONS

- What are the most urgent problems that can be solved by on-board technology? Creating a ranked list of issues can assist with planning.
- What in-agency or local contracted resources are available to support on-board technology over time?
- What down-time is allowable for the given element of on-board technology?
- Who in the organization would take charge of documenting, maintaining, and training regarding on-board technology?

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TECHNOLOGY TOOLS

Fare collection can be a resource intensive process and the pandemic has resulted in increased interest in contactless fare systems. While cash, paper tickets, and other fare media like magnetic stripe cards are not touched by drivers, they place passengers in close proximity to drivers (closer than six feet). If keeping passengers at some distance is a primary concern, consider fare media that can use readers by the rear door. Contactless fare systems are generally used by transit agencies with a significant amount in annual fare revenue. There are two basic types of contactless fare systems:

- **Card-based systems** allow a user to swipe a physical card by a reader and the fare amount is reduced from the card. A card can be used by anyone and if lost, the value of the card is lost. With card-based payment systems, account information is stored on a card, typically with a magnetic stripe but potentially using an RFID chip in the card.
- **Account-based systems** (also known as “profile-based”) associate a value with an individual or funding account and generally allow customers to use their mobile phone to display a ticket or enable near-field communication (NFC) for payment. Account-based payment systems store transit value via an account often enabling multiple payment mechanisms such as an issued card, NFC-enabled smartphone, or other bank (debit or credit) card. INIT and Cubic (Touchpass product) are examples of vendors that offer account-based systems geared towards large transit agencies. Masabi (EZFare) and Token Transit are widely used account-based systems that can be easily implemented by small and medium-sized agencies.

There are several business models for mobile fare payment, but at present vendors tend to handle mobile app development, payment processing (via Square, PayPal, etc.), and compliance requirements. Vendors are paid based on a portion of sales (e.g., 10%) and implementation costs may be very low.

BACKGROUND: FAREBOXES AND FARE MEDIA

Fareboxes have developed from simple locked boxes to ones that can accept a wide variety of fare payments, including bills, and scan a variety of media. Transit agencies often accept an array of fare payment options and maintain a variety of outlets where tickets and passes can be purchased. As electronic and contactless payment options have grown in recent years, some agencies have had to purchase new farebox systems or to retrofit their existing fareboxes with readers for contactless fare systems, resulting in vehicles that have two or even three different fare media collection methods.

How do contactless systems store and transmit information?

- **Magnetic Stripe Cards** store information and can be read by a reader with a magnetic head. Some magnetic stripe cards also have RFID chips included.
- **Radio-Frequency Identification** (RFID) is wireless technology employing a microchip to broadcast, via radio waves, a unique identifier to a receiver. The receiver relays the data to a computer.
- **Near-Field Communication** (NFC) is a type of RFID, which uses a specific high-frequency for close-range communications. A radio communication is established by touching two mobile or handheld devices within approximately 10 centimeters of one another. NFC is the primary method for contactless payments. NFC payments are encrypted and dynamic, making them more secure than magnetic-stripe cards.

CONSIDERATIONS

Fare Policy

A documented fare policy is very important and should include proper fare/cash handling procedures and ways to reconcile passenger counting with fares. The fare policy can impact the user-friendliness and choice of the fare media. While the current generation of electronic fare (e-fare) systems are relatively easy to implement, specialization is needed when there are unique fare rules that an agency needs the vendor to support.

Coordinated Procurement/Fare Sharing

Multiple transit-systems can participate in a coordinated procurement effort if this makes sense geographically or structurally. effective participation of multiple agencies depends on agreed-upon business rules and agreements (revenue sharing, fare rates (including zonal fares) and policies) as well as information sharing (see Maturity and Integration for more information below).

Hardware

Consider if there will be in-vehicle hardware for reading the fare instrument. Some agencies get around that by relying on a smartphone app that presents an image viewed by the driver. Consider mounting, flow of boarding passengers, and ability of the driver to maintain a safe distance.

Maturity and Integration

These systems are now mature enough for relatively low-risk implementation within a single agency. If two neighboring agencies wish to make it easy for riders to pay with a fare instrument from either system, currently that would require both agencies to contract with the same e-fare vendor.

Multiple agencies and modes can participate in a single system through a set of defined application programming interfaces (APIs), but fewer agencies have implemented multi-agency or multi-mode installations. API-based systems offer a high level of platform accessibility, opening the door to an e-fare system that can be used as a general-purpose “mobility wallet” to pay for transit, bike-share, taxis, and other shared modes.

What has not yet developed are the data standards that would allow independent fare systems to integrate seamlessly for the rider. Presently, the connection between the different parts of the systems (apps, vehicle hardware, and back-office systems) are all proprietary, which limits the ability to integrate with other systems such as a bike share system. When selecting e-fare technology, consider what data can be shared with related technology systems (e.g., the scheduling system identifies that a passenger has paid a fare).

It is critical that customers specify their interoperability needs for fare payment solutions, as customers large and small will drive product development plans for these technology vendors. Having multiple fare payment devices on buses is challenging to maintain and a bit confusing for boarding customers. When evaluating new equipment and tools for fare payment, ask for information about how this will work with the existing fare policy and other equipment and software systems. Also, get operations and maintenance guidelines of the devices for the maintenance team to evaluate maintainability of the equipment.

Equity Considerations

A primary equity consideration is maintaining cash or tickets so customers without internet-connected phones or bank accounts can continue using transit services. The locations where customers can load value to their card is important, especially for those who lack reliable internet.

A common challenge with account-based systems is the ability of a lower income transit user who cannot afford to buy the most cost-effective method once a month (e.g., a monthly pass for \$100 the first day of the month) but might buy single fares or multi-day passes. Some agencies have overcome this challenge by setting a price ceiling - once a customer has spent so much via their account in a month, then a monthly pass is automatically applied to their account.

What is appropriate for my system?

Determining what is a good fit requires consideration of the amount of fares collected, how and where riders purchase their fares at present, the costs for handling fares, and how all of these things might change if a digital fare option were to be available. Adding a digital option would increase payment options for riders, especially younger ones who prefer to pay via a mobile app.

For most agencies, adding a digital option does not eliminate the need for other fare payment systems. The cost of cash handling or printing passes will be reduced in proportion to the percentage of riders who switch to a digital option. This may increase in time, but initial rollouts indicate 5-15% of fares may be paid with a digital option.

If minimal fares are received, an electronic fare system may not make sense. In terms of cash handling costs and protecting drivers, the smallest agencies may wish to consider switching to a donation-based system. Through a donation-based system, drivers do not need to handle cash with all donations going through the administrative staff.

Cybersecurity Considerations

Electronic fare payment systems result in a large amount of personally identifiable information. Consider the information that will be generated with each system, how long it will be stored, and how it will be protected.

Fare payment systems are evolving rapidly as of this writing in early 2021. Several vendors are working with regional or multi-agency coalitions to test contactless, integrated fare payment systems to advance the goals of mobility as a service and more equitable mobility. As these pilot studies play out, the consulting team anticipates seeing some consolidation in the market as well as some features becoming “standard” as these technology companies continue to improve their products.

Cost Considerations

Understanding the current costs for fare collection is key to making decisions on when or if an e-fare system will be appropriate. There is a wide range of costs for e-fare systems. Some vendors charge very low installation fees but take about 10% of the fare revenues as their fee. Is 10% more or less than the cost for other fare collections? Will enough riders use the e-fare system to warrant these costs?

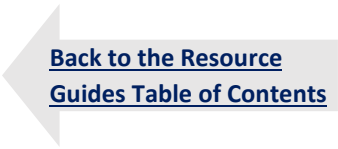
QUESTIONS

When considering expanding/updating an agency's fare collection technology, begin by documenting the existing fare collection processes and costs. First gather this important data - how are fares paid today? What comes in through the farebox? Through pass or ticket sales? Through agency billings? What are the current costs for fare collection?

Then consider - what would the costs be with an electronic fare payment system, either for the agency or in partnership with surrounding transit agencies in the region? What might change, and by how much, if a digital option were available? Has rider feedback been solicited? If so, how has this feedback been considered? If not, consider a rider survey to assess needs and desires.

Some questions to ask to assess the kind of fare system that might be right for an agency include:

- How will the collection system fit in the boarding area? Can an existing fare collection system be modified/ upgraded, or will this be a separate, independent system?
- Will the new equipment be able to satisfy the desired fare policy related to transfers, means of payment, and different fares?
- Is the fare media accepted on neighboring agencies?
- Is the fare policy and program equitable?
- Is a regional and governance structure desirable or planned? How would an e-fare system impact a regional fare system?
- How will an electronic fare system impact cybersecurity requirements?
- What are the state's or region's goals for equitable mobility, and how does the fare program reflect those goals?



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TECHNOLOGY AND ANALYSIS TOOLS

The tools described in this section are primarily for agencies charged with regional transportation planning in small-urban areas and/or for the larger fixed route agencies.

Fixed route service planning is traditionally conducted by identifying areas with high trip origins or destinations and designing a network that provides service in line with agency goals. Competing demands must be balanced as the service planner strives for routing that considers:

- Direct service with quick travel times for the most common origins/destinations.
- Analysis of transit dependent and Title VI populations.
- A minimum of transfers with good connecting times or short waits.
- Effective use of vehicle resources.
- Employee work rules and the development of good driver shifts.

This work is a good fit for technology as it uses a good deal of data (such as ridership, travel times, and demographic data), mapping, and analysis. As data collection has become easier and more efficient through Geospatial Information System (GIS), automated passenger counters (APCs), and other analysis and in-vehicle tools, more sophisticated service planning tools have been developed. Technology tools include:

- GIS tools can link Census information to coverage of routes and service areas. GTFS data can be uploaded to a GIS system and plotted with ridership data to explore service coverage and access metrics.
- Demand analysis tools range from spreadsheets to sophisticated travel demand modeling software such as Cube or Emme. Planners can use census data, local Metropolitan Planning Organization (MPO) surveys, or even custom-designed market research surveys to understand where customer demand for transit exists and how well it is served by existing routes.
- Integrated route, schedule, and demand analysis tools - companies like Conveyal, Optibus, and Remix have developed tools that allow transit planners to import their GTFS data and adjust routes and schedules via a map-based interface and see the schedule and cost impacts updated in real-time. Planners can also typically export the schedules developed in these tools into the GTFS format. These dynamic planning tools can make it much easier for service planners to develop their seasonal schedules, as well as design operations for special events or emergencies (when certain streets are closed or bus garages will be inaccessible).

FOUNDATIONAL/FUNCTIONAL CONSIDERATIONS

System/Organization Assessment

Determining if these tools would be a good investment has more to do with organizational capacity, technical expertise, staffing levels, and the frequency with which an agency would use them.

- Is there a dedicated staff planner at the agency? What technology tools would support the planner's work?
- What training is needed?
- How do the transit agency and MPO share responsibilities for planning activities? Who is responsible for service planning, short-range planning, long-range planning, and Title VI plans?
- What interfaces between transit operating data (such as ridership by location) and regional planning activities would be useful?

- Maps are used for a variety of purposes, from customer information to a variety of planning purposes. As more digital applications are used, the interfaces between applications will become more important. Identify the base maps used in the region, especially for digital applications, and consider what integration might be useful.

These tools require training and regular use to develop and maintain proficiency. They have been in a phase of rapid development and the user interfaces have improved significantly, making them easier to use. This trend is anticipated to continue. Additionally, agencies can also contract out these services rather than maintaining in-house expertise - consider the frequency service planning/revision is needed prior to investing in technologies that may be better invested as a contracted service.

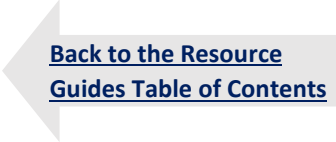
COST CONSIDERATIONS

Many commercial off-the-shelf (COTS) service planning tools are built for large agencies with large fleets; these may not be appropriate for most agencies in Greater Minnesota. Planning tools are generally cost-effective in urbanized areas due to planning requirements. Agencies with 50 or more fixed route vehicles would find these tools useful for meeting Title VI standards, although agencies with more than 30 fixed route vehicles may gain enough benefits to offset the costs.

Numerous “start-up” companies have emerged thanks to open data standards and creative thinking for more dynamic planning tend to have pricing that is based on fleet size so may be affordable for agencies with 20 - 50 fixed route vehicles.

QUESTIONS

- What is the current service planning process? Why is this process used and can it be improved?
- How might the service planning process feed into short and long-range planning processes?
- How variable is the demand throughout the day and week? Are there other types of service that might better serve the customers?
- How might service planning coordinate with the neighboring agencies or RTCCs? If coordination occurs, what kind of tool could be used together?
- How often does service planning occur? Could staff sharing be considered across agencies? Who might be responsible for service and other planning activities? Would these tools enable strategic service planning to be regularly and reliably scheduled?



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TECHNOLOGY TOOLS

Many state DOTs rely on some sort of management system that tracks a variety of federal and state compliance information including assets, fiscal activities, grant management and compliance. Some states use software tailored to their specifications developed by a software vendor (such as Salesforce) while others use systems designed for these functions (like BlackCat by Panther). MnDOT falls into the latter category utilizing BlackCat, which includes numerous functions including:

- Asset inventory/tracking
- Grant administration (applications, contracts, financial reporting/invoicing, compliance (document repository), 10-year project plan)
- Procurement
- Resources (training tools, best practices, contact information, etc.)
- Reporting (passenger trips, revenue hours, revenue miles, on-time performance, etc.)
- BlackCat is able to import/export CSV/Excel files

The tools described above focus on functions related to transit agency oversight. There are numerous grant management systems developed for agencies. Many of the functions include employee and fiscal management. Some examples include Oracle Netsuite, Bloomerang, Salesforce for Nonprofits, etc.

CONSIDERATIONS

Training

MnDOT regularly communicates with the transit agencies through BlackCat instructions and training opportunities. MnDOT offers BlackCat training at the MPTA conference, at the spring workshop and prior to RFP processes.

Remember: “If things run amok, contact Chuck!”

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Enhancements

To make things easier for transit agencies, the following actions are recommended:

- Develop a user guide for transit agencies. A user guide helps users to understand the easiest ways of entering data and updating files, resulting in more consistent use of the system. A user guide eases training when staff changes and increases user accuracy and functionality.
- BlackCat develops the ability to import/export financial reporting through CSV files. Currently a manual data entry process is used that is very labor intensive.
- Interoperability is ideal, with BlackCat integrating operating and financial data via an application Programming Interface (API). This allows state-level reports and analysis and reduces manual efforts and/or repetitive data entry.

QUESTIONS

- Where is the most repetitive data entry occurring? How much staff time does this take?
- What would be required for both the various software systems used by transit agencies and for BlackCat to be able to automate data flows through CSV files or an API connection?
- What costs would be incurred and what would be the implementation challenges?



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Goal-Strategy-Action Details

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Purpose and Development

Summary of Goals and Key Strategies

Strategy Cluster: Public Service Delivery

Sub-cluster: Coordination and Integration

Sub-cluster: Mobility

Sub-cluster: Customer Engagement

Strategy Cluster: Operations and Decision Making

Sub-cluster: Knowledge Acquisition

Sub-cluster: Procurement and Investment

Sub-cluster: Innovation

Sub-clusters: Implementation; Evaluation and Data

Conclusion

PURPOSE AND DEVELOPMENT

Strong, consensus-based goals and strategies are central to creating a robust and useful Greater Minnesota Transit Technology Plan. While MnDOT has primary responsibility for implementing the Plan, the transit agencies will purchase and install most of the technology systems. As a result, the statewide goals and strategies must reflect and address the priorities of both MnDOT and transit agencies. The collective, statewide process used to draft and refine these helps ensure that the goals resonate well across all stakeholders and link directly to agency missions/visions. This approach also aims for supporting actions that are sufficiently relevant and valuable to be incorporated into ongoing planning and implementation as MnDOT and transit agencies incorporate transit technology.

The goals, strategies, and actions were jointly developed in a multi-step process by MnDOT, [Steering Committee](#) members, and leaders from Greater Minnesota transit agencies using “visual strategy mapping,” which is a *causal* mapping process. The consulting team first reviewed prior project work and previous plans to identify a starter set of ideas, then launched the strategy mapping effort with this key question: “What must MnDOT and Greater Minnesota public transit systems do over the next 5-7 years to advance a transition to digital operations that help meet organizational objectives and rider needs?”

Over five workshops in January and February 2021, participants from the various groups generated, organized, and refined strategies and actions, then built upward to identify long-term goals by articulating causal connections between and among the activities, asking for each, “What do we get as a result of this...?”

The strategy map articulates the foundation that must be in place to achieve the goals as well as the relationships between the various actions. This is a “working” set of actions, strategies, and goals to guide more detailed workplans toward common ends. Such workplans may be developed by MnDOT, transit agencies, and Regional Transportation Coordination Councils (RTCCs). This strategy map is expected to be refined over time to reflect accomplishments, institutionalized change, technology evolution, new information, and refined priorities.

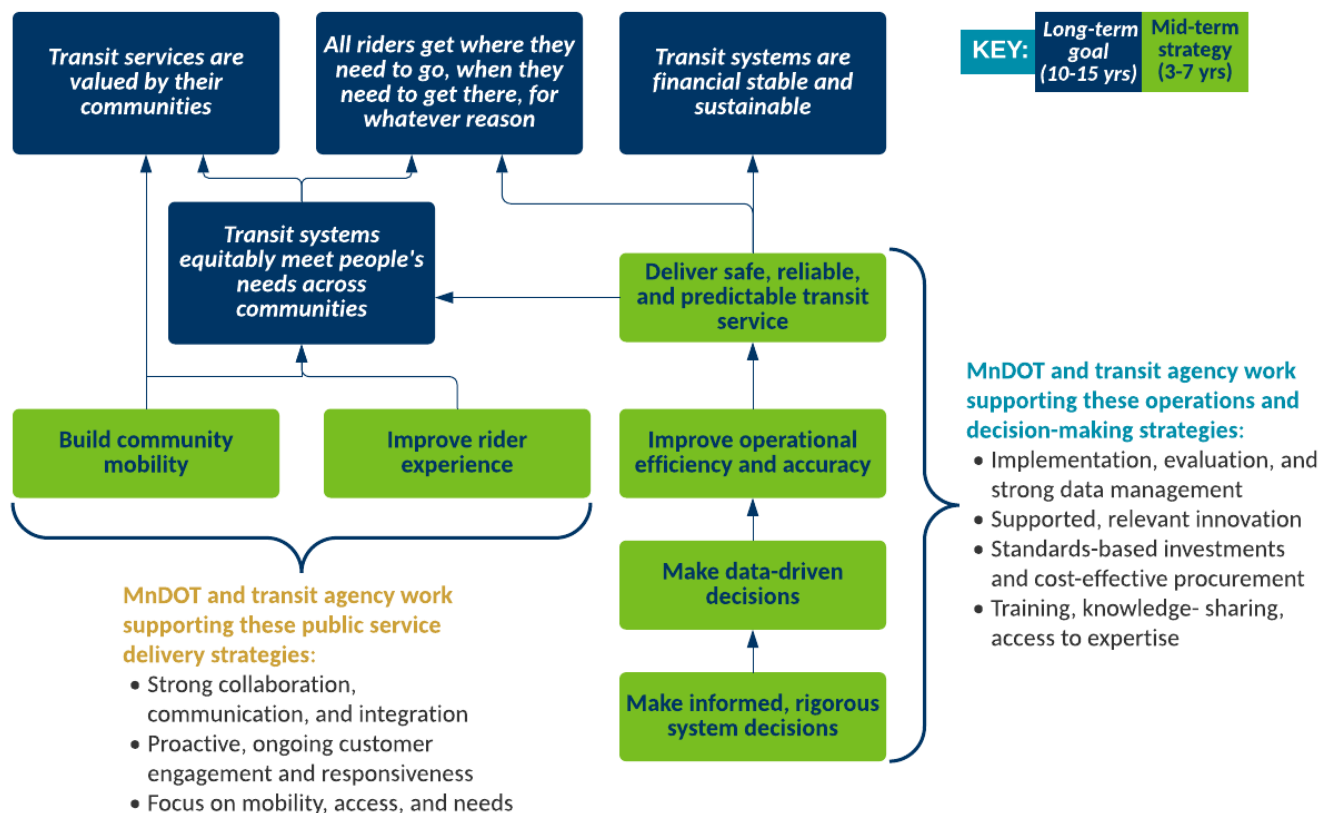
Key Definitions

- **Goals (blue):** The “whys” that drive the work. They are statements of ends or outcomes, not means, and look out 10-15 years. They resonate well across all stakeholders, remain relevant for many years, and are both inspirational and aspirational.
- **Key strategies (green):** These strong, substantive, mid-term (3-7 years) efforts are the “whats” that will make the “whys” (goals) happen.
- **Actions:** These are the “hows” that drive progress on the strategies and in turn the goals.
- **Causal relationships:** The actions, strategies, and goals all clustered and connected as they relate *causally* to each other.

SUMMARY OF GOALS AND KEY STRATEGIES

Figure 1 shows the statewide long-term technology goals and mid-term key strategies. The four very long-term goals (blue) speak to statewide priorities common across transit systems. The goals are long-term aspirations, intentionally written as outcomes. They will result from MnDOT and Greater Minnesota transit agencies working together to successfully advance key strategies (green). The key strategies and additional sub-strategies described later, in the sub-strategy clusters, support these goals.

Figure 1: Statewide Goals and Key Strategies



The goals and key strategies reflect common goals and objectives of agencies providing transit services and are not exclusively related to technology. Well-selected technology helps transit agencies meet such broad imperatives and improve their functioning. Even this high-level summary of goals and key strategies illustrates the breadth of areas that may be impacted by technology and the causal relationships between steps on the strategy map.

The long-term goal on the top left, **Transit services are valued by their communities**, is part of a cluster of strategies about public service delivery. It is most directly supported by another goal: **Transit systems equitably meet people's needs across communities**. Along with the central goal, **All riders get where they need to go, when they need to get there, for whatever reason**, these three goals are directly supported by two mid-term key strategies related to public service delivery: *Build community mobility* and *Improve rider experience*. These goals are also supported by a set of strategies about operations and decision making that culminate in: *Deliver safe, reliable, and predictable transit service*. That key strategy is further supported by the three strong

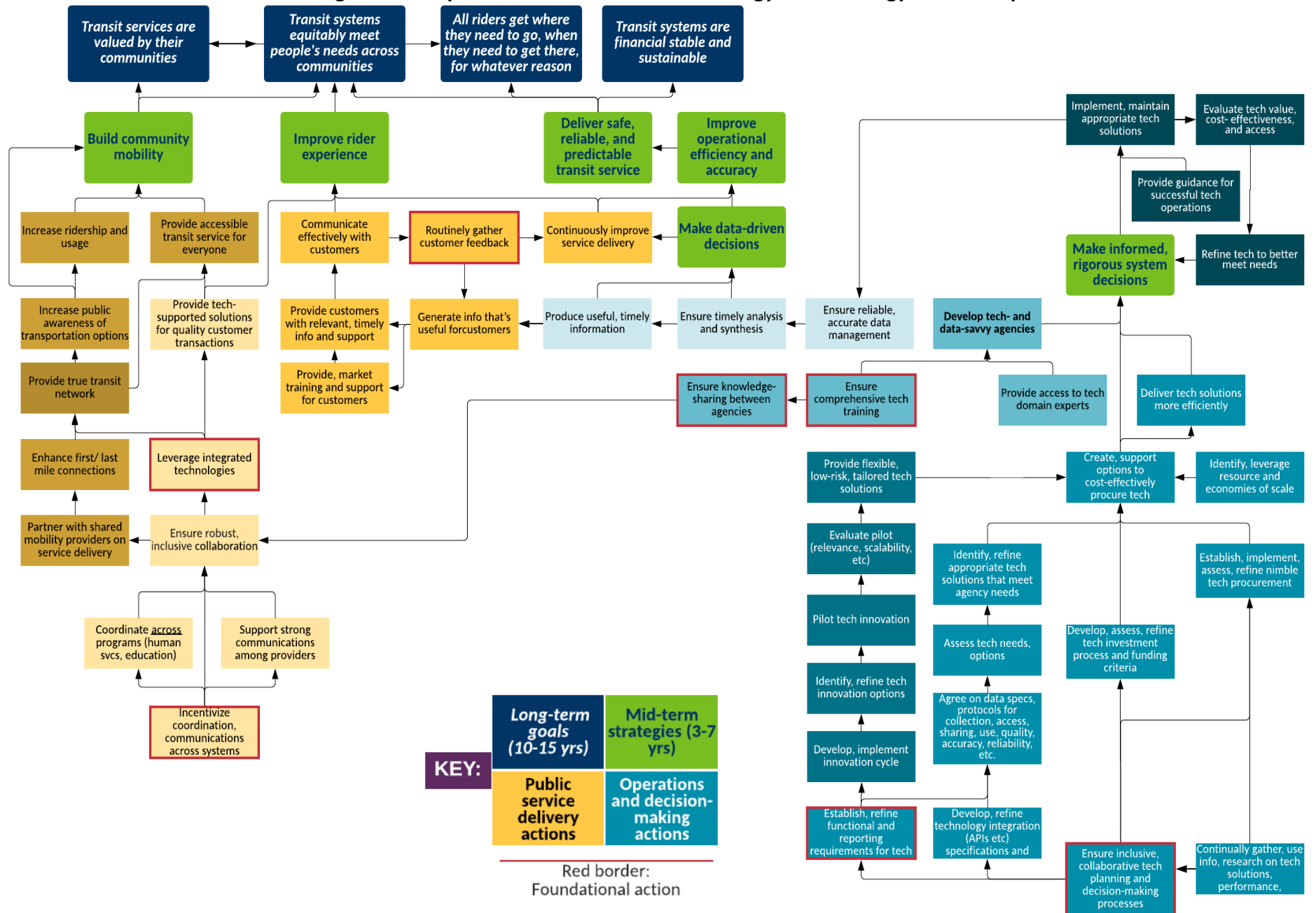
strategies shown above, and that set of key strategies directly drives the final long-term goal related to operations and decision making: **Transit systems are financially stable and sustainable.**

Figure 2 on the next page shows the complete statewide transit technology goal-strategy map.

- There are two major clusters of strategies and actions:
 - On the left (yellows) are strategies and actions supporting public service delivery
 - On the right (turquoise) are strategies and actions supporting operations and decision making
- Red-bordered actions are considered foundational – they are essential for success

Following the complete map are detailed descriptions of sub-clusters and the role of technology.

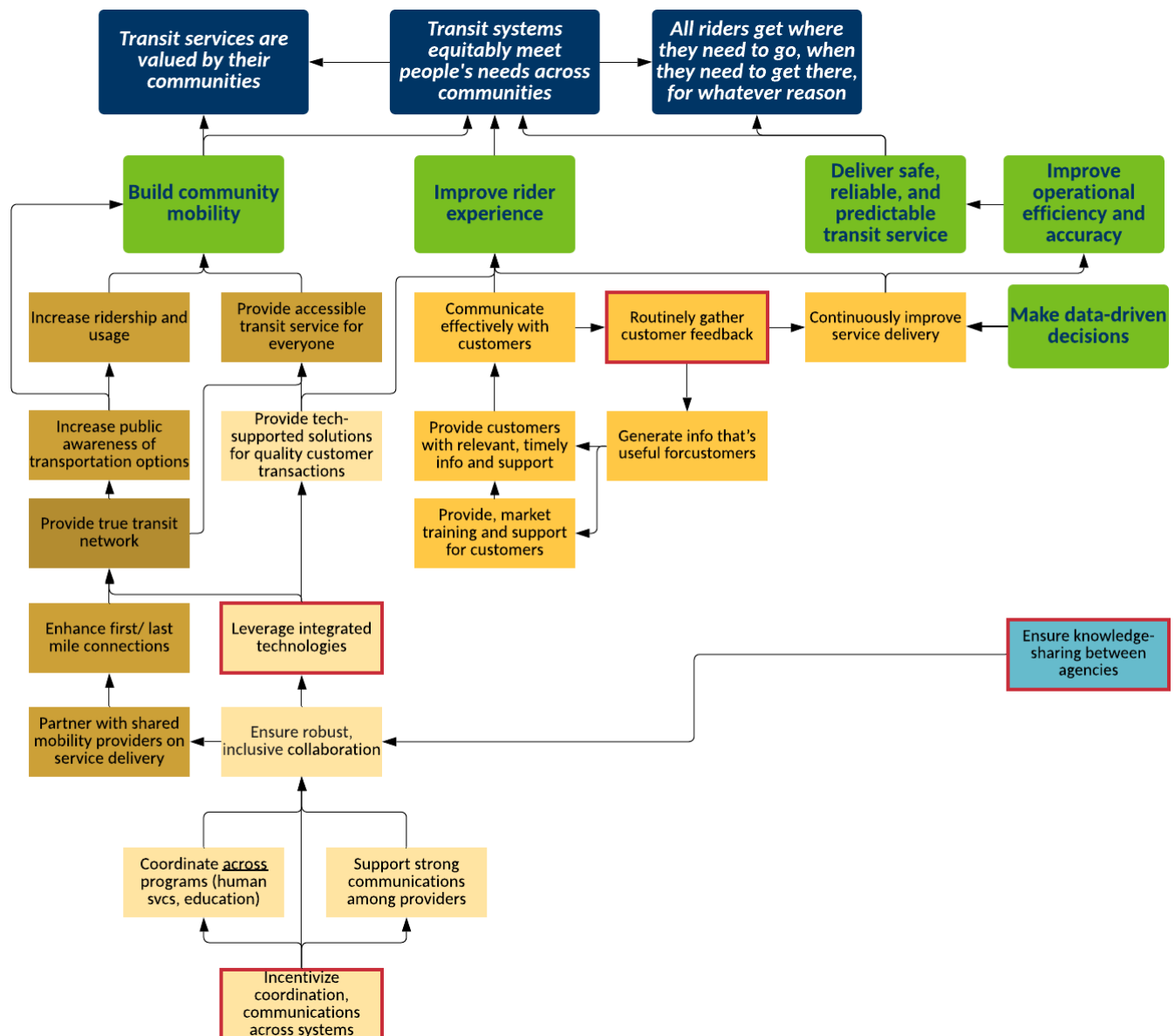
Figure 2: Complete Statewide Transit Technology Goal-Strategy-Action Map



STRATEGY CLUSTER: PUBLIC SERVICE DELIVERY

- Build community mobility
- Improve rider experience
- Improve operational efficiency and accuracy (which supports the key strategy: Deliver safe, reliable, and predictable transit services)

- Transit services are valued by their communities
- Transit systems equitably meet people's needs across communities
- All riders get where they need to go, when they need to get there, for whatever reason.



Sub-cluster: Coordination and Integration

This sub-cluster begins at the bottom of the Public Service cluster and follows the middle pathway. It includes three foundational actions (red borders):

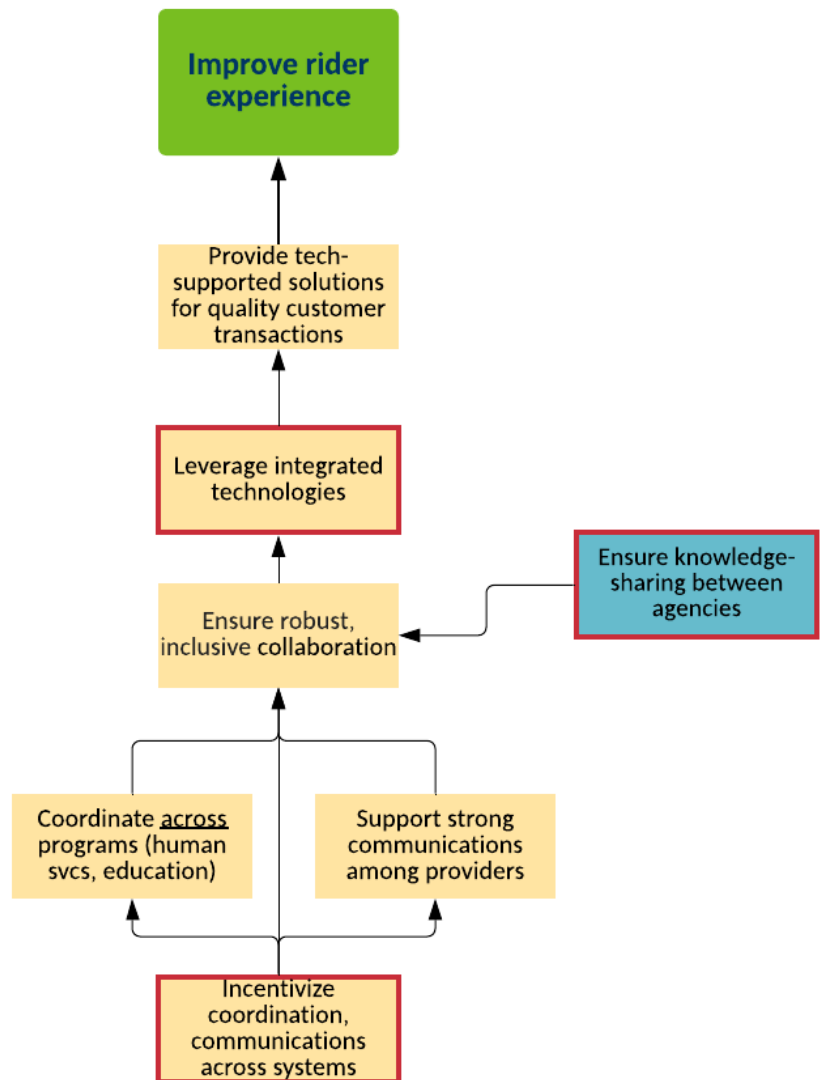
- Incentivize coordination and communications across systems
- Leverage integrated technologies
- Ensure knowledge-sharing between agencies – this one also serving as a critical bridge from the Operations and Decision-Making cluster

These actions reflect the priority of coordination in other MnDOT plans and the ability of technology to enable coordination in a way that previously has been difficult to achieve.

- **Incentivizing coordination, communications across systems** will require attention to creating business rules agreed to by all participating agencies.
- **Leveraging integrated technologies** is possible by utilizing existing integrated technologies and coordination tools.

If technologies are not currently integrated, actions are required in the Operations and Decision-making cluster. That includes **Develop, refine technology integration (APIs, etc.) specifications and requirements** and moves into procurement and implementation.

Figure 4: Coordination and Integration Sub-cluster



Once integrations are developed, work can advance on actions later in this [Public Service cluster](#), including:

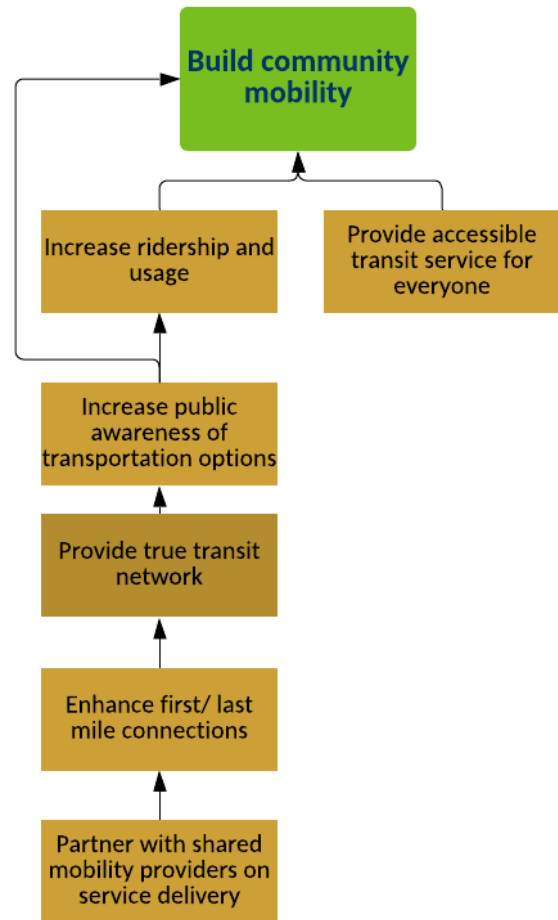
- Partner with shared mobility providers on service delivery
- Create a true transit network
- Provide tech-supported solutions for quality customer transactions

Sub-cluster: Mobility

These actions (right) are grounded in strong partnerships that **Enhance first/last mile connections** and lay the foundation for **true community transit networks**.

They result in **accessible transit services** along with **increased awareness or transportation options**, and **increasing ridership**, which, together, build critical community mobility.

Figure 5: Mobility Sub-cluster



Sub-cluster: Customer Engagement

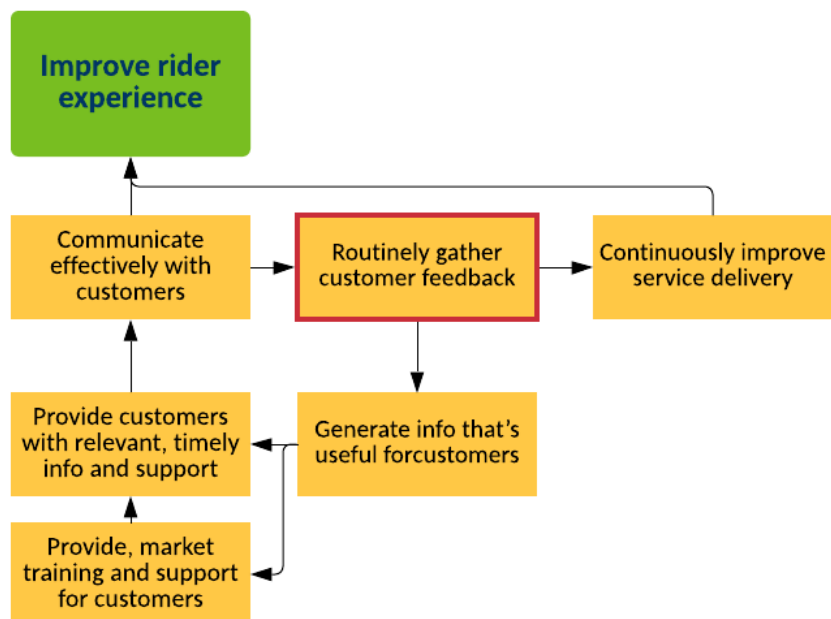
This set of actions (below) in the Public Service Delivery cluster consider not only riders, but also the broader set of “customers” served, which includes other organizations, agencies, and those acting on behalf of the rider.

It centers on a foundational action (red border): **Routinely gather customer feedback**. Its inclusion in the strategy map reflects the importance of being responsive to customer needs. Technology supports include trip planning tools that use GTFS or GTFS-realtime information, social media, text messages for service alerts, websites, automated reminder calls, and instant surveys to gather rider opinions.

The strong customer-support actions related to useful data, training, and timely information reasonably results in effective communications and improved service delivery.

Accomplishing these strategies will certainly help improve the rider experience, which in turn directly supports essential goals around transit equity and community value.

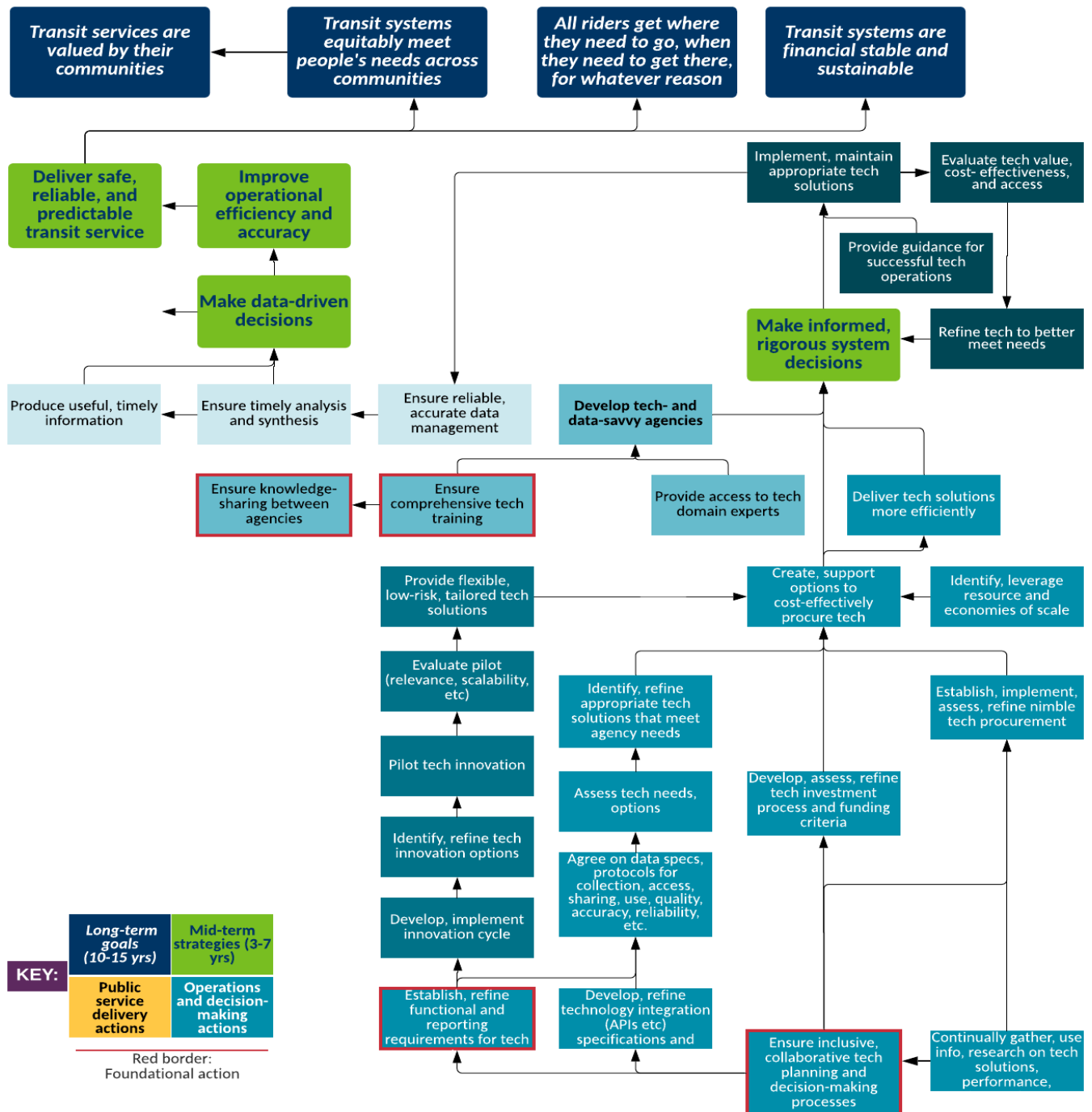
Figure 6: Customer Engagement Sub-cluster



STRATEGY CLUSTER: OPERATIONS AND DECISION MAKING

This robust, detailed Operations and Decision-making cluster explicitly applies to MnDOT and transit agencies, and directly supports key strategies around rigorous system decisions, data-driven decisions, operational efficiency and accuracy, and safe, reliable, and predictable transit services. These in turn drive all four critical goals: Transit systems are financially stable and sustainable, Transit services are valued by their communities, Transit systems equitably meet people's needs across communities, and All riders get where they need to go, when they need to get there, for whatever reason.

Figure 7: Operations and Decision-making Cluster



Sub-cluster: Knowledge Acquisition

This small but mighty set of actions addresses the critical need for agencies to acquire the knowledge and skills necessary to make informed and rigorous system decisions.

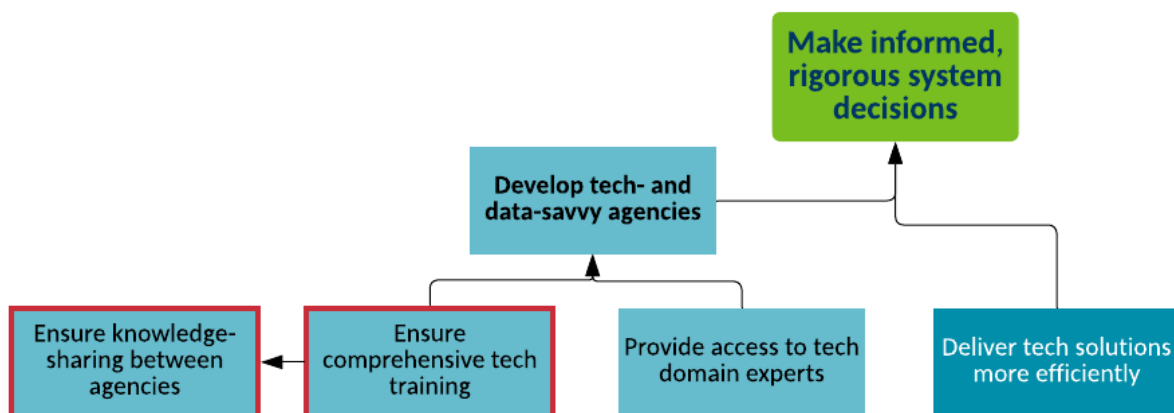
It begins with two foundational actions:

- **Ensure comprehensive technology training** is available where and when it is needed
- Explicitly calling out the tremendous value and benefits of **agencies learning from each other**

Also note that the knowledge-sharing action is a critical “bridge” between here in the Operations and Decision-Making cluster, and the Public Service Delivery cluster, where it provides the same important boost to strategies coordination, communication, and integration.

This sub-cluster also calls out the importance of ensuring **access to technology domain experts** from a variety of sources, and combined with **knowledge sharing** and **training** results in **tech- and data-savvy agencies** that are much better prepared to make informed and rigorous system decisions.

Figure 8: Knowledge Acquisition Sub-cluster



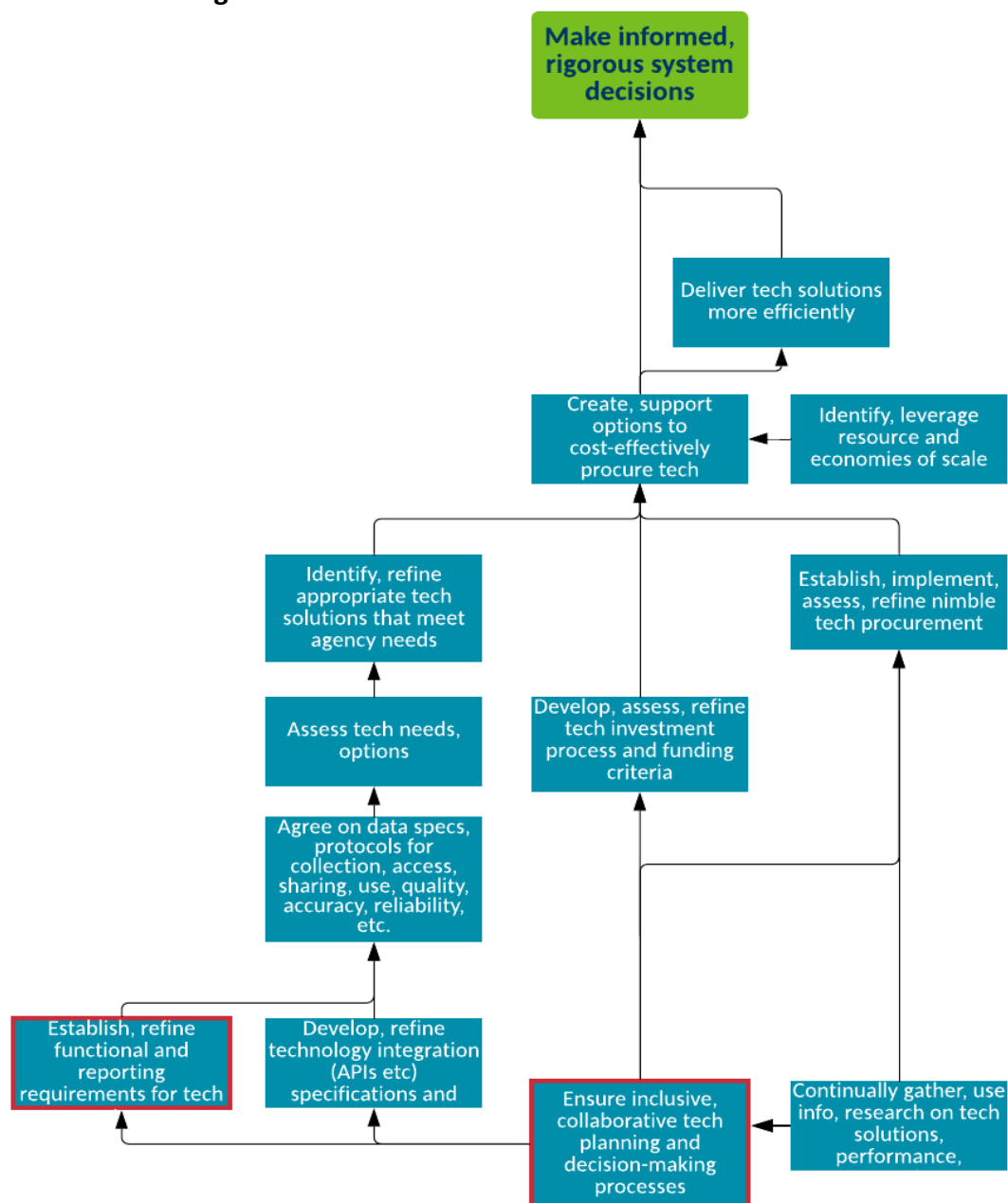
Sub-cluster: Procurement and Investment

This set of actions challenges MnDOT and transit agencies to collaboratively plan and implement various processes and actions in order to yield informed and rigorous system-level decisions. It holds two foundational actions (red borders):

- The first insists on **inclusive technology planning and decisions**, such as through a standing statewide advisory committee (e.g., the recommended Transit Technology Committee), routine consultations and feedback loops with transit agencies and other key players.
- The other foundational action to **establish technology system requirements** results from creating such a collaborative structure, plus an ongoing commitment to gather and incorporate the most current technology information and research into the work being done.

(Description continued on next page)

Figure 9: Procurement and Investment Sub-cluster



The left pathways build directly from quality information and collaboration to assertively detail actions needed to develop specifications and requirements. Two actions necessary to make significant progress in many areas are:

- Develop, refine technology integration (APIs, etc.) specifications and requirements
- Agree on data specs, protocols for collection, access, sharing, use, quality, accuracy, reliability, etc.

These actions will result in technology that is able to interoperate so agencies can obtain tailored solutions and increase coordination.

Combined with the essential actions around a **technology investment process and funding criteria**, along with a **“nimble” procurement process**, this results in cost-effective procurement and substantiated system decisions.

Finally, on the top right note the important actions that seek additional resources to support these technology investments (such as federal grant funding) and ways to leverage economies of scale – further supporting both cost-effective and efficient technology solutions.

Effectively communicating the procurement tools, procurement process, and funding opportunities helps ensure appropriate technology solutions are equitably acquired by Greater Minnesota transit agencies.

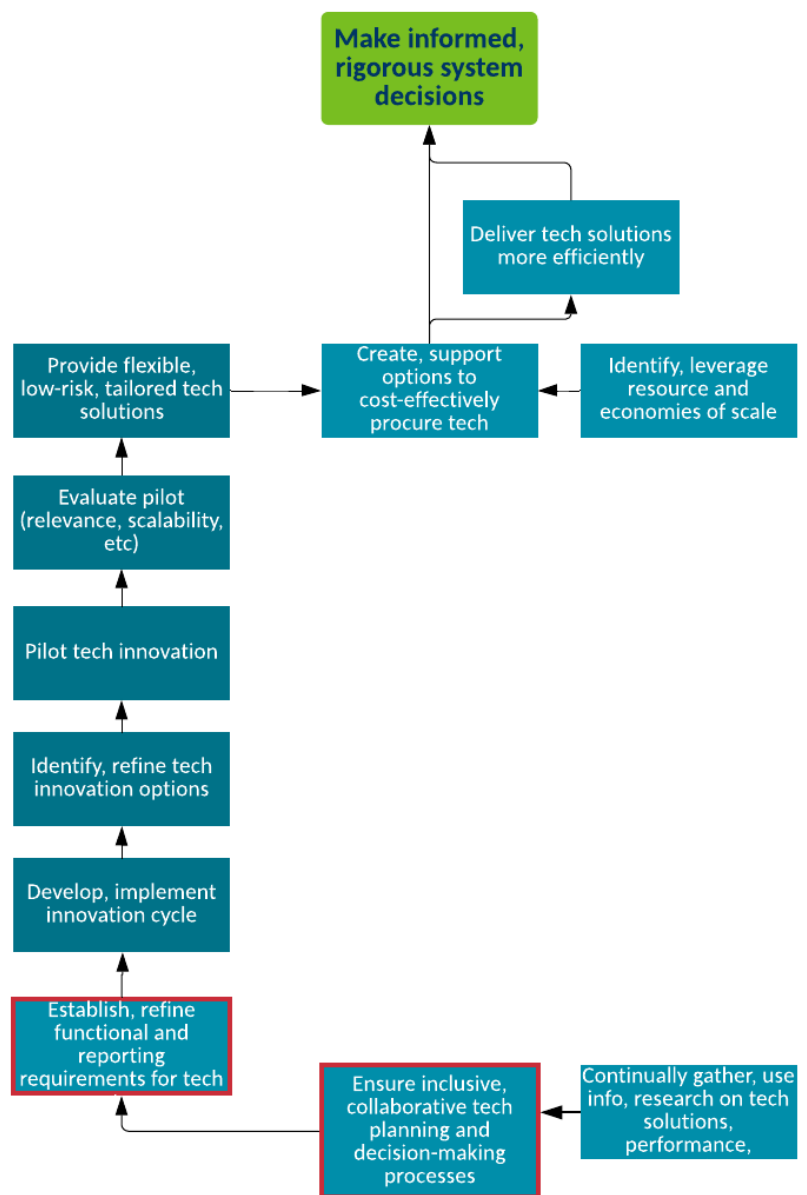
Sub-cluster: Innovation

Innovation projects are an important way to try new technology solutions and/or improve operations in a less risky manner. Numerous funding opportunities exist to ease innovation projects and allow other agencies to learn from the success and challenges of the projects.

The innovation pathway ensures Greater Minnesota transit agencies stay current on and have access to technology that benefits the people they serve. The actions put in place explicit processes to explore, pilot, and evaluate options, and then help make the best choices accessible.

Sharing the information learned from such projects will help other transit agencies learn and advance their technology knowledge and ability to apply it faster.

Figure 10: Innovation Sub-cluster

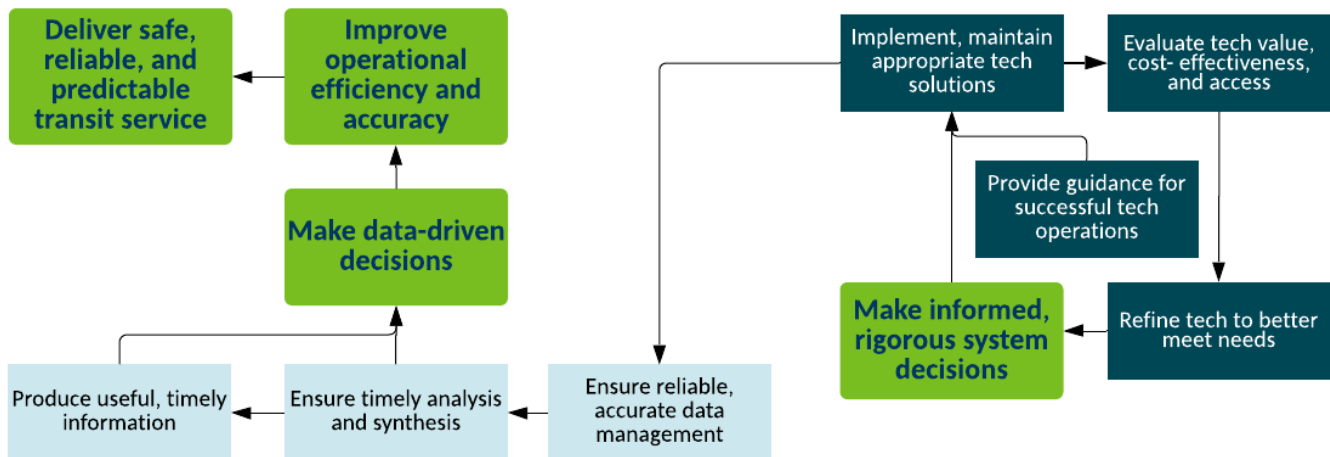


Sub-clusters: Implementation; Evaluation and Data

The two sub-clusters in the top right of the overall goal-strategy map (implementation/evaluation at right and data at left) are presented together because of the tight causal links: They advance all four key strategies in the Operations and Decision-making (green), and in turn drive toward all four long-term goals

As a result of the key strategy **making informed, rigorous system decisions**, note the actions call out technology implementation and maintenance, and use “appropriate” to ensure these are tailored to the diverse mix of transit agencies and service levels.

Figure 11: Implementation/Evaluation and Data Sub-cluster



With the addition of the action to provide agencies with the guidance they need for successful technology operations, this is the beginning of a “virtuous cycle” of **evaluation, refinement, decision making, and implementation** that measurably strengthens operations, internal processes, and results.

The implementation and maintenance action combined with the evaluation cycle specifically prepares organizations to deliver reliable and accurate data management, analysis/synthesis, and useful information (light blue). Emerging from the key strategy of informed and rigorous system decisions and the numerous, strong actions underlying it, together these support the critical key strategies (green) for data-driven decisions, operational efficiency and accuracy, and safe, reliable, predictable transit service.

CONCLUSION

The statewide goals and strategy map describes the critical work necessary to thoughtfully and efficiently integrate technology into transit planning, management, and operations. It will take time to adapt the existing planning, funding, management, and operations of transit agencies to include the technology considerations described in the strategy map and to increase the rigor of the transit technology efforts.

Those efforts are well worth the opportunity to advance the powerful statewide goals:

- Transit services are valued by their communities
- Transit systems equitably meet people’s needs across communities
- All riders get where they need to go, when they need to get there, for whatever reason.
- Transit systems are financially stable and sustainable

Transit Technology Flowcharts

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INTRODUCTION

Another resource to assist transit agencies in designing effective technology systems is the transit technology flowchart. These flowcharts, also known as transit stacks, illustrate the technology tools and processes used by transit agencies. These diagrams show the relationship of different transit technologies to each other and show the dependencies between them, illustrating what can be free-standing (such as on-vehicle cameras) and what may require foundational technologies to be in place. For example, Automatic Vehicle Location (AVL) is needed for several technologies. These dependencies can assist in identifying where it will be useful to integrate two or more systems.

Thinking about all the ways in which a transit agency uses technology fosters a system approach to technology development. This includes making decisions about how to develop the overall system as well as what needs to be interconnected and what can be free-standing.

While an overview of transit technology flowcharts is included in Chapter 4 of the main report, this document contains additional detail and sample flow charts for transit agencies of different sizes and complexities.

OVERVIEW OF TRANSIT TECHNOLOGY FLOWCHARTS

Each of the flowcharts has common features and will be used in similar ways. Each flowchart has five columns, as labeled here, and below each column are the technology systems related to that function.



**Service Planning
and Scheduling**



**Customer
Information and
Service**



**In-Vehicle
Technology**



Back Office



Reporting

These categories generally align with those described in the Resource Guides, but some Resource Guides (such as Communication with Riders and the Public and Customer-Facing Trip Planning) will fall into the same flowchart category (Customer Information and Services).

SAMPLE FLOWCHARTS

Three flowcharts are presented in this document. The first, Figure 2, is intended for agencies with fewer than 10 vehicles in their fleet. Automated processes or software may not provide enough benefit to these agencies to implement many transit technology systems. They can, however, use a mix of spreadsheets and lightweight technology with thoughtful integrations. The second flowchart, Figure 4, is for medium agencies or those with 10 to 29 vehicles. It offers some guidance on optional components to consider if an agency has the capacity to maintain the additional technology. The third flowchart, Figure 5, is one appropriate for large agencies (30 or more vehicles). It is the most complicated, but it also illustrates the most comprehensive set of technology systems and relationships.

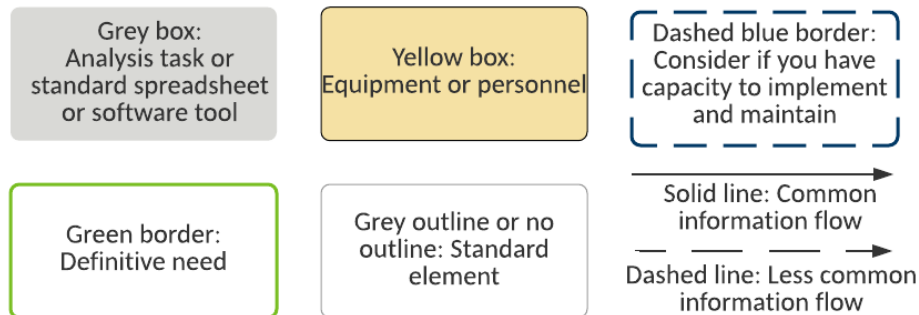
These typical flowcharts are intended to guide transit agencies and identify the relationships between technology systems and how they may develop the technology that is right for their agency. The reader is cautioned to keep in mind the diversity that exists between transit agencies. Even within a given size category,

two agencies will have different technology need and make very different technology decisions. An agency with three vehicles will look quite different than an agency with nine and, therefore, have different technology needs.

Flowchart Legend

The diagrams presented on the following pages show how technology components fit together. The legend image indicates the type and criticality of each element. The colors of the box represent the type of element as follows:

Figure 1: Legend for Transit Technology Flowcharts



- Grey boxes represent software or spreadsheet tools or analysis tasks. These tasks might be automated via a software tool, or it could be a multi-step analysis process that an employee follows.
- White boxes indicate data that results from a technology tool or process.
- The cream-colored boxes indicate where an element is a piece of equipment or agency personnel (such as a driver). Agency dispatchers, drivers, and maintenance personnel are critical components of a technology program.

The borders of the boxes represent how critical an element is to the operation:

- Items outlined in a solid green line are those which any agency should consider having as part of their technology stack.
- Elements outlined in a dashed blue line are elements that should only be considered if an organization has the capacity to implement them. These might be commonplace, but they take resources to implement and maintain. Agencies and MnDOT should think about how they will be maintained over the course of their life, and if the time required is worth the resulting data/information that tool can generate.
- Items with a grey border are generally standard, or each agency might determine if they apply to their operation based on other elements of the technology stack.

The lines in the diagram also indicate a direction that information flows. The information may be generated by a technology system, equipment, or staff. It may be transmitted manually (such as through a report) or electronically, such as AVL information that flows automatically to one or more technology systems.

Solid **black lines** are common flows - that is, a standard tool should generate the information to a report or format that can be used by the downstream tool. An example is that the demand-response schedule and dispatch software will generate a schedule, which might be printed as a paper manifest for a driver or pushed to an MDT or tablet in near-real-time. The **dotted lines** indicate flows that are important for processes to work

together, but the integration is not yet commonplace. An example of this is that while GTFS data has become the de facto standard for fixed-route schedule data, not every software system allows users to export GTFS data.

Small Agency Technology Flowchart

For agencies with fewer than ten vehicles, a combination of manual processes, sturdy equipment, and some easy-to-use tools can provide flexibility without a high maintenance or financial burden.



Service Planning and Scheduling. The must-have tools for scheduling demand response trips might be enterprise software tools, but they could just as easily be spreadsheet tools. The resulting schedules might be pushed over to the “In-Vehicle Technology” column to a driver tablet. If tablets are not the right choice for an agency, then the schedules would be printed for the driver. Another important tool for small, fixed route services is GTFS data, generally in a static format (as opposed to GTFS-realtime). Spreadsheets can be used to submit GTFS data, but digital tools are also available.



Customer Information and Service. A website that provides customers with accurate and updated information is a critical technology system for all agencies. Another important item for small transit agencies is a telephone system, preferably capable of making automatic calls to riders using interactive voice response (IVR) technology and capable of sending and receiving text messages (SMS technology).



In-Vehicle Technologies. Small agencies have a variety of in-vehicle technologies, but they are more likely to use simple or mechanical versions rather than digital versions. Fareboxes, radios and cell phones, cameras, tablet for drivers displaying demand response trips, AVL, and headsigns for fixed route buses are all common. Most systems are likely to be free-standing rather than integrated.

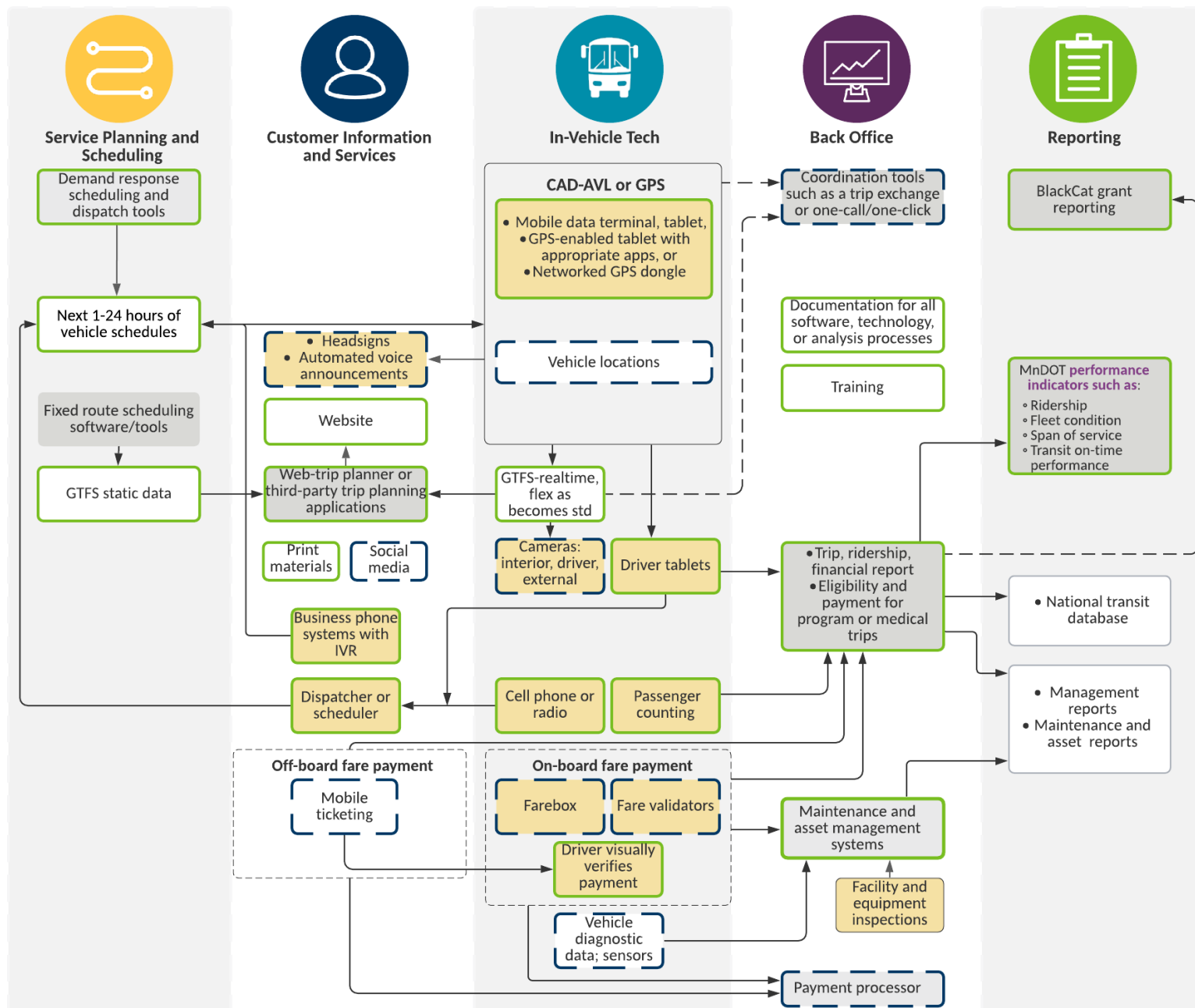


Back-Office. The most common systems are those supporting the tracking and reporting of ridership, trips, and financial reports. Also important are those supporting tracking and reporting eligibility of trip costs for specific funding programs and billing the fund source for trips delivered. Some common programs are ones providing medical trips, all types of trips for people who are elderly, and trips for job access and training activities. Another technology system that is widely used are maintenance or logistic programs that enable tracking of maintenance, identifying upcoming preventive maintenance, and/or allowing for pre- and post-trip vehicle inspections by drivers.



Reporting. While it may be simpler than for more complex transit agencies, all of the transit agencies in Greater Minnesota submit financial, performance, and asset reports into BlackCat. National Transit Database information also must be reported. Additionally, all agencies need to prepare basic reports for their funding agencies.

Figure 2: Small Agency Technology Flowchart



Customer Information and Services is the point where planning and operations intersect. On the diagram, this is illustrated by lines between the columns. For example, drivers generally use cell phones or radios to communicate with dispatch and administration in order to report/ receive emergency information, schedule changes, and other relevant information. A radio or cell phone connection to the dispatcher may also be the means by which dispatchers update customers on their vehicle's arrival time. The dispatcher can then enter the information back into the scheduling system or provide other necessary updates.

There are a number of elements outlined in a dashed blue line, indicating they could be considered if an agency has the capacity to implement and maintain them. Examples include:

- Third-party trip planning applications. If an agency generates GTFS or GTFS-Realtime data, there are online aggregators of this information that can help expose the feeds to trip planning tools, including Google Maps, Apple Maps, and the Transit App (among other trip planning applications). These applications have APIs that an agency could use on their website, which would allow customers to plan trips directly on the agency's website.
- Just as maintaining a website takes resources, maintaining social media accounts and up to date print materials can take significant staff time. While print materials could be updated at semi-annual or annual intervals, the same information posted on a website can be updated more frequently. Social media could be used to share more time-sensitive information (such as service changes due to construction or special events).
- Vehicle diagnostic data can be helpful for fleet management, but if the mechanics follow a recommended maintenance schedule based on dates and mileage, it might not be necessary.
- Similarly, cameras can be a way to mitigate risk. The captured video can be used for incident investigation, meeting insurance requirements, and even used in training to identify opportunities for improvement. As with other tools, the time invested in maintaining cameras might be compared to benefits in the form of reduced insurance costs, reduced maintenance costs or customer complaints, or improved driver performance.
- GPS dongles are inexpensive hardware that can be installed in the vehicle allowing dispatchers to know where vehicles are located. These are rugged, mature devices that use standard cell networks and affordable software-as-a-service systems. They are often called "telematics".
- Computer Aided Dispatch (CAD) coupled with Automatic Vehicle Location (AVL) is often referred to as the combination CAD/AVL. The CAD aspect allows dispatchers to plan routes, schedules and detours as well as manage driver runs. The AVL aspect allows for real-time monitoring. Working together, CAD/AVL allows transit managers to visualize, process and react to schedule adherence, headways, and (when combined with passenger counting) vehicle loads.
- Finally, fare payment technology is part of the customer as well as in-vehicle columns. Some smaller agencies are finding value in mobile ticketing systems. Mobile ticketing options have expanded in recent years and there are several mature options on the market. These systems might depend on a driver to visually validate a customer's ticket, or they could use fare validators. If an agency does not accept fares or offers donation-based services, then fareboxes on vehicles likely are not necessary.

Minimizing the amount of equipment in the vehicle can be beneficial to drivers as well as technology maintainers. This is especially true in small agencies but is also applicable to larger agencies. It is worth noting that there are some technology vendors that offer "lightweight" technology solutions that do not require significant equipment investment for interoperability. Ubitransport is one vendor that offers a dashboard for

monitoring CAD-AVL, and the system includes a simple fare payment module, as shown in Figure 3. The fare payment system allows customers to pay cash (which a driver logs via a smartphone/tablet application) or use a tap card. In other words, the same equipment is used for tracking vehicle location and recording fare information. The smartphone/tablet could have a variety of applications loaded, and if other applications use open standards or offer APIs, there is a higher likelihood these applications can interface with the current system components. Simple web forms (like Google Forms, Survey Monkey, or ArcGIS's Survey123 tool) can also be used to record information on the smartphone/tablet. In this way, boxes that appear separately in the flowchart diagram could be served by the same piece of equipment.

Figure 3: Example of Lightweight Card-Reader and Smartphone In-Vehicle Technology⁹



Medium Agency Technology Flowchart

For agencies that have between 10-29 vehicles, service might be primarily fixed-route, primarily demand response, or a mix of the two. From an operating standpoint, this can be challenging because these are distinct services, and the products/software tools available for one do not necessarily translate to the other. This flowchart, Figure 4, builds on the small-agency stack. While many of the same technology systems are needed, for this size agency each may be more sophisticated and have more features. Additions to the small agency technology flowchart include the following:



Service Planning and Scheduling. A medium-sized agency is more likely to benefit from scheduling and dispatch software for demand response trips and less likely to find spreadsheet tools to be adequate.



Customer Information and Service. These larger fixed route systems are also likely to find GTFS-realtime information to be a valuable addition for customers, a supporting a web-based or third-party trip planning application. At this juncture, it is important to consider if the scheduling and dispatch software accurately generates GTFS-realtime data streams.

⁹ Source: <https://www.ubitransport.com/wp-content/uploads/2018/09/ubitransport-quipe-la-ca-privas.jpg>



In-Vehicle Technologies. Advances in this area include having a more sophisticated CAD-AVL system, integrated headsigs and automated voice announcement systems, and automated passenger counters. Integration of CAD-AVL systems is an important technological step involving significant staff time and likely the service of a domain expert.

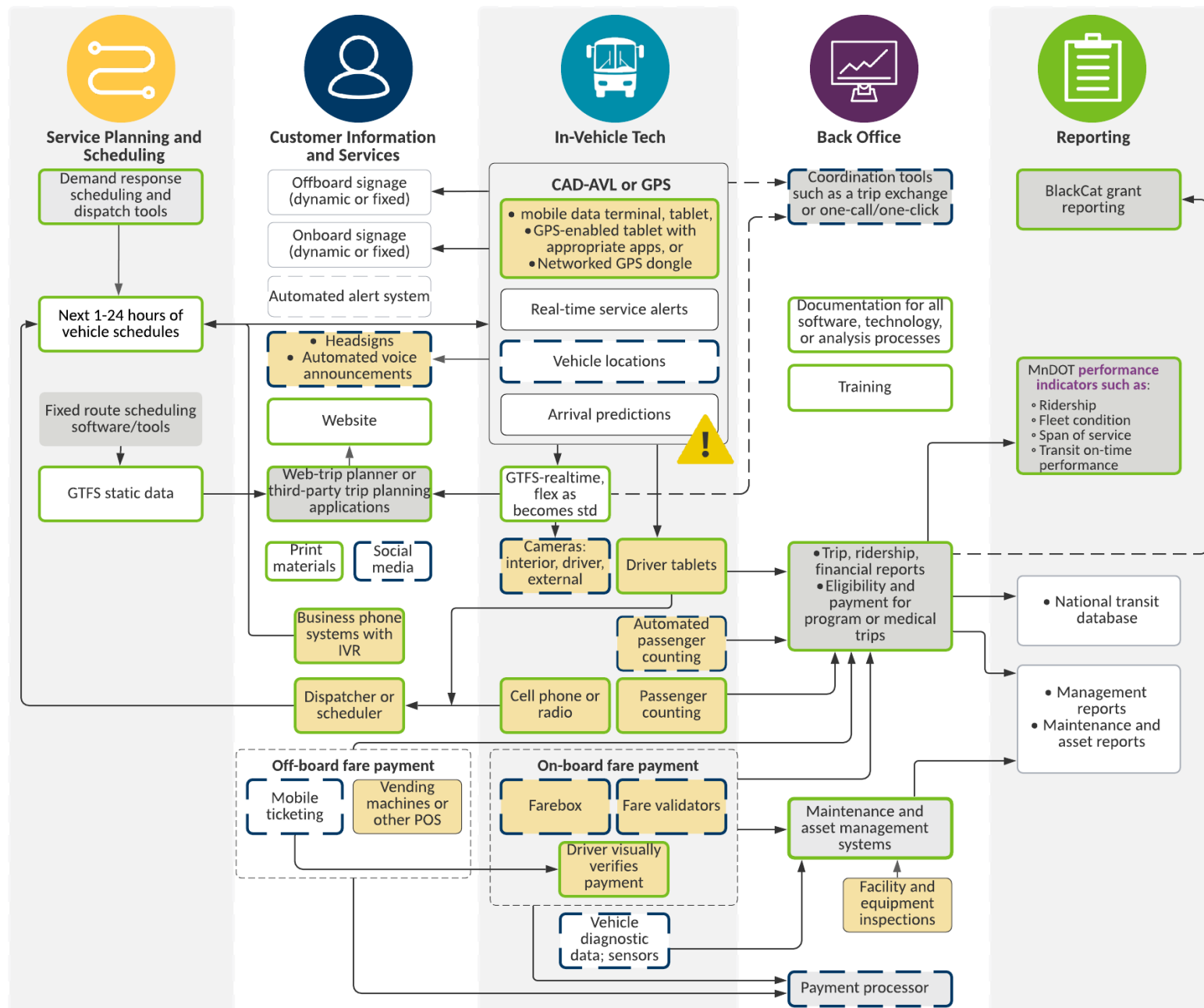


Back-office. Agencies of this size might support ticket vending machines or other points of sale, such as grocery stores that keep fare media available for sale. Most medium-sized agencies will have maintenance software in place that generates and tracks work orders, allocates mechanic time, and maintains an inventory. They may also have a module for asset management functions. Many components of the transit flowchart can inform administrative, operational, and reporting activities if data is exported and manipulated in support of those functions.



Reporting. While there are no significant additions, the larger and more complex the transit agency, the more complex the reporting requirements will be. While all agencies have back office and reporting responsibilities, full integration of these systems may not be a priority except for the larger agencies. It is useful for medium-sized agencies to begin considering where back office and reporting responsibilities may link to other activities. For example, all agencies need documentation of technology systems.

Figure 4: Medium Agency Technology Flowchart



CAD/AVL

At this size, an agency's services may be large enough to benefit from CAD/AVL technology while also being small enough to use the same dispatchers or vehicles to operate both fixed-route and flexible services. There is a CAUTION symbol on the CAD/ AVL portion of the flowchart to remember that these tools are not one size fits all – the transit agency's business model and service policy will influence and be influenced by the selected technology. At this level, GPS-enabled tablets with the right combination of applications might be appropriate for an agency. These tablets could have applications pre-loaded for drivers to complete rides and collect fares; the same tablet could have applications for inspecting vehicles and equipment to log in to an asset management system. Procuring unique equipment and software for these management and reporting activities can be time-consuming and expensive, so consider whether the same equipment can be utilized, like ruggedized tablets, for multiple purposes.

Vendors tend to specialize in either one service mode or another, resulting in a complex set of trade-offs when assessing the value of using one vendor's solution for all modes or integrating two vendors' solutions to work together in one dispatch center or on one vehicle (e.g., using one tablet to support multiple vendor apps). Selecting different vendors for the different services is more feasible today than before as many specific applications have made efforts to integrate their services. For example, a fare payment application may be integrated with a mobile app designed for customer information. It is reasonable to consider using scheduling software for demand response services and spreadsheets for fixed route vehicle schedules. When exploring options, careful consideration needs to be given to a wide range of factors, including long-term agency goals, existing vendor relationships, the internal capacity to support the integration of technology systems, and budget.

INTEGRATED HEADSIGNS AND AUTOMATED VOICE ANNOUNCEMENTS

Agencies of this size with fixed route services may benefit from integrated headsigs and Automated Voice Announcements. These systems provide benefits to customers while relieving some of the burden on drivers. An important issue as agencies get larger is the degree of integration of these systems.

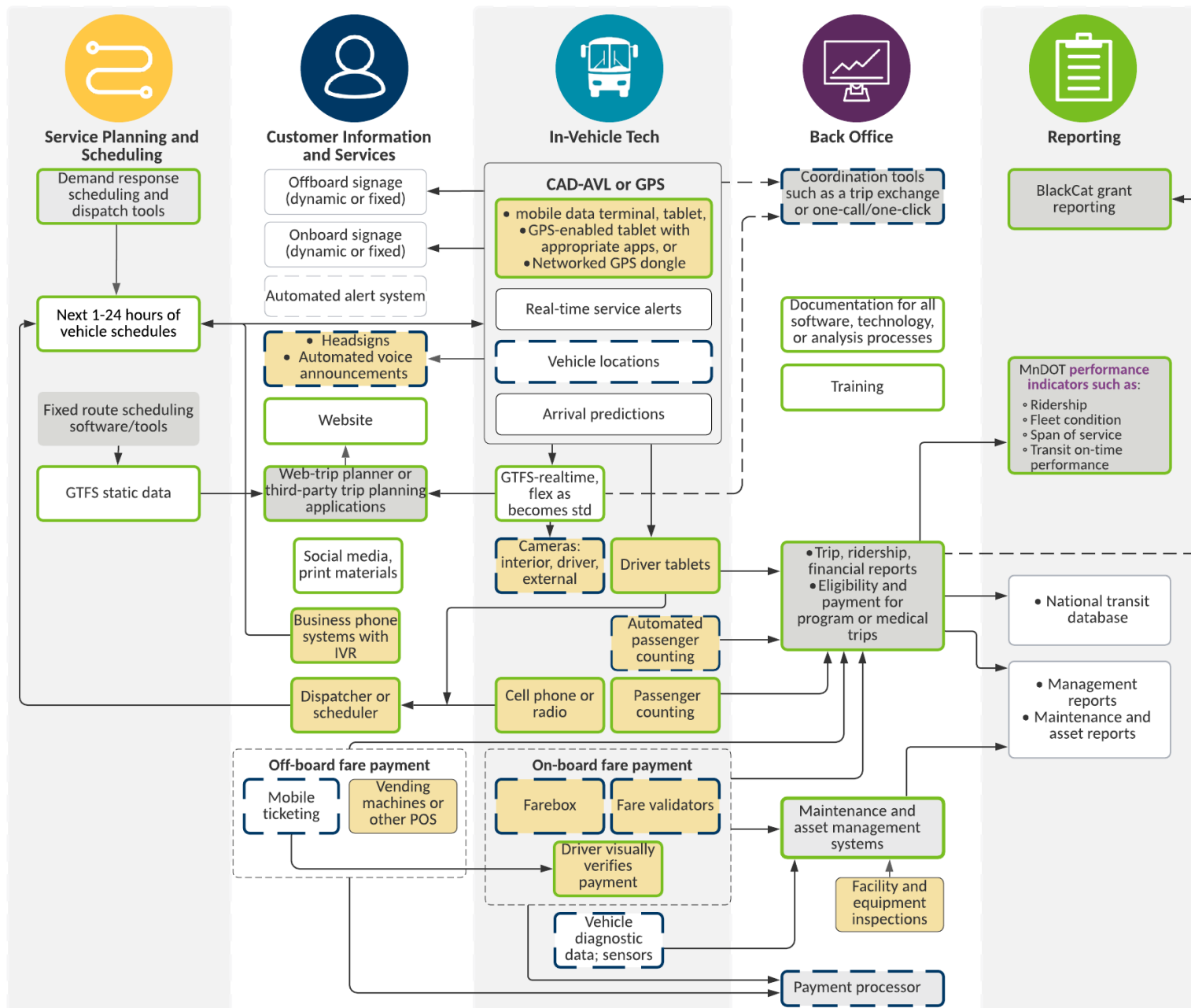
AUTOMATED PASSENGER COUNTERS

Automated Passenger Counting (APC) might be needed in the busiest fixed-route agencies, potentially only on selected routes or during times of day when demand is higher. The need for APCs is related to the farebox system and fare media used. Transit agencies could ask themselves whether is such a system needed to assure reliable ridership figures.

Large Agency Technology Flowchart

This comprehensive stack is designed for the largest agencies and builds on the stack for medium agencies. Again, for larger agencies, each technology system may be more sophisticated and contain more features. Importantly, more systems are integrated rather than free-standing.

Figure 5: Large Agency Technology Flowchart



Additions to the large agency technology flowchart include the following:



Service Planning and Scheduling. While no significant additions are identified, a large agency is likely to require scheduling and dispatch tools with adequate detail and flexibility to respond to the complexity of the services provided.



Customer Information and Service. These larger fixed route systems are also likely to find GTFS-realtime information to be a valuable addition for customers, supporting a web-based or third-party trip planning application. GTFS also has benefits for service planning and reporting as it can be used to gather information for service planning. GTFS is an open data standard, allowing agencies to work together and share data for traveler applications.



In-Vehicle Technologies. A more sophisticated CAD-AVL system with an integrated mobile data terminal as an option. AVL systems are integral to a transit agency's technology systems.



Back-office. A full-featured maintenance and asset management system, more comprehensive payment processing systems, and coordination tools may all be considered. The asset management system may use vehicle diagnostic data and include facility and equipment inspections. A payment processor is needed for a mobile ticketing solution, typically managed in the "Back Office" by an agency's finance team. Coordination tools enable planning by using GTFS or other map data. Sometimes they allow booking/re-booking or cancellation. For booking or cancellation, these tools need to ingest real-time information about available provider capacity and potentially be able to send and receive information from driver tablets/ manifests in order to modify trips.



Reporting. Additional integration of technology systems is likely to be a priority.

Looking at the large agency technology flowchart, one can see why the integrated vision for planning, booking, and payment for transportation can be complicated. For example:

- Information from many systems feed into the "Back Office" and "Reporting" columns. Many of these information flows are solid black lines because there are likely already processes in place to, for example, translate trip, ridership, and financial reports into MnDOT's performance metrics or for National Transit Database (NTD) reports.
- The Trip Planner and Off-board Fare Payment components in the first column connect to a scheduling tool (to reserve the trip), as well as potential coordination tools (in the Back Office column) such as a One-Call/One-Click system

Other connections are generally less established in the industry and are indicated with the dashed line:

- Coordination tools, while increasing in number, are not widespread. These tools enable planning by using GTFS or other map data. Sometimes they allow booking/re-booking or cancellation. For booking or cancellation, these tools need real-time information about available provider capacity and potentially be able to send and receive information from driver tablets/manifests in order to modify trip schedules.
- In Minnesota, transit agencies are able to upload ridership performance metrics by uploading comma-separated values (csv) files into BlackCat. However, at present, transit agencies are not able to upload csv files for financial reporting into BlackCat, necessitating manual entry for each line item.

TECHNOLOGY FLOWCHART SUMMARY

These three examples present guides to assist transit systems to identify the relationships between technology systems and how they may develop the technology that is right for their system. In these diagrams, the ability for elements to function in the system is related to those supports. Some examples include:

- Documentation of Standard Operating Procedures for data governance is a major challenge for many state DOTs and agencies. To be able to share data among agencies, a consistent procedure and format for that data are important. Anywhere that data is used for “Back Office” or “Reporting,” a common standard should be defined. This standard does not need to be complicated - defining the type and content of key variables for each report can simplify reporting.
- The technology stack is also subject to cybersecurity best practices; agencies should maintain an inventory of physical and digital technology assets and who has access to them. Using electronic payment options creates additional challenges to assure that customer’s payment data is secure.
- Personnel who translate and relay information between planning, operations, and maintenance need appropriate training and other supports to ensure the technology is “talking” to one another.
- Managing the technology stack requires keeping up with training and market research. In the market, there are typically “single-vendor solutions,” which are large enterprise software systems that can perform a wide range of functions. With the growth of software-as-a-service (SaaS), more modular, custom-built applications have emerged. These custom applications tend to be purpose-built to perform specific tasks and generally utilize open standards or documented APIs that can be used to share information.

Transit technology flow charts support the system approach to technology development that is integral to the MnDOT Greater Minnesota Public Transit Technology Plan. Such systems planning will support a strong development strategy, a capital plan for replacement and new technology, and a maintenance plan for technology, feeding into both operating and capital budgeting processes.

Transit Agency Assessments and Growth Plans (including samples and forms)

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[3 - Growth Plan Template](#)

[4 - Sample Growth Plan](#)

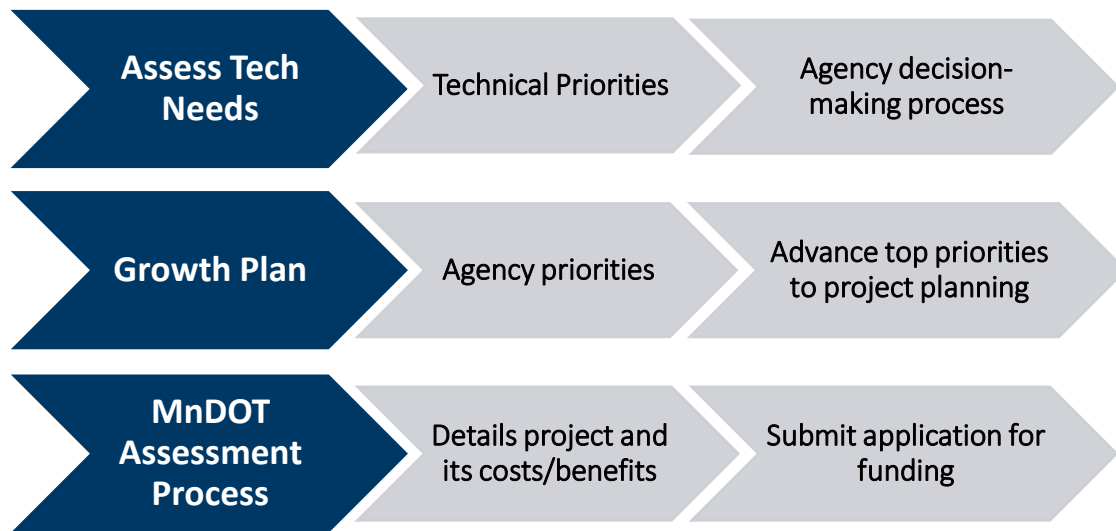
INTRODUCTION

The materials in this appendix provide templates and examples for 1) assessing technology needs, and 2) developing a growth plan.

The objectives of these activities are to identify agency technology needs and then, in conjunction with agency leadership, prioritize and refine a list of technology projects that has the support of agency leadership. This remains fairly high-level planning.

Additional project planning specific to one project is expected to be needed as part of the grant application process and/or as a specific project implementation activity.

Figure 1: Assessment, Growth Plan, and Project Planning Activities



1: TRANSIT AGENCY TECHNOLOGY ASSESSMENT TEMPLATE

INSTRUCTIONS: This template is a Word document that is intended as a guide. As such, the writer may adapt it to suit the needs of the agency. It can be embellished or streamlined. Use this template in conjunction with the Sample Assessment as the sample provides an idea of the appropriate level of detail and items that are important to consider.

This assessment largely is technical, asking: What technology systems exist? What systems are not in place and how would they improve agency functionality? What is due for upgrading? It is a high-level assessment rather than detailed.

This is to be written for the agency leadership (it may be a team of people or a single manager) as well as for funders who may not be familiar with the details of the system. For people who may not be familiar with your system, it is important to provide background information. For all readers, it is important to link the recommendations to how the proposed investment will help the agency meet its goals and improve primary functions.

Instructions are italicized and in a blue font. Delete these as you complete each section. The sample that follows has an assessment that has been completed. Use the sample in conjunction with this template.

Cover Information

Agency Name

Technology Systems Assessment

Date

Assessment Completed by: This may be staff or an outside contractor

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Table of Contents

Longer documents benefit from a table of contents.

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Executive Summary

Managers and other decision-makers often appreciate a summary. Include the key findings and recommendations.

1. Introduction

Identify the audience, scope, and focus of the assessment. Is this a baseline assessment or an update brought on by a single project?

Identify who has prepared the assessment and the audience.

2. Current Conditions

The assessment should begin with a brief description of the agency's general context. This may include demographic and geographic facts related to the service area, current services, annual ridership, fleet size, staffing levels, annual budget and funding sources, growth patterns, and any other additional information that allows the reader to better understand the environment where technology investments would be made.

Address:

- *Service area*
- *Services operated*
- *Operations*
- *Finances*

The sample document uses tables to concisely present information in each category. It is helpful to include any planned changes, in addition to existing conditions, as planned changes may affect technology needs. You may copy and adapt the tables from the sample or present the information in another format. Tailor the information so it is appropriate to the agency.

If this is an update for a specific project, describe the planned project. Address:

- *Project scope*
- *Benefits*
- *Schedule*
- *Budget*

3. Agency Goals

Identify key goals, and/or the functions the technology plan is seeking to improve. This section is important in describing to the reader why and how the technology improvements will aid the agency in meeting its goals, better serving customers, or improving efficiencies.

4. Technology Supports

Provide a brief overview of the agency's capacity to support technology investments. For each relevant technology support category, identify where they are strong and where improvements are needed.

5. Analysis of Current Technology Systems

Compare the technology systems in place to those in the MnDOT Baseline Transit Technology Reference Chart (see Chapter 4 of the Greater Minnesota Public Transit Technology Plan). Compare the existing technology systems with those identified as appropriate to an agency of similar size and complexity. Remember that the Reference Chart is a guide. If there are items that do not seem appropriate, they can be skipped. If there are items not listed but which would provide value for your agency, add them, perhaps with an explanation.

6. SWOT Analysis and Recommendations

A SWOT analysis is recommended as a simple but comprehensive way to identify recommendations. Address the following categories: strengths, weaknesses, opportunities, threats.

Finally, identify recommended improvements. The recommendations in the sample are very brief examples. An actual assessment should include enough information so that the agency can clearly understand the “what” and the “why” of each recommendation. For recommendations that include a technology investment, support-related and technical elements of a cost-benefit analysis (CBA) should be included as part of that recommendation. These elements would then be incorporated into a broader CBA that may also include non-technical costs and benefits such as environmental impact or equity considerations.

List them in order of priority and identify any that need to be grouped together or for which the sequence is important. These recommended priorities will be presented from the standpoint of technology and improving functionality within the agency.

The next step is to take these recommendations forward through the agency decision-making process, where they will get weighed against other agency priorities.

2: SAMPLE AGENCY TECHNOLOGY ASSESSMENT

Acme Transit Service

Technology Systems Assessment

December 31, 2020

Assessment Completed by Very Good Consulting (VGC)

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3. Agency Goals

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5. Analysis of Current Technology Systems

6. SWOT Analysis and Recommendations

6.1 Strengths

6.2 Weaknesses

6.3 Opportunities

6.4 Threats

6.5 Recommendations

Executive Summary

Acme Transit Service (ATS) provides fixed-route and demand-responsive services to Anytown and the surrounding area. The agency is in a good position to invest in new technology, and its service types should be adequately served by technology currently available on the market. By procuring more specialized systems instead of a single solution serving both fixed and demand-responsive modes, we believe that ATS can achieve its goals more quickly and at a lower cost.

Summary of Technology-Related Recommendations

Following the process established by MnDOT for transit agency technology assessments, ATS agency developed the following recommendations:

- **Strengthen Documentation of Systems.** For those staff who have critical and undocumented system knowledge, adjust workloads to schedule time to document standard operating procedures (SOPs) and support staff cross-training.
- **Organize Change Management at the Agency Level.** Rather than planning upgrades at the department level, schedule them for the entire organization to minimize unintended side effects.
- **Seek Domain Expertise for Planning and Development of Technical Requirements.** Rather than manage procurement in-house, engage technical expertise (i.e., a contractor, another agency) to develop technical requirements and assist with the procurement process.
- **Procure a Standards-Compliant Real-Time Vehicle Location System for Fixed Route.** Engage with MnDOT staff to see what similar agencies have procured and review their implementation process. Carry out a market survey and consider releasing an RFI.
- **Replace Demand-Responsive Scheduling and Dispatch.** Based on the roadmap provided by the software vendor, the current system should be replaced in the next 2-3 years.
- **Procure a SaaS Fleet Management System.** Based on the roadmap provided by the software vendor, the current system should be replaced in the next 2-3 years.
- **Carry Out a Cost-Benefit Analysis for Automatic Passenger Counters (APC).** While APCs may be beneficial for the agency, a full analysis is outside the scope of this assessment. We recommend partnering with MnDOT and other interested agencies to explore options.

1. Introduction

1.1 Assessment Audience, Scope, and Focus

As Minnesota invests in small and rural transit services, those service providers face a complex array of options for technology solutions to help them grow. This assessment is intended to guide decision-making about the procurement and implementation of technology, and considers all aspects of transit operations, from fleet management and dispatching to rider-facing applications.

Our recommendations are based on the landscape of current and future technology options and the unique needs and attributes of the agency. They prioritize the most urgent needs of the agency as well as those that have the largest potential impact.

1.2 Sources of Information

This assessment is based on information gathered in a phone interview by VGC staff with the General Manager, an onsite visit, and in-person interviews with the following staff: [*schedulers, dispatchers, drivers, IT specialist, etc...*]

2. Current Conditions

2.1 Service Area

Service area	120 square miles
Service area population, 2018	56,536
Average Population Density, 2018	1,052.2 people/square mile
Percent Age 65 or Older, 2018	14.7%
Percent Under Age 65 with a Disability, 2013-2017	14.8%
<i>Other facts that might be useful to inform the report, e.g., median income, languages used, etc.</i>	The 65 and older population is projected to grow 85% in the next five years, from a current 8,300 to 15,400, comprising 25% of the total population

2.2 Services

Total Count of Routes, Fixed and Intercity	• 12 Fixed routes • 1 Intercity route • Combined paratransit & dial-a-ride • A seasonal service to a nearby ski resort
Total Route Miles, Fixed and Intercity	• 120.08 Fixed route miles • 30 Intercity route miles
Planned Changes	• 3 additional intercommunity services to towns around the greater Anytown area, resulting in 45 additional route miles.
Total Trips, 7/2019 to 6/2020	412,585
Estimated Trips by Riders Age 65 or Older, 7/2019 to 6/2020	90,600, 22% of total
Total Vehicle Service Hours, 7/2019 to 6/2020	35,976
Total Vehicle Service Miles, 7/2019 to 6/2020	560,805

2.3 Operations

Vehicles Used for Service	• 15 40-foot buses (requiring CDL) • 10 14-passenger cutaways (not requiring CDL) • 2 Ford Transits • 1 Trolley
Drivers	• 20 full-time paid • 15 part-time paid • 0 volunteers
Non-Driver Paid Staff	• 1 General Manager • 1 Assistant General Manager • 1 CFO • 1 Grant Manager • 1 IT Specialist • 3 Mechanics • 1 part-time Service Planner • 2 Dispatcher/Administrative Specialists • 2 Field Supervisors

2.4 Finances

Total operating budget, 7/2019 to 6/2020	\$ 4,632,237
Funding Sources, 7/2019 to 6/2020	• 5310, 11% • 5311, 35% • 5339, 5% • Older American's Act, 14% • Local taxes, 25% • Farebox, 10%

2.5 Current Project

(Include this section only if assessment is associated by a specific technology project)

ATS needs to replace its current fixed route scheduling and dispatch system.

Scope

The project is anticipated to replace the following current systems:

- The existing scheduling and dispatch system
- Several spreadsheets being maintained by operations and fiscal staff
- Personnel tracking (timesheets, training, and licensing requirements)
- [...]

The project is expected to affect the following systems that will remain in place

- Financial software
- Asset management system
- [...]

Benefits

The updated system will reduce the time required for various manual systems and will integrate some processes. Once in place, it is estimated to save approximately 48 hours of labor per month, reducing administrative costs per ride, and enabling the agency to continue functioning with current staff levels. We anticipate only a minor improvement in productivity (e.g., about 0.2 trips per hour) but that too will improve system productivity. The updated system will have improved security features.

Schedule

Funding will need to be applied for and could take two years to get under contract. This project will need to also consider two related activities: (1) upgrading of the fleet maintenance software and (2) the addition of GTFS-realtime data.

Budget

Total grant amount is \$80,000, with an agency match of \$20,000.

3. Agency Goals

Acme Transit is expecting service expansion in the coming year and is interested in procuring technology to help operations run more smoothly and to enhance riders' experience. Priorities are ranked as follows:

1. Increasing service reliability
2. Improving rider access to real-time service information
3. Reducing manual effort involved in tracking preventive fleet maintenance
4. Meeting increased service demand
5. Reduce manual effort tracking personnel-related tasks

These agency goals stand in addition to key strategies established by MnDOT with respect to technology:

- Make informed, rigorous, and data driven system decisions
- Improve operational efficiency and accuracy
- Deliver safe, reliable, and predictable transit service
- Improve rider experience
- Build community mobility

These strategies support the following overarching goals for public transportation in Minnesota:

- Transit services are valued by their community
- Transit systems equitably meet people's needs across communities
- Transit systems are financially stable and sustainable
- All riders get where they need to go, when they need to get there, for whatever reason

4. Technology Supports

The following table provides a brief overview of the agency's capacity to support technology investments. Ratings are approximate and intended to convey rough levels of effort required. A number one rating indicates the most action is needed; a number three rating indicates no action is needed.

Support	Level of Effort	Comments
System Design & Planning	1	Staff have articulated that developing the technical requirements for a scheduling and dispatch system feels overwhelming
Procurement	2	Resources for the non-technical elements of procurement are in place, though they require that staff be pulled away from regular duties
Grant Management	3	Grant management staff are capable of overseeing grant requirements
Vendor Support	3	Vendor support for current systems is satisfactory
Training	2	Training is available as staff request it, but it is being managed on an ad-hoc basis without consideration of minimum or recurring training expectations for some positions.
Documentation	1	Many systems are managed by single staff people who hold key knowledge in their heads. There is risk of significant system knowledge being lost in the event of a sudden staff departure
Access to Domain Experts	2	Local IT support for non-transit systems is good
Cybersecurity	2	Current tracking of PII is minimal, resulting in low risk. There is currently no recurring cybersecurity training in place to mitigate the risk of phishing attacks, ransomware, etc.
Evaluation of Outcomes	N/A	There have been no recent major investments subject to evaluation
System Testing	N/A	There have been no recent major investments subject to testing
Other supports	3	Internet access is fast and redundant

5. Analysis of Current Technology Systems

Systems addressed in this analysis are based on the MnDOT [Baseline Transit Technology Reference Chart](#) (Figure 4.3). The following statements compare Acme's existing applications with the baseline reference chart.

- Acme Transit is using Apex software for paratransit scheduling and reporting. This system offers basic scheduling functionality, but lacks some features desired by the agency, including a calendar view, multiple route view for intuitive scheduling, and more automatic processes for tracking customer information. Scheduling currently requires considerable work to be done by hand with no auto-routing features being utilized.
- Cameras are present on buses, and Acme Transit is interested in procuring cameras for some demand-response vehicles as well.
- Acme Transit uses a desktop-based fleet management system called Apex Plus.
- A robust website and social media presence allow Acme Transit to effectively communicate with users. Business telephone systems are present with call queuing functionality.
- Acme Transit uses paper timesheets and paper files to track personnel.
- Through a contractor, Acme Transit provides a static GTFS feed that appears on Google Maps, Transit App, and other rider-facing wayfinding applications. GTFS-realtime feeds, which would require integration with on-board GPS, are not in place.

KEY: ● = NO ○ = MAYBE NA = Not applicable	FLEET SIZE					
	1 to 9 vehicles		10 to 29 vehicles		30+ vehicles	
	DR	CR	DR	FR	DR	FR
Scheduling/Dispatch Software and Related Management Systems						
Client mgmt and scheduling DR trips	○	NA	●	NA	●	NA
Scheduling FR vehicle runs	NA	●	NA	●	NA	●
Algorithm to optimize schedule	●	NA	●	NA	●	NA
Driver and vehicle scheduling and mgmt	●	●	●	●	●	●
Reporting	●	●	●	●	●	●
Interfaces and export/import ability	○	○	○	○	○	○
Driver manifests on tablets or PDs	○	NA	○	NA	○	NA
Reminder calls	○	NA	○	NA	○	NA
Customer-facing Trip Planning						
Trip planning for riders	○	○	○	●	○	●
GTFS	NA	●	NA	●	NA	●
GTFS-realtime	NA	○	NA	○	NA	○
GTFS-time	○	NA	○	NA	○	NA
Communications with Riders and Public						
Web page	●	●	●	●	●	●
Social media	○	○	○	○	○	○
Business telephone systems	○	○	○	○	○	○
Asset Management						
Vehicle maintenance	●	●	●	●	●	●
Facility maintenance/other	○	○	○	○	○	○
Pre-trip inspections	○	○	○	○	○	○
In-Vehicle Technology						
Automated voice announcements	NA	○	NA	○	NA	○
Cameras	○	○	○	○	○	○
Automatic vehicle location or GPS	○	○	○	○	○	○
Automated passenger counters	NA	○	NA	○	NA	○
Collision avoidance systems	○	○	○	○	○	○
Mobile data terminal/computer	○	○	○	○	○	○

6. SWOT Analysis and Recommendations

6.1 Strengths

- Agency has recently completed several projects, including a new financial system, a fixed route reporting module, and new cameras for the entire fleet.
- Several staff have intermediate to advanced expertise with Excel.
- Rider surveys report a high level of satisfaction with the transit service:
 - 87% of riders rate the service good or excellent.
 - 91% of riders rate the communication efforts good or excellent.

6.2 Weaknesses

- Current fixed route data management systems suffer from a high degree of manual work and are prone to errors. Significant energy goes into cleaning up data at the end of every month.
- The number of systems in need of replacement over the next 5 years may significantly tax agency staffing.
- After two recent complex upgrades (financial software and fixed route reporting) that ended up happening concurrently, some expressed concern of losing staff if other upgrades were similarly stressful.
- Staff expressed concern that procurement for a new paratransit scheduling and dispatch system will be very difficult staffing-wise, given planned service expansion.
- The lack of rider-facing real-time service data results in a high number of calls from riders inquiring about the location of their bus.

6.3 Opportunities

- The rise of SaaS offerings across all major data tracking systems means that, adjusting for inflation, replacement costs may drop significantly.
- Technology can help reduce the amount of manual effort required for many tasks (personnel tracking, etc.).

6.4 Threats

- Several systems that the agency relies on for core operations are at risk of no longer being supported over the next few years:
 - A desktop-based asset management system.
 - The scheduling and dispatch system for paratransit.
 - Mobile data terminals used by both.

6.5 Recommendations

These recommendations are very brief examples. An actual assessment should include enough information so that the agency can clearly understand the “what” and the “why” of each recommendation. For recommendations that include a technology investment, support-related and technical elements of a cost-benefit analysis (CBA) should be included as part of that recommendation. These elements would then be incorporated into a broader CBA that may also include non-technical costs and benefits such as environmental impact or equity considerations.

Strengthen Documentation of Systems

For those staff who have critical and undocumented system knowledge, adjust workloads to schedule time to document standard operating procedures (SOPs) and support staff cross-training.

Organize Change Management at the Agency Level

Rather than planning upgrades at the department level, schedule them for the entire organization to minimize unintended side effects.

Seek Domain Expertise for Planning and Development of Technical Requirements

Rather than manage procurement in-house, engage technical expertise (i.e., a contractor, another agency) to develop technical requirements and assist with the procurement process.

Procure a Standards-Compliant Real-Time System for Fixed Route

Engage with MnDOT staff to see what similar agencies have gotten and review their process. Carry out a market survey and consider releasing an RFI.

Replace Demand-Responsive Scheduling and Dispatch

Based on the roadmap provided by the vendor, the current system should be replaced in the next 2-3 years.

Procure a SaaS Fleet Management System

Based on the roadmap provided by the vendor, the current system should be replaced in the next 2-3 years.

Carry Out a Cost-Benefit Analysis for Automatic Passenger Counters

While APCs may be beneficial for the agency, a full analysis is outside the scope of this assessment. We recommend partnering with MnDOT and other interested agencies to explore options.

3: AGENCY TECHNOLOGY GROWTH PLAN TEMPLATE

INSTRUCTIONS: This template is a Word document that is intended as a guide. As such, the writer may adapt it to suit the needs of the agency. Use this template in conjunction with the Sample Technology Growth Plan as the sample document provides an idea of the appropriate level of detail and items that are important to consider.

While the assessment is largely technical, the growth plan adds to the technical assessment the larger concerns of the agency. The growth plan is the result of agency leadership considering the technical priorities and balancing them with other agency plans, priorities, and resources. As a result, the Technology Growth Plan priorities could be different than in the Technology Assessment.

This remains a high-level plan rather than a detailed one. Projects over \$25,000 that will be moved forward to a grant application will require more detailed project planning. The MnDOT pre-application scoping process, following the Transit System Analysis form version 3.02 will continue to be used to develop a more detailed cost estimate for these projects.

Instructions are italicized and in a blue font. Delete these as you complete each section. The sample that follows has an assessment that has been completed by an outside contractor.

Note that the document is structured to be free-standing. An agency may also format it as a memorandum or use the format most commonly used in the agency for such information.

Cover Information

Agency Name

Technology Systems Growth Plan

Date

Assessment Completed by: This may be staff or an outside contractor

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Recommended Technology Growth Plan

Provide a brief introduction explaining the document and the process.

Summary of Priority Technology Projects

Provide both a narrative summary and a table listing key information about each project. The narrative summary will help readers understand the information in the table. It will explain any conditions, such as projects that need to be carried out together or sequentially. It might describe connections to other projects, such as an upgrade that will coincide with a major service improvement.

The information in the summary table will come from the detailed sheets for each priority project.

Table 1. Summary of Technology Priorities/Activities

Prioritized Activities	Year to Implement	Initial Capital Cost	Ongoing Operating Costs	Internal/External Staff Support Required
1. <i>List each project</i>	<i>List year or years.</i>	<i>\$ Estimate costs</i>	<i>\$ Estimate costs</i>	<i>Estimate internal staff time and identify if outside assistance is needed.</i>
2.		\$	\$	
3.		\$	\$	
4.		\$	\$	
5.		\$	\$	

Details on Priority Technology Projects

Provide a summary of each priority project. Complete the following table for each project. Duplicate it for as many projects as are in the agency technology growth plan. Add any additional information that is useful to track, such as whether grant funding will be sought or when more detailed project planning may be completed.

Priority Number and Project Name
Summary of Project. <i>Briefly describe the project.</i>
Cost and Staffing Resources - Budgeted expenses. <i>Provide information on initial expenses and ongoing expenses.</i> - Staff resources. <i>Estimate the time required of staff. Include the departmental involvement and whether time is needed from supervisory and line staff.</i>
Sequence and Timing - Sequence. <i>Identify if the project needs to be completed in conjunction with other projects (technology or non-technology projects). Do other projects need to be completed first or is this a project that needs to be completed prior to other activities?</i> - Length of Project. <i>How long will the project take to complete? Will it be done in phases?</i> - Grant Funding and Project Planning. <i>Will a Transit System Analysis version 3.02 need to be completed? How will that affect the timing of the project?</i> - Timing. <i>When is it recommended to be scheduled?</i>

4: SAMPLE AGENCY GROWTH PLAN

Acme Transit Service

Technology Systems Growth Plan

April 1, 2021

Recommended Technology Growth Plan

This summary of recommended technology projects for Acme Transit Service (ATS) is based on a technology assessment completed in January 2021. Results of the technical assessment have been reviewed by ATS leadership and priorities adjusted to reflect other agency priorities. These recommendations will serve as a guide for grant applications and annual budgeting. They will be reviewed annually as part of the budget preparation process.

Narrative Summary

The growth plan includes strengthening existing support systems, changing the ways in which system changes are implemented, and upgrades to specific technology systems.

Three activities are related so initial research must consider these as a package although due to staff time constraints they will need to be implemented sequentially. When replacing the scheduling system, it is important that the new system be able to automatically generate GTFS-realtime data feeds. When replacing the fleet management system, it is important to investigate mobile options that are independent from, but potentially integrated with, the scheduling system and to consider options that are add-on modules to the scheduling system.

The leadership team recommends prioritizing GTFS-realtime information in an effort to better serve customers with accurate information and assure that dispatchers have the tools needed to improve service reliability. In addition, the last project was dropped due to lack of staff resources, but it may be considered in a future revision (in one to two years).

Table 1. Summary of Technology Priorities/Activities

Prioritized Activities	Year to Implement	Initial Capital Cost	Ongoing Operating Costs	Internal/External Staff Support Required
1. Strengthen documentation	2021-2022	\$ -0-	\$ -0-	Internal staff time estimated at 240 hours
2. Establish technology procurement process	2021-2022	\$ -0-	\$ -0-	Internal staff time estimated at 120 hours
3. GTFS-realtime	2023	\$ 12,000	\$ 18,000	Domain expert plus internal staff
4. Fleet management system	Early 2024	\$ 5,000	\$ 3,000	Internal staff research options
5. Replace DR Scheduling & Dispatch System	Late 2024 or early 2025	\$ 8,000	\$ 10,000	Domain expert plus internal staff

Details on Priority Technology Projects

Strengthen Documentation

Summary of Project. The assessment identified a need for improving documentation of existing technology. This is an ongoing need, but this project places an emphasis on getting documentation in place in a relatively short period of time. This will support all future technology projects and support making good decisions. A balance will be needed between providing detail on systems that will be replaced and documenting the key workflows that need to be continued.

Cost and Staffing Resources.

- None.
- This will require time for existing staff so will be carried out as time allows. An estimated 240 hours of staff time is estimated. Time for both line staff and supervisory staff needs to be budgeted.

Sequence and Timing.

- This project can be done without additional funding and separately from individual technology system procurements.
- Ideally this will be completed in a four-month period so that momentum is maintained.
- No grant funding is required.
- It is recommended this be scheduled for late 2021 to early 2022.

Establish Agency Technology Procurement/Implementation Process

Summary of Project. The assessment recommended that changing technology be managed at the agency level. The intention is that rather than planning upgrades or technology installations at the department level, they be undertaken in a process that involves the entire organization to minimize unintended side effects. The assessment also recommended a process for obtaining domain expertise to assist in technology procurements, such as in writing specifications. This project covers both activities. It will establish an agency-wide process that defines who will be involved in each type of technology improvement. It also will set up a system for engaging domain experts on an on-call basis when software is procured.

Cost and Staffing Resources

- None.
- This will require time for existing staff but is limited in scope.

Sequence and Timing

- This project is limited in scope. Setting up an agency-level system can be completed within a two-month period. Setting up access to domain experts may involve an additional six to nine-month procurement process.
- No grant funding is required.
- It is recommended this be scheduled for late 2021 through mid-2022.

Real-Time System for Fixed Route Services

Summary of Project. Procure a standards-compliant real-time system for fixed route to enable riders to obtain current information on where their bus is and to provide accurate information to dispatchers as they work to maintain system reliability. The project will assist the agency in meeting two goals, that of improving reliability and of improving customer information.

Based on conversations with other agencies that have GTFS realtime in place, it will be necessary to consider how to best integrate the various technology systems using GPS systems and to make sure our software automatically produces accurate GTFS-realtime data streams, without any manual intervention. This will require staff work prior to the procurement process.

Cost and Staffing Resources

- Initial budgeted cost = \$12,000. Ongoing impact on operating budget = \$18,000.
- Staffing required to research current options and determine impacts on upgrades to DR scheduling system.
- Staffing also required to procure and fully implement.

Sequence and Timing

- This project needs to be researched in conjunction with scheduling system upgrades.
- The project planning phase may result in a decision to integrate all CAD/AVL systems.
- Initial project planning is estimated at six to nine months. Procurement is estimated at six months. Implementation is estimated at 3 months.
- Funding is not yet secured so an application needs to be submitted at the first opportunity.
- Based on a desired implementation date of 2023:
 - Funding will be requested in 2021. Detailed project planning will be carried out in early 2021.
 - Internal funds will be budgeted in 2022 and 2023. (Some staff time and domain expertise time is anticipated in 2022).
 - Procurement activities will occur in late 2022 and into 2023.
 - Implementation will occur in 2023.

Fleet Management System - SaaS

Summary of Project

Replace the current fleet management system with a SaaS Fleet Management System. This project involves research into available options, identifying how the system may be integrated with or a part of the new software scheduling & dispatch system (and the fixed route services), and then procuring and installing the new system. The project will assist the agency in reducing manual effort involved in tracking preventive fleet maintenance.

Cost and Staffing Resources

- Initial budgeted cost = \$5,000. Ongoing impact on operating budget = \$3,000.
- Staffing required to research current options and identify overlaps, gaps, or integration needs (if any) with DR scheduling system so these can be addressed.
- Staffing also required to procure and fully implement.

Sequence and Timing

- This project needs to be researched in conjunction with scheduling system upgrades.
- The project planning phase may consider options such as telematics.
- Initial project planning is estimated at six to nine months and will be done in conjunction with research on GTFS-realtime and the replacement of DR scheduling software. Procurement is estimated at four to six months. Implementation is estimated at 1 month.
- Funding is not yet secured, so an application needs to be submitted at the first opportunity.
- Based on a desired implementation date of early in 2024:
 - Funding will be requested in 2021. Detailed project planning will be carried out in early 2021.
 - Internal funds will be budgeted in 2023 and 2024. (Some staff time is anticipated in 2022).
 - Procurement activities will occur in late 2022 and into 2023.
 - Implementation will occur early in 2023.

Replace Demand-Responsive Scheduling and Dispatch System

Summary of Project

Replace the current scheduling and dispatch system for demand-response services. This project involves research into available options, identification of required features, and identifying what integrations may be required. The procurement and installation activities include migration to the new system and training staff.

The project will assist the agency in reducing the manual effort tracking personnel related tasks and in meeting increased service demand. It will also provide dispatchers with additional tools for increasing service reliability. If an IVR option is purchased, the project will also result in better informed customers and reduce no-shows.

Cost and Staffing Resources

- Initial budgeted cost = \$8,000. Ongoing impact on operating budget = \$10,000.
- Staffing required to research current options and identify overlaps, gaps, or integration needs with CAD/AVL systems.
- Staffing also required to procure and fully implement.

Sequence and Timing

- This project needs to be researched in conjunction with GTFS-realtime as it is important to address how CAD/AVL will be integrated across systems.
- The project planning phase will consider various optional modules such as reminder calls to customers.
- Initial project planning is estimated at six to nine months and will be done in conjunction with research on GTFS-realtime and the replacement of DR scheduling software. Procurement is estimated six to nine months. Implementation is estimated at 3 months.
- Based on a desired implementation date of late in 2024:
 - Funding will be requested in 2022. Detailed project planning will be carried out in late 2021 through early 2022.
 - Internal funds will be budgeted in 2023 and 2024. (Some staff time is anticipated in 2023).
 - Procurement activities will occur in late 2023 through mid-2024.

