MUSKEGON AREA TRANSIT SYSTEM

Transit Technology Implementation Plan

Executive Summary

August 2019

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Overview

The Muskegon Area Transit System (MATS) is a mid-sized transit provider servicing Muskegon County Michigan. Like many transit providers, MATS faces a range of challenges that affect service quality and efficiency. To address these challenges, MATS developed a Transit Technology Implementation Plan. This document summarizes the findings from four Technical Memorandums and identifies the most pressing technology challenges, the technological solutions that can address them, the process for implementing these new technologies, and cost estimates broken down by phase. Links to the full Technical Memorandums are provided at the end of this document.

Current Environment

MATS provides public transportation throughout Muskegon County with its fixed route and GoBus on-demand services. Quick Facts:

- 550,000 passengers annually
- 70 staff (over 50 drivers)
- 36 revenue vehicles including 7 accessible mini vans
- Two passenger facilities

MATS receives accounting support from Muskegon County's Finance and Management Services Department, and technology support from Information Systems Department to help manage and operate its transit service. However, several of the resources provided to MATS are not transit-specific nor designed to meet the unique needs of public transit organizations. These include systems and applications to handle financial or personnel information or supporting systems such as networking or data storage.

Technology Focus Areas

As part of the Transit Technology Implementation Plan, MATS focused on exploring technological tools within the following five areas:

1. Fleet tracking and telemetry
2. Staff scheduling and management
3. Call tracking, scheduling, and dispatching
4. Fare collection and management; and
5. Ridership data collection and management.

These five areas were chosen for their impact across MATS functional areas and systems and the immediate effect on service quality. These focus areas also provide a technology foundation that MATS can leverage to provide more advanced, customer-facing services in the future.

Challenges Facing MATS

The first step in creating the technology implementation plan was a review of existing documentation and interviews with Muskegon County staff. The review revealed limitations on the range of services that MATS could offer, impacts on the quality of service, and on the efficiency of the organization. Issues coalesced around three functional areas: fare handling, service improvements, and staff/organizational issues. Table 1 presents a summary of the nine issues documented.

Table 1. Challenges and Identified Issues

Challenges		Issues
Fare Handling	Limited payment options	**Description:** Cash and paper fare cards are the only options for fare payment, no electronic payments. Cash must be paid in exact change on the vehicle, and fare cards require manual punching by the driver.
		Impact: Reduced options and manual interactions decrease the convenience and appeal of service, decreasing ridership.
	Drivers handle cash & card inventories	**Description:** Drivers must sell fare cards while on routes, which requires cash handling and managing the inventory of fare cards.
		Impact: Boarding times are increased (up to several minutes), affecting schedule compliance; manual cash handling introduces errors and potential for revenue loss.
	Cash management	**Description:** Vaults must be extracted from each vehicle's fare box and manually counted by two staff to provide accuracy checks.
		Impact: Staff time is consumed with a process that could be largely automated. Manual counts have the potential to introduce errors, leading to expending additional staff time to correct.
Service Improvements	On-demand trip requests	**Description:** Requests for service cannot be confirmed in real-time, requiring operators to manually schedule trips, requiring excessive staff time and call backs to the customer.
		Impact: High staff workload, results in service requests going to voicemail for later processing. Few same-day trips are possible; customers have less choice when booking trips.
	Vehicle location / route compliance data	**Description:** Without manually contacting each vehicle via voice radio, there is no way to know current location. There is no on-going record of vehicle locations.
		Impact: Schedule compliance is unknown, leaving no mechanism to assess and improve. Emergency response is hampered without knowing the exact location of the vehicle.
	Ridership data	**Description:** Ridership must be manually counted during a study sample, making data incomplete and sporadic.
		Impact: Routes cannot be planned to best serve riders' needs and travel patterns, resulting in sub-optimal service.
Staff / Organizational	Driver scheduling	**Description:** Creating shift schedules and managing time off/sick requests is a slow, labor-intensive process. Locating staff to cover absences requires calling a series of available drivers.
		Impact: Excessive staff time is used in the scheduling and management of absences. Service can be affected if drivers cannot be scheduled.
	Computer and network reliability	**Description:** Sporadic outages of either network connectivity or desktop virtualization infrastructure affect ability to take trip requests, update manifests, etc.
		Impact: Staff is unable to service trip requests. If expanded technology tools are deployed, functionality and benefits will be reduced upon network outages.
	Staff availability and expertise limitations	**Description:** Ability to research and deploy new tools to manage service is limited, affecting overall operations. Availability of dedicated and capable technical staff is lacking.
		Impact: MATS is unable to deploy tools that will reduce cost, save labor and improve service quality.

Solutions

Technical approaches for each of the identified issues are available from multiple vendors. However, many vendors combine not only the software used by operators, but also the on-vehicle devices such as mobile data hardware, mobile computers and fare payment systems. Alternatively, MATS could attempt to combine individual solutions by integrating them in-house. A set of basic evaluation criteria were developed to guide selection (Table 2).

Table 2. Implementation Principles and Evaluation Criteria

Principle/Evaluation Criterium	Questions to Consider
Cost of Capital/Hardware	What is the up-front cost to implement? What funding sources are available?
Cost of Operations and Maintenance	What is the ongoing (e.g., annual) cost to maintain and staff the system
Reliability	How can the system fail? What is the likelihood and impact of an outage
Compatibility	Does the technology integrate with current MATS systems and processes?
Flexibility/Modularity	Can additional modules be added later? Will it integrate with other systems?
User Experience	Can end users use the technology easily? What training is needed?
Ease of Deployment	How long implementation take? Does MATS have the expertise needed? What level of external support is needed?

Once the most pressing issues were identified, a survey of existing solutions and the research documenting the benefits of implementation was completed. Each functional area is summarized below:

Fare Handling

Fare handling solutions encompass two broad areas: cash management and fare payment systems. While these elements can be implemented separately, they are most commonly combined into a single device on the vehicle. However, there are two distinct functions involved that MATS should invest in:

- **Registering fareboxes** capable of counting cash, passengers, and providing location data, and;
- **Electronic payments** such as refillable "smart cards" or phone apps.

Benefits reported by other transit agencies from similar fare payment system investments include:

- 3% to 17% increase in fare revenue
- Reduced staff time and costs associated with collecting, processing, and reconciling fares
- Increased customer satisfaction
- Faster boarding and less dwell time
- Ability to capture rich customer data
- Fostering fare policy innovation and tailoring

Service Improvements

The three service improvement issues (trip request processing, schedule compliance/performance monitoring, and data collection) can be addressed by technologies such as:

- **Paratransit & fleet management software** to improve effectiveness and efficiency of operations, dispatching, and data collection
- **Mobile data computers** (and mobile data) to enable vehicle tracking and fare payment systems
- **Automatic passenger counters** to collect detailed boarding, alighting, and load data for fixed route service, enabling efficiencies of operations and resource allocation

Benefits reported by other transit agencies from similar service improvement investments:

- Demand response operating costs decreased by as much as 30%-35% and reduced cost per passenger trip
- Increased demand response passengers per hour by 44%, on average

- Ability to allow customers to book rides directly via website or mobile application, eliminating phone calls
- Significantly decrease demand response "no shows"
- 45% to 80% reduction in "where's my bus" calls received by transit staff
- Improved on-time performance by 25%
- Increased customer satisfaction
- Ability to redistribute scarce resources to maximize efficiency and effectiveness

Staff and Organizational

Solutions in this category address the issues related to driver scheduling, computer and network reliability, and staff availability and expertise limitations. These solutions would enable MATS to operate more efficiency and reliably, while improving customer experience.

- **Dedicated Staffing** in the short- and long-term for deployment, training, and ongoing support and maintenance. Ensuring a successful deployment will require dedication of staff time.
- **IT infrastructure investments** to ensure sufficient network capacity with little to no down time. Desktop services systems must offer continuous availability during MATS operations. Network reliability is essential to implementing technology solutions for MATS.
- **Driver scheduling software** to simplify the scheduling process and enhance communication between management and drivers, while saving time and money
- **Call center management software** to improve efficiency, capacity, and customer experience

Staffing and IT infrastructure investments are critical to the launch and long-term success of the other software and hardware solutions identified in this project. Without them, MATS will be unable to reap the full benefits of the other solutions. Advanced driver scheduling software alone has, according to other transit agencies, freed up dozens of weekly staff hours.

The relationships between MATS's stated issues and challenges and the proposed solutions to address are shown in Table 3 and summarized below.

Table 3. Challenges – Solutions Matrix

Challenges		Solutions								
		'Registering' Fareboxes	Electronic Payments	Paratransit & Fleet Man-agement Software	Mobile Data Computers	Automatic Passenger Counters	Staff Scheduling Software	IT Infrastructure	Call Center Management	Staffing
Fare Handling	Limited payment options		X		X					
	Drivers handle cash & card inventories		X		X					
	Cash management	X	X		X					
Service Improvements	On-demand trip requests			X	X				X	
	Vehicle location and route compliance data			X	X					
	Ridership data	X		X		X			X	
Staff and Organizational	Driver scheduling						X			
	Computer and network reliability							X		X
	Staff availability and expertise limitations							X	X	X

Recommendations

The specific products implemented by MATS should be selected by a competitive bidding process in accordance with Federal Transit Administration (FTA) guidelines. This section outlines subsystems that address the identified issues and provides a recommendation for selecting a subsystem type based on the current state of industry practice and MATS' operational environment.

System Characteristics

1. Use a hosted "cloud" solution for system software

Back-office software may be either installed on-premises or hosted by the provider in the cloud. MATS has noted issues with the Muskegon County server and network infrastructure, including reliability and applying updates/patches to software. Adding additional staff specifically to address these issues is unlikely to be compatible with MATS budget, therefore **a hosted "cloud" solution is recommended, provided that pricing is acceptable.**

2. Use an integrated solution, rather than build and integrate components in-house

The other major distinction is between integrated solutions from a single vendor or vendor team, and an in-house developed solution. In-house solutions offer high modularity and flexibility. However, selection, installation, integration, and maintenance of in-house developed solutions will require substantial technical expertise and staff time. Changing components in the future is also likely to introduce compatibility issues. **To minimize staffing requirements and best protect investments, an integrated solution from a single vendor or vendor team is recommended, rather than an in-house developed solution.**

Implementation

The process used to design the system, choose providers and validate the final product has direct bearing on the success of the deployment. By following a stepwise approach, a solution will be defined that addresses the underlying challenges, operates as expected and is maintainable over the long term by MATS.

Process Overview

The overall process for implementation is presented in detail in Technical Memorandum #3. A high-level overview consisting of the steps is summarized here.

1. Pre-Deployment
    a. Define Functional Requirements: Describe in specific terms what the recommended investments should do
    b. Issue a Request for Information (RFI) to technology suppliers
    c. Issue a Request for Proposals (RFP)
2. Deployment
    a. Award Contract
    b. Pre-deployment Preparation
    c. System Build-Out
    d. System Cut-Over
3. On-Going Use

Although it is shown as a single step here, Step #1-a "Describe Functional Requirements" entails a complete process in itself. This is commonly called Systems Engineering and is a standardized way of managing the design and deployment of complex systems. This process may be informed by completing Step #2 and gathering information from vendors, or it could be completed beforehand to guide the specific questions to be asked in the RFI.

Systems Engineering

The FHWA has defined a standard process for transportation-related systems. It is most commonly illustrated with a "V" diagram, such as that shown in Figure 1.

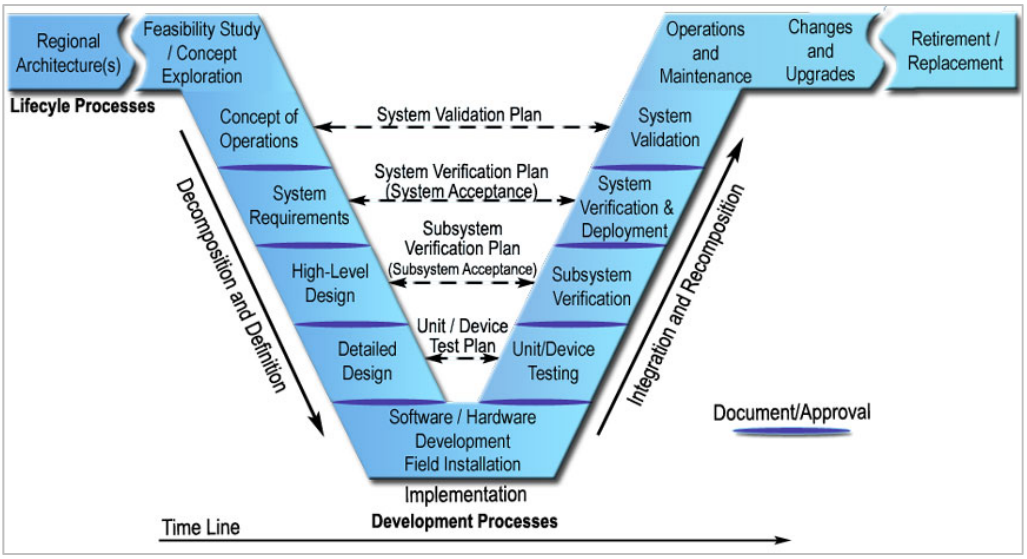


Figure 1. Systems Engineering "V" Diagram

This Transit Technology Implementation Plan represents the Concept Exploration phase of systems engineering. By following the remaining steps in the process, MATS will develop a clear description of the desired system. That description with its Concept of Operations, Requirements and test plans will enable a procurement process that is specific, objective, testable and avoids conflicts between MATS and system vendors. Following this process is encouraged to give MATS the greatest chance of a successful deployment.

Sequencing

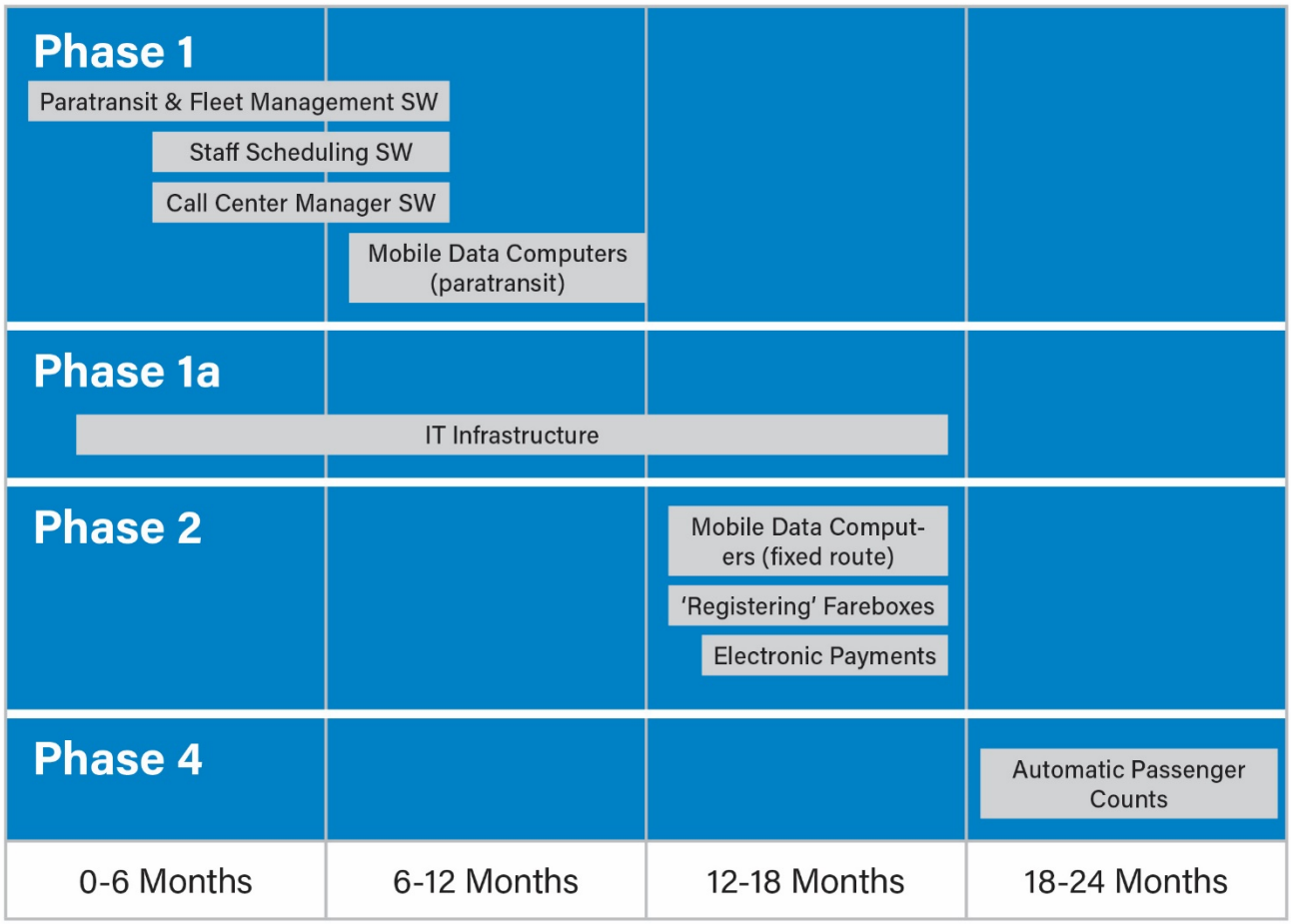
The introduction of new technologies into MATS operations should be managed in a stepwise fashion. This will allow an orderly transition for staff and provide an opportunity to make any needed improvements to information technology systems to accommodate the new functions.

There are four phases envisioned for the MATS deployments:

- **Phase 1** updates existing paratransit software, adds call center management functionality and introduces a new driver schedule system. The new software will transition to a hosted provider during this phase. MDCs and mobile data will be added once the management software is in place.
- **Phase 1a** is concurrent with Phase 1 and introduces any needed upgrades to desktop computers, networking and Internet connectivity.
- **Phase 2** Introduces electronic payments and advanced, registering fare boxes. This phase will also introduce mobile communications and GPS to the fixed route vehicles. It may also provide an MDC for each fixed-route vehicle, depending on specific vendor packages.
- **Phase 3** completes the technology upgrades with automatic passenger counters. MATS will now have continuous data collection for fixed route system use, and operators will have access to real time vehicle occupancy data.

Sequencing is envisioned to take place over a 24-month period, following issuance of an RFP for the initial system deployment. This timeline is illustrated in Figure 2.

Figure 2. Implementation Timeline



An integrated solution is the preferred approach, but procurement and deployment can be broken into phases such as those shown in Figure 3. When releasing the initial RFP, a complete description of all phases can be included, and vendors encouraged to describe their approach to providing all component while providing a bid for only the initial phase. This approach allows MATS to deploy systems at its own pace, while maintaining competitive pressures for prospective vendors.

Figure 3. Solutions-Phase Matrix

Challenges		SOLUTIONS								
		PHASE 1				PHASE 1A	PHASE 3		PHASE 4	ALL PHASES
		Paratransit & Fleet Management Software	Staff Scheduling Software	Call Center Management	Mobile Data Computers *Paratransit	IT Infrastructure	Registering Fareboxes	Electronic Payments	Automatic Passenger Counters	Staffing *Make Adjustments as you go
Fare Handling	Limited payment options				X			X		
	Drivers handle cash & card inventories				X			X		
	Cash management				X		X	X		
Service Improvements	On-demand trip requests	X		X	X					
	Vehicle location and route compliance data	X			X					
	Ridership data	X		X			X		X	
Staff and Organizational	Driver scheduling		X							
	Computer and network reliability					X				X
	Staff availability and expertise limitations			X		X				X

Cost Estimates

As outlined in this report, MATS has many options in selecting technology solutions to address current needs and must weigh many considerations before implementing new technology solutions. Without these details, it can be difficult to estimate the cost of these service improvement hardware and software solutions prior to the RFI and RFP process with great accuracy. The actual costs to MATS will depend on the vendor, specific system elements and support options and level of integration with other MATS systems, among other consideration.

Table 4 summarizes cost estimate ranges for the recommended solutions. These cost estimates are illustrative and are based on per vehicle unit costs developed from research conducted of recent procurement of similar transit technology solutions by multiple transit agencies in North America.

Reliable intelligent transportation systems cost databases have little information available from the last five years on the solutions MATS is considering.[1] In this short period of time, transit technology solutions have evolved significantly and become much more commonly deployed at transit systems of similar size to MATS. Given this, public procurement records were collected through online research to gather several comparable transit technology procurement examples from the last few years for a more appropriate comparison. Additional discussion of the methods and assumptions used to derive these estimates, plus other cost considerations, are listed in the following section.

Table 4. Cost Estimate Ranges for Recommended Solutions

Phase	Solution Element		One-time/Capital Cost (Total for MATS)	Ongoing/Operating and Maintenance Cost (Total for MATS)
System Engineering	Planning and Systems Engineering		250 to 350 person-hours	--
Phase 1	Service Improvements	Paratransit & Fleet Management Software	$50,400 to $201,600	$4,320 to $32,400 annually
		Mobile Data Computers on Paratransit Vehicles	$10,200 to $136,000	$850 to $10,200 annually
	Staff and Organizational	Staff Scheduling Software	TBD. Often included as part of paratransit & fleet management software suite	TBD. Often included as part of paratransit & fleet management software suite
		Staffing	0.5 FTE	0.1 to 0.3 FTE

[1] Often a reliable source, the U.S. Department of Transportation's Intelligent Transportation Systems Knowledge Resource Cost Database (https://www.itscosts.its.dot.gov/its/benecost.nsf/CostHome) includes little information about the solutions MATS seeks to implement that is current and suitable for comparison. Most records for relevant transit technology solutions are more than a decade old; in many instances, enabling technologies and common configurations have changed dramatically, and solutions have become more cost-effective, in this time.

Phase 1a	Staff and Organizational	IT Infrastructure	TBD	TBD
Phase 2	Fare Handling	'Registering' Fareboxes	$540,000 to $720,000	$5,400 to $10,800 annually
		Electronic Payments		
	Staff and Organizational	Staffing	0.5 FTE	0.1 to 0.3 FTE
Phase 3	Service Improvements	Automatic Passenger Counters	$26,600 to $32,300	$190 to $5,130 annually
	Staff and Organizational	Staffing	0.2 FTE	0.1 FTE

Links to Technical Memorandums

Technical Memorandum #1: Baseline Conditions

Technical Memorandum #2: Baseline Analysis

Technical Memorandum #3: Research and Review of Available Technologies

Technical Memorandum #4: Implementation and Cost Estimates

MUSKEGON AREA TRANSIT SYSTEM

Transit Technology Implementation Plan

Technical Memorandum #1: Baseline Conditions

May 2019

SRF Consulting Group

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Introduction

The Muskegon Area Transit System (MATS) is developing a Transit Technology Implementation Plan to identify their technology needs, available solutions, estimates of cost, and deployment plan. A thorough understanding of the existing environment into which new solutions will be deployed is critical to both technical success and maximizing the value of investments. This memorandum summarizes the activities and findings on baseline conditions, including areas of interest for further investigation.

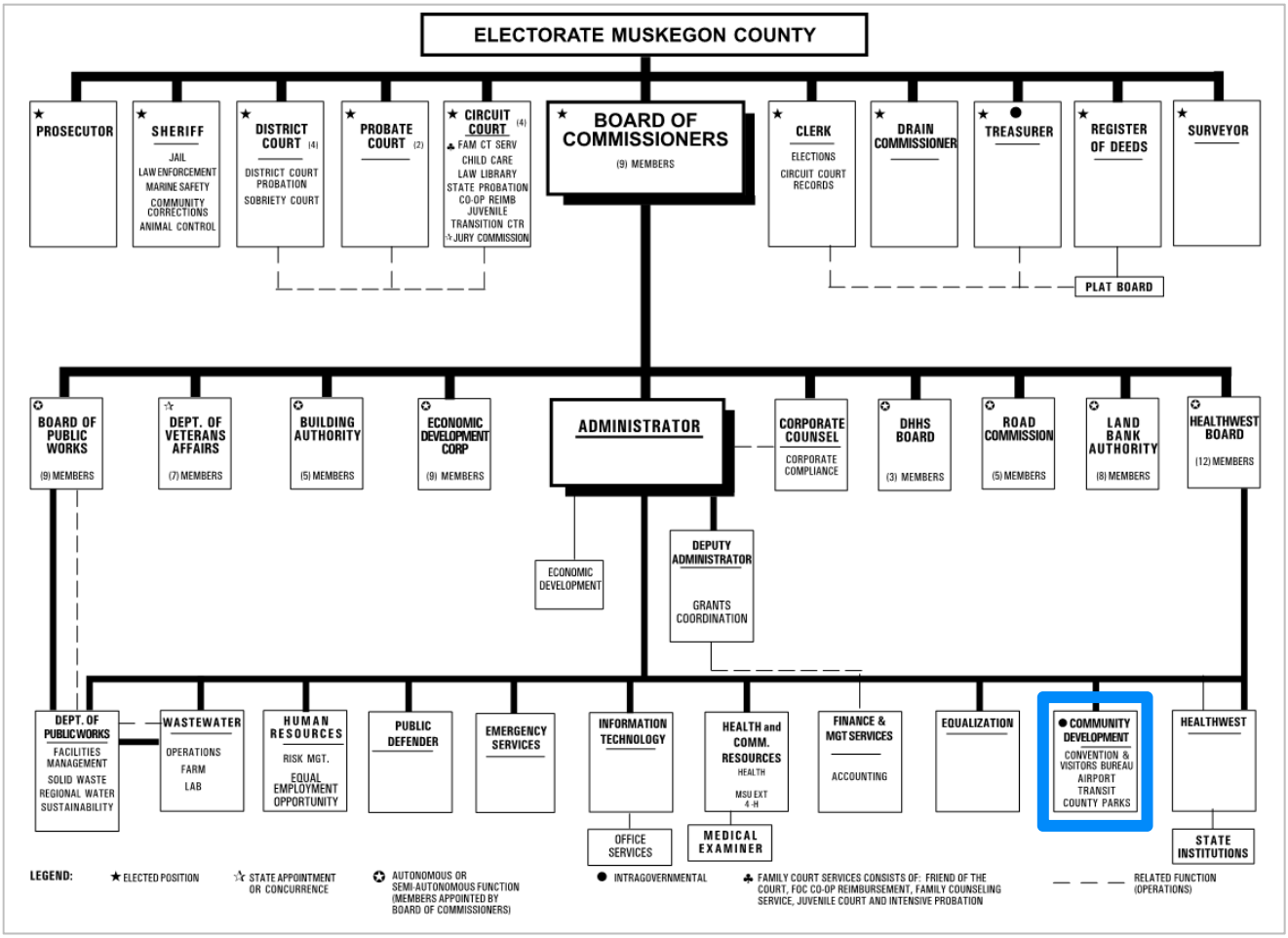
Background

MATS is a service of Muskegon County, housed within the County's Community Development Department. The Muskegon County organizational chart is shown in Figure 1. Over 170,000 people live in Muskegon County.[1]

Like other County departments and their sub-groups, MATS receives accounting support from Muskegon County's Finance and Management Services Department, and technology support from Information Systems Department to help manage and operate its transit service. However, several of the resources provided to MATS are not transit-specific or designed to meet the unique needs of public transit organizations. These include systems and applications to handle financial or personnel information or supporting systems such as networking or data storage.

[1] U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates

Figure 1. Muskegon County Organizational Chart



Muskegon Area Transit System

MATS provides public transportation throughout Muskegon County with its fixed route and GoBus on-demand services. The principal public transit provider in Muskegon County, MATS serves over 550,000 passengers annually. MATS organizational structure includes approximately 70 staff positions, including over 50 drivers (Figure 2).

The MATS fleet includes 36 revenue vehicles, including 19 heavy-duty buses (Figure 3), 10 light-duty cutaway buses (Figure 4), and 7 accessible mini-vans. In addition to its many bus stops throughout the community, MATS serves and maintains two larger passenger facilities: the Herman Ivory Terminal in downtown Muskegon (Figure 5) and the Muskegon Heights Passenger Facility in Muskegon Heights. The MATS administration and maintenance facility – where most staff are based – is the Louis A. McMurry Center in Muskegon Heights (Figure 6).

Figure 2. Muskegon Area Transit System Organizational Chart

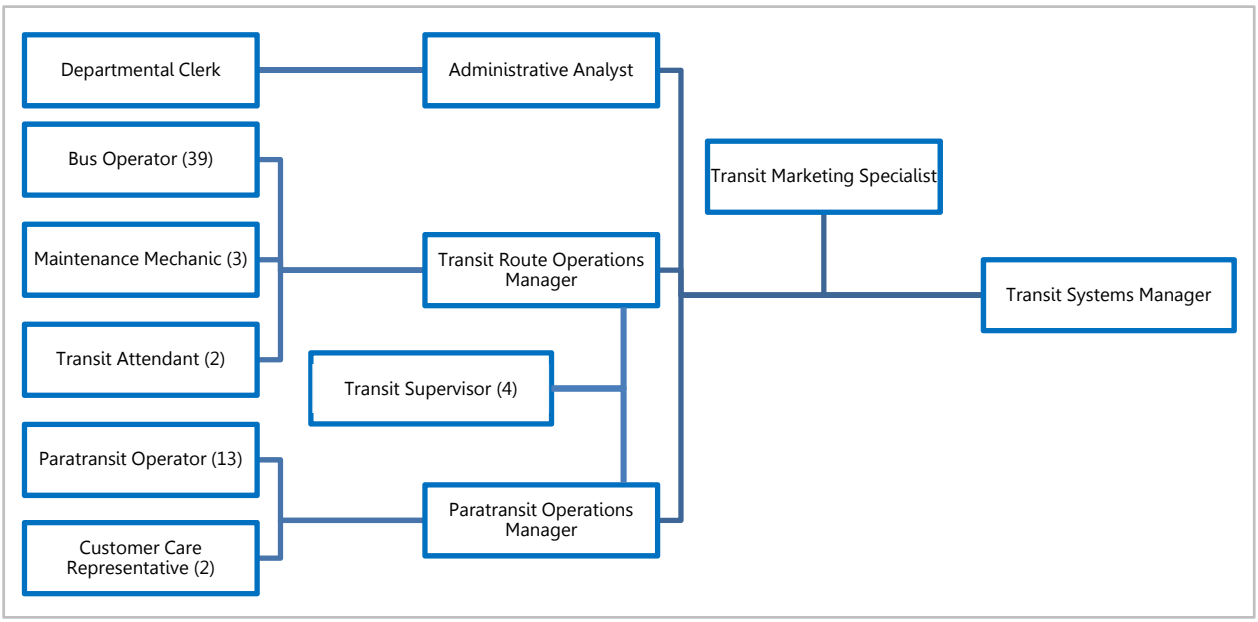


Figure 3. Muskegon Area Transit System Fixed Heavy-Duty Bus

Figure 4. Muskegon Area Transit System Cutaway Bus

Figure 5. Herman Ivory Terminal

Figure 6. Louis A. McMurry Center

Information Systems Department

Information technology support for MATS is provided by Muskegon County Information Systems. Information Systems manages desktop support for all county agencies and offices, network connectivity, Internet services, server infrastructure and wireless connectivity. The Information Systems Department includes a geographic information systems (GIS) group, that provides management, analysis and collection of geospatial data, as well as application development.

Finance and Management Services Department

Muskegon County's Finance and Management Services Department supports MATS in their payroll and revenue management systems.

Process to Establish Baseline Conditions and Priorities

As part of the Transit Technology Implementation Plan, MATS is focused on exploring technological tools within the following five areas:

1. Fleet tracking and telemetry
2. Staff scheduling and management
3. Call tracking, scheduling, and dispatching
4. Fare collection and management; and
5. Ridership data collection and management.

While numerous technology solutions could be employed to address all aspects of MATS, these five were chosen as areas of focus due to their reach/impact across various MATS functional areas and systems, and their ability to improve transit operations and service reliability and directly impact the customer experience. Moreover, these five areas are foundational; in many cases, MATS must first address these before it can effectively and efficiently implement additional technologies in the future.

Review of existing documentation and interviews with Muskegon County staff were performed to better understand the context in which technology solutions could be applied to the five focus areas.

Existing Documentation

Reviewing existing manuals, handbooks, and memoranda and other documentation used by MATS and the County to train staff and disseminate proper procedures provides insight into baseline conditions. Existing documentation relevant to the focus categories were reviewed extensively and used to develop the inventory of systems (listed in Appendix A).

Staff Interviews

A comprehensive picture of the vision and prioritization of future technology directions for MATS can be captured using proven interview processes created for developing regional technology plans.

For the Transit Technology Implementation Plan, interviews with system users and stewards were used to develop a comprehensive understanding of processes and systems, as well as identify needs, goals, and interests. Interviewees were asked about goals for service or efficiency improvements, interests in emerging technologies, and perceived needs for MATS.

Several hours of interviews with County staff were conducted to inform the inventory of systems and identification of needs and priorities. Staff who participated in interviews are listed in Table 1. The questions and content covered in the staff interviews were based on the review of existing documentation and the five Transit Technology Implementation Plan focus areas. Staff interviews centered around the systems and processes listed in Table 2.

Table 1. Interviewees List

Department or Group	Title
MATS	Transit Systems Manager
MATS	Transit Route Operations Manager
MATS	Paratransit Operations Manager
Information Systems	Director
Information Systems	Manager

Table 2. Inventory of Systems and Processes

Department or Group	System
MATS	Transit Operations
MATS	Finance and Administration
MATS	Planning
Information Systems	Wide Area Network (WAN)
Information Systems	Server Infrastructure
Information Systems	Desktop Environment
Information Systems	Telephony
Information Systems	Geographic Information Systems (GIS)

Inventory of Systems

The existing systems and processes in place at MATS and Information Systems were documented to better understand how the five focus area technologies might be applied

Where applicable, the following are identified for each system inventoried:

- Existing/potential challenges and issues
- Needs, goals, and interests

These are summarized for each system and process inventoried on the following pages.

Systems Findings Summary

Table 3 and Table 4 summarize findings of the existing/potential challenges and issues, and the needs, goals, and interests for each of the systems inventoried. These findings provide direction on where to focus efforts for the next phase of the Transit Technology Implementation Plan, which will research and review available technologies that could be applied to MATS. The needs, goals, and interests are representative of feedback collected during the interview process; items not listed will not be excluded from consideration.

The remaining chapters of the document describe each of these systems in greater detail.

Table 3. Findings Summary: MATS

System	Challenges and Issues	Needs, Goals, and Interests
Scheduling Staff	• Process uses two paper forms and four separate software programs/modules • The Celayix driver scheduling software does not sufficiently account for union driver work rules, nor does it track actual work completed	• Minimize paper-based data collection processes (e.g., staff sign-up sheets for picking work and requesting time off) • Integrated solution for staff scheduling and payroll • Ability to communicate with drivers via automated electronic notification with read receipt functionality • Enable the Route Operations Manager to easily view and re-distribute work on a daily and weekly basis • Better incorporate complex driver work rules into the driver scheduling process • Scheduling program that documents actual work completed and tracking of work by driver, rather than used solely as a planning tool • Simplify process of complete and document day-to-day scheduling changes (i.e., call-offs) and allows for easy scheduling and tracking of extra board and stand-by drivers • Ability to produce driver work assignments that can be updated quickly, and easily shared with full-time and part-time drivers
Scheduling Vehicles	• Underutilization of Manager+ fleet management software	• None identified during staff interviews
Driver Pre- and Post-Trip Procedures	• Paper-based data collection process and filing system	• None identified during staff interviews

Continued on the following page

System	Challenges and Issues	Needs, Goals, and Interests
Dispatch-Driver Communications	• CCRs' and Supervisors' inability to know the location of an in-service vehicle without calling the driver • Two types of radio technologies used within two separate systems	• Reliable communications infrastructure with built-in redundancy to ensure transit operations are not critically disrupted in the event of primary system failure • Integrated communication system capable of meeting the three primary needs: communication between Dispatch and fixed route drivers, between Dispatch and GoBus drivers, and among Supervisors • Service with voice and text communication options, prompted manually and automatically • Integration with other MATS's systems (e.g., dispatch software) • Provide drivers and Dispatch staff with automatic notifications of schedule adherence issues, minimizing reliance on driver calling in • Vehicle tracking and telemetry systems to reduce reliance on radios and to enable drivers to focus on providing safe, reliable, and expert service
General In-Service Supervision and Service Reliability	• Supervisors' and CCRs' inability to know the location of an in-service vehicle without calling the driver • Supervisors' and CCRs' inability to learn of and address reliability issues in real time • Inability to make data-driven decisions to address operational issues, design schedules, and allocate resources • Several different onboard camera and surveillance systems, each requiring unique software and hardware	• Vehicle tracking and telemetry systems to aid operations supervision, customer service, and analysis of on-time performance

Continued on the following page

System	Challenges and Issues	Needs, Goals, and Interests
GoBus Trip Scheduling and Operations	• The current MATS phone system allows for only four incoming calls at a time; the fifth concurrent incoming call, and any others, go straight to the voicemail system, which the CCRs must then check • The underlying street network that MATS's Trapeze PASS software uses to most efficiently allocate trip reservations has not been updated since 2002 • Drivers are not provided with routing instructions, requiring them to make on-the-go decisions about how to most efficiently route from point to point; drivers will reference a separate GPS (e.g., from a personal cell phone) to locate and route to addresses they are unfamiliar with • Trapeze PASS includes a vehicle and driver scheduling feature that MATS does not use • CCRs' and Supervisors' inability to know the location of an in-service vehicle without calling the driver • For each pick-up and drop-off, the driver is required to write down the actual time and mileage on their paper manifest • Paper-based GoBus driver daily manifests do not reflect day-of reservation changes, requiring such changes to be communicated to the driver by CCRs using the radio system • CCRs' must enter deviations from the previous day's driver manifest into the Trapeze PASS system such that the actual run information is in the system for record-keeping and reporting purposes	• Phone reservation system that can handle more than four incoming calls at a time • Options for GoBus customers to schedule trips online • Upgrade current Trapeze PASS software to the latest version, or seek an alternative platform • Reduce time CCRs spend taking trips reservations and editing GoBus operating data, freeing up time to serve customers in person and by phone and complete other tasks • Move away from a paper-based system to an electronic one to reduce manual data entry and reconciliation process for CCRs and drivers, and allow or more reliable data and more robust analysis • Real-time, automatic updates to driver manifests to reduce need for radio communication between drivers and CCRs • In-vehicle routing system such that drivers do not need to reference a cell phone or other GPS device to efficiently drive to and from destinations • Options for in-vehicle electronic documentation of the time and mileage immediately after completing a passenger pick-up or drop-off

Passenger Fares and Revenue Collection	• Due to County policies, MATS is currently unable to process credit card sales
	• Mechanical drop box fareboxes do not validate fares; thus, information about fare evasion trends and quantification of lost passenger revenue is limited
	• Mechanical drop box fareboxes do not collect detailed data on fare media usage by passenger type or geotag locations.
	• MATS drivers have expressed concern about the requirement that they sell transit passed aboard vehicles while in service; these include safety concerns about handling relatively-large sums of cash (and fare value) and the impact sales have on schedule adherence. In response, some drivers have reportedly stopped selling 10-ride and monthly passes to passengers while in service, resulting in inconsistent customer service from driver to driver.
	• The process of collecting, storing, sorting, counting, reconciling, and depositing cash fares is time-consuming and inherently risky
		• Enable MATS to accept credit cards as payment for bus passes and other revenue-generating products like advertising
		• Implement farebox solutions that
		  o Enable MATS to track passenger fares by type and medium, validate fares, and know when and where people are boarding the bus
		  o Allow for the future use of refillable "smart card" (or "contactless card") bus passes to reduce the amount of cash collected on the vehicle and the time and effort spent reconciling cash fares
		  o Could allow for future integration of mobile payment options
		• Develop solutions that allow MATS to reassign bus pass sales away from drivers to improve consistency and quality of customer service, improve schedule adherence, and increase driver safety

System	Challenges and Issues	Needs, Goals, and Interests
Payroll	• Paper-based employee timecards • Timecards are shuffled between desks and mailboxes multiple times per week, increasing the likelihood one may be misplaced • Time-consuming process, requiring many staff to complete; although, more staff is also a benefit for validation purposes • Original data are re-entered twice, increasing likelihood of errors	• Minimize paper-based data collection processes • Integrated solution for staff scheduling and payroll • Minimize the number of platforms (i.e., paper, spreadsheets, and financial software) needed to complete the payroll process • Minimizes manual data entry, simplify the reconciliation process, and free-up time for Supervisors
Data Collection and Reporting	• Paper-based data collection • Original data are written down then keyed into a spreadsheet, increasing likelihood of errors • Fixed route and GoBus data collection processes are stored in two separate systems • The current data collection processes in place at MATS allow it to analyze and report the minimum required amount of ridership and operations data • Within the current staffing and technological frameworks, MATS cannot use data to better understand the following aspects of its fixed route service, that impact customer satisfaction and funding: o How reliable service is provided, including the average on-time performance of a scheduled trip, a route, at a particular bus stop timepoint, or the average of the entire MATS fixed route system o The use of different fare media (i.e., cash, 10-ride pass, monthly pass) by various passenger classifications (i.e., standard, disabled, senior, and transfer) o When, where, and between which routes passengers are transferring most commonly o How many vehicle revenue hours and vehicle revenue miles are actually operated throughout a service day o Which bus stops have the greatest passenger activity on average o Whether passenger amenities such as bus stop shelters and benches are provided in all high-demand areas and whether they are distributed equitably o How many passenger miles are traveled using the service throughout a given year o How full its buses are (the vehicle's "load") at various point along the route to ensure sufficient capacity and appropriate vehicle deployment	• Minimize paper-based data collection processes (e.g., ridership data on timecards and GoBus manifest) • Gather, manage, and analyze data to enable data-driven decision making for service and capital planning and throughout all MATS functional areas • Establish systems for automatic data collection throughout the course of operations in a way that provides for robust historical records and analyses of trends, such that staff are not required to manually collect and/or enter data so that they can focus on providing safe, reliable, and expert service • Collect data at a fine-grained levels to allow for analysis at various spatial and temporal levels (e.g., bus stop, vehicle, trip, time of day, etc.) to improve customer service

Table 4. Findings Summary: County Information Systems

System	Potential Challenges and Issues	Needs, Goals, and Interests
Wide Area Network	• The County-maintained fiber optic network has substantial capacity (10 Gbit/sec) on the trunk lines, but redundant paths are not included in the system; network outages and the associated effects on operations are a concern for MATS operations • Networking in the County uses cellular connections for remote or mobile data communications; a private data radio network is not available	• A resilient network connection with redundancy to ensure smooth MATS operations
Server Infrastructure	• Reliability and robustness of server infrastructure	• MATS's needs for more robust servers should be included in the "hyperconverged" infrastructure deployment, as should their need for high-availability at the call-taking/dispatch center
Desktop Environment	• Reliability and robustness of desktop environment	• MATS staff need to interact with customers in real-time for reservations and inquiries, making desktop availability critical
Telephony	• Reliability and robustness of telephone system	• MATS's real-time interaction with customers relies on the telephone systems operating with a minimum of downtime, similar to the "five nines" target originally used for the Bell Telephone System (99.999% availability)
Geographic Information Systems (GIS)	• Integration of technology solutions to simplify user experience of MATS staff and customers	• Deployment of improved traveler information and fleet management software at MATS may be assisted by the GIS group, both in populating route and address information databases, as well as providing real-time service information to the public through custom-designed web applications

Inventory of Systems: MATS

The following are descriptions of existing systems and processes in place at MATS and Information Systems, based on a review of existing documentation and staff interviews. The existing systems and processes described in this section may or may not employ technology solutions. However, developing a full understanding the existing systems and processes that do not yet use software or hardware to complete the daily work of operating MATS transit service are equally important to understand as those that do.

For MATS, systems and processes inventoried in this document include MATS's transit operations, finance and administration, and planning. These systems are described in greater detail in this section and in Appendix B. Table 5 summarizes the primary software and hardware used in the various MATS systems described in the preceding sections.

Table 5. Primary Software and Hardware Used by MATS

MATS System	ArcGIS	Adobe Creative Cloud 2018	BS&A Timesheet Module	Diamond Mechanical Fare-boxes	Denominator (Onboard)	eTime Xpress by Celayix	Manager+	Microsoft Excel	Microsoft PowerPoint	Paper	Radio System (Onboard)	Trapeze PASS	Video Surveillance Systems
Staff Scheduling						X		X	X	X			
Vehicle Scheduling										X			
Driver Pre-and Post-Trip Procedures										X	X		
Driver-Dispatch Communications											X		
In-Service Supervision and Service Reliability											X		X
GoBus Trip Scheduling and Operations										X	X	X	
Passenger Fares and Revenue Collection				X				X		X			
Payroll			X					X		X			
Data Collection and Reporting								X		X		X	
Vehicle Maintenance							X						
Marketing	X	X								X			

MATS Transit Operations

The operations functional area presents many opportunities for employing technology solutions to address the efficiency and effectiveness of MATS service. While all MATS employees affect the operations function in some way, the following staff positions play the most essential roles in daily operations: Bus Operator and Paratransit Operator, Customer Care Representative (CCR), Transit Supervisor, Transit Route Operations Manager, Paratransit Operations Manager, and Transit Systems Manager. Within MATS transit operations are several critical subsystems and processes related to scheduling staff, scheduling vehicles, driver pre- and post-trip procedures, driver-dispatch communications, in-service supervision and service reliability, and GoBus trip scheduling and operations.

Scheduling Staff

There is a multi-step process for scheduling MATS drivers and assigning work, which is summarized in Figure 7. To complete this process, MATS uses several paper forms and multiple electronic platforms (some of which are shown in Figure 8 through Figure 11). The staff scheduling process is described in greater detail Appendix B.

Figure 7. Staff Scheduling and Work Assignment Process

Text shown in color and bolded indicate a unique format or platform used to complete the process

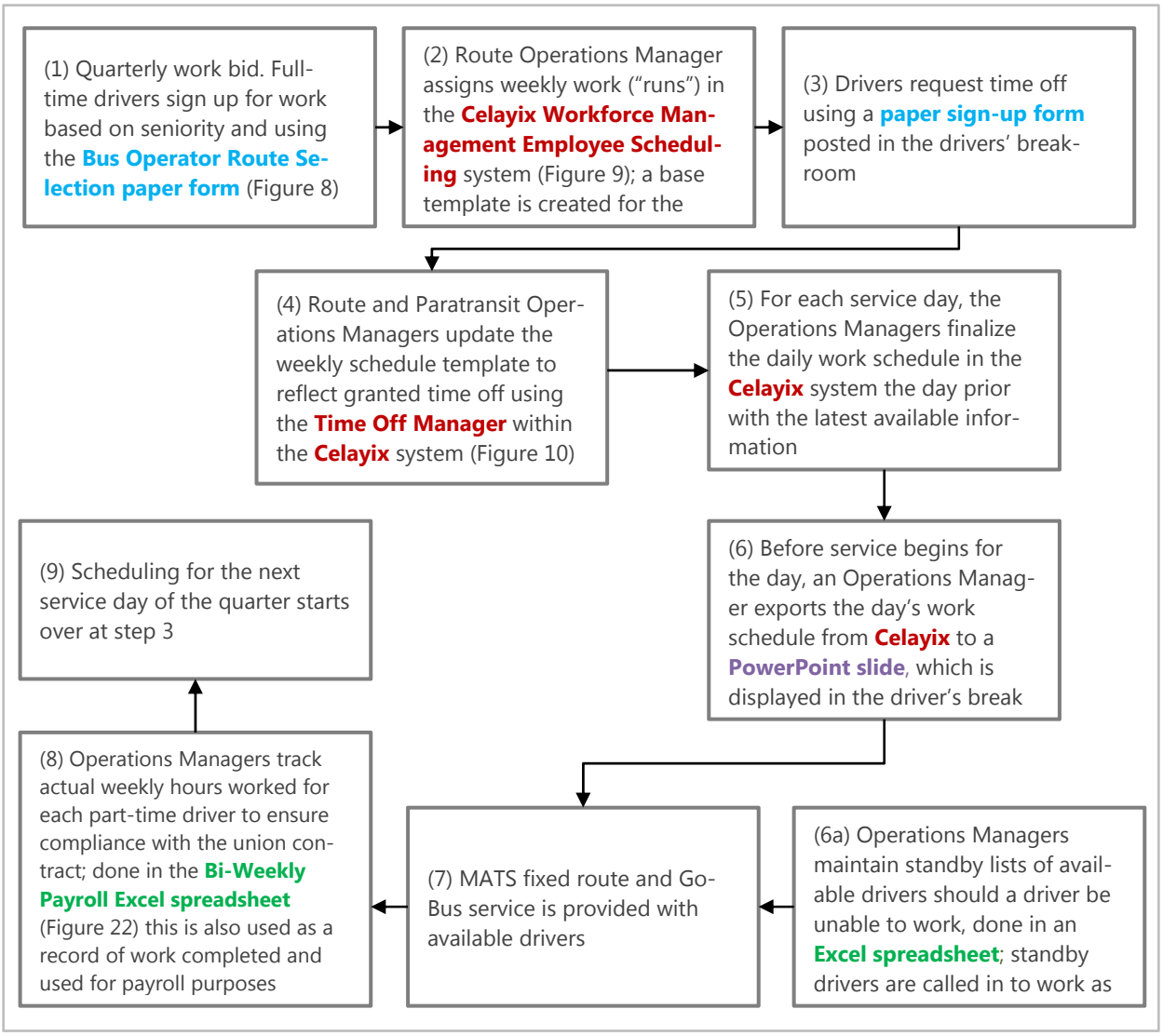


Figure 8. Fixed Route Bus Operator Route Selection Sheet, Completed Quarterly (Paper Form)

Bus Operator Route Selection

Please select your preferred route by signature, and denote your preferred days of work for that route.
This selection is by bargaining unit seniority. At least 3 FT drivers must include Saturday work.
Sign up must be completed by December 28, 2018
Effective Date: **Monday, January 7, 2019**

Ensure to sign for Opt-In/Out OT Sign-up

Early Routes

10	Henry	6:35am – 2:29pm	[illegible]	M T W TH F S
15	Sixth	6:11am – 2:37pm	[illegible]	M T W TH F S
25	Apple #2	6:28am – 2:59pm	R. HANSARD	M T W TH F S WWS
30	Getty/Wood	6:11am – 2:37pm	D. HARTON	M T W TH F S WWS
35	Lakeshore/Sherman	6:28am – 2:59pm	[illegible]	M T W TH F S
40	Peck/Sanford North	6:26am – 2:29pm	E. Young	M T W TH F S
50	Harvey	6:20am – 2:37pm	[illegible]	M T W TH F S
55	East Sherman	6:17am -- 2:29pm	[illegible]	M T W TH F S

Late Routes

15	Sixth	2:21pm – 10:57pm	Cora Fox	M T W TH F S
25	Apple #2	2:33pm – 10:57pm	[illegible]	M T W TH F S
30	Getty/Wood	2:21pm – 10:57pm	[illegible]	M T W TH F S
35/ 60	Lakeshore/Sherman Lakeshore/Henry	2:33pm – 10:57pm	A. Bergen	M T W TH F S
50	Harvey	2:21pm – 10:33pm	R. HALL	M T W TH F S WWS
55	East Sherman	2:03pm – 10:46pm	R. SHARP	M T W TH F S WWS

Mid Day, Split Routes & Extra Board

20	Apple #1	10:03am – 6:14pm	Major	M T W TH F S
45	Peck Sanford South	10:06am – 6:14pm	[illegible]	M T W TH F S
*70	Marquette Express	12:03pm – 7:59pm	[illegible]	M T W TH F
20 10	Apple #1 Henry	6:11am – 10:29am 2:03pm – 6:08pm	Casse	M T W TH F S
45 115	Peck/Sanford South Montague	6:28am – 10:23am 2:03pm – 6:13pm	Cooley	M T W TH F S
	**Extra Board #1	Variable (**See note below)	[illegible]	M T W TH F S
	**Extra Board #2	Variable (**See note below)	[illegible]	M T W TH F S

*For Marquette Express, the fifth work day will be determined after all route selections are completed.
**Extra Board includes early 8, mid-day, or split shift routes. No 2nd shift work.

MARC Routes

115	Montague	6:23am – 2:29pm	R. Nichols	M T W TH F

All Scheduled End Times are estimated. Actual End Time may vary.

Figure 9. Weekly Fixed route Run Schedule (eTime Xpress/Celayix Employee Scheduling System)

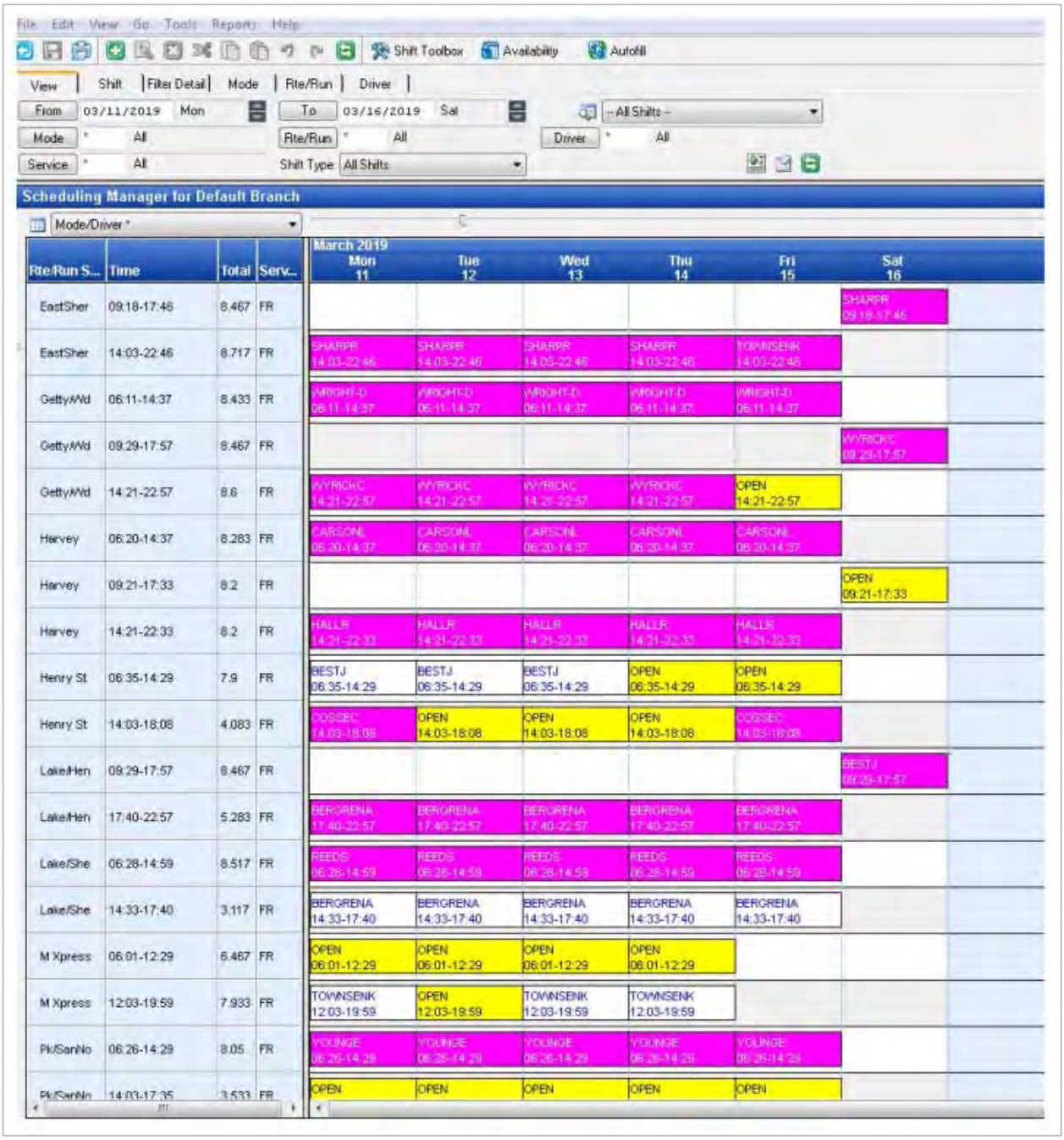
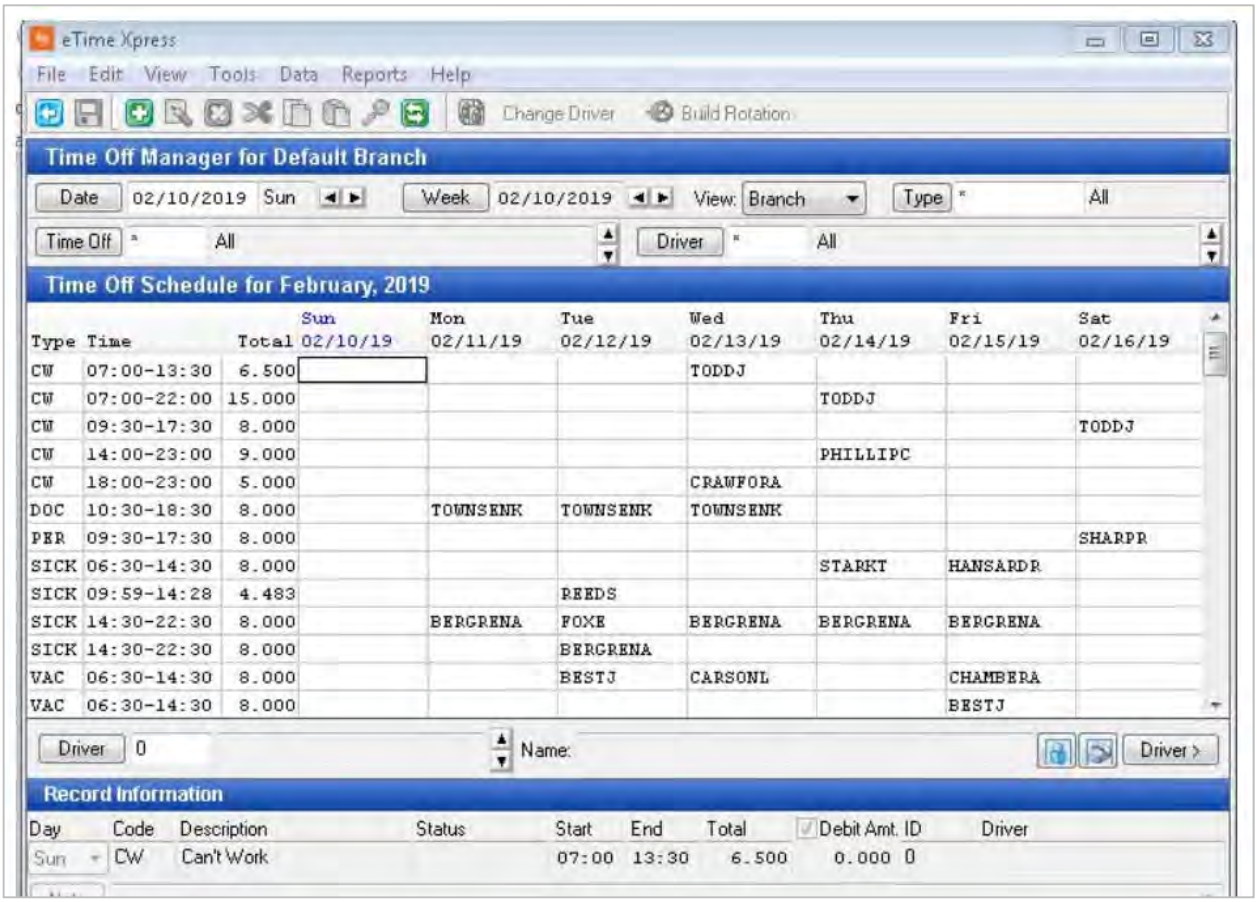
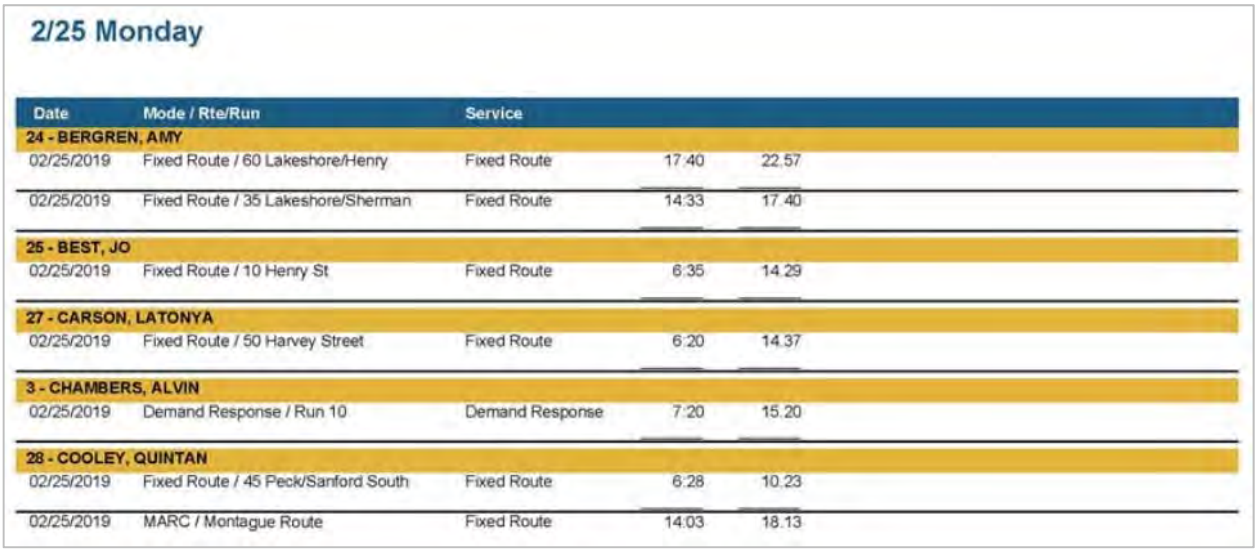


Figure 10. Time Off Scheduling Tool (Celayix Workforce Management Employee Scheduling System)



Type	Time	Total	Sun 02/10/19	Mon 02/11/19	Tue 02/12/19	Wed 02/13/19	Thu 02/14/19	Fri 02/15/19	Sat 02/16/19
CW	07:00-13:30	6.500				TODDJ			
CW	07:00-22:00	15.000					TODDJ		
CW	09:30-17:30	8.000							TODDJ
CW	14:00-23:00	9.000					PHILLIPC		
CW	18:00-23:00	5.000				CRAWFORA			
DOC	10:30-18:30	8.000		TOWNSENK	TOWNSENK	TOWNSENK			
PER	09:30-17:30	8.000							SHARPR
SICK	06:30-14:30	8.000					STARKT	HANSARDR	
SICK	09:59-14:28	4.483			REEDS				
SICK	14:30-22:30	8.000		BERGRENA	FOXE	BERGRENA	BERGRENA	BERGRENA	
SICK	14:30-22:30	8.000			BERGRENA				
VAC	06:30-14:30	8.000			BESTJ	CARSONL		CHAMBERA	
VAC	06:30-14:30	8.000						BESTJ	

Figure 11. Daily Driver's Schedule (PowerPoint Slide on Monitor in Drivers' Room)



2/25 Monday

Date	Mode / Rte/Run	Service		
24 - BERGREN, AMY				
02/25/2019	Fixed Route / 60 Lakeshore/Henry	Fixed Route	17:40	22:57
02/25/2019	Fixed Route / 35 Lakeshore/Sherman	Fixed Route	14:33	17:40
25 - BEST, JO				
02/25/2019	Fixed Route / 10 Henry St	Fixed Route	6:35	14:29
27 - CARSON, LATONYA				
02/25/2019	Fixed Route / 50 Harvey Street	Fixed Route	6:20	14:37
3 - CHAMBERS, ALVIN				
02/25/2019	Demand Response / Run 10	Demand Response	7:20	15:20
28 - COOLEY, QUINTAN				
02/25/2019	Fixed Route / 45 Peck/Sanford South	Fixed Route	6:28	10:23
02/25/2019	MARC / Montague Route	Fixed Route	14:03	18:13

Challenges and Issues

- Process uses two paper forms and four separate software programs/modules
- The Celayix driver scheduling software does not sufficiently account for union driver work rules, nor does it track actual work completed

Needs, Goals, and Interests

- Minimize paper-based data collection processes (e.g., staff sign-up sheets for picking work and requesting time off)
- Integrated solution for staff scheduling and payroll
- Ability to communicate with drivers via automated electronic notification with read receipt functionality
- Enable the Route Operations Manager to easily view and re-distribute work on a daily and weekly basis
- Better incorporate complex driver work rules into the driver scheduling process
- Scheduling program that documents actual work completed and tracking of work by driver, rather than used solely as a planning tool
- Simplify process of complete and document day-to-day scheduling changes (i.e., call-offs) and allows for easy scheduling and tracking of extra board and stand-by drivers
- Ability to produce driver work assignments that can be updated quickly, and easily shared with full-time and part-time drivers

Scheduling Vehicles

Revenue vehicles – for paratransit and fixed route service – are assigned to routes on a daily basis by the maintenance mechanic who opens the shop before service begins for the day. Drivers do not select their own vehicles, nor are they regularly assigned the same vehicle. Maintenance Mechanics have access to Manager+ fleet management software, but do not use the software for documenting which vehicles are available for revenue service, tracking preventive maintenance, parts withdrawals or inventory, or budgeting purposes.

In determining the available fleet for the day, the maintenance mechanic will check fluids and start each bus to ensure it is ready for service (additionally, all drivers are to complete a separate pre-trip inspection of their vehicle prior to starting their shift). The maintenance mechanic pulls available buses out of the garage and set up in two rows; he then writes down the location of each vehicle for the transit supervisor to reference. Next, the transit supervisor on duty will assign each available vehicle to a route, based on which route departs first. Buses are rotated daily and are not assigned to specific route (with the exception of route 115, which requires specific vehicles).

The transit supervisor assigns vehicles to each route by indicating the vehicle number on the paddle clipboard (which includes detailed shift work assignments) for each route and placing the clipboard in the office mailbox corresponding to each route. When preparing for their shift, drivers collect their paddle clipboard from the office mailbox to know which vehicle to retrieve.

Challenges and Issues

- Underutilization of Manager+ fleet management software

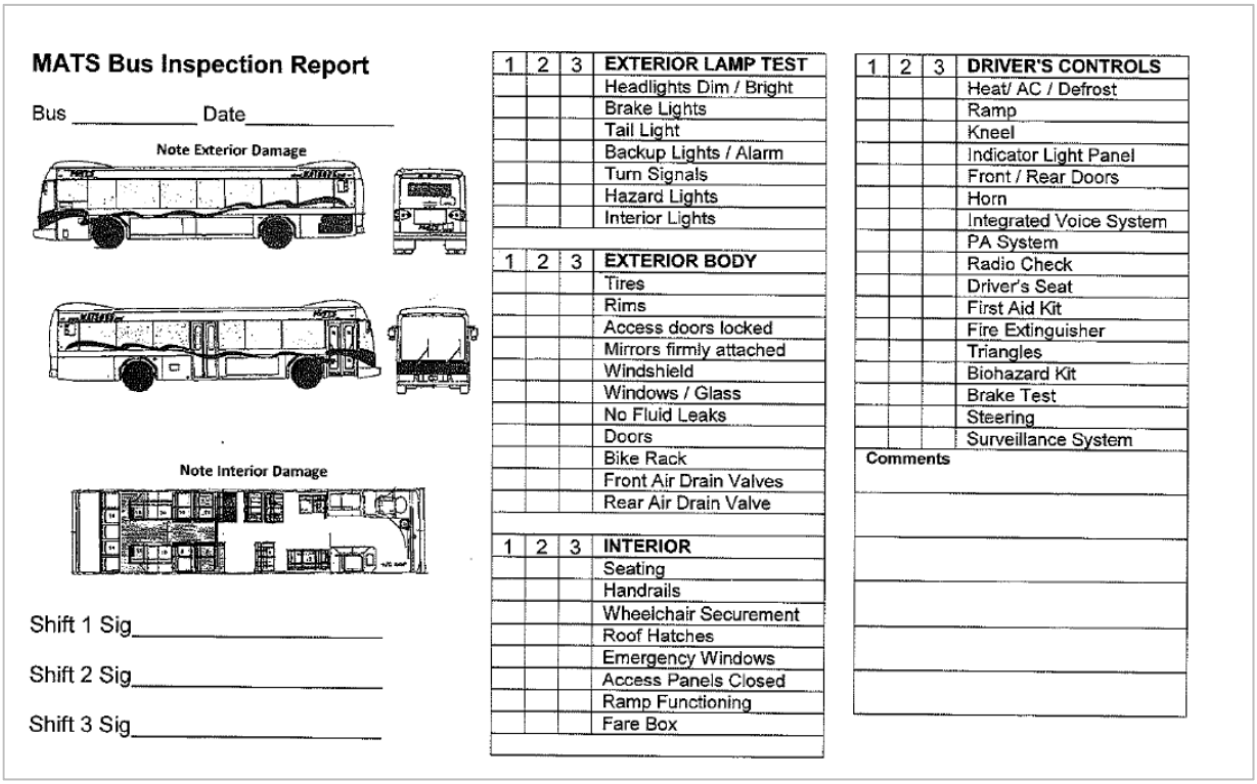
Driver Pre- and Post-Trip Procedures

All MATS drivers are required to complete a pre-trip Bus Inspection Report to document vehicle conditions prior to the beginning their shift. The Bus Inspection Report for heavy-duty buses operating fixed route service is shown in Figure 12; a similar form exists for drivers of MATS's light-duty cutaway buses and accessible mini-vans. Pre-trip procedures help to ensure safe operations and avoid unnecessary route delays and costly service calls.

The Bus Inspection Report is completed on paper and signed by each driver operating the vehicle within the day (up to three driver shifts per bus per day).

Mid-day, end-of-shift procedures include the completion of paperwork (i.e., timecard, passenger tally). End-of-day, end-of-shift procedures include paperwork, fueling and bus wash.

Figure 12. Fixed route Bus Inspection Report (Paper Form)



MATS Bus Inspection Report

Bus _____ Date_____

Note Exterior Damage

Note Interior Damage

Shift 1 Sig_____

Shift 2 Sig_____

Shift 3 Sig_____

1	2	3	EXTERIOR LAMP TEST
			Headlights Dim / Bright
			Brake Lights
			Tail Light
			Backup Lights / Alarm
			Turn Signals
			Hazard Lights
			Interior Lights

1	2	3	EXTERIOR BODY
			Tires
			Rims
			Access doors locked
			Mirrors firmly attached
			Windshield
			Windows / Glass
			No Fluid Leaks
			Doors
			Bike Rack
			Front Air Drain Valves
			Rear Air Drain Valve

1	2	3	INTERIOR
			Seating
			Handrails
			Wheelchair Securement
			Roof Hatches
			Emergency Windows
			Access Panels Closed
			Ramp Functioning
			Fare Box

1	2	3	DRIVER'S CONTROLS
			Heat/ AC / Defrost
			Ramp
			Kneel
			Indicator Light Panel
			Front / Rear Doors
			Horn
			Integrated Voice System
			PA System
			Radio Check
			Driver's Seat
			First Aid Kit
			Fire Extinguisher
			Triangles
			Biohazard Kit
			Brake Test
			Steering
			Surveillance System

Comments

Challenges and Issues

- Paper-based data collection process and filing system

Driver-Dispatch Communications

The driver communications function at MATS is a primary responsibility of CCRs, with back up from the on-duty Transit Supervisor (collectively, "Dispatch"). CCRs are based at the Herman Ivory Terminal; Supervisors work from the administration and maintenance facility when they are not in the field. The primary method of communication between drivers and CCRs is a two-way radio, with separate channels for fixed route and GoBus service. Supervisors use a third radio channel to communicate amongst one another. MATS uses an owned 800 MHz radio system for dispatching of fixed route buses. GoBus vehicles use owned ultra-high frequency (UHF) radios on a shared transmission tower and contracted frequency owned by a radio service company.

Radios are monitored throughout the operational day. Dispatch will contact fixed route drivers to verify location, divert to stops that are demand request only stops, to pass information, or in cases of emergency. Dispatch will contact GoBus drivers to add or cancel rides and to verify the actual time relative to progress made on the driver's manifest in order to update the dispatch software system to ensure it remains accurate. Drivers will contact Dispatch when they go into or out of service, or arrive at various transfer points. Drivers will also communicate directly with Supervisors or Mechanics as necessary. Drivers are allowed to have cell phones with them in case of

emergencies but are prohibited from using the cell phone while in service (except for GoBus drivers using them briefly for navigational purposes as needed).

Challenges and Issues

- CCRs' and Supervisors' inability to know the location of an in-service vehicle without calling the driver
- Two types of radio technologies used within two separate systems

Needs, Goals, and Interests

- Reliable communications infrastructure with built-in redundancy to ensure transit operations are not critically disrupted in the event of primary system failure
- Integrated communication system capable of meeting the three primary needs: communication between Dispatch and fixed route drivers, between Dispatch and GoBus drivers, and among Supervisors
- Service with voice and text communication options, prompted manually and automatically
- Integration with other MATS's systems (e.g., dispatch software)
- Provide drivers and Dispatch staff with automatic notifications of schedule adherence issues, minimizing reliance on driver calling in
- Vehicle tracking and telemetry systems to reduce reliance on radios and to enable drivers to focus on providing safe, reliable, and expert service
-

General In-Service Supervision and Service Reliability

Daily supervision of MATS operations is completed primarily by the Paratransit Operations Manager, Transit Route Operations Manager, four Transit Supervisors, and the Transit Systems Manager. CCRs assist in completing many in-service supervision tasks at the direction of the preceding staff.

MATS does not currently have systems in place for automatically monitoring daily operations conditions such as schedule adherence or the magnitude of passenger activity. Most commonly, Transit Supervisors, Operations Managers, and CCRs communicate with drivers via radio to understand on-the-street conditions at a given time. Transit Supervisors and Operations Managers conduct most of their daily business at the administrative and maintenance facility in Muskegon Heights. Fixed route passenger activity (i.e., boarding, alighting, and transfer) is greatest at the Herman Ivory Terminal in downtown Muskegon and the Muskegon Heights Transfer Point in Muskegon Heights. Moreover, most fixed route drivers have an 8-12-minute scheduled break ("recovery" or "layover" time) at the Herman Ivory Terminal.

Operating policies are established to foster reliable MATS service. However, actual operations performance monitoring is limited due to staff capacity and technology limitations. MATS's on-time performance standard is for 95 percent of fixed route trips to depart the beginning point of their hourly route on time, defined as no earlier than the scheduled departure time and no later than three minutes after the scheduled departure time. For GoBus service, a scheduled pick-up is considered on time no earlier than the scheduled pick up time and no later than 15 minutes after the scheduled pick up time. Fixed route and GoBus drivers are instructed to contact CCRs when operating behind schedule. Moreover, fixed route drivers are expected to radio in when arriving at the Herman Ivory Terminal. This assists supervisory staff assess conditions and make necessary adjustments to ensure high-quality service is delivered to passengers. Yet driver compliance with these operating policies is inconsistent.

MATS uses a variety of onboard camera systems aboard its revenue and non-revenue vehicles. These systems record and store video for the purposes of promoting public safety, reviewing customer complaints and incidents, and evaluating crashes and driver behavior as necessary. The onboard video systems include removable data storage devices ranging from 128GB to 500GB; each has its own playback software. The following onboard camera systems are in use on MATS vehicles:

- Safety Vision road recorder 6000/600 Pro, 7000
- Angeltrax multi-camera system
- REI System multi-camera system
- Vacron dash camera

Moreover, MATS uses DIGIOP Connect video surveillance monitoring system at its Herman Ivory Terminal.

Challenges and Issues

- Supervisors' and CCRs' inability to know the location of an in-service vehicle without calling the driver
- Supervisors' and CCRs' inability to learn of and address reliability issues in real time
- Inability to make data-driven decisions to address operational issues, design schedules, and allocate resources
- Several different onboard camera and surveillance systems, each requiring unique software and hardware

Needs, Goals, and Interests

- Vehicle tracking and telemetry systems to aid operations supervision, customer service, and analysis of on-time performance

GoBus Trip Scheduling and Operations

MATS's GoBus service fulfills its requirement to provide Americans with Disabilities Act (ADA) complementary paratransit. GoBus operates throughout Muskegon County, exceeding the minimum service area of ¾-mile from the fixed route system required under ADA. The county-wide shared-ride service requires pre-scheduled reservation, operates curb-to-curb, and is available to persons over age 65 or persons with a disability. GoBus fares vary based on the trip origin and destination; the fare is determined using three geographic service area zones (from $2.00 to $5.00 per one-way trip). Exact fare is collected on board the vehicle.

MATS does not have a robust process for determining ADA paratransit eligibility. Since GoBus operates beyond the minimum service area and is available to all persons over age 65 – regardless of the presence of a disability that limits their ability to use the fixed route service – very few GoBus customers have opted to go through the certification process (estimated to be less than one percent). However, MATS staff will certify riders who go through the process to prove their eligibility; doing so entitles certified riders to the promise of zero trip denials during regular service operations when following the established reservation policies.

MATS's process for GoBus trip scheduling and operations is summarized in Figure 13. To complete this process, MATS staff primarily use telephones, radios, paper forms, and Trapeze PASS computer-aided dispatch (CAD) system. The GoBus trip scheduling and operations process is described in greater detail Appendix B.

Figure 13. GoBus Trip Scheduling and Operations Process

Text shown in color and bolded indicate a unique format or platform used to complete the process

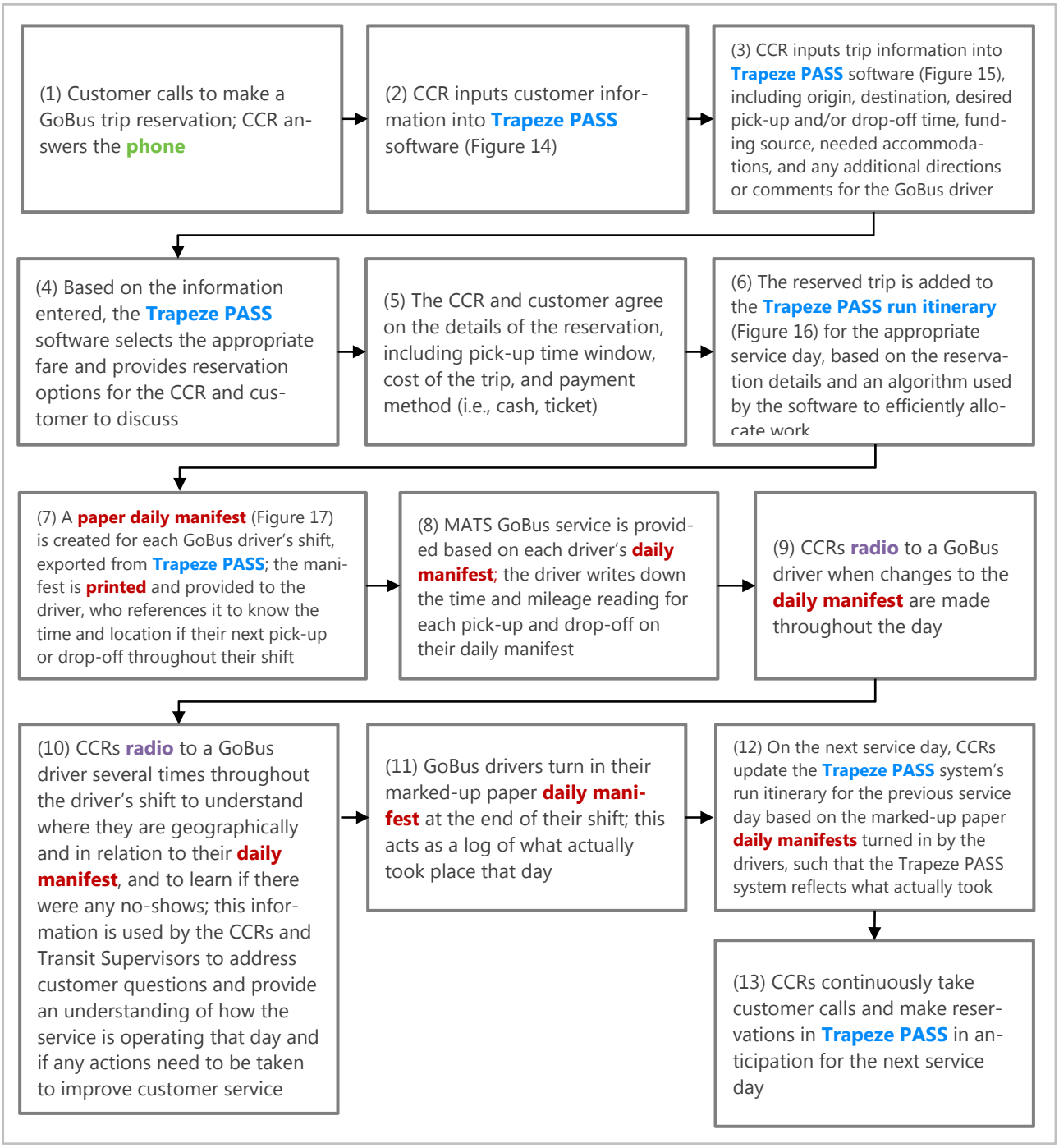


Figure 14. GoBus Customer Information (Trapeze PASS)

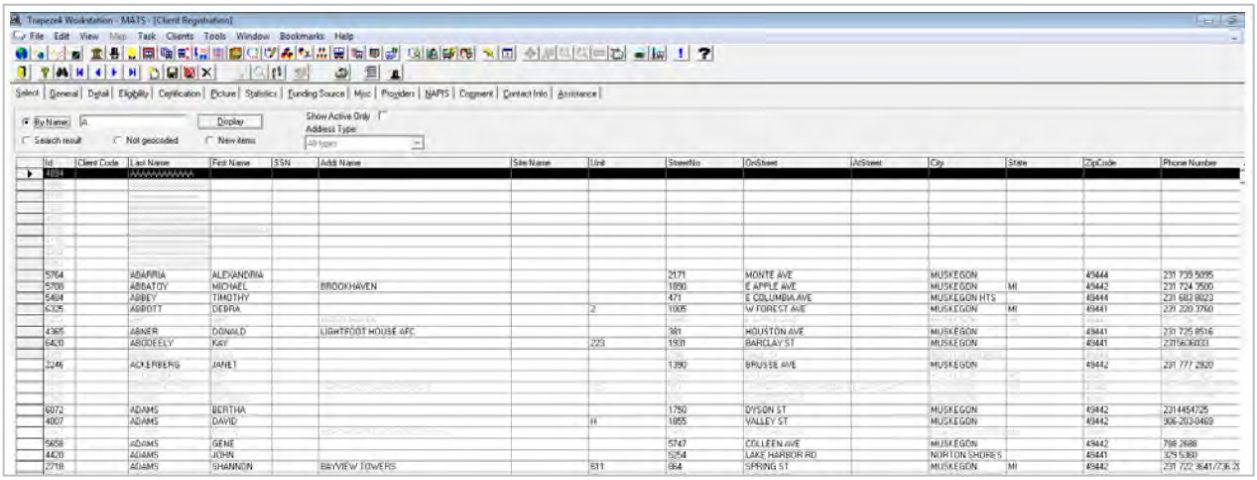


Figure 15. GoBus Trip Booking (Trapeze PASS)

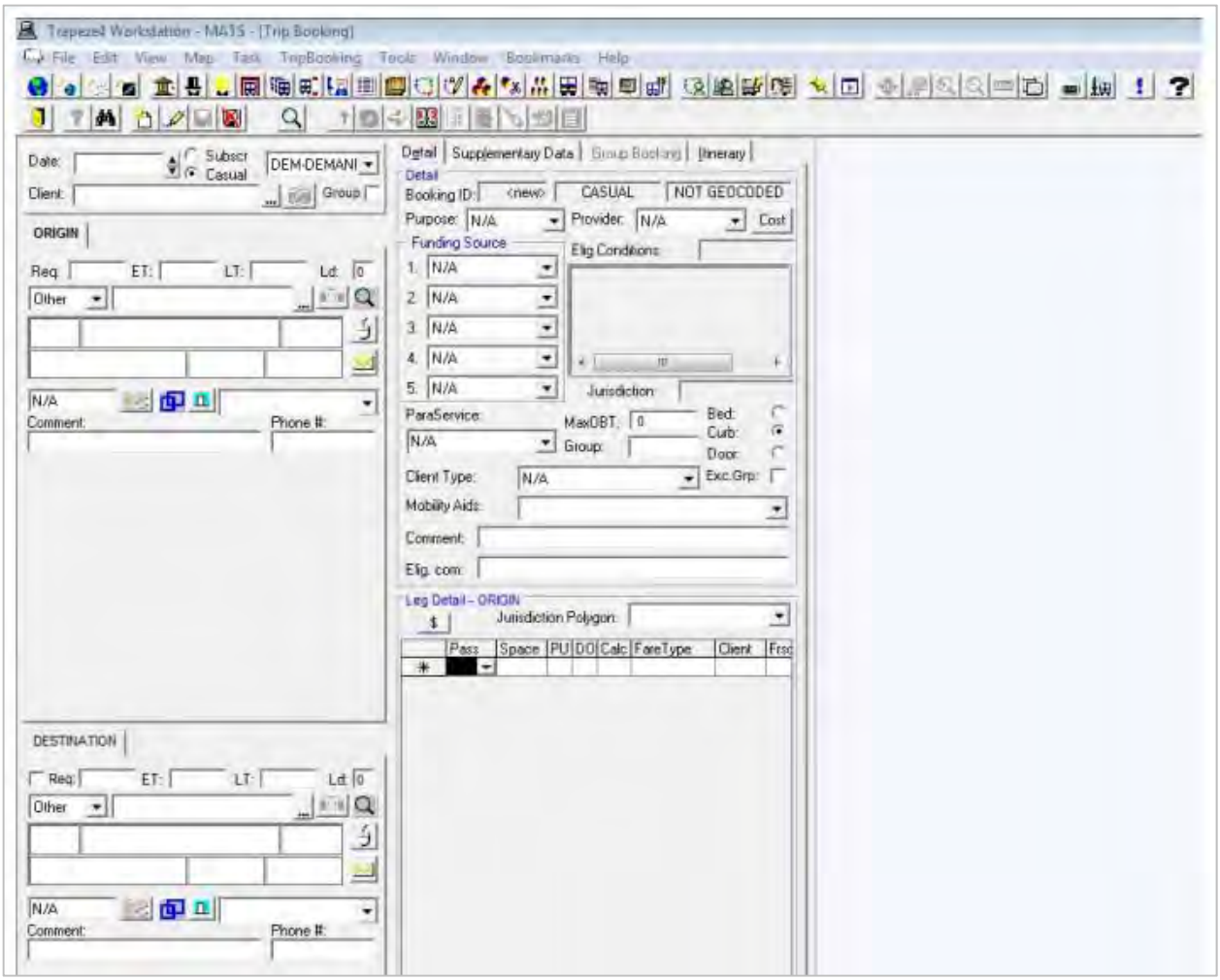


Figure 16. GoBus Run Itinerary (Trapeze PASS)

Schedule Editor - Run Itinerary

Edit View Find Cancel/NoShow Mark Map

View Options

Sched=[Live 03-06-2019, Wednesday] - Para Run = 10, Veh = , CapType = 5, MDT = 0][Direction=][OrderNow=]

Violations	Run	Stat	SubT	Act	SpaceOB.F	Client	Location	Sched	Est	ReqL	Slack	Distance	Travel	DwellTi	Comment
	10	S		Out			MUSKEGON AREA TRANSIT SYSTEM,6TH ST@WI	7:06	7:06		0				
	10	S	SUB-SUBSCRIPTION	P	AM1	BOSCH, JENNIFER	3104 OAK AVE	7:20	7:26			6.5	19	2	
	10	S	SUB-SUBSCRIPTION	P	AM2	WISEMAN, ETHEL MAE	1188 CENTER ST	7:24	7:34			1.7	5	2	
	10	S	SUB-SUBSCRIPTION	P	AM3	FODROCY, LORRAINE	1390 BRUSSE AVE	7:32	7:43			2.3	7	2	
	10	S	SUB-SUBSCRIPTION	P	AM4	ACKERBERG, JANET	1390 BRUSSE AVE	7:40	7:45				0	0	
	10	S	SUB-SUBSCRIPTION	P	AM5	SLATER, DONALD	1390 BRUSSE AVE	7:40	7:46				0	0	
	10	S	SUB-SUBSCRIPTION	P	AM5,WC1	JAMISON, MERRY	1324 MARQUETTE AVE	7:48	7:48			0.3	1	4	
	10	S	SUB-SUBSCRIPTION	P	AM5,WC2	OUTWIN, CHELSEA	862 FOREST PARK RD	7:55	8:08			7.2	16	4	"THE MARY HOUSE" D
BT	10	S	SUB-SUBSCRIPTION	D	AM4,WC2	BOSCH, JENNIFER	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:15			0.6	2	1	
	10	S	SUB-SUBSCRIPTION	D	AM3,WC2	SLATER, DONALD	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:16				0	0	
BT	10	S	SUB-SUBSCRIPTION	D	AM2,WC2	WISEMAN, ETHEL MAE	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:16				0	0	
	10	S	SUB-SUBSCRIPTION	D	AM2,WC1	JAMISON, MERRY	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:19				0	3	
	10	S	SUB-SUBSCRIPTION	D	AM2	OUTWIN, CHELSEA	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:22				0	3	
	10	S	SUB-SUBSCRIPTION	D	AM1	FODROCY, LORRAINE	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:22				0	0	
	10	S	SUB-SUBSCRIPTION	D		ACKERBERG, JANET	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		8:23				0	0	
	10	S	DEM-DEMAND	P	AM1	RENDER, RANDY	834 S SHERIDAN RD, #P-103	8:30	8:40			7.5	17	2	ARBOR CROSSING
	10	S	DEM-DEMAND	P	AM2	KANTOLA, TIM	495 GLEN OAKS DR, #1A	8:43	8:46			1.2	4	2	
	10	S	DEM-DEMAND	D	AM1	KANTOLA, TIM	HEALTHWEST-MAIN, 376 E APPLE		8:57	9:00		2.4	7	1	SLIDER DOOR IN MIDDL
	10	S	DEM-DEMAND	D		RENDER, RANDY	DAYBREAK LAKE FOREST, 572 LAKE FOREST LN		9:12			4.7	14	1	
	10	S	SUB-SUBSCRIPTION	P	AM1	WAITE, JOHN	3234 NESTROM RD	9:30	9:34			15.1	22	5	USES LIFT, WHITEHALL
	10	S	SUB-SUBSCRIPTION	D		WAITE, JOHN	FRESENIUS MUSKEGON DIALYSIS, 1080 W NORTI		10:04	10:10		14.2	21	3	
	10	S	DEM-DEMAND	P	WC1	GONZALEZ, BONNIE	HEALTHWEST-MAIN, 376 E APPLE	10:18	10:18			4.7	14	6	SLIDER DOOR IN MIDDL
	10	S	DEM-DEMAND	D		GONZALEZ, BONNIE	525 W SUMMIT AVE		10:41	11:00		3.7	12	5	
	10	S		D			2624 6TH ST	10:40	10:45			0.8	3	15	
	10	S	SUB-SUBSCRIPTION	P	AM2	MWEENE, MELISSA	12326 CROCKERY CREEK DR	11:15	11:24			16.6	24	3	
	10	S	SUB-SUBSCRIPTION	D		MWEENE, MELISSA	MCC, 221 S QUARTERLINE RD		11:54	12:15		16.8	25	1	
	10	S	DEM-DEMAND	P	AM1	POLANYI, CINDY	2029 CASTLE CT	12:14	12:14			8.4	19	2	OFF MCCRACKEN, BLIND
	10	S	DEM-DEMAND	P	AM1,WC1	GONZALEZ, BONNIE	525 W SUMMIT AVE	12:14	12:22			1.8	6	6	
	10	S	DEM-DEMAND	D	WC1	POLANYI, CINDY	TARGET, 6057 HARVEY ST		12:45	13:00		7.1	16	1	
	10	S	DEM-DEMAND	D		GONZALEZ, BONNIE	HEALTHWEST-MAIN, 376 E APPLE		13:10			8.5	19	5	SLIDER DOOR IN MIDDL
SL3	10	S	DEM-DEMAND	P	AM1	BUYS, MARK	2259 E APPLE AVE, #9	13:00	13:18			2.4	8	2	EASTWOOD VILLAGE
	10	S	DEM-DEMAND	D		BUYS, MARK	VA OUTPATIENT CLINIC, 5000 HAKES DR		13:37	14:00		7.2	16	1	PU/DO FRONT DOOR OI
	10	S	DEM-DEMAND	P	AM1	KUHAREVICZ, KATHY	1255 YORKTON PKWY, #lot 21	13:47	13:47			3.0	10	2	
	10	S	DEM-DEMAND	D		KUHAREVICZ, KATHY	SERVICES OF HOPE, 1061 S GETTY ST		14:01			3.3	10	1	CLOSEST CROSS STREE
	10	S	DEM-DEMAND	P	AM1	SCHROEDER, STEVE	1020 GORDON	14:06	14:06			1.4	4	2	
	10	S	DEM-DEMAND	P	AM2	BURMEISTER, JOE	1887 BARBARA ST	14:00	14:12			1.2	4	2	S OF LAKETON
	10	S	DEM-DEMAND	D	AM1	BURMEISTER, JOE	GOODWILL-APPLE, 271 E APPLE AVE		14:26	15:00		3.4	11	1	CAREER CENTER IN BA
	10	S	DEM-DEMAND	D		SCHROEDER, STEVE	600 W CLAY AVE, ##113		14:32			1.2	4	1	
FinL4	10	S		In			MUSKEGON AREA TRANSIT SYSTEM,6TH ST@WI	14:35	14:39			2.3	7		

Figure 17. GoBus Operator Manifest Example (Paper Form)

Driver:

MATS Manifest

Date: 2019-03-06

Route: 20

Vehicle:

Run Begin

Run End

Beginning Mileage

End Mileage

Total Daily Mileage

Est Time	Sch /Appt. Time	Arr Time Dep Time	Odometer	Client Name / ID / Comments	Address	Fare Type	Fare Amount	Pass Number	Pass Type	Space Type
10:45 Start	10:45				6TH ST MUSKEGON AREA TRANSIT SYSTEM					
10:52 Pickup	10:52			SCHROEDER, STEVE 2037	600 W CLAY AVE, ##113	MET	$2.00	1	CLI	AM
11:02 Pickup	11:00			PATTON, BOBBY 279	2924 PARK ST IF W/C STOPS, CHECK PLUG IN THE BACK	MET	$2.00	1	CLI	WC
11:13 Dropoff				PATTON, BOBBY 279	2500 HENRY ST PLANET FITNESS PLAZA ON HENRY SHERMAN					
11:29 Dropoff				SCHROEDER, STEVE 2037	1020 GORDON					
11:45 Pickup	11:30			ELMER, JANET 4900	2501 8TH ST	MET	$2.00	1	CLI	AM
11:53 Pickup	11:53			HETH, MARY 5916	350 HOUSTON AVE, #202 NELSON PLACE	MET	$2.00	1	CLI	AM
12:02 Dropoff				HETH, MARY 5916	1000 S GETTY ST WALGREENS APPLE GETTY					
12:07 Dropoff				ELMER, JANET 4900	354 SPRING ST, #700 BAYVIEW TOWERS					
12:30 Pickup	12:30			GALANDA, CARRIE 5515	1358 KINSEY ST, #2 N OF HACKLEY P25, 117, 120, S OF LAKETON	MET	$2.00	1	CLI	AM

Challenges and Issues

- The current MATS phone system allows for only four incoming calls at a time; the fifth concurrent incoming call, and any others, go straight to the voicemail system, which the CCRs must then check
- The underlying street network that MATS's Trapeze PASS software uses to most efficiently allocate trip reservations has not been updated since 2002
- Drivers are not provided with routing instructions, requiring them to make on-the-go decisions about how to most efficiently route from point to point; drivers will reference a separate GPS (e.g., from a personal cell phone) to locate and route to addresses they are unfamiliar with
- Trapeze PASS includes a vehicle and driver scheduling feature that MATS does not use
- CCRs' and Supervisors' inability to know the location of an in-service vehicle without calling the driver
- For each pick-up and drop-off, the driver is required to write down the actual time and mileage on their paper manifest
- Paper-based GoBus driver daily manifests do not reflect day-of reservation changes, requiring such changes to be communicated to the driver by CCRs using the radio system
- CCRs' must enter deviations from the previous day's driver manifest into the Trapeze PASS system such that the actual run information is in the system for record-keeping and reporting purposes

Needs, Goals, and Interests

- Phone reservation system that can handle more than four incoming calls at a time
- Options for GoBus customers to schedule trips online
- Upgrade current Trapeze PASS software to the latest version, or seek an alternative platform
- Reduce time CCRs spend taking trips reservations and editing GoBus operating data, freeing up time to serve customers in person and by phone and complete other tasks
- Move away from a paper-based system to an electronic one to reduce manual data entry and reconciliation process for CCRs and drivers, and allow or more reliable data and more robust analysis
- Real-time, automatic updates to driver manifests to reduce need for radio communication between drivers and CCRs
- In-vehicle routing system such that drivers do not need to reference a cell phone or other GPS device to efficiently drive to and from destinations
- Options for in-vehicle electronic documentation of the time and mileage immediately after completing a passenger pick-up or drop-off

MATS Finance and Administration

Passenger Fares and Revenue Collection

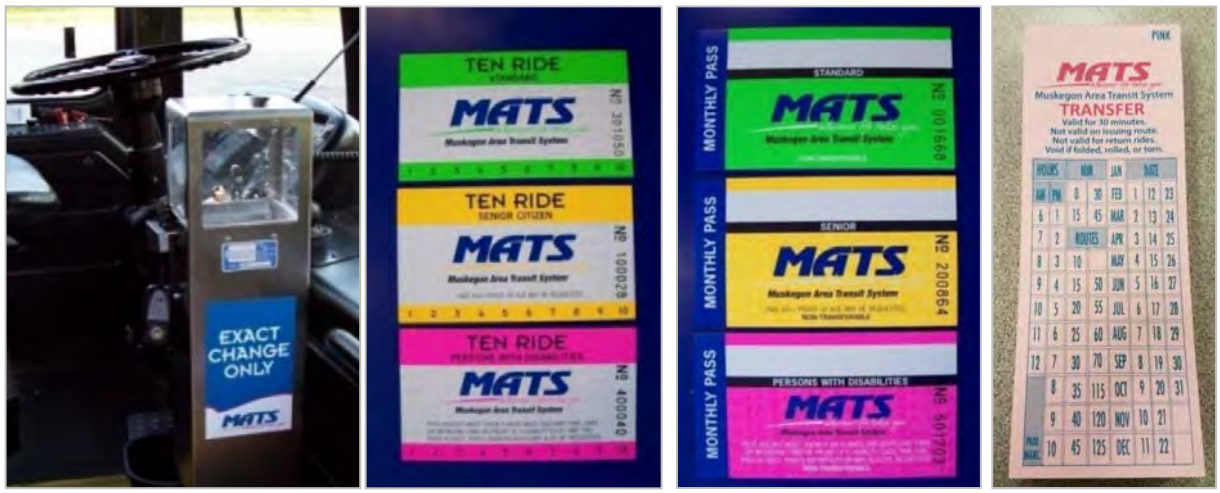
MATS drivers are responsible for making certain that customers pay the appropriate fares. Fares can be paid in cash (coins and/or bills; no change provided), or using a 10-ride pass, monthly pass, or driver-issued transfer (Figure 18). Cash fares are inserted directly into the on-board farebox by passengers, while passes and transfers are shown to the driver; the use of a 10-ride pass or transfer is documented by the driver using a hand hole punch. GoBus fares can be paid using cash or 10-ride ticket booklet.

Cash fares aboard fixed route buses are collected via a Diamond brand fare drop down collection box. The bus operator visually inspects the amount placed in the farebox and drop it into the locked vault. Because they do not have electronic validating fareboxes, this quick visual inspection by the driver is the extent of MATS's fare validation procedures in place today.

Ten-ride and monthly passes are sold aboard buses by drivers and by office staff at the Herman Ivory Terminal and MATS administrative and maintenance facility; staff are accountable for both the passes and the money issued to them. Employees are issued, and sign for, a certain number of passes for each month. They are responsible for either having passes and or money representing sold passes that equals the value of passes issued to them.

The money pouches used by the drivers to store passes and associated cash are locked up nightly in the MATS office. As drivers sell passes, they are encouraged to turn in the money collected for additional passes, keeping their balance of money low. Periodically, the money pouches are audited at random to ensure that the number of passes sold and money collected match. Cash collected is kept locked up and deposited periodically. Passes are serialized for further accountability and protection against loss. Sales are tracked in an Excel spreadsheet. Only cash is accepted by MATS for the purchase of bus passes.

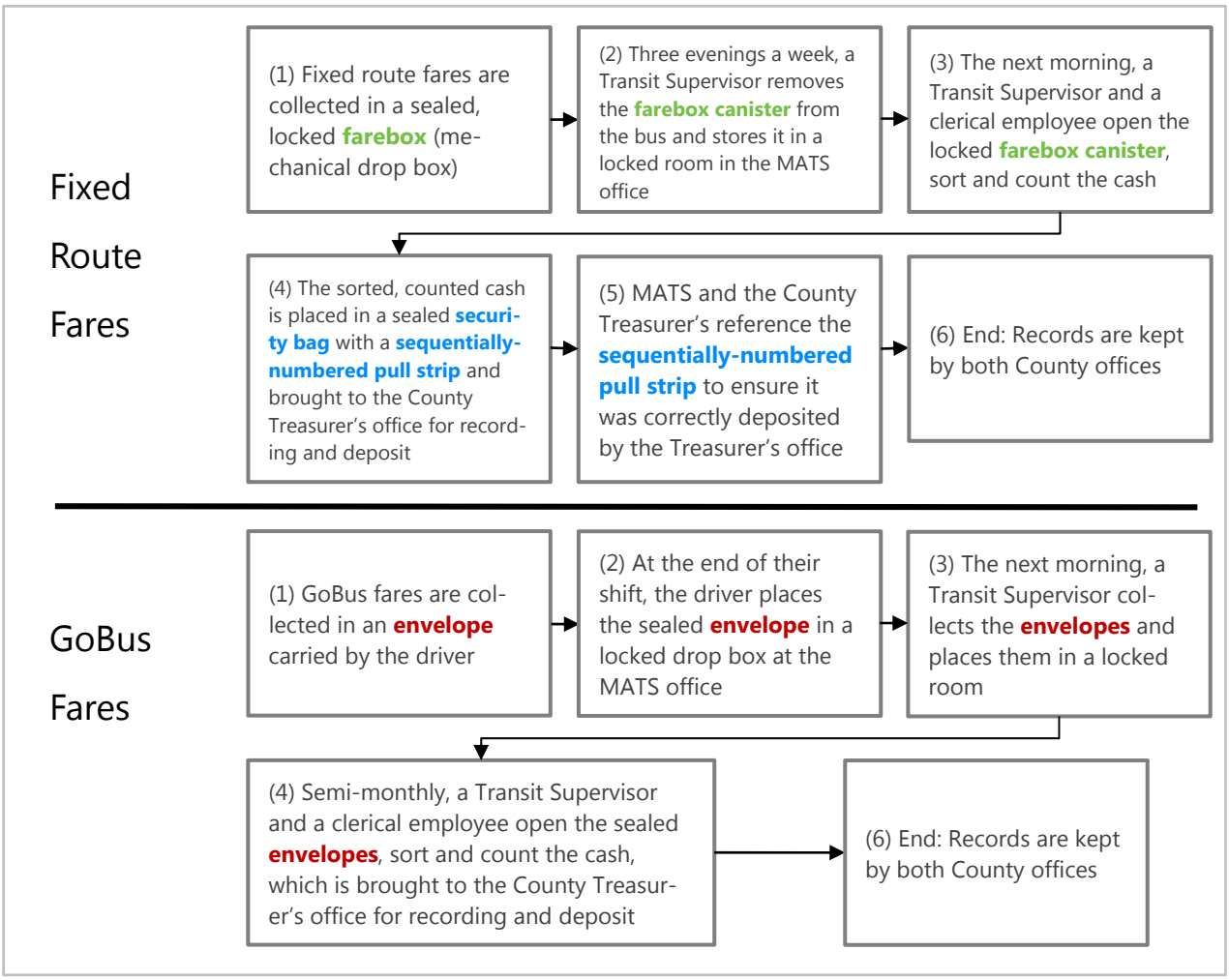
Figure 18. Passenger Fare Media



The off-board passenger revenue handling and accounting process is summarized in Figure 19 and described in greater detail Appendix B. To complete this process, MATS staff primarily use their locked mechanical fareboxes, cash and coin sorting machines, security bags, and sealed envelopes.

Figure 19. Passenger Revenue Accounting Process

Text shown in color and bolded indicate a unique format or platform used to complete the process



Challenges and Issues

- Due to County policies, MATS is currently unable to process credit card sales
- Mechanical drop box fareboxes do not validate fares; thus, information about fare evasion trends and quantification of lost passenger revenue is limited
- Mechanical drop box fareboxes do not collect detailed data on fare media usage by passenger type or geotag locations.
- MATS drivers have expressed concern about the requirement that they sell transit passed aboard vehicles while in service; these include safety concerns about handling relatively-large sums of cash (and fare value) and the impact sales have on schedule adherence. In response, some drivers have reportedly stopped selling 10-ride and monthly passes to passengers while in service, resulting in inconsistent customer service from driver to driver.
- The process of collecting, storing, sorting, counting, reconciling, and depositing cash fares is time-consuming and inherently risky

Needs, Goals, and Interests

- Enable MATS to accept credit cards as payment for bus passes and other revenue-generating products like advertising
- Implement farebox solutions that
  - Enable MATS to track passenger fares by type and medium, validate fares, and know when and where people are boarding the bus
  - Allow for the future use of refillable "smart card" (or "contactless card") bus passes to reduce the amount of cash collected on the vehicle and the time and effort spent reconciling cash fares
  - Could allow for future integration of mobile payment options
- Develop solutions that allow MATS to reassign bus pass sales away from drivers to improve consistency and quality of customer service, improve schedule adherence, and increase driver safety

Payroll

The multi-step employee payroll process is summarized in Figure 20 and described in greater detail Appendix B. To complete this process, MATS staff use paper timecards, Excel spreadsheets, and BS&A payroll software.

Figure 20. Employee Payroll Process

Text shown in color and bolded indicate a unique format or platform used to complete the process

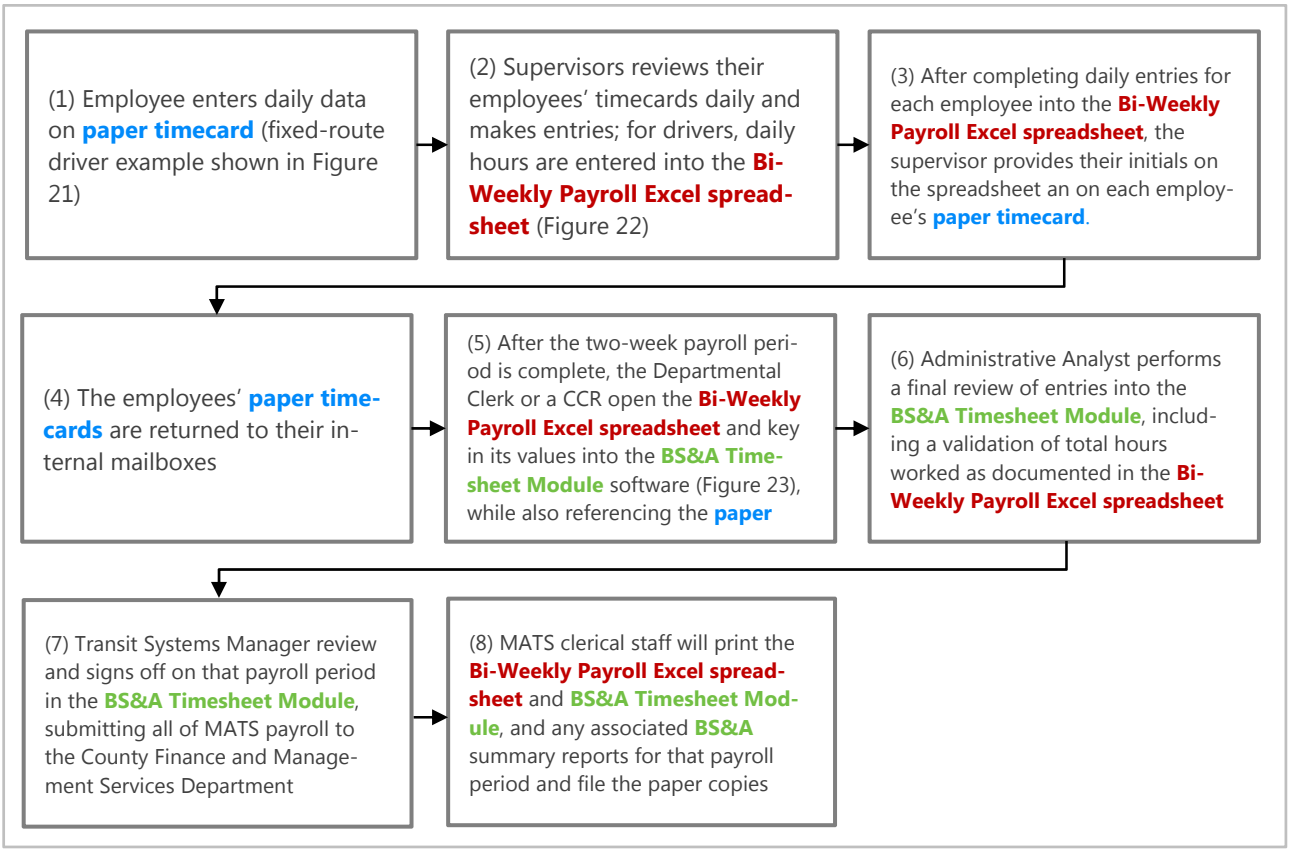


Figure 21. Fixed route Driver Weekly Timecard (Paper Form)

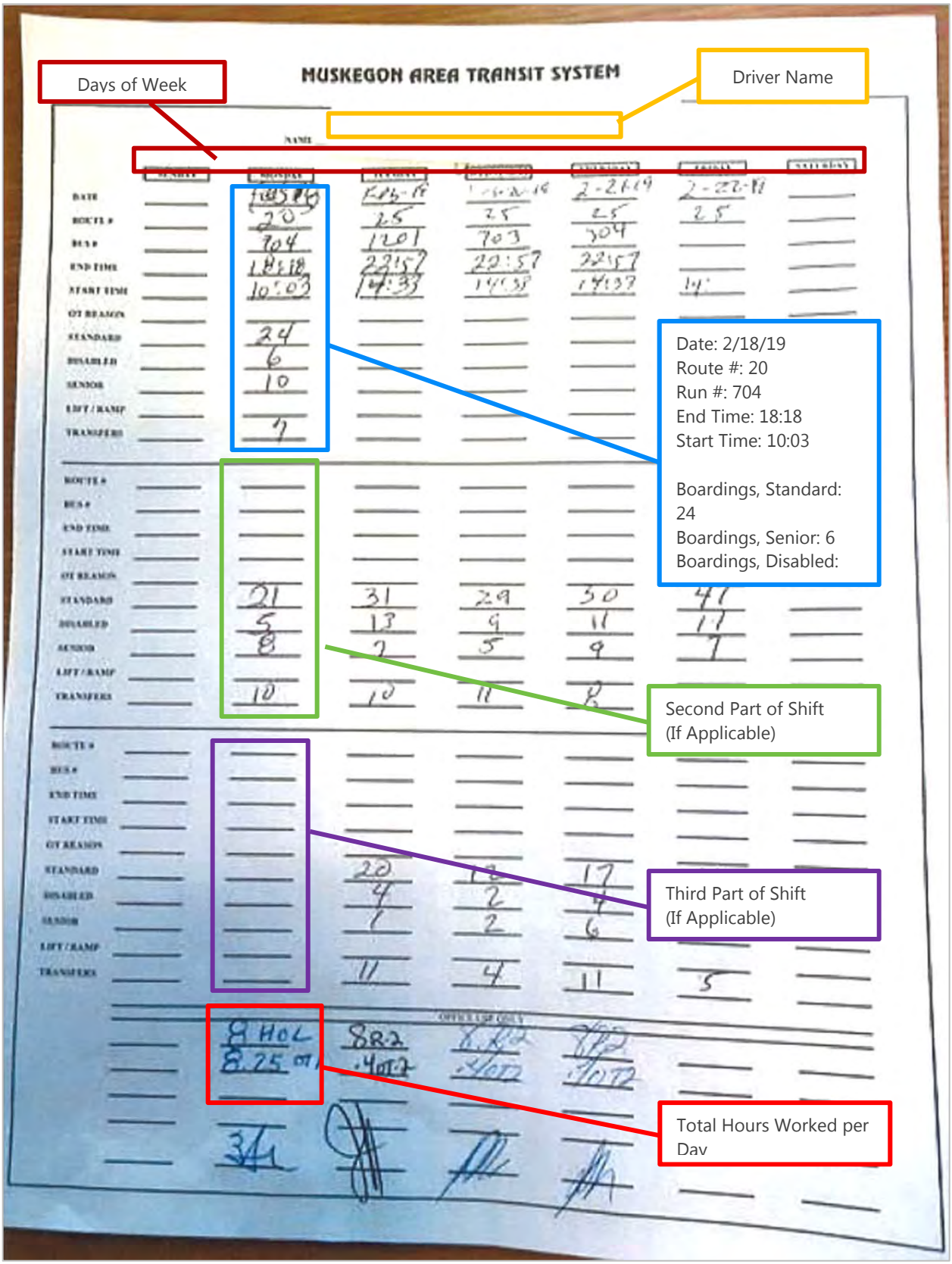
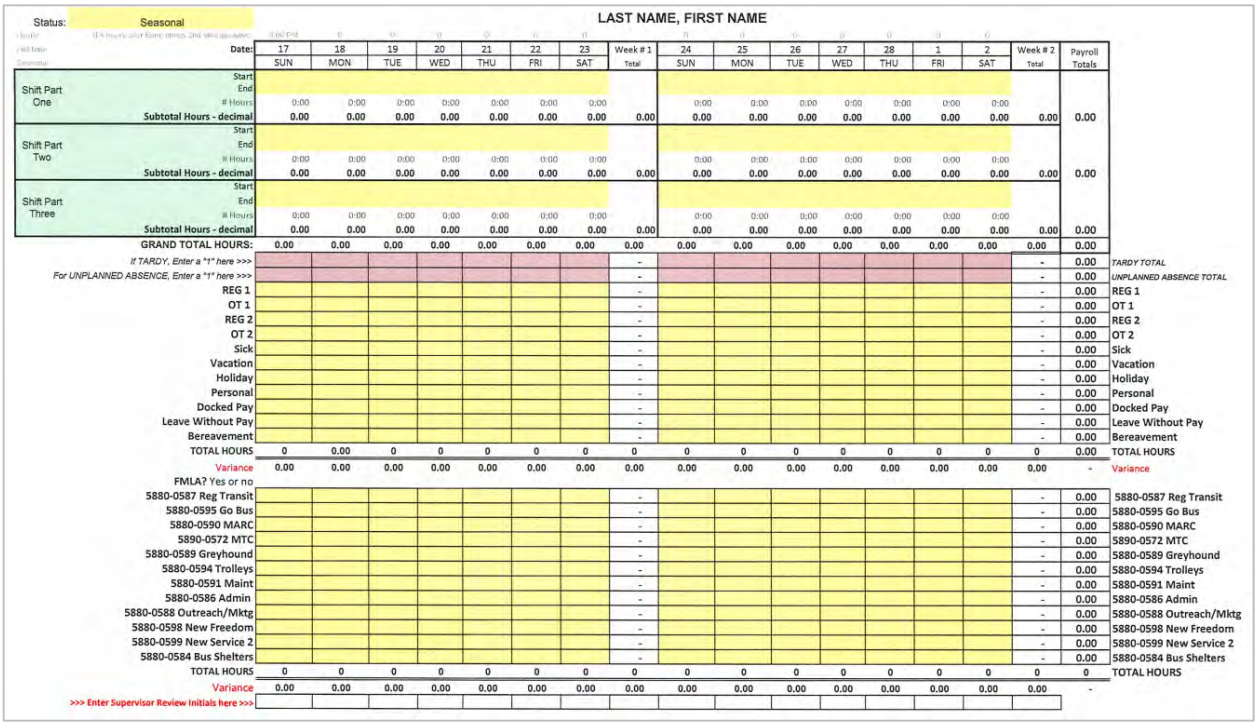


Figure 22. Bi-weekly Payroll Worksheet (Excel Spreadsheet)

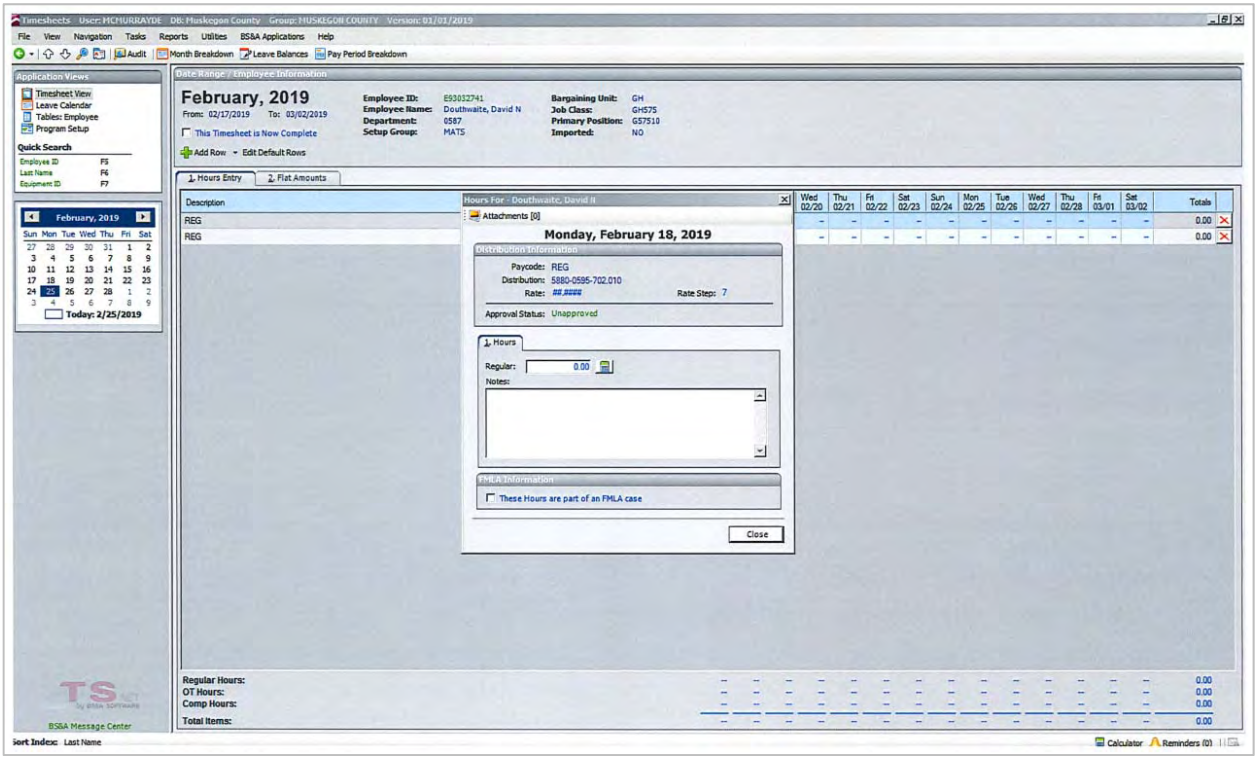


Status: Seasonal

LAST NAME, FIRST NAME

Date:	17	18	19	20	21	22	23	Week # 1 Total	24	25	26	27	28	1	2	Week # 2 Total	Payroll Totals
	SUN	MON	TUE	WED	THU	FRI	SAT		SUN	MON	TUE	WED	THU	FRI	SAT		
Shift Part One – Start																	
Shift Part One – End																	
Shift Part One – # Hours	0:00	0:00	0:00	0:00	0:00	0:00	0:00		0:00	0:00	0:00	0:00	0:00	0:00	0:00		
Shift Part One – Subtotal Hours - decimal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shift Part Two – Start																	
Shift Part Two – End																	
Shift Part Two – # Hours	0:00	0:00	0:00	0:00	0:00	0:00	0:00		0:00	0:00	0:00	0:00	0:00	0:00	0:00		
Shift Part Two – Subtotal Hours - decimal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shift Part Three – Start																	
Shift Part Three – End																	
Shift Part Three – # Hours	0:00	0:00	0:00	0:00	0:00	0:00	0:00		0:00	0:00	0:00	0:00	0:00	0:00	0:00		
Shift Part Three – Subtotal Hours - decimal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRAND TOTAL HOURS:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
If TARDY, Enter a "1" here >>>								-								-	0.00 *TARDY TOTAL*
For UNPLANNED ABSENCE, Enter a "1" here >>>								-								-	0.00 *UNPLANNED ABSENCE TOTAL*
REG 1								-								-	0.00 REG 1
OT 1								-								-	0.00 OT 1
REG 2								-								-	0.00 REG 2
OT 2								-								-	0.00 OT 2
Sick								-								-	0.00 Sick
Vacation								-								-	0.00 Vacation
Holiday								-								-	0.00 Holiday
Personal								-								-	0.00 Personal
Docked Pay								-								-	0.00 Docked Pay
Leave Without Pay								-								-	0.00 Leave Without Pay
Bereavement								-								-	0.00 Bereavement
TOTAL HOURS	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00 TOTAL HOURS
Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- Variance
FMLA? Yes or no																	
5880-0587 Reg Transit								-								-	0.00 5880-0587 Reg Transit
5880-0595 Go Bus								-								-	0.00 5880-0595 Go Bus
5880-0590 MARC								-								-	0.00 5880-0590 MARC
5890-0572 MTC								-								-	0.00 5890-0572 MTC
5880-0589 Greyhound								-								-	0.00 5880-0589 Greyhound
5880-0594 Trolleys								-								-	0.00 5880-0594 Trolleys
5880-0591 Maint								-								-	0.00 5880-0591 Maint
5880-0586 Admin								-								-	0.00 5880-0586 Admin
5880-0588 Outreach/Mktg								-								-	0.00 5880-0588 Outreach/Mktg
5880-0598 New Freedom								-								-	0.00 5880-0598 New Freedom
5880-0599 New Service 2								-								-	0.00 5880-0599 New Service 2
5880-0584 Bus Shelters								-								-	0.00 5880-0584 Bus Shelters
TOTAL HOURS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TOTAL HOURS
Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
>>> Enter Supervisor Review Initials here >>>																	

Figure 23. BS&A Timesheet Module (BS&A Financial Management Software [Countywide])



Challenges and Issues

- Paper-based employee timecards
- Timecards are shuffled between desks and mailboxes multiple times per week, increasing the likelihood one may be misplaced
- Time-consuming process, requiring many staff to complete; although, more staff is also a benefit for validation purposes
- Original data are re-entered twice, increasing likelihood of errors

Needs, Goals, and Interests

- Minimize paper-based data collection processes
- Integrated solution for staff scheduling and payroll
- Minimize the number of platforms (i.e., paper, spreadsheets, and financial software) needed to complete the payroll process
- Minimizes manual data entry, simplify the reconciliation process, and free-up time for Supervisors

MATS Planning

Data Collection and Reporting

As described elsewhere in the summary of service reliability, GoBus operations, passenger fares, and payroll functions, MATS staff collect a limited amount of ridership and operations data on a daily basis. While in service, fixed route drivers collect the following information during each shift:

- number of boardings by classification (i.e., standard, disabled, senior, and transfer),
- number of transfers, and
- number of instances where the vehicle lift/ramp was deployed.

MATS's process for collecting and organizing ridership and operations data is summarized in Figure 24; this process is described in greater detail in Appendix B.

Figure 24. Process for Documenting Daily Ridership

Text shown in color and bolded indicate a unique format or platform used to complete the process

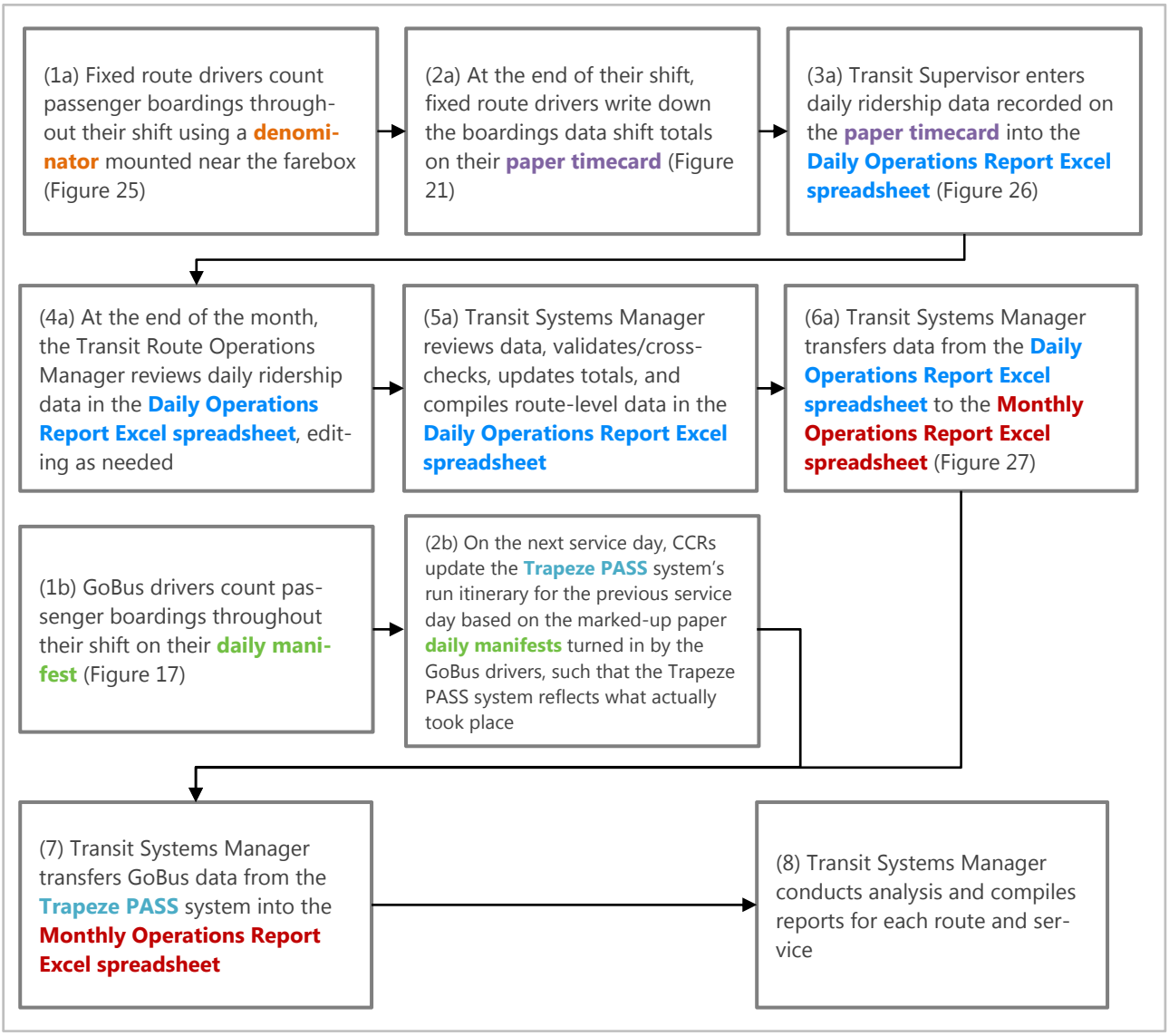


Figure 25. Passenger Denominator Aboard Fixed Route Buses

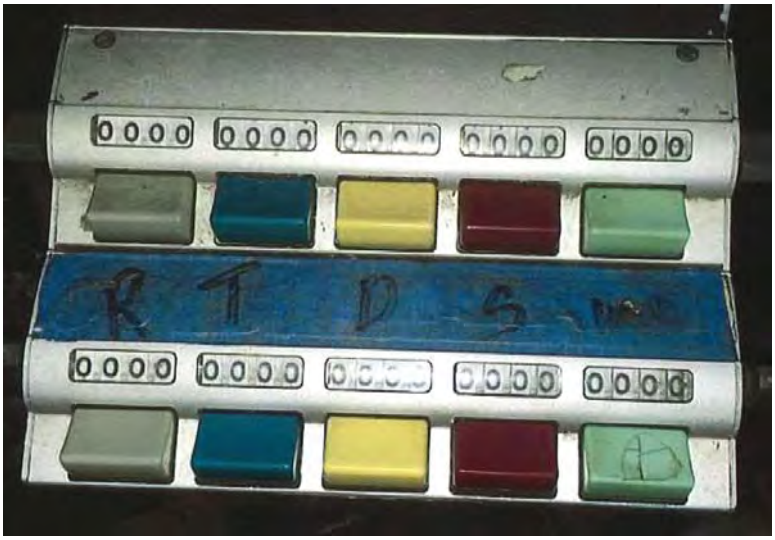


Figure 26. Excerpts from Daily Operations Report (Excel Spreadsheet)

Top: Daily ridership and operating statistics for Routes 10, 15, and 20.
Bottom: Monthly total ridership by weekday and weekend, by passenger fare type for fixed route ("linehaul") and GoBus demand response services

DATE: 12/14/18
DAY OF WEEK: Friday
WEATHER: Overcast/fog

	BOARDINGS							PERFORMANCE			
ROUTE	SENIORS	DISABLED	REGULAR	TOTAL	TRANSFERS	RAMP DEPLOYS	VEHICLE	REVENUE HRS	ROUTE PPH	REVENUE MILES	ROUTE PPM
10	12	32	29	73	16	0	902	7.33			
10	6	17	58	81	18	0	0	3.67	HENRY		HENRY
SUB TOTAL	18	49	87	154	34	0		11.00	14.0	141.02	1.1
15	13	26	47	86	30	2	904	8.00			
15	17	22	46	85	17	0	904	3.62			
15	6	8	53	67	21	0	904	4.58	SIXTH		SIXTH
SUB TOTAL	36	56	146	238	68	2		16.20	14.7	176.06	1.4
20	1	9	27	37	4	0	1201	3.67			
20	11	17	48	76	19	0	0	7.67	APPLE 1		APPLE 1
SUB TOTAL	12	26	75	113	23	0		11.34	10.0	140.61	0.8

LINEHAUL (Including Trolley Route)

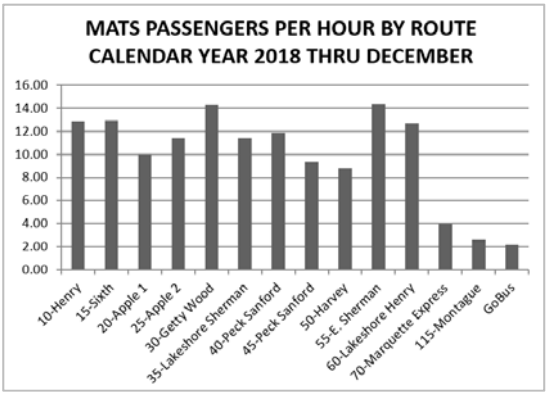
DATE	SENIOR	DISABLED	REGULAR	TOTAL
M-F TOTALS	3509	7892	19897	31298
% OF TOTAL	11%	25%	64%	100%
SAT TOTALS	359	681	1931	2971
% OF TOTAL	12%	23%	65%	100%
Total	3868	8573	21828	34269
				34,269

GOBUS

	SENIOR	DISABLED	TOTAL
M-F TOTALS	350	1025	1,375
SAT TOTALS	0	80	80
Total	350	1,105	1,455
			1,455

Figure 27. Excerpts from Monthly Operations Report: 2018 Annual Totals (Excel Spreadsheet)

ROUTE	PASSENGERS	REVENUE HOURS	PASSENGERS PER HOUR
10-Henry	35,782	2,772.0	12.91
15-Sixth	58,320	4,513.1	12.92
20-Apple 1	28,642	2,857.7	10.02
25-Apple 2	50,494	4,422.3	11.42
30-Getty Wood	64,655	4,513.2	14.33
35-Lakeshore Sherman	31,429	2,751.8	11.42
40-Peck Sanford	31,044	2,618.3	11.86
45-Peck Sanford	26,290	2,819.9	9.32
50-Harvey	39,276	4,457.2	8.81
55-E. Sherman	64,209	4,472.0	14.36
60-Lakeshore Henry	21,196	1,670.5	12.69
70-Marquette Express	6,806	1,719.9	3.96
115-Montague	7,338	2,821.2	2.60
GoBus	22,154	10,276.0	2.16



Challenges and Issues

- Paper-based data collection
- Original data are written down then keyed into a spreadsheet, increasing likelihood of errors
- Fixed route and GoBus data collection processes are stored in two separate systems
- The current data collection processes in place at MATS allow it to analyze and report the minimum required amount of ridership and operations data
- Within the current staffing and technological frameworks, MATS cannot use data to better understand the following aspects of its fixed route service, that impact customer satisfaction and funding:
  - How reliable service is provided, including the average on-time performance of a scheduled trip, a route, at a particular bus stop timepoint, or the average of the entire MATS fixed route system
  - The use of different fare media (i.e., cash, 10-ride pass, monthly pass) by various passenger classifications (i.e., standard, disabled, senior, and transfer)
  - When, where, and between which routes passengers are transferring most commonly
  - How many vehicle revenue hours and vehicle revenue miles are actually operated throughout a service day
  - Which bus stops have the greatest passenger activity on average
  - Whether passenger amenities such as bus stop shelters and benches are provided in all high-demand areas and whether they are distributed equitably
  - How many passengers miles are traveled using the service throughout a given year
  - How full its buses are (the vehicle's "load") at various point along the route to ensure sufficient capacity and appropriate vehicle deployment

Needs, Goals, and Interests

- Minimize paper-based data collection processes (e.g., ridership data on timecards and GoBus manifest)
- Gather, manage, and analyze data to enable data-driven decision making for service and capital planning and throughout all MATS functional areas
- Establish systems for automatic data collection throughout the course of operations in a way that provides for robust historical records and analyses of trends, such that staff are not required to manually collect and/or enter data so that they can focus on providing safe, reliable, and expert service
- Collect data at a fine-grained levels to allow for analysis at various spatial and temporal levels (e.g., bus stop, vehicle, trip, time of day, etc.) to improve customer service
  Enable MATS to regularly and reliably gather performance data such as passenger miles traveled, vehicle revenue miles, vehicle revenue hours, and passenger trips so that it can apply for additional federal funding available under FTA's Small Transit Intensive Cities (STIC) program

Inventory of Systems: County Information Systems

The following are descriptions of existing systems and processes in place at Muskegon County Information Systems, based on a review of existing documentation and staff interviews. Understanding the existing systems and processes of Muskegon County Information Systems is essential to developing feasible technology solutions for MATS. The critical systems of Muskegon County Information Systems Department include wide area network (WAN), server infrastructure, desktop environment, telephony, and geographic information systems (GIS).

County Information Systems

Information technology support for MATS is provided by Muskegon County Information Systems. Information Systems manages desktop support for all county agencies and offices, network connectivity, Internet services, server infrastructure and wireless connectivity. Additional detail for these functions is provided in the sections below.

Wide Area Network (WAN)

All county facilities are connected by an Ethernet network. The WAN supports desktop/business applications, telephony and SCADA devices. Both fiber optic facilities and wireless connectivity are used in the WAN deployment. Characteristics of the WAN are shown below and in Table 6.

Fiber Optic Plant

This network is configured in a star (non-redundant) topology and supports speeds up to 10Gbit/second between individual buildings. Fiber cable is a combination of aerial and underground installation.

Wireless Data

Information Systems maintains in-building and limited exterior accessible Wi-Fi (802.11) networks and uses cellular data routers for remote facilities, such as wastewater management. Exterior-accessible Wi-Fi is intended for specific purposes, such as downloading security video from vehicles and other non-continuous applications and is limited to areas around county facilities.

The cellular systems operate on Verizon 3G networks, although 4G (LTE) is available in the area. Cellular data is restricted to machine to machine applications such as pump/lift station monitoring and other low-bandwidth uses. Data plans for these applications are reported to be inexpensive as they have low monthly total usage.

No mobile (in-vehicle) wireless data systems are maintained by the County Information Services.

Table 6. Wide Area Network (WAN) System Characteristics

System Location	Muskegon County (generally within City of Muskegon)
Geographic Area Served	County facilities within Muskegon County
Intended Customers	Muskegon County Agencies, other local agencies and non-profit entities
O&M Responsibilities	Muskegon County Information Systems
Contact Person	Ivan Phillips, Information Systems Director, Muskegon County

Potential Challenges and Issues

- The County-maintained fiber optic network has substantial capacity (10 Gbit/sec) on the trunk lines, but redundant paths are not included in the system; network outages and the associated effects on operations are a concern for MATS operations
- Networking in the County uses cellular connections for remote or mobile data communications; a private data radio network is not available

Needs, Goals, and Interests

- A resilient network connection with redundancy to ensure smooth MATS operations

Server Infrastructure

Muskegon County employs a two data centers that house the county's storage and application servers. This overall architecture is not anticipated to change, but the County is currently evaluating proposals to substantially revise the implementation. Characteristics of the server infrastructure are shown below and in Table 7.

Current Environment

The majority of the County's server deployments are virtualized, using VMware hypervisors. Individual servers are generally based on MS Windows Server, but special-purpose servers may run various distributions of Linux. The Linux server are primarily maintained by the vendors of the applications which require them, but Information Systems staff performs basic system administration.

The data center also supports MS Windows Virtual Desktop Infrastructure (VDI), which allows the functional aspects of individual user's desktop computers to be centralized in the data center, simplifying maintenance and administration of desktops for users in all county locations.

Planned Environment

Substantial revisions are planned for the server infrastructure during 2019. Information Systems is currently reviewing proposals to implement a "hyperconverged" sever implementation to replace the existing virtualized server infrastructure. The new architecture will virtualize all functional aspects of the network, servers and storage systems, along with the definition of storage abstractions (volumes).

The new architecture allows for a common platform for compute and storage systems and promises to offer better overall performance while offering the flexibility to re-define the capacity of different virtualized services as needed without hardware changes.

The physical hardware on which the new converged environment will run is planned to be housed in the existing data centers maintained by the County.

Table 7. Server Infrastructure System Characteristics

System Location	Muskegon County Services Building (Apple Ave)
Geographic Area Served	County facilities within Muskegon County
Intended Customers	Muskegon County Agencies
O&M Responsibilities	Muskegon County Information Systems
Contact Person	Ivan Phillips, Information Systems Director, Muskegon County

Potential Challenges and Issues

- Reliability and robustness of server infrastructure

Needs, Goals, and Interests

- MATS's needs for more robust servers should be included in the "hyperconverged" infrastructure deployment, as should their need for high-availability at the call-taking/dispatch center

Desktop Environment

The standard desktop operating system used by Muskegon County is Microsoft Windows 7, although an upgrade to Windows 10 is on-going. Most user workstations use VDI clients to connect a desktop server located in one of the County's two data centers. Under this system, the user desktop and applications are housed and run remotely, facilitating centralized maintenance of software.

There are a limited number of stand-alone workstations in use, primarily isolate the applications on the workstations from network performance or reliability concerns.

Potential Challenges and Issues

- Reliability and robustness of desktop environment

Needs, Goals, and Interests

- MATS staff need to interact with customers in real-time for reservations and inquiries, making desktop availability critical

Telephony

The County uses a Voice Over IP (VOIP) telephone system for communications. This system uses the general purpose WAN to provide telephone service to all county facilities without using separate copper telephone lines to each building. The VOIP system has been in place since approximately late 2012. Characteristics of the telephony system are shown in Table 8.

Table 8. Telephony System Characteristics

System Location	Muskegon County Services Building (VOIP/SIP server) (Apple Ave)
Geographic Area Served	County facilities within Muskegon County
Intended Customers	Muskegon County Agencies
O&M Responsibilities	Muskegon County Information Systems
Contact Person	Ivan Phillips, Information Systems Director, Muskegon County

Potential Challenges and Issues

- Reliability and robustness of telephone system

Needs, Goals, and Interests

- MATS's real-time interaction with customers relies on the telephone systems operating with a minimum of downtime, similar to the "five nines" target originally used for the Bell Telephone System (99.999% availability)

Geographic Information Systems (GIS)

Muskegon County's GIS group is part of the Information Systems Department. GIS provides management, analysis and collection of geospatial data, as well as application development. The primary platform for GIS data management and development is ESRI's ArcGIS platform, but other tools are also used as needed. Characteristics of the Muskegon County GIS are summarized in Table 10.

Data Warehouse

Muskegon County GIS maintains a library of data to support internal analyses, GIS applications, and for distribution to external customers. Internally-accessible data includes over 400 different 'layers' of geospatial data. The layers most relevant to MATS operations are bus route (linear features) and bus stops (point features).

Several of these are accessible to the public. Municipal boundary data and roadway centerlines are freely downloadable. Parcel data and aerial photography are also available for fees determined by the amount of data.

Geospatial data is stored in on-premises servers and replicated across redundant data centers. Backups of data are performed both as incremental daily backups and weekly full backups to ensure that data can be recovered or reverted if necessary. No data availability or data loss issues have been reported that were not the result of user actions.

GIS Tools and Platforms

Muskegon County GIS is typical of county-level GIS departments in that it uses a variety of software tools and provides analysis services and user-accessible GIS applications for both internal County needs and to the general public.

The primary geospatial data platform is the ArcGIS suite, which is a modular software solution offering enterprise data management (ArcGIS Enterprise), workstation software (ArcGIS Desktop, ArcGIS Pro) and a variety of specialized data management modules for real-time data, data analytics and business intelligence solution. Currently there are three full-time GIS staff and approximately 7 other ArcGIS users of various technical proficiency levels. Table 9 lists some of the tools used by GIS that may be relevant to future transit applications.

Table 9. GIS Software tools

AutoCAD LT (AutoDesk)	Engineering and design
PictometryOnline and PictometryExplorer (PIC)	Oblique aerial image capture, processing and display
Apex Sketch (Apex Software)	Creating vector data from aerial images through manual sketch processes
Geocortex Essentials (Geocortex)	On-line map publishing framework

Applications

Access to data for non-GIS technicians is provided through custom-developed applications, which typically are accessed through a web browser. Creation of an application is typically initiated by a County or other local government business unit that approaches the GIS manager with a specific need or idea for development. The GIS group will then assess the technical feasibility and level of effort needed for implementation. If feasibility and effort are acceptable to all parties, the GIS group will develop, publish and maintain the application.

The GIS group has developed and maintained several applications that enable easy access to geospatial data for audiences outside of the GIS group itself. Many of these are accessible to the general public through the County's web site. These include:

- **Property Viewer**: Parcel locations, assessment and ownership data.
- **Who's My Commissioner**: Map showing County districts with commissioner contact data.
- **Elections Polling Places**: Locations and contact information for polling places with address searching to locate an appropriate polling place
- **Land Bank Properties**: The Muskegon County Land Bank acquires and rehabilitates properties, then offers them for sale to encourage redevelopment. The Land Bank Properties application displays locations of Land Bank properties and provides details on each.
- **Muskegon Cemeteries**: Provides location details for gravesites located in Muskegon County. Also provides details on specific plots where data is available.
- **Ashland Township Cemeteries**: Provides location details for gravesites located in Ashland Township. Also provides details on specific plots where data is available.
- **Muskegon Holiday Displays**: Displays locations of holiday decorations on public and private properties. This application is unique in that it allows the public to input data such as locations and photographs of displays.

Muskegon County's GIS group also provided geospatial data analysis and management for other communities within the County, such as the City of Muskegon and Muskegon Township. Muskegon GIS also maintains several on-line applications for partner communities, such as:

- **City of Muskegon Zoning Viewer**: Provides a parcel-level map of zoning classifications in Muskegon. The application also provides search tools for Parcel Identification Number, address and owner.

County specific applications are used for a variety of functions but are not a not made available to the public through the County's web site. Geospatial analysis supports a number of functions within the county, including survey, planning, property management and public works record keeping.

The GIS Group also maintains applications intended specifically for mobile device usage, such as tablets or cellular phones. These serve both public and internal users, depending on the specific function. The mobile-specific applications are:

- **Land Bank Lot Condition**: Allows on-site recording of lot clean-ups and other condition changes to parcels managed by the Land Bank.
- **Storm Water Drainage:** Enables County Public Works employees to record storm water flow and other information.
- **Muskegon Holiday Display**: Story Map: Provides the public with a way to enter private holiday displays into the database for display on the web application.

Table 10. GIS System Characteristics

System Location	Muskegon County Services (141 E Apple Avenue, Muskegon, MI)
Geographic Area Served	Muskegon County
Intended Customers	Muskegon County Agencies, Local Agencies, General Public
O&M Responsibilities	GIS Group (Muskegon County Information Systems)
Contact Person	Tom VanBruggen

Potential Challenges and Issues

- Integration of technology solutions to simplify user experience of MATS staff and customers
- Availability of technical staff with appropriate skills to collect and manage data
- Limited familiarity with mobile/embedded data sources such as Automatic Vehicle Location (AVL)

- Data layer maintenance updates are prioritized by frequency of use. Low usage layers may not reflect changes like changed bus stop locations or routes
- Lack of a formal structure (such as a standing quarterly meeting) to provide information exchange between MATS and GIS staff

Needs, Goals, and Interests

- Deployment of improved traveler information and fleet management software at MATS may be assisted by the GIS group, both in populating route and address information databases, as well as providing real-time service information to the public through custom-designed web applications

Next Steps

The findings from this Technical Memorandum #1: Baseline Conditions were used as the basis for identifying, and summarizing, issues and potential solutions in Technical Memorandum #2: Baseline Analysis.

Appendix A: Existing Documentation Provided

Existing documentation relevant to the focus categories were reviewed extensively and used to develop the inventory of systems. Table 11 lists the source materials referenced in creating an inventory of existing MATS systems.

Table 11. Existing Documentation Reviewed

Category	Document
Organizational Structure	MATS Organizational Chart
Organizational Structure	Muskegon County Organizational Chart
Organizational Structure	MATS Job Classifications
Organizational Structure	MATS Personnel Rules
Organizational Structure	Teamsters Local 214 Collective Bargaining Agreement
Assets	MATS Transit Asset Management Plan
Assets	MATS Facilities List
Assets	Louis A. McMurry Center Facility Plans
Assets	Herman Ivory Terminal Facility Plans
Assets	Lift of Software Used by MATS
Assets	Trapeze PASS v12 User Guide
Assets	Manger+ User Guide
Assets	Celayix eTime Xpress User Guide
Operations	MATS Driver Manual
Operations	Supervisor Typical Duties
Operations	Narrative and Example of Operations Processes
Finance	Narrative and Example of Finance Processes
Planning	MATS Public Comment Process
Planning	MATS Title VI Program
Planning	Narrative of Ridership Tracking and Reporting Processes
Planning	Daily Ridership Report Spreadsheet
Planning	Monthly Ridership Report Spreadsheet

Appendix B: Additional Information on MATS Systems

The following are detailed descriptions of select MATS systems processes, expanding upon that summarized in the preceding chapters.

Scheduling Staff

There is a multi-step process for scheduling MATS drivers and assigning work, which is summarized in Figure 7. Full-time MATS Bus Operators ("fixed route drivers") bid on work based on seniority and as outlined in the union contract. On a quarterly basis, full-time fixed route drivers sign up for the routes, runs, and days of the week they wish to work for the next three months; this process is completed using the Bus Operator Route Selection form, a paper sheet posted at the MATS administration and maintenance facility (Figure 8).

Following the bidding process, the Transit Route Operations Manager assigns work ("runs") for the quarter to all fixed route drivers (full-time, part-time, and seasonal) using the eTime Xpress application of Celayix Workforce Management Employee Scheduling system, a desktop software (Figure 9). The eTime Xpress/Celayix software allows the Route Operations Manager to view and re-distribute work among drivers. Each quarter, a new base template is created based on the new work bid. The Route Operations Manager updates this template on a weekly basis to reflect scheduled time off and other expected changes.

Drivers follow a process for asking for advanced time off using a paper sign-up sheet. The Operations Managers then input time-off requests into a module of the Celayix software (Figure 10). These pre-planned changes are reflected in the weekly Celayix drivers schedule. Once a schedule is set for each service day (in the morning, before service begins), an Operations Manager exports the daily schedule from Celayix and imports it into a PowerPoint slide, which is displayed in the drivers' break room (Figure 11).

MATS full-time and part-time drivers (fixed route and paratransit) are included in the Teamsters Local 214 Bargaining Unit ("union"), which has a collective bargaining agreement ("union contract") with Muskegon County. The union contract includes work rules for full-time and part-time drivers, including limitations on weekly hours worked for part-time employees. The Celayix driver scheduling software does not sufficiently account for these work rules. As such, the Route Operations Manager and Paratransit Operations Manager maintain a separate Excel spreadsheet for tracking weekly hours worked for all part-time drivers.

Moreover, when a driver calls in unable to work, the Route Operations Manager fills that piece of work with a driver from a pre-determined "extra board" or from a standby pool of available drivers. These relatively-common daily changes are reflected in the Route Operations Manager's Excel spreadsheet, but are not reflected in the Celayix software. The Excel spreadsheet maintained by the Operations Managers is representative of actual work completed for each driver. Thus, the Celayix software proves to be a useful tool for planning purposes, but not for payroll.

GoBus Trip Scheduling and Operations

All GoBus reservations are made by phone and fielded by the CCRs. MATS guarantees the trip if a reservation is made on the day prior; same-day requests are accommodated as possible. The current MATS phone system allows for only four incoming calls at a time. The fifth concurrent incoming call, and any others, go straight to the voicemail system, which the CCRs must then check; this occurs frequently.

To schedule trip reservations, CCRs use Trapeze PASS software, a computer-aided dispatch (CAD) system for scheduling and dispatching demand response service. MATS began using Trapeze PASS around 2002, and are currently using version 12 of the software, released around the same time. Annually, MATS pays approximately

$17,000 for support from Trapeze to use its software. Moreover, the underlying street network that MATS's Trapeze PASS software uses to most efficiently allocate trip reservations has not been updated since 2002.

Trapeze PASS is used by CCRs to maintain a databased of GoBus customers, book individual and reoccurring rides, and develop daily run itineraries and driver manifests (Figure 14, Figure 15, Figure 16, Figure 17). When the a CCR enters trip origin and destination for a reservation, the software identifies the appropriate zone-based fare; this and other key information is communicated to the customer at the time of reservation. The attributes of MATS's fleet have been loaded into the software, such that vehicles loads are not exceeded in the creation of driver manifests. Trapeze PASS includes a vehicle and driver scheduling feature that MATS does not use.

In dispatching trips and developing daily driver manifests, the software employs an algorithm to distribute and order pre-scheduled scheduled pick-ups and drop-offs in the most efficient manner, based on routing and the reservation attributes (i.e., scheduled time, origin, destination, ambulatory ability, etc.). An example daily driver manifest is shown in Figure 17. For each pick-up and drop-off, the driver is required to write down the actual time and mileage on the manifest.

Despite the capabilities of the GoBus dispatch and scheduling software, CRRs often must communicate day-of changes to drivers via radio and spend time updating the system. Each GoBus driver's daily manifest is printed the previous day. While in service, the driver references the printed manifest to know the details and order of their pick-ups and drop-offs. Day-of reservation cancellations, additions, and adjustments are not automatically reflected on the driver's manifest, requiring frequent communication between CCR and driver. When there is a deviation from the printed manifest, CCRs radio to drivers to collect information reflective of actual conditions, which they then manually input into the software. Doing so ensures CCRs understand where the driver is, geographically and relative to their manifest schedule, so that they can address customer questions and expand opportunities for new riders.

Trapeze PASS identifies the most efficient routing for the driver to complete between pick-ups and drop-offs. However, with MATS's paper-based system, this is not communicated to the drivers. As such, drivers are expected to possess a strong understanding of the service area and make on-the-go decisions about how to most efficiently route from point to point. Some drivers will use a separate GPS (e.g., from a personal cell phone) to locate and route to addresses they are unfamiliar with.

Upon completion of a GoBus driver's shift, they turn in their marked-up paper manifest, which acts as the log of what actually took place, including which trips were successfully made, when, and at what mileage. The completed manifest is given to a CCR, who enters its data into the Trapeze PASS system such that the actual run information is in the system for record-keeping and reporting purposes.

Off-Board Passenger Revenue Handling and Accounting Process

Fixed route cash fares are collected in a sealed farebox at the front of the bus and held secure until returning to the bus garage. Three evenings of each week, the on-duty Transit Supervisor uses a single-purpose key to remove the fare canister from the bus. As it is being removed, the fare canister locks, and its contents become inaccessible to the Transit Supervisor. An empty canister is inserted in its place for the next service day. The full fare canister is stored in a locked room until the next morning, when two employees – a Transit Supervisor and a clerical employee – open the canisters using the clerical employee's single-purpose key. The cash is straightened, and coins are run through a coin counter. All cash is then placed in a sealed security bag and brought to the County Treasurer's office for recording and deposit. The sequentially-numbered pull strip from the sealed security bag is maintained at MATS and is verified to the finance system, ensuring that the sequentially numbered security bag was deposited by the Treasurer's Office.

GoBus drivers collect cash fares in an envelope which is reconcile at the end of each shift. The front of the envelope provides space for the driver to indicate how many cash customers and how many prepaid ticket customers they carried. Envelopes are placed in a locked drop box at the MATS office by the driver at the end of their shift. The Transit Supervisor later collects these envelopes and places them in a safe in a locked room until such time as they can be opened, sorted, and counted. The contents of the envelope may be checked by two Transit Supervisors at random to ensure that each envelope contains the correct amount of cash and prepaid ticket stubs. GoBus cash and receipts are brought to the County Treasurer's office semi-monthly for deposit.

The process of collecting, storing, sorting, counting, reconciling, and depositing cash fares is time-consuming and inherently risky. Allowing passengers to use alternative fare media (e.g., refillable "smart cards" or "contactless cards," online and mobile payment options) would reduce financial risk and free up time for MATS drivers, supervisors, and clerical staff.

Payroll

Fixed route and GoBus drivers complete a paper timecard documenting hours worked or each shift, which is kept in an internal employee mailbox. For fixed route drivers, this paper timecard includes additional information such as passenger boardings by classification (Figure 21). On a daily basis, a supervisor collects timecards, reviews entries for errors or inconsistencies, and manual enters the information into a Bi-Weekly Payroll Excel spreadsheet (Figure 22); hours are entered into various expense codes based on the type of work completed. This spreadsheet is updated daily, and a new version of the file is created every two weeks. Following daily entry into the Bi-Weekly Payroll Excel spreadsheet (Figure 22), the supervisor initials the paper timecard (Figure 21) and returns it to the employee's internal mailbox. The supervisors of non-driver employees conduct a similar process, wherein the daily hours worked for each MATS employee is assigned to an expense code within the Bi-Weekly Payroll Excel spreadsheet (Figure 22).

After the two-week pay period is complete, the Departmental Clerk or a CCR will open the Bi-Weekly Payroll Excel spreadsheet (Figure 22) and key its values for each employee into the BS&A Timesheet Module (Figure 23), while also cross-referencing the employee's time original paper timecard (Figure 21). The BS&A Timesheet Module is part of BS&A Financial Management software, which the County uses across all departments.

Next, the Administrative Analyst will review all entries for the two-week period in the BS&A Timesheet Module (Figure 23), including a validation of total hours worked as documented in BS&A Timesheet Module and the Bi-Weekly Payroll Excel spreadsheet (Figure 22). The Transit Systems Manager will then review and sign off for the period in BS&A Timesheet Module; upon doing so, the entire MATS payroll is sent to the County Finance and Management Services Department.

Lastly, MATS clerical staff will print the Bi-Weekly Payroll Excel spreadsheet (Figure 22) and BS&A Timesheet Module (Figure 23), and any associated BS&A summary reports for that payroll period and file the paper copies.

Data Collection and Reporting

While in service, drivers use a denominator mounted near the farebox to track these data throughout their shift (Figure 25). These data are then transfer to the drivers' paper timecard at the end of his or her shift (Figure 21). During the driver payroll process that takes place daily, a Transit Supervisor enters daily ridership information from the timecard into the Daily Operations Report Excel spreadsheet (Figure 26) corresponding to the appropriate route and run. At the end of the month, these daily data are reviewed by the Transit Route Operations Manager and Transit Systems Manager.

GoBus drivers document passenger pick-ups and drop-offs on their daily manifest (Figure 17), including the time and odometer reading for each. The following day, the completed manifest is given to a CCR, who enters its data into the Trapeze PASS system such that the actual run information is in the system for record-keeping and reporting purposes.

Once the GoBus data have been entered into the Trapeze PASS system, and the Transit Systems Manager has reviewed the Daily Operations Report Excel spreadsheet (Figure 26), the data from both services are then transferred into the Monthly Operations Report Excel spreadsheet. The Transit Systems Manager pairs these ridership data with scheduled vehicle revenue hours and scheduled vehicle revenue mile values to conduct route-level analyses and reporting (Figure 26, Figure 27) that are shared with policy-makers and funding partners.

MUSKEGON AREA TRANSIT SYSTEM

Transit Technology Implementation Plan

Technical Memorandum #2: Baseline Analysis

May 2019

SRF Consulting Group

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Overview

This memorandum presents an analysis of the findings documented in Technical Memorandum #1: Baseline Conditions prepared for the MATS Transit Technology Implementation Plan. This analysis summarizes the major issues identified in the Baseline Conditions document, describes the solutions that can be used to address those issues, and identifies the enabling technologies that must be deployed to implement the various solutions. This technical memorandum provides MATS with a clear description of the connection between issues and proposed solutions. The solutions can then be prioritized for detailed research, and an in-depth review of suitable technologies.

Identified Issues

Several related categories of operational and administrative issues were described by MATS and other staff. These are described in detail in the Baseline Conditions memorandum and are summarized here:

- Limited payment options are restricted to cash and paper fare cards.
- Drivers handle cash & card inventories.
- Ridership data is hand-recorded and transcribed.
- Driver scheduling is labor intensive and lacks quick notification and acknowledgement mechanisms.
- On-demand trip requests cannot be confirmed in real time and driver manifests cannot be easily updated in real time.
- Cash management is a manual process from fare box vaults.
- Vehicle location and route compliance data is not available in real time.
- Computer and network reliability issues make real-time operations difficult.
- Staff availability to manage technology deployments is limited.

Potential Solutions

The issues identified can be addressed by a set of process and technology improvements to MATS current management systems. These include hardware deployments on vehicles, software upgrades and staffing changes within the MATS organization. The initial categories of solutions explored for the Transit Technology Implementation Plan are summarized below.

Electronic Payments

Refillable/rechargeable payment cards that are readable by hardware on the vehicle. Both monthly and ride-based passes can be accommodated by payment cards, which could then be sold at transit service centers and refilled via automatic payments, on line, or in person. A related change is implementing a compatible credit card/debit card electronic funds transfer service. As a part of the payment upgrades, more sophisticated fare boxes that incorporate cash separation and counting hardware can be deployed to reduce cash management workload.

Demand Response Management Improvements

The Trapeze PASS software is currently used to record ride requests and generate trip manifests. This process does not allow real-time confirmation of ride reservations and does not allow for real-time updates of manifests. Implementing real-time fleet tracking and in-vehicle displays to work with upgraded software would allow for a more responsive system that is able to serve more trips.

Staff Scheduling

Transit management software can incorporate improved tracking of hours, on-duty/off-duty check-ins via smart cards for drivers, alternate management and on-line staff requests/confirmations for call-in replacement drivers. Staff scheduling software upgrades can be incorporated into an overall software upgrade strategy.

Passenger Data Collection

Locations of boardings and alightings as well as passenger classifications are critical pieces of data that enable service planning and operations reporting. A passenger data collection system for fixed route vehicles would provide location data for the vehicles and present an interface to the driver to categorize boarding passengers. This system could also be connected to electronic payment cards to automate data collection.

Staffing

Although not a technological solution, assigning staffing resources to implementing and maintaining the various technologies noted in this section increased the likelihood of long-term success of the deployments. Staff may be part of the MATS organization or part of Information Services with specific responsibilities for supporting the systems used by MATS. Appropriate staffing for successful implementation of new technologies and systems includes thorough and continued preparation and training for the users of the technology systems.

The relationship of the potential solutions to identified issues is shown in Table 1.

Table 1. Identified Issues and Potential Solutions

Identified Issues	Potential Solutions			
	Electronic Payments	Demand Response Management Improvements	Staff Scheduling	Passenger Data Collection
Limited payment options	X			
Drivers handle cash & card inventories	X			
Ridership data	X			X
Driver scheduling			X	
On-demand trip requests		X		
Cash management	X			
Vehicle location and route compliance data				X
Computer and network reliability		X	X	
Staff availability	X	X	X	X

Enabling Technologies

Each of the potential solutions relies on a set of enabling technologies. These are foundational mechanisms that allow the implementation of integrated solutions. To support the solutions described above the following technologies are required in some form for deployment:

Mobile Data

The ability to communicate location, fare transaction and manifest data (for demand responsive service) to and from vehicles is a critical foundational technology. Cellular data is the most common solution, but is limited by coverage and service limitations (data caps) imposed by providers. As alternates, satellite data and private data radio networks may be considered, although these have specific limitations as well. Mobile data hardware may also contain automatic vehicle location hardware, such as GPS receivers, or it may receive position data from another component on the vehicle, such as a mobile computer.

Mobile Computers

Mobile computers are available in many physical formats and have a range of capabilities. At a minimum, the computer must have a display to present information to a driver, an input mechanism (touchscreen, keyboard or dedicated buttons) to accept information and a data connection to MATS systems.

Paratransit Software

Efficiently managing trip data and processing information from the field relies on specialized software. MATS currently employs Trapeze PASS, but only uses a subset of its features. Expanding the role of this software package to include real-time vehicle location and data communications addresses several issues identified.

Human Resources (HR) Software

Software tools to manage employee scheduling, paid time off and substitutions are common. However, there are solutions that are directly integrated, or can be interfaced with transit management packages. This approach addresses the workload not only of managing staff resources, but also assignment to routes or specific passengers for on-demand service.

Fare Card Readers

Fare cards use magnetic stripes or Radio Frequency Identification (RFID) chip to contain information related to account identifiers, account balances or other information. Fare cards can be used indefinitely and re-filled with a number of passenger boardings or monetary values. Each vehicle will require a reader device to use the cards. Depending on the technology chosen, a “contactless” card reader can be used or a device that requires a card to be inserted or “swiped” is available as an alternative. Contactless cards provide longer card life, but at higher individual unit costs.

Fare Boxes

Fare boxes that provide fare card readers, improved cash management and scanners for mobile-phone based payments are available in a number of configurations. Fare boxes can also integrate more directly with revenue

management software. Registering fare boxes automate cash counting and can reduce workload and improve accuracy of cash accounting.

The relationship of the enabling technologies to the potential solutions described in the previous section is shown in Table 2.

Table 2. Potential Solutions and Enabling Technologies

Potential Solutions	Enabling Technologies					
	Mobile Data	Mobile Computers	Paratransit Software	HR Soft-ware	Card Readers	Fare Boxes
Electronic payments	X				X	X
Demand-response management improve-ments	X	X	X			
Staff scheduling			X	X		
Passenger data collection	X	X	X			

MUSKEGON AREA TRANSIT SYSTEM

Transit Technology Implementation Plan

Technical Memorandum #3:
Research and Review Available Technologies

July 2019

SRF Consulting Group

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Introduction

The Muskegon Area Transit System (MATS) is developing a Transit Technology Implementation Plan to identify their technology needs, available solutions, estimates of cost, and deployment plan. Previous stages of the Transit Technology Implementation Plan documented baseline conditions and identified major issues affecting MATS today. Next, a universe of higher priority potential solutions was established to address the identified issues, followed by categorization of the enabling technologies.

This memorandum presents technology implementation principles; summarizes enabling technologies that could address priority potential solutions; and initiates an implementation plan for MATS and Muskegon County.

Identified issues

A series of items that presented operational issues were identified through engagement with MATS staff and other Muskegon County personnel. These manifested themselves as limitations on the range of services that could be offered, impacts on the quality of service, or the efficiency with which MATS could operate. Table 1 presents a summary of the nine issues documented.

Table 1. Identified Issues

Identified Issue	Description
Limited payment options	Cash and paper fare cards only. No electronic payments available
Drivers handle cash & card inventories	Slows drivers while on routes and introduces unneeded cash handling
Cash management	Manual counting is time consuming and can introduce errors
Driver scheduling	Slow, labor-intensive process that can affect service availability
On-demand trip requests	Requests cannot be confirmed in real-time
Vehicle location and route compliance data	Service quality cannot be managed in real-time
Ridership data	Ridership must be manually counted during a study sample
Computer and network reliability	Ability to take trip requests, update manifests, etc., is impacted by remote desktop availability
Staff availability and expertise limitations	Ability to research and deploy new tools to manage service is limited, affecting overall operations.

Potential Solutions

The issues identified in the baseline conditions analysis can be addressed through a set of process and technology improvements to MATS current management systems. These include potential hardware deployments on vehicles, software upgrades, and staffing changes within the MATS organization. Each potential solution represents a family of transit deployments and is agnostic to the underlying technologies or methods. The prioritized categories of solutions explored for the Transit Technology Implementation Plan are summarized in Table 2.

Table 2. Potential Solution Summaries

Potential Solutions	Description
Electronic Payments	• Refillable/rechargeable payment cards that are readable by hardware on the vehicle. • As a part of the payment upgrades, more sophisticated fareboxes that incorporate cash separation and counting hardware can be deployed to reduce cash management workload.
Operations and Reservation Improvements	• The Trapeze PASS software is currently used to record ride requests and generate trip manifests. This process does not allow for real-time confirmation of rides delivered or for real-time updates of manifests as ride reservations are added, dropped, or updated in the middle of a driver's shift. • Implementing real-time fleet tracking and in-vehicle displays to work with upgraded software would allow for a more responsive system that is able to serve more trips.
Passenger Data Collection	• Locations of boardings and alightings as well as passenger classifications are critical pieces of data that enable service planning and operations reporting. • A passenger data collection system for fixed route buses would provide location data and present an interface to the driver to categorize boarding passengers.
Staff Scheduling	• Transit management software can incorporate improved tracking of hours, on-duty/off-duty check-ins via smart cards for drivers, alternate management and on-line staff requests/confirmations for call-in replacement drivers.
Staffing	• Although not a technological solution, assigning staffing resources to implementing and maintaining the various technologies will increase the likelihood of long-term success of the deployments. • Staff may be part of the MATS organization or part of Information Services with specific responsibilities for supporting the systems used by MATS. • Appropriate staffing for successful implementation of new technologies and systems includes thorough and continued preparation and training for the users of the technology systems.

Each of the potential solutions relates to one or more of the identified issues, as summarized in Table 3. Detailed descriptions of the identified issues and potentials solutions are presented in Technical Memorandum #1: Baseline Conditions.

The specifics of solutions deployment (e.g., which options to choose for a given product) or the level of integration between systems undertaken may restrict a given solution to addressing a given issue. Decisions on future deployments will be based on a set of requirements generated during the procurement process.

Table 3. Identified Issues and Potential Solutions

Identified Issues	Potential Solutions			
	Electronic Payments	Operations and Reservation Improvements	Passenger Data Collection	Staff Scheduling
Limited payment options	X			
Drivers handle cash & card inventories	X			
Cash management	X			
Driver scheduling				X
On-demand trip requests		X		
Vehicle location and route compliance data			X	
Ridership data	X		X	
Computer and network reliability		X		X
Staff availability and expertise limitations	X	X	X	X

Implementation Principles and Evaluation Criteria

Each of the potential solutions can be implemented in a number of different ways. Moreover, there are different underlying technologies that enable enhancement to MATS systems. To evaluate the different technologies in the context of MATS priorities, capabilities, and readiness, the project team established a set of principles and evaluation criteria to guide the development of the transit technology implementation plan for MATS; these are shown in Table 4.

Table 4. Implementation Principles and Evaluation Criteria

Principle/Evaluation Criterium	Questions to Consider
Cost of Capital/Hardware	What is the up-front cost to implement? What funding sources are available?
Cost of Operations and Maintenance	What is the ongoing (e.g., annual) cost to implement? What are the staffing implications? What infrastructure (e.g. network upgrades) are needed?
Reliability	What are the failure points of the system? How likely are outages, and what is the impact of an outage?
Compatibility	How well does the technology integrate with that currently used by MATS? Does the use of a given technology preclude the use of others?
Flexibility/Modularity	Can separate components or modules be incorporated after initial implementation? Can components from other systems be easily integrated?
User Experience	Will end users be able to use the technology effectively? What training/skill sets are needed for operation?
Ease of Deployment	How long and what level of effort is required for implementation? Does MATS have adequate expertise available in-house? What level of external support is needed?

The evaluation criteria provide a flexible set of comparisons that can be used to choose between alternative technologies and eventually between competing products within a technology class. These evaluation criteria were applied to compare different technologies in the sections below.

Enabling Technologies

Each of the potential solutions in Table 2 relies on a set of enabling technologies. These are foundational mechanisms that allow the implementation of integrated solutions. Table 5 shows the relationships of the enabling technologies to the potential solutions.

Table 5. Potential Solutions and Enabling Technologies

Potential Solutions	Enabling Technologies						
	Mobile Data	Mobile Computers	CAD/AVL System	Demand Response Software	Fareboxes and Fare Media	APC System	HR Software
Electronic payments	X				X		
GoBus Operations and Reservation Improvements	X	X	X	X	X		
Staff Scheduling			X				X
Passenger Data Collection	X	X		X	X	X	

Mobile Data

Mobile data technologies focus on connectivity between vehicles and back-end or "host" systems. There are several approaches available to transfer data with vehicles; these are summarized below and in Table 6.

- Cellular data – A common solution used for personal cell phones and industrial applications. Cellular provides wide coverage, good performance, and is generally paid for as a monthly service.
- CBRS (Private LTE) – An emerging solution that uses techniques similar to cellular (4G/LTE) data, but on a dedicated network, isolated from the commercial cellular network. Performance can be very good, but coverage is limited compared to cellular data.
- Private Data Radio – Commonly used in older public safety data systems, a dedicated base station/repeater network is used to create a closed system of data communications. Performance is limited compared to more modern systems, and costs can be high as the base station equipment must be maintained by users.
- Satellite Data – Recent advances in satellite communication have made it more practical for mobile applications. Smaller antenna systems that do not require continuous alignment with satellites and higher data rates/lower costs enable the use of satellites to connect to vehicles. However, limited data rates, long latencies created by network management systems, and comparatively high costs are still drawbacks to this approach. Newer providers such as Starlink and OneWeb may make satellite data more attractive in the future, however.
- Wi-Fi hotspots – Common in homes, public spaces, and business, Wi-Fi enables good to very good performance and very low cost. This technology was developed with service to small areas in mind and is generally not suitable for continuous coverage unless very large numbers of hotspots are deployed.

While these may be implemented in different ways, the existing 800 MHz and ultra-high frequency (UHF) radios[1] used aboard MATS buses could remain in place to facilitate real-time communications with drivers or remain as an emergency fallback system.

Why are mobile data necessary for a modern transit agency?

Mobile data is a foundational technology that enables a wide variety of safety and efficiency improvement for transit service. The mobile data system will allow transit operations managers to know in real-time where the vehicles are, and better monitor on-time performance. Software can automatically choose the best vehicle to efficiently service a paratransit trip request and collect data on how well customers are served. Mobile data systems also allow operators to update drivers' list of customers' trips (manifests) and enable safety improvements like "panic buttons" and real-time video transmission to operations centers, which can help assist emergency response.

Nearly all advanced fare payment methods, such as smart cards and app-based payments require real-time data connections for processing. Future enhancements like traffic signal priority (TSP) also rely on the vehicle's ability to communicate its position and request green lights from traffic signals to improve on-time performance.

Table 6. Technology Comparisons: Mobile Data

	Cellular Modem	CBRS (Private LTE)	Private Data Radio	Satellite Data	Wi-Fi Hotspots
Coverage	+++	++	++	++/+++	-
Performance	++	++	+	+	+++
Integrated GPS	Y	Y	N	Y	N
Cost: Capital/Hardware	$$	$$	$$$	$$$	$
Cost: O&M	$$	$$	$$	$$$	$
Reliability	++	+++	+++	++	++
Compatibility	++	++	++	++	++
Flexibility/Modularity	+++	++	+	++	+++
User Experience	N/A	N/A	N/A	N/A	N/A
Ease of Deployment	+++	+	-	+	++

Mobile Computers

The mobile computer presents an interface to the vehicle driver and can also function to bring together data from other on-board systems, such as fareboxes, passenger counters and GPS. The mobile computer can take many physical forms from a cellular phone, to a dedicated, purpose built personal computer, generally supplied by a transit software vendor. Typically, mobile computers are included as part of a larger transit technology systems package (e.g., CAD/AVL system). Categories of mobile computer considered for this analysis are summarized below and in Table 7.

- Cellular Phone – Characterized by a high performance per dollar ratio due to their large production volume, cellular phones are capable of running a variety of applications, integrate GPS, communications in-

[1] UHF and 800 MHz are two systems within the broader category of land mobile radio (LMR) communication systems, which are commonly used by public agencies for emergency response.

terfaces and provide touchscreen displays for drivers. However, their highly integrated nature and limited connection ports limits their ability to be integrated into other systems. The small size of the display and lack of ruggedized design features also limits their suitability to the vehicle environment.

- Tablet – Essentially a larger cellular phone, tablet computers have been used in transit vehicles for user interfaces and computing tasks. Although these alleviate the screen size issue, tablets generally carry the same drawbacks as cellular phones.
- Embedded Mobile Data Computer (MDC) – The MDC is generally a purpose-built device meant to interface with transit vehicle systems and management software. MDCs may be supplied by a software vendor as part of an integrated package and are optimized for the rugged vehicle environment and to present an optimized interface for drivers. Their purpose-built nature may limit their flexibility and interoperability.
- Industrial Laptop – A general-purpose computer optimized to function in harsh environments, industrial laptops are highly flexible and are commonly used in law enforcement vehicles. These devices are generally considerably larger than other options, which can make placing them in the vehicle a challenge. They also have a higher cost than a comparably specified consumer laptop as features like heated screens, shock-mounted components and sealed cases can be expensive options.

Why are mobile computers necessary for a modern transit agency?

Mobile computers increase the efficiency of interactions between the driver and dispatchers/managers. Unlike a simple voice communication system like a radio or cell phone, MDCs allow for rich text and graphical data to be displayed, often in real time. Trip manifests for drivers, text instructions, maps, real-time schedule adherence, and even photos of riders who need assistance can be displayed in real time on the MDC.

The MDC also allows the driver to send a variety of information like trip complete messages and data from automatic passenger counters (APCs). This functionality enables more efficient data management and minimizes the staff time needed for service analysis, planning, and improvement.

Table 7. Technology Comparisons: Mobile Computers

	Cellular Phone	Tablet	Embedded MDC	Industrial Laptop
Cost: Capital/Hardware	$	$	$$	$$$
Cost: O&M	$$	$$	$	$
Reliability	+	+	++++	+++
Compatibility	++	++	+	+++
Flexibility/Modularity	++	+++	+	++++
User Experience	+	++	+++	+++
Ease of Deployment	++	++	++	+

Computer-Aided Dispatch/Automatic Vehicle Locator (CAD/AVL) System

Most modern transit technology systems incorporate a computer-aided dispatch/automatic vehicle locator (CAD/AVL) system, or associated elements. The CAD/AVL system is the interface between on-vehicle mobile computers and back office software responsible for driver communication, dispatching, and scheduling. Most often, CAD/AVL systems are deployed principally for fixed route operations; however, depending on the transit agency's needs, the system can also be connected to demand response modes and specific demand response dispatch software (in order to incorporate real-time vehicle location).

With the advance of transit technology solutions, the CAD/AVL system is often used as an all-the encompassing term used to describe many different functionalities and solutions. Aside from its primary functions of vehicle location and communications and dispatch, it is common to incorporate additional modules and subsystems within a modern CAD/AVL system; examples of these add-on modules are, listed below:

- Automatic passenger collection (APC) systems
- Automatic fare collection (AFC) systems
- Schedule adherence analysis
- Route and schedule optimization
- Advanced service analytics and reporting
- Automatic vehicle announcement (AVA) systems
- Real-time passenger information systems
- Transit signal priority (TSP)
- Demand response dispatching
- Demand response reservation systems
- Driver bidding
- Driver scheduling and availability
- Driver notification and reporting for duty
- Vehicle assignment
- Automated vehicle monitoring (AVM) systems
- On-vehicle security systems

Vendors often offer a CAD/AVL system as their core, foundational product; one that is capable of sharing information with other modules or subsystems (e.g., AFC, APC, AVA, etc.) offered by vendor or, in some cases, those offered by third parties. However, the level of compatibility between software and hardware systems offered by different vendors can vary greatly. As such, when implementing new solutions, many transit agencies choose to work within a single "ecosystem," in hopes of working with one or two vendors. The advantages and disadvantages to this integrated approach should be weighed in the unique context of each transit agency. (Integrated and separated implementation approaches are discussed elsewhere in this report [see Table 10].)

Today, the most popular CAD/AVL system software systems can be implemented "on-premises" using a server infrastructure (e.g., operated and maintained by Muskegon County), or can be "cloud"-based, located on a provider's server infrastructure and accessed over an Internet connection. Each of these options involves a set of characteristics that must be weighed in terms of technical capacity to maintain the system, reliability, and cost. These are discussed further in the Implementation Considerations section of this report.

How can a transit agency benefit from AVL data?

Automatic vehicle locator (AVL) systems provide real-time and historical information on vehicle location and speed, enabling a better understanding of operating conditions. Transit agencies use historical AVL data to assess on-time performance, schedule design, dwell time, and route design. Moreover, real-time AVL data provide for more efficient service supervision, emergency management, and service coordination (intra- and inter-agency). For a modern transit agency, AVL data are essential for the development and operations of efficient and high-quality fixed route and demand response services.

Service reliability is critical for transit agencies to ensure customer satisfaction and loyalty. In addition to frequency and coverage, service reliability and speed are often cited as among the most important factors in transit service satisfaction and are affect transit mode choice.[2,3] AVL data are critical in allowing transit agencies to uncover opportunities to increase bus speeds and improve reliability. On-time performance (OTP) is a key reliably performance measure used by FTA and most transit agencies around the world. Upon implementing and appropriately utilizing an AVL system, transit agencies have been able to improve OTP by more than 25%.[4]

[2] Transit Center. Who's on Board 2019. Available at http://transitcenter.org/publications/whos-on-board-2019/.
[3] Alam, Nixon, and Zhang. Investigating the Determining Factors for Transit Travel Demand by Bus Mode in US Metropolitan Statistical Areas. 2015. Mineta Transportation Institute. Available at https://transweb.sjsu.edu/research/investigating-determining-factors-transit-travel-demand-bus-mode-us-metropolitan.
[4] https://availtec.com/case_studies/avtas-on-time-performance-jumps/

In addition to improved reliability, AVL data provide an opportunity for advanced passenger-oriented tools that answer the "where's my bus?" question. Enabling passengers to track the location of their bus in real time – on a map or through predictive data on bus arrival times – can increase customer confidence and satisfaction. These tools are increasingly in demand from transit users and would-be users. Through route schedule adjustments and enhanced, real-time customer information made possible by AVL, transit agencies have reported 45% to 80% reductions in "where's my bus" type of calls and other customer complaints, freeing up significant staff time.[5, 6, 7]

Demand Response Software

MATS currently uses Trapeze PASS to record requests for demand responsive trips and to generate manifests for drivers indicating origin, destination, time, and passenger details for a given trip. However, PASS and other products offer a much broader range of features that could be used to enhance the service MATS offers to customers and reduce the manual workload for system operators.

Modern demand response software with emphasis on paratransit service often incorporate CAD/AVL. When deployed properly, modern demand response software with CAD/AVL allow for real-time dispatching and operations that are more flexible. This can result in transit service that is more cost effective, more productive, and more convenient for customers. Among the many potential solutions offered by modern demand response software are:

- Eligibility determination and processing
- Customer registration and information management
- Trip booking and scheduling
- Self-service passenger reservation features
- Customer notifications
- Financial reporting and invoicing
- Driver communications
- Live manifest updates
- Route and schedule optimization
- In-vehicle navigation
- Schedule adherence analysis
- Advanced service analytics and reporting

As described in the preceding section, when integrated with a broader CAD/AVL system used for fixed route service, demand response software can benefit from other systems such as APC, AFC, AVA, passenger information systems, driver scheduling, and AVM, among others. However, demand response software can be implemented as a stand-alone system, as MATS does today with its Trapeze PASS software.

Like broader CAD/AVL software, demand response software can be implemented "on-premises" or "cloud"-based, – each with advantages and disadvantages (see: Implementation Considerations section of this report).

How might demand response software affect productivity and operating cost?

Transit agencies have reported a wide range of benefits upon implementing demand response software, including ridership and productivity increases, decreased costs, and decreased rider "no-show" rates.

[5] https://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/67C2BC0789B01F84852578B10066D351?OpenDocument&Query=Home
[6] https://www.routematch.com/client-stories/porterville-transit/
[7] https://www.routematch.com/client-stories/coast-transit-authority/

- Increased productivity (passengers per hour of service) ranging from 5% to 400%, with one software system reporting an average increase of 44 percent[8,9,10]
- Increased capacity and ability to meet same-day demand (non-guaranteed/standby rides)
- Overall operating costs decreased by as much as 30%-35%[11,12] and reduced cost per passenger trip[13,14]
- Significant decrease in rider "no shows" through advanced notification systems[15]

Fareboxes and Fare Media

Fareboxes are available in a number on configurations, from simple mechanical locked fareboxes to highly sophisticated electronic devices capable of collecting, verifying, and reporting cash and non-cash fare media. Today, many transit agencies are faced with the challenge of either maintaining (and struggling to find parts for) decades-old, since-discontinued fareboxes, or investing in new technologies that are significantly more sophisticated and address consumer modern trends (i.e., non-cash fare media), but at a higher up-front expense.

A primary distinction among most fareboxes used by transit agencies is whether or not they are "registering." The "non-registering" and registering farebox categories are compared in Table 8. Registering (or validating) fareboxes automate cash counting and reject invalid cash, coin, or other items placed in the farebox; they free up drivers to focus on driving while in service and reduce the amount of staff time spent counting fare revenue, while increasing accuracy. When combined with an automated fare collection (AFC) system, registering fareboxes can collect detailed revenue and ridership data. AFC systems can be purchased through the farebox hardware vendor or a third party and can be integrated with a CAD/AVL system or a stand-alone system.

Registering fareboxes are more costly than non-registering ones but come with advanced functionality and modularity, while enabling non-cash media (e.g., smart cards, mobile apps). Mobile data are required to fully-operate registering fareboxes; the data connection allows the use of validated non-cash media and communication with other technology systems like CAD/AVL. Non-registering fareboxes are simpler but require many small mechanical parts that are often no longer offered by vendors. In many instances, the transition to modern fareboxes reduces the cost and time spent on farebox maintenance (however, this depends on the mix of fare media accepted).

Table 8. Technology Comparisons: Fareboxes

	Non-Registering (Non-Validating)	Registering (Validating)
Mobile data required (integrated or otherwise)	N	Y
Fare data collection and processing	N	Y
Ridership data collection and processing capabilities	N	Y
Communication with other systems (e.g., AVL, APC)	N	Y
Non-cash fare media integration compatible	N	Y
Cost: Capital/Hardware	$	$$

[8] https://www.ecolane.com/ecolane-roi-calculator
[9] https://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/78E9490FC83AE4EF8525772F006C08FD?OpenDocument&Query=Home
[10] https://www.routematch.com/client-stories/porterville-transit/
[11] Ibid.
[12] https://ddswireless.com/resources/adept-case-study/
[13] https://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/AEFB8E9732D8E798852578B10068FD35?OpenDocument&Query=Home
[14] https://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/78E9490FC83AE4EF8525772F006C08FD?OpenDocument&Query=Home
[15] https://www.routematch.com/client-stories/fairbanks-north-star-borough-bus-system/

Cost: O&M	$	$/$$
Reliability	++	++
Compatibility	+	-
Flexibility/Modularity	-	++
User Experience	+	++
Ease of Deployment	++	+

In addition to cash, most registering fareboxes accept other fare media, including: temporary paper cards with magnetic stripe (e.g., transfer), refillable smart cards ("contactless" cards), and fares stored on mobile phones (Table 9). Modern smart cards use magnetic stripes or near-field communication (NFC) chip technology[16] to contain information related to account identifiers, account balances, or other information. Smart cards can be used indefinitely and re-filled with a number of trips or monetary values. Temporary in nature, paper cards with magnetic stripes are less durable and less flexible.

Table 9. Technology Comparisons: Non-Cash Fare Media

	Magnetic Stripe Paper Card	Smart Card (Magnetic Stripe)	Smart Card (NFC)	Mobile (QR, Barcodes, NFC)
Driver Interaction Required	++	+	+	+
Refillable	N	Y	Y	Y
Account-Based Capability	N	Y	Y	Y
Cost: Capital/Hardware*	$	$$	$$	$$
Cost: O&M*	$	$$	$$	$$
Reliability	+++	++	++	++
Compatibility	+	-	-	-
Flexibility/Modularity	-	+	++	+++
User Experience	+	++	++	+++
Ease of Deployment	+++	++	++	+

Mobile payment options

In response to demographic trends, modern transit agencies are planning for and implementing fare payment systems that allow customers to pay with a mobile app. While equity concerns should remain forefront, research suggests smartphones availability and use continues to grow, even among lower-income individuals:

"According to recent Pew research (Rainie 2017), 77% of all Americans have a smartphone – 64% of those with incomes less than $30,000 per year and 90% or more of those with incomes greater than $75,000 per year. Rates of smartphone ownership are similar for whites, African-Americans, and Hispanics, although minorities are more likely to use a smartphone to access the Internet, which suggests they are less likely to have broadband service at home. More than 90% of urban millennials reported owning a smartphone in the Pew research."[17]

[16] NFC is a form of Radio Frequency Identification (RFID); NFC is most commonly used in the transit farebox industry to describe the process by which the use of smart cards are enabled.

[17] National Academies of Sciences, Engineering, and Medicine. Transit Research Cooperative Program (TCRP) Report 201: Understanding Changes in Demographics, Preferences, and Markets for Public Transportation. 2018. Available at http://www.trb.org/Main/Blurbs/177709.aspx.

Fare payment is just one element of a modern transit mobile app. Many transit technology vendors now offer mobile apps that incorporate fare payment, trip planning, and shared use mobility integration (e.g., bikeshare, TNCs). These mobile apps are fed by AVL location and GTFS schedule data to provide real-time information and trip planning tools, while also connecting to the onboard farebox.

By introducing mobile payment options, transit agencies provide their customers with greater choice and convenience. However, continuing to accept other fare media – including cash and smart cards – will necessary for reasons of convenience and equity. For smaller transit agencies, enabling mobile payments is rightly treated as a secondary of tertiary priority, rather than an immediate need. It is often implemented after introducing other non-cash fare media, like account-based smart cards.

Each transit vehicle will require a reader device to effectively use the non-cash fare media. Reader devices can be integrated or separate from the main cash-collecting farebox. The capital and maintenance costs of non-cash fare readers vary by media type, number of reader units, and mix of equipment types. For example, smart card and mobile readers can have lower capital and maintenance costs than magnetic stripe readers, which have many moving parts; comparatively, smart card and mobile readers are sealed and durable systems which result in less overall maintenance. Generally, transit agencies and farebox vendors are moving away from magnetic stripe technology in favor of smart cards and mobile payment.

Benefits of Modern Fareboxes and Fare Payment Systems

Transit fareboxes, card readers, and automated fare collection (AFC) systems – collectively referred to as fare payment systems – have evolved significantly in the last decade and undoubtedly will continue to do so. Transit agencies upgrade their fareboxes and fare payment systems for many reasons; 0 summarizes common goals and objectives.

Figure 1. Example: Transit Agency Fare Payment System Goals and Objectives

GOALS				Characteristics or Objectives For Transit Fare Payment Systems
Improve Customer Experience	Improve Technical Operations	Improve Financial Operations	Improve Overall System Operation	
✓			✓	Increased customer convenience: Ease of use
✓				Increased customer convenience: More fare media options
✓			✓	Achieve seamless travel across all modes of own system
✓			✓	Achieve seamless travel with partner transit agencies / regional travel
✓		✓		Increase fare options and pricing flexibility
✓	✓	✓	✓	Ensure smooth implementation of new fare payment system
✓	✓			Improve reliability of fare equipment
		✓	✓	Reduce fare collection costs
		✓	✓	Reduce fare abuse and evasion
		✓	✓	Reduce use of cash
		✓	✓	Increase prepayment
		✓		Improve revenue control / accountability
		✓	✓	Improve fare revenue allocation in a multi-operator system
			✓	Improve data collection and reporting capabilities
	✓	✓		Upgrade existing system with forward-capable technology
	✓		✓	Flexibility in hardware replacement and lifecycle renewal
✓	✓	✓	✓	Reduce system complexity
		✓		Get out of the payments and settlements business
			✓	Increase ridership

Source: Transit Research Cooperative Program (TCRP) Report 177: Preliminary Strategic Analysis of Next Generation Fare Payment Systems for Public Transportation, 2015.

A 2015 Transit Cooperative Research Program (TCRP) publication[18] notes that transit systems are using next generation fare payment systems to provide the following benefits, relative to legacy fare payment systems that focus on cash collection:

- Reduced costs associated with fare collection, revenue processing, and reconciliation
- Reduced fraud
- Faster bus boarding and less dwell time
- Increased ease, speed, convenience and flexibility with which customers may purchase fare products
- Enable self-service features to allow customers to directly manage pre-paid fare accounts.
- Ability to capture rich customer data, including boarding location, transfer patterns, and fare purchase pattern
- Foster fare policy innovation and tailoring

[18] National Academies of Sciences, Engineering, and Medicine. Transit Research Cooperative Program (TCRP) Report 177: Preliminary Strategic Analysis of Next Generation Fare Payment Systems for Public Transportation. 2015. Available at https://doi.org/10.17226/22158.

How might new fareboxes affect fare revenue?

According to one North American fare systems vendor, transit agencies who switch from manual, non-registering systems to their registering fareboxes (and associated AFC system) see fare revenues increase 3%-17%; this efficiency is reportedly the result of increased compliance and reduced fare evasion.[19]

Automatic Passenger Counter (APC) System

Rather than rely on drivers to manually collect passenger data, transit agencies are using automated processes to understand how and where people use transit services. Such is often done through analysis of electronic fare-box data, automatic passenger counter (APC) systems, or some combination. However, unlike a farebox, which can mark the boarding location, APC systems can also provide insight into how many passengers get off a bus and how full a bus is at a given point and time.

APC systems can be based on an interface with the farebox, a simple "beam break" infrared device, sophisticated video analytic approach or can be semi-automated, prompting the driver to enter a category for each passenger as they board. APCs can be interfaced directly with broader operations and management software, like a CAD/AVL system, or function as a stand-alone system.

Why do transit agencies use APC systems?

APC systems allow an agency to continuously collect fine-grained passenger data at various spatial and temporal levels, including by stop, trip, and route. Doing so enables transit managers to ensure limited resources are allocated effectively, and more quickly and appropriately respond to ridership trends. APC data provide more descriptive and useful evidence of use and enable data-driven decision making.

With stop-level APC data, managers can identify areas of high and low ridership activity and adjust service accordingly to better distributed limited resources more efficiently. APC data can help identify and prioritize where to invest in amenities such as benches and shelters to achieve the greatest impact. Alternatively, many transit agencies maintain significant numbers of bus stops that have zero or very little ridership. Eliminating unused, unnecessary stops can increase bus speeds and improve reliability.

In general, APC systems require some specific hardware on the vehicle and will be connected to a mobile data system to allow for data retrieval. Commonly, hardware (e.g., infrared device) are mounted at the front and rear doors of the bus to collect information on the time and location of boardings and alightings. With this information, vehicle load (i.e., how many people are aboard the bus at a given time) can be determined throughout a service period. Sophisticated systems can report vehicle loading in real time, which provides supervisors a new way to gather insight about operating conditions.

Human Resources (HR) Software

Software tools to manage employee scheduling, paid time off and substitutions are common. However, transit software vendors are increasingly offering staff management features as modules to larger operations software systems. Some of these modules can incorporate complex work rules and agency-specific policies in the process of bidding and scheduling and make day-of changes based on driver availability. More advanced systems incorporate driver notifications, payroll, and employee records and performance. Examples of transit integration in-

[19] https://www.genfare.com/wp-content/uploads/2017/09/BR_NOV-DEC-2016_ebook.pdf

clude the ability to consider customer preferences for specific drivers when substituting, ability to provide mobility assistance, etc.

If managing transit specific work rules does not offer a substantial advantage for MATS operation, there are a number of products that provide basic shift and worker management. Online tools such as Deputy, Shiftboard, and Humanity offer scheduling/substitution tools, employee portals for notifications or requests, integration with payroll systems (ADP, Intuit) and forecasting tools. These solutions are generally offered as SaaS (Software as A Service), with users accessing the system through a web browser. A monthly cost will be assessed, generally based on the number of active users, but these can be subject to a minimum charge.

Call Center Management Software

Call management enables efficient lookup of customer records, minimizes the time needed to service a call, provides consistent electronic records of customer interaction, and gives managers an accurate view of operator performance. Deployment of call management will improve the efficiency of existing call taking functions and expand capacity by decreasing the average amount of time needed to service each call.

If an integrated call management/transit management package is not desirable, there are a number of stand-alone solutions available to assist operators answer calls and record details or service requests.

While there are many different feature sets available, most products will include:

- Automatic caller identification and registered customer lookup
- Operator performance metrics (call time, abandoned calls, calls per day, etc.)
- Service ticket management or interfaces to customer relationship management (CRM) software
- Real-time monitoring of performance
- Interactive voice response (IVR) customer menu systems
- Voice message management

If implemented as a stand-alone product, call management will require integration into the existing telephone (Voice over IP) system and importation of customer records. Customer record management may be time consuming as an existing record system and call management must be kept synchronized.

Many call management systems are offered as a hosted solution for a fixed price per user per month. See the Implementation section for more discussion of hosted solutions.

Implementation

Implementation Considerations

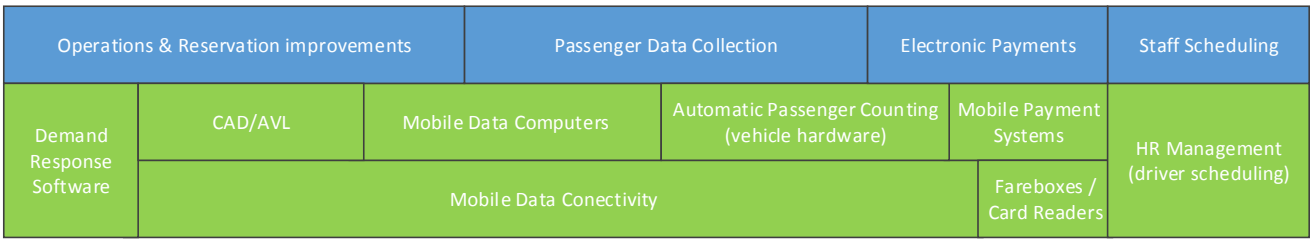
Transit/Paratransit management systems represent a substantial investment for any transit agency. As with any complex system, finding an optimal solution requires balancing a large number of factors. In addition to the general principals listed in Table 4, agencies must consider interdependence and integration when planning for and investing in transit technology solutions.

Interdependence

Management systems rely on a number of interconnected technologies to provide services to users. Some of these may be monolithic, that is, they can provide some degree of functionality regardless of whether they interact with other systems. Others provide no direct functionality unless combined with other subsystems.

Figure 2 shows the technology "stack" in green, with the supported solutions shown in blue.

Figure 2. Technology Stack



Integration

An important consideration when planning for future technology deployments is the "ecosystem" of products that will be implemented. Some suppliers can provide all or nearly all of the software functionality and hardware for any desired transit management system. Other providers offer only a subset of the desired functions.

During the procurement phase, MATS will need to consider the implications of each approach. Table 10 presents a short summary of the differences between the integrated and separated approaches.

Table 10. Comparison of Integrated and Separated Implementation Approaches

Integrated	Separated
Single supplier	Multiple Suppliers
Subsystems fully integrated	Subsystems integrated as needed
Interoperability guaranteed	Interoperability dependent on supplier cooperation
Limited choices for components	Components chosen by MATS
Migration to other products difficult	Migration to other somewhat easier
Support may be from supplier with single contract	Support managed between MATS & multiple suppliers

On-Premises vs. Hosted ("Cloud") solutions

Commonly known as "Software as a Service" or "SaaS" software solutions that do not require a server installation at the customer's site are increasingly popular. This approach minimizes the hardware and network management infrastructure to be managed by the customer and allows users to access software using a web browser rather than a dedicated client.

SaaS approaches offer rapid deployment of software and provides a single point for both server and client software, eliminating the need to administer multiple servers and workstations. Since the server infrastructure generally serves multiple customer sites, it can be robust and provide good protection against failures at a reasonable cost per customer.

There are several drawbacks to hosted solutions that must be considered, however. First, they are heavily reliant on adequate Internet connectivity. A loss of connection at either the customer or host end would prevent use of the system. Second, the customer is tied to a recurring cost, which may increase unpredictably. Since the system is dependent on the host, there is no option to continue using an existing installation without on-going payments.

A related issue to recurring cost is that the customer is vulnerable to "forced upgrades" that may change or remove functionality at the host's option. If processes are developed that rely on a specific feature that is discontinued, substantial operational disruption could occur.

In general, hosted solutions should be considered when:

- Internet connectivity is reliable and has adequate capacity
- Minimizing initial costs is a priority
- Minimizing internal support costs is a priority
- The provider provides some guarantees limiting cost increases

Hosted solutions are less attractive when:

- Networking conditions are unpredictable
- Minimizing on-going costs are a priority
- Existing IT support infrastructure can accommodate the application without significant additional costs
- The long-term viability of the provider is unknown or uncertain

General Recommendations

The guiding principles described on page 3 were applied to the options described for the enabling technologies to identify a subset of options that best serve MATS. The seven most significant principles are:

- Cost of Capital/Hardware
- Cost of Operations and Maintenance
- Reliability
- Compatibility
- Flexibility/Modularity
- User Experience
- Ease of Deployment

Individual classes of technology are evaluated against these principles above; however, they must also be applied to specific proposals when a procurement is undertaken as comparisons of technology classes are only a rough guide to their characteristics.

The new technical solutions envisioned may require skill sets and staffing not currently in place at MATS or Muskegon County. An examination of the maintenance needs for server software, any desktop applications, and on-vehicle devices should be compared to existing commitments of staff at MATS and at the County's IT support group. If internal support is not feasible due to staffing constraints or lack of necessary skill or tools, contracting

with a supplier for external support or remotely hosting systems to reduce on-premises workload should be considered.

Recommended Investments

Technology solutions for MATS should be implemented over time, starting with the Recommended Technology Investments shown in Table 11 and Table 12.

Table 11. Recommended Technology Investments: Relationship to Identified Issues

Identified Issues	Recommended Technology Investments			
	1. Mobile Data and Mobile Computers	2. Farebox Modernization	3. Operations Software (CAD/AVL)	4. APC System
Limited payment options	X	X		
Drivers handle cash & card inventories	X	X		
Ridership data	X	X		X
Driver scheduling			X	
On-demand trip requests	X		X	
Cash management	X	X		
Vehicle location and route compliance data	X		X	
Computer and network reliability				
Staff availability and expertise limitations	X	X	X	X

The Recommended Improvements comprise both on-vehicle and server/desktop subsystems as shown in Figure 3. New or enhanced subsystems are shown in orange, with existing or unchanged subsystems in blue.

Table 12 provides detailed information about the recommended investments along with the expected benefits.

Figure 3. Transit Technology Subsystems

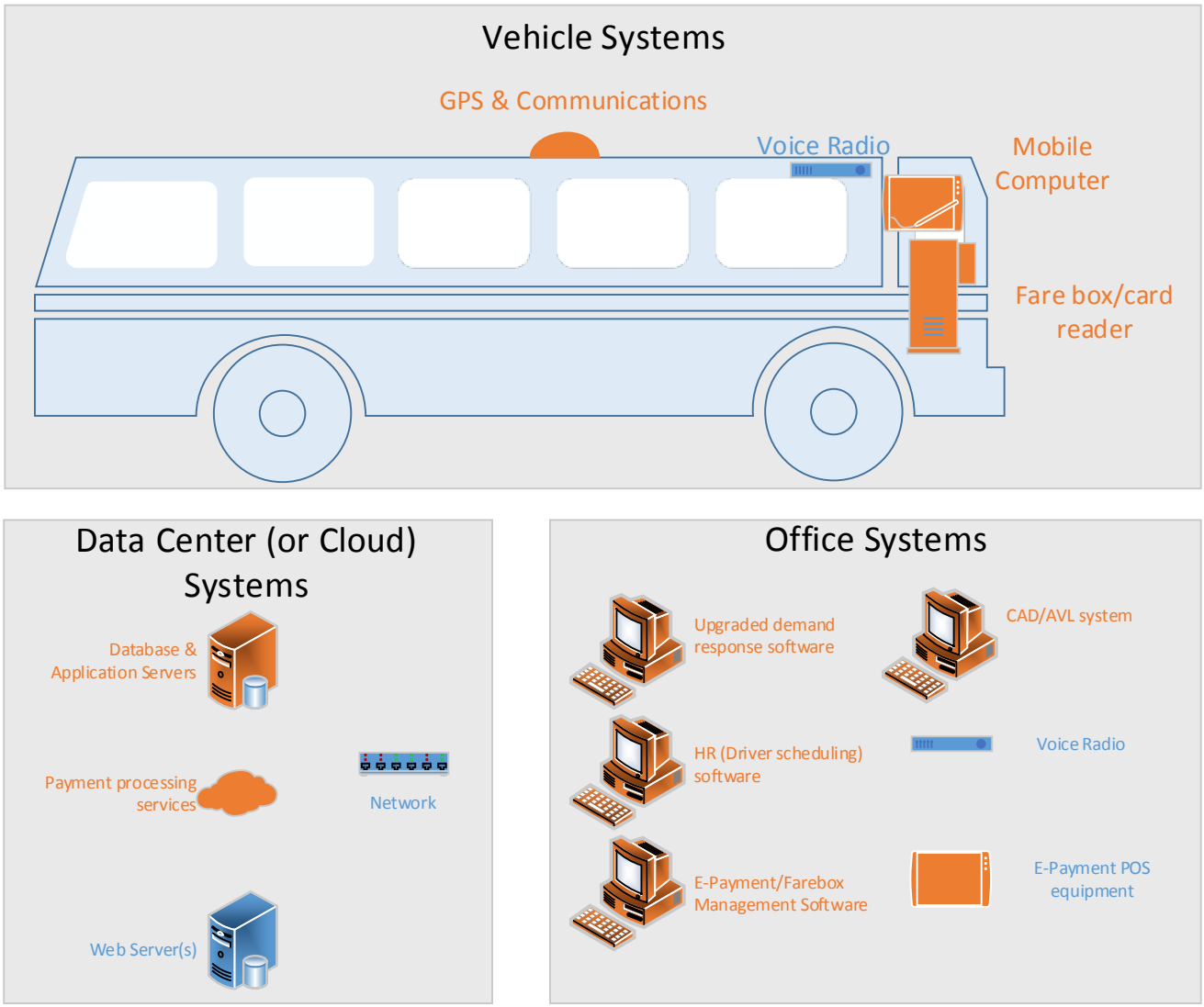


Table 12. Recommended Technology Investments

Recommended Investment	Configuration and Deployment	Benefits
1. Mobile Data and Mobile Computers	• Installed on all fixed route buses and GoBus vehicles used to carry passengers in revenue service • Dedicated MDC or tablet device • GoBus deployments will have displays suitable to present driver manifests • Fixed route displays suitable for presenting instructions and schedules and allow driver input of passenger type for ridership studies.	• Enables data-driven decision making • Modernizes MATS service, presenting opportunities to improve its product and attract new riders • Enables the other transit technology systems used to track vehicles, collect ridership and service data, analyze and plan service, and provide passengers-oriented online tools
2. Modernize Farebox System	• Install new multi-media fareboxes that allow for the collection of cash (coins and bills), smart cards, and future integration of mobile ticketing; smart card and mobile fare collection elements can be integrated with the main farebox unit, or as a separate reader system mounted nearby • Combine hardware upgrades with an automated fare collection (AFC) system to manage multi-media fare collection (i.e., cash, , smart cards, mobile) for MATS's fixed route and GoBus services • Farebox hardware can be linked to an AFC system provided by the hardware vendor, or, in many cases, by a third party	• Minimizes financial risk, improves driver safety, and enables data-driven decision making • Reduced fraud with cash fare validation and the use of smart cards • Provides users with greater flexibility and convenience in purchasing and managing fares • Reduces driver interaction with cash, including the discontinuation of onboard sales of ten-ride and monthly passes; allows driver to focus on driving and improves consistency and quality of customer service • Reduces staff time and effort to count and manage cash • Enables MATS to collect data on fare use by passenger type and media, and transfer activity (for smart cards and mobile) • Ability to collect stop-level ridership data when integrated with CAD/AVL system

Recommended Investment	Configuration and Deployment	Benefits
3. Upgrade Operations Software (CAD/AVL plus demand response)	• Introduce systemwide CAD/AVL system with an integrated demand response software, designed to interact with the mobile data and mobile computers installed aboard all revenue vehicles • Enable fixed route and GoBus vehicle tracking through an automatic vehicle location (AVL) system capable of schedule adherence, speed, and dwell time analytics • Integrated demand response software with computer-aided dispatch (CAD), live manifest updates, in-vehicle navigation, documentation and reporting, customer information management and notification, and options for self-service passenger reservation features • Integrated driver bidding and scheduling module capable of also documenting hours worked (in- and out-of-service) to seamlessly interface with the County's BS&A payroll software • The CAD/AVL system can act as MATS's core transit software; many vendors offer CAD/AVL systems capable of sharing information with other technology systems (e.g., AFC, APC, AVA, etc.) offered by vendor or, in some cases, those offered by third parities	• Enables data-driven decision making • Gather data to design more accurate and optimized schedules • Improve service reliability and customer satisfaction • Enables live vehicle tracking, resulting in efficiencies and improvements for managers and Customer Care Representatives (CCRs) • Enables integrated driver scheduling processes that are responsive to driver rules and availability, simplifies communication of assignments between drivers and managers, and minimizes data entry used for payroll purposes • Provides live manifest updates and documentation of GoBus service provided, reducing calls between CCRs and drivers, and minimizing reconciliation process • Operating efficiencies achieved through modern CAD and in-vehicle navigation • Enables online reservation tools, reducing time CCRs spend on the phone with making reservations
4. Automatic Passenger Counter (APC) System	• Hardware and software components • Hardware installed on all fixed route buses to continuously collect boarding, alighting, and vehicle load data • Ideally, integrated with the on-vehicle mobile computer, which feeds into the CAD/AVL system; however, the APC system could be a standalone system	• Enables data-driven decision making • Improves reporting, service and capital planning, and resource allocation • Minimizes manual data collection and data entry, saving staff time and producing more reliable results • Continuous data collection enables frequent analysis and comparison of ridership data at various spatial and temporal levels (e.g., bus stop, vehicle, trip, time of day, etc.)

Implementation Process

With the near-term technology enhancements defined (Table 12) the process for implementation can be established. Since different suppliers take different approaches to implementing the desired functionality, documenting desired functionality and gathering data on specific technical approaches is key to delivering a solution that best serves MATS and the traveling public.

A step-wise methodology such as the one described below is recommended as a path to implementation:

1. Define Functional Requirements – Describe in specific terms "What" the recommended investments should do.
    a. Describe the desired features of each subsystem
    b. Describe the operational environment (physical and technical) into which the system will be deployed.
    c. Describe organizational constraints, such as support needs, data management, etc.
    d. Establish system expansion needs (for example, how many additional vehicles, etc. will be added in the next five years, etc.)
2. Issue a Request for Information (RFI) to technology suppliers
    a. Compile functional requirements into a request document that establishes the type of information requested and the desired format of responses.
    b. Release RFI to suppliers.
    c. Review responses and revise functional requirements
3. Issue a Request for Proposals (RFP)
    a. Develop schematic design for prospective system; Include details such as on-premises or hosted service, quantifiable network reliability needs, points of access to the system, security, etc.
    b. Create detailed requirements as necessary
    c. Package and release RFP
4. Award Contract
    a. Review proposals
    b. Choose preferred solution
    c. Negotiate as required & enter agreement
5. Pre-deployment Preparation
    a. Based on schematic design implement improvements to MATS or County infrastructure
    b. Develop training/system use policies for staff prior to introduction of new systems
    c. Identify any incompatible rolling stock, mobile communications coverage gaps, etc.
6. System Build-Out
    a. Review, revise and approve system validation and acceptance plans
    b. Working with contractors, install vehicle hardware, software, etc.
    c. Train staff as appropriate
    d. Conduct system validation and acceptance
7. System Cut-Over
    a. Establish fallback procedures in the event of system failures
    b. Define cut-over date and process
    c. Enable new systems to run in parallel with existing systems
    d. Discontinue use of existing systems

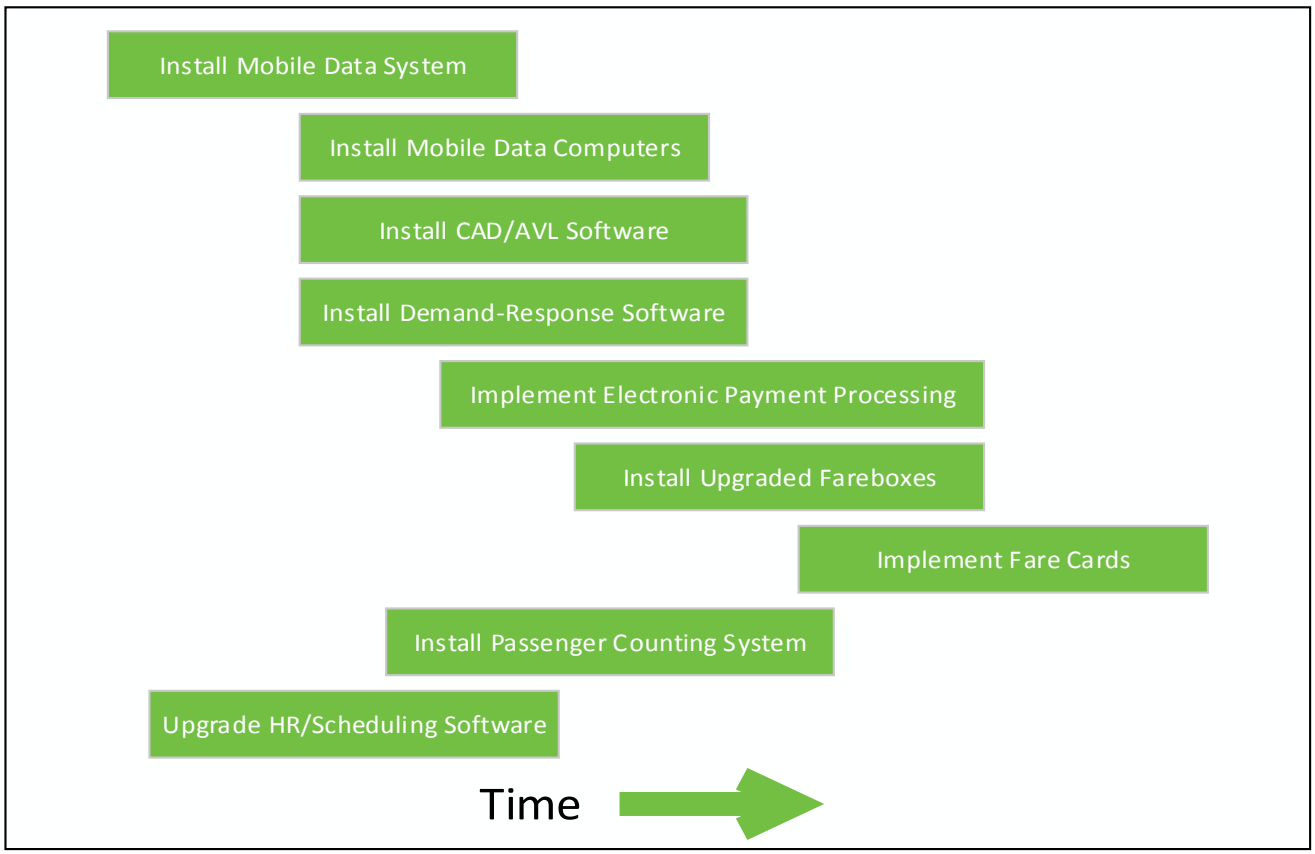
   e. Begin use of new systems as per previous training

8. On-Going Use
   a. Monitor compliance with established procedures by system operators
   b. Monitor system reliability
   c. Document efficiency or other service improvements
   d. Update system software per suppliers' recommendations.

Subsystem Implementation Staging

The exact sequence of deployment of subsystems and their components will be influenced by the specific technology selected and if a single supplier or multiple suppliers are used. However, at a schematic level, the staging may follow the sequence shown in Figure 4.

Figure 4. Subsystem Staging Sequence



MUSKEGON AREA TRANSIT SYSTEM

Transit Technology Implementation Plan

Technical Memorandum #4: Implementation and Cost Estimates

August 2019

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Overview

The Muskegon Area Transit System is a mid-sized transit provider servicing Muskegon County Michigan. Like many transit providers, MATS continually seeks to improve service to transit users while reducing internal costs, resulting in a more efficient and responsive organization.

To achieve these goals, MATS began a process to identify its highest-priority needs, technical approaches best suited to meet them, and an implementation process. This document briefly summarizes the current MATS operational environment, the identified need areas and potential deployments.

The design/procurement decisions to be made, systems engineering approach, prospective timeline and cost estimates are presented in subsequent sections. A final report will then be compiled containing this and previous materials prepared for the project to serve as a near- to mid- term guide for MATS technology deployments.

Current Environment

MATS provides public transportation throughout Muskegon County with its fixed route and GoBus on-demand services. The principal public transit provider in Muskegon County, MATS:

- Serves over 550,000 passengers annually
- Employs approximately 70 staff, including over 50 drivers
- Maintains and operates a fleet of 36 revenue vehicles, including 19 heavy-duty buses, 10 light-duty cut-away buses, and 7 accessible mini-vans
- Serves and maintains two passenger facilities
- Based out of a central MATS administration and maintenance facility

Challenges Facing MATS

Like many transit systems, operational and administrative issues affect overall cost-effectiveness and service qualities. The first step to addressing these issues is to identify and categorize those having the greatest impact.

For MATS, the identified issues are grouped into three broad categories: Fare Handling; Service Improvements, and; Staffing and Organizational needs. Each category has several specific items to be addressed, which are summarized in the following sections.

Fare Handling

Fare handling encompasses the payment mechanisms, on-vehicle payment systems and cash management of the organization. Three specific fare handling issues were identified:

Limited payment options	**Description:** Cash and paper fare cards are the only options for fare payment. Cash must be paid in exact change on the vehicle, and fare cards require manual punching by the driver. No electronic payments are available.
	Impact: Reduced options and manual interactions decrease the convenience and appeal of service, decreasing ridership.
Drivers handle cash & card inventories	**Description:** Drivers must sell fare cards while on routes, which requires cash handling and managing the inventory of fare cards.
	Impact: Boarding times are increased (up to several minutes), affecting schedule compliance; manual cash handling introduces errors and potential for revenue loss.
Cash management	**Description:** Vaults must be extracted from each vehicle's fare box and manually counted by two staff to provide accuracy checks.

	Impact: Staff time is consumed with a process that could be largely automated. Manual counts have the potential to introduce errors, leading to expending additional staff time to correct.

Service Improvements

The quality of service provided to riders is the key to viability of a transit systems. These service improvements include elements such as the ability to service requests for on-demand trips, on-time performance for fixed route busses and route optimization. The highest priority service issues are:

On-demand trip requests	**Description:** Requests for demand responsive service cannot be confirmed in real-time, requiring operators to manually schedule trips, which requires excessive staff time to complete and contact the customer to confirm.
	Impact: High staff time commitments and workload, resulting in service requests going to voicemail for later processing. Decreased service quality as fewer same-day trips are possible and customers have less choice when booking trips due to capacity constraints.
Vehicle location and route compliance data	**Description:** Without manually contacting each vehicle via voice radio, there is no way to know current location. There is no on-going record of vehicle locations.
	Impact: Schedule compliance is unknown, leaving no mechanism to assess and improve. Emergency response is hampered without knowing the exact location of the vehicle. Unable to address customer schedule complaints without a record of vehicle location.
Ridership data	**Description:** Ridership must be manually counted during a study sample, making data incomplete and sporadic.
	Impact: Routes cannot be planned to best serve riders' needs and travel patterns, resulting in sub-optimal service.

Staff and Organizational

A number of issues relate to the internal functions of MATS itself rather than interactions with riders. These include:

Driver scheduling	**Description:** Creating shift schedules and managing time off/sick requests is a slow, labor-intensive process. Constraints such as union seniority rules must be manually accounted for and locating staff to cover absences relies on managers calling a series of available drivers.
	Impact: Excessive staff time is used in the scheduling and management of absences. Service can be affected if drivers cannot be scheduled.
Computer and network reliability	**Description:** Sporadic outages of either network connectivity or desktop virtualization infrastructure affect ability to take trip requests, update manifests, etc.
	Impact: Staff is unable to service trip requests. If expanded technology tools are deployed, functionality and benefits will be reduced upon network outages.
Staff availability and expertise limitations	**Description:** Ability to research and deploy new tools to manage service is limited, affecting overall operations. Availability of dedicated and capable technical staff is lacking.
	Impact: MATS is unable to deploy tools that will reduce cost, save labor and improve service quality.

Solutions

Technical approaches that address each of the identified issues are available from multiple vendors. However, many vendors in the transit-solutions market offer integrated solutions that combine not only the software used

by operators, but also the on-vehicle devices such as mobile data hardware, mobile computers and fare payment systems. This and other factors to consider are discussed below.

General Considerations

Integrated vs In-House

While it is possible to assemble desired functionality either from individual suppliers or, in some cases, to develop solutions in-house, two caveats should be considered prior to selecting "stand-alone" solutions for deployment:

1. In general, components from one system will not be re-usable by another. If a decision is made at a future date to change suppliers, most or all hardware and software components will be discarded for the transition.
2. Integration of systems – such as data from a stand-alone [automatic vehicle location] AVL system into separate demand-responsive and fixed route management software – may be challenging and in some cases will rely on cooperation from vendors that they are reluctant to supply.

Conversely, selecting an 'integrated' solution from a single vendor (or team of vendors acting as a single provider) carries its own concerns:

1. Components of the system are selected by the vendor and may not be "best of breed" or may not provide the optimal feature mix for MATS.
2. Support will only be available from a single source. If MATS is dissatisfied, there will not be alternative providers.
3. Changing to an alternative system in the future may be more difficult than migrating from a collection of in-house developed and stand-alone solutions. A collection of systems will already have had data interface and interoperation issues resolved, whereas an integrated system will be monolithic and controlled by an entity with no incentive to assist with migration.

On-Premises vs Hosted

Similar to the Integrated vs In-House decision is whether a solution should be located "On-Premises" (software and data managed on servers maintained by MATS/Muskegon County) or Hosted (software and data on a 3rd party server access through an Internet connection). Each of these options also presents value trade-offs to MATS.

On-Premises solutions:

1. Do not rely on external Internet connections or on the maintenance of servers by a 3rd party.
2. Keep all data under the control of MATS.
3. Allow MATS to make decisions about upgrade adoption and timing.
4. Allow MATS to continue functioning without support of the provider.

However, the On-Premises approach requires qualified staff to maintain the software and ensure that the server infrastructure has both sufficient capacity and reliability for MATS needs. These needs can represent a substantial cost.

By contrast, a Hosted or "cloud" solution:

1. Work best when Internet connections are reliable and high-performance.

2. Reduces initial deployment costs by shifting payments to a subscription model.
3. Places all maintenance responsibilities on the provider.
4. Has no requirements for new server hardware.
5. Will always present the most current version of the software to the user.

While the initial cost benefits of a hosted model are attractive, buyers should carefully consider the on-going costs and how they affect operations budgets. In addition, dispute resolution with the hosting vendor can be complicated by their ability to terminate service, thereby disabling MATS capacity to provide service.

Solution Overview

There are several products available to address the issues listed above, which are offered in integrated or in-house forms and may be either hosted or on-premises deployments. To guide selection, a set of basic evaluation criteria were developed. These were:

1. **Cost of Capital/Hardware** – Initial costs must be compatible with a capital improvement program.
2. **Cost of Operations and Maintenance** – On going costs must be accommodated within the MATS operating budget.
3. **Reliability** – The installed solution should function as intended with little to no intervention from staff.
4. **Compatibility** – Components of the installed solution should interoperate with each other and exchange data between them and with other MATS solutions without requiring staff time from MATS or IT services.
5. **Flexibility/Modularity** – MATS should be able to select individual functional components to deploy for immediate needs, with the ability to add additional functions, or expand the use of existing functions in the future.
6. **User Experience** – System elements should be easy to use, minimize training needs and give a consistent experience for users.
7. **Ease of Deployment** – Systems must be deployable/maintainable by MATS or Muskegon County IT Services staff and should require a minimum of additional supporting infrastructure.

These criteria will be used to guide a design and procurement process as well as evaluate specific, proposed solutions. For each of the issue categories, classes of solutions were identified through research of the industry.

Fare Handling

Fare handling solutions encompass two broad areas of farebox modernization: cash management and fare payment systems. While these elements can be implemented separately, they are most commonly combined into a single device on the vehicle. However, there are two distinct functions involved:

'Registering' Fareboxes

MATS currently uses a simple "vault" system. These deposit cash into a secure box that can be removed from the farebox for counting by MATS staff. Fareboxes are available that automate counting, saving a substantial amount of time.

Electronic Payments

Transit customers increasingly want to use electronic payments in place of cash. This can be enabled through a number of different customer-side technologies, such as RFID cards, Near Field Communications (NFC) devices and smartphone-based apps that use visual QR codes or other machine-readable displays.

All of these approaches have three elements in common: an identifier carried by the passenger, an on-vehicle device to read the identifier, and a mobile data system to process the fare transaction. By moving to an electronic payment system, the need for drivers to handle cash can also be reduced if sales are moved to an on-line or physical storefront operated by MATS.

Service Improvements

The three service improvement issues (trip request processing, schedule compliance/performance monitoring, and data collection) can be addressed by technologies commonly used by transit properties, specifically:

Paratransit & Fleet Management Software

Computer-assisted systems for automatically loading details of paratransit customers during a call to request a trip, identifying the availability of a vehicle to service the trip, confirming the reservation and updating the driver's manifest on an in-vehicle display is available from a number of vendors. Similar software can also be used to track locations of fixed route busses for schedule compliance, operations service data reporting, and safety purposes. Increasingly, paratransit and fleet management software providers offer modules that enable customers to plan, request, and book a ride with minimal wait times using a web platform or mobile application (i.e., offering an experience similar to Uber or Lyft).[1] These customer-facing tools are paired with the required back-end computer-aided dispatch software that enables this type of "mobility on demand" service.

Mobile Data Computers (and Mobile Data Communications)

Moving data to and from vehicles is a critical component of a service improvement. A continuous record of vehicle locations can improve schedule compliance, enhance route planning and enable real-time updates to drivers providing on-demand service. These systems generally include a GPS receiver, wireless data connection and an interface for the driver to send and receive information – a mobile data computer or "MDC" (a general term, this can refer to a mobile phone, tablet, embedded computer, or industrial laptop).

Automatic Passenger Counters

Knowing the location of boardings and drop offs and how many passengers are served at each is a key to providing the best, most cost-effective service. Currently, MATS relies on manual counts conducted by staff over short periods of time. This approach is labor intensive and gives only a "snapshot" of conditions. By deploying passenger counting systems on the vehicles, an accurate, continuous picture of how transit is used by the public can be developed. This information can then allow MATS to leverage its existing resources to provide better service.

Staff and Organizational

Staff Scheduling Software

Scheduling drivers for vehicles can be a complex activity, particularly for on-demand services and when it is necessary to replace a driver who is unavailable due to illness. The various restrictions on scheduling due to union rules or other parameters can best be handled by specialized human resources management software. In addition to scheduling, the software can provide fill in requests via text message or other mechanisms, allow for driver "bidding" on shifts and manage time card punch-in, punch-out timekeeping functions. Most software packages offer differing levels of features at different price tiers, and those specifically created for the transit market will better fit the use cases of MATS.

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[1] When such rides are shared, this is occasionally referred to as "microtransit" or mobility on demand (MOD).

IT Infrastructure

Data-driven solutions require highly reliable, high-performance infrastructure. The network itself must offer sufficient capacity with little to no down time and the underlying data storage, application, and desktop services systems must offer continuous availability during MATS operations.

Network reliability can be improved by deploying redundant data routes in the wide area network and implementing self-healing protocols to ensure data follows an available path. Other IT services can be configured for high availability on premises or can be located in a cloud environment offered by the software provider, who is then contractually responsible for service availability.

Call Center Management

Operation of the on-demand service requires that requests be handled by telephone operators. Even when online "self-service" booking is available, many users still must rely on direct conversation with operators. Manually determining customer details in written logs or simple electronic contact managers is time consuming and leads to incoming calls being routed to voice mail as operators are busy servicing other customers.

Call center software can automate client detail look ups by interfacing directly with the telephone system, enable information look-up from the transit scheduling software for recurring trips or display caller service preferences.

Management software also can provide valuable metrics for managing services that are not available now. MATS currently has limited detailed ability to determine how long an operator takes to service a call, how long calls may be on hold, and whether calls go to voice mail. With proper reporting, changes can be made to how operators manage calls to improve service.

Staffing

While advanced technology can provide substantial benefits for operations, the systems themselves require support to be effective. Both on-vehicle and "back office" systems require training, maintenance and repairs. In MATS case, the specific needs for staffing will vary based on the extent and complexity of the eventual system, but will include:

- Training of operators and managers for new software
- Training of system administrators for server maintenance and network connectivity
- Training of drivers for on-vehicle systems (MDCs, fareboxes, etc.)
- Training of vehicle mechanics for repair and replacement of on-vehicle equipment
- Software upgrades and workstation maintenance
- Repairs to damaged on-vehicle equipment
- Development of new operations/administrative procedures

Some of these costs may be converted to a direct expense by using a hosted or cloud solution, but others will be specific to MATS and will require on-site staff.

Ensuring a successful deployment will require dedication of staff time. During initial deployment, it is likely that 0.5 FTE will be needed for between six months and one year. After the system becomes operational, this time may be reduced, but will likely remain between 0.1 and 0.3 FTE, varying based on short term needs, such as deploying major system upgrades, etc.

Connection to Challenges

"Traceability" – the connection between the challenges to be addressed and the solutions proposed – is a vital part of the initial system design and provides an accountability framework for the eventual deployment. The

traceability relationship can be summarized in a matrix, which clearly shows which issues drove the selection of solutions. This relationship is shown in Table 1.

Table 1. Challenges – Solutions Matrix

Challenges		Solutions								
		'Registering' Fareboxes	Electronic Payments	Paratransit & Fleet Management Software	Mobile Data Computers	Automatic Passenger Counters	Staff Scheduling Software	IT Infrastructure	Call Center Management	Staffing
Fare Handling	Limited payment options		X		X					
	Drivers handle cash & card inventories		X		X					
	Cash management	X	X		X					
Service Improvements	On-demand trip requests			X	X				X	
	Vehicle location and route compliance data			X	X					
	Ridership data	X		X		X			X	
Staff and Organizational	Driver scheduling						X			
	Computer and network reliability							X		X
	Staff availability and expertise limitations							X	X	X

Recommendations

The specific products implemented by MATS should be selected by a competitive bidding process in accordance with Federal Transit Administration (FTA) guidelines. This section outlines the types of subsystems that can be considered by MATS and provides a recommendation for selecting a subsystem type based on the current state of industry practice and MATS' operational environment.

System Characteristics

While on-vehicle hardware must be installed on the vehicle itself, the back-office software may be either installed on-premises or hosted by the provider in the cloud. MATS has noted issues with the ability of Muskegon County server infrastructure, applying upgrades to software, and network reliability that affect their ability to use existing software tools. **For these reasons, a hosted cloud solution is recommended, provided that pricing of the solution is compatible with MATS' budget**.

The other major distinction is between integrated solutions from a single vendor or vendor team, and an in-house developed solution. In-house solutions offer high modularity and the ability to choose products best suited for each task. However, selection, installation, integration, and maintenance of in-house developed solutions will require substantial technical expertise and staff time. MATS has concerns over staff availability to support transit technology, making labor-intensive solutions less attractive.

In addition, the re-usability of in-house hardware is generally very low if a change is desired after deployment. For example, if a passenger-counting system is deployed on a vehicle as a stand-alone solution, it is likely that it will not be reusable if it is to be integrated into a fleet-management software package, which will specify a compatible passenger detector. The same is true with items such as cellular modems for mobile data. A transit management software package will likely require on-vehicle hardware that includes its own communications device.

To minimize staffing requirements and best protect investments, an integrated solution is recommended.

Fare Handling

An integrated cash management and electronic payment solution is recommended for deployment on fixed route vehicles. These solutions include a registering (cash counting) farebox and an electronic payment reader. The technology used for the reader system (RFID, NFC, App/QR, etc.) may be determined during the requirements development phase or left as an item for vendors to propose. Electronic payment readers should be available aboard both fixed route and demand response buses. However, farebox solutions for demand response buses may differ from those for fixed route buses, depending on specific needs.

Sales of fares may be through point-of-sale locations or on-line. Ten-ride and monthly passes would no longer be sold on vehicles.

Benefits reported by other transit agencies from similar fare payment system investments:

- 3% to 17% increase in fare revenue
- Reduced staff time and costs associated with collecting, processing, and reconciling fares
- Increased customer satisfaction
- Faster boarding and less dwell time
- Ability to capture rich customer data
- Foster fare policy innovation and tailoring

Service Improvements

The existing on-demand software should be either updated to a more recent and capable version or replaced. This software should interface with the telephone system to automatically identify passengers and simplify entry of trip requests. Paratransit vehicles and fixed route buses should be equipped with MDCs (whether a tablet, embedded computer, or other device) that have displays suitable for reading trip manifests and driver assignments. Fixed route vehicles should be equipped with GPS/AVL hardware and automatic passenger counters (APCs). Fleet management software will be needed and should be integrated with the on-demand system.

Benefits reported by other transit agencies from similar service improvement investments:

- Demand response operating costs decreased by as much as 30%-35% and reduced cost per passenger trip
- Increased demand response passengers per hour by 44%, on average
- Ability to allow customers to book rides directly via website or mobile application, eliminating phone calls
- Significantly decrease demand response "no shows"
- 45% to 80% reduction in "where's my bus" calls received by transit staff
- Improved on-time performance by 25%
- Increased customer satisfaction
- Increased bus speeds
- Ability to understand and respond to passenger trends
- Ability to redistribute scarce resources to maximize efficiency and effectiveness

Staff and Organizational

Driver scheduling software must be flexible enough to make rules-based schedule recommendations, provide a simple user interface for managers, and have a notification and accept/decline function for drivers when replacement shifts for sick and vacation absences are needed.

Benefits reported by other transit agencies from similar staff and organizational investments:

- Freed up dozens of weekly staff hours by simplifying and streamlining the management of driver vacations, same-day driver scheduling

Supporting the new scheduling system and the other technology improvements noted above will require additional infrastructure within MATS and Muskegon County. Specifically, the new systems will work in real-time, and rely on high availability of both server and networking systems.

Server system availability can be addressed through the hosted approach to application delivery. However, it may be necessary to provide enhanced connectivity between MATS offices and cloud servers. This may be through an alternative Internet gateway on the Muskegon County network at a data center (supported by redundant network paths to the gateways) or a secondary gateway at the MATS offices.

Desktop virtualization should also be reviewed to ensure it provides the needed level of reliability for MATS operations. If needed, improvements can be made to the infrastructure providing desktop software to workstations, or local "stand-alone" installations can be used for software on a limited number of operator workstations.

Even with hosted solutions, the additional systems will require support by either MATS or other Muskegon County personnel. Initial deployment and training should be supported by approximately 0.5 FTE. On-going operations are likely to require between 0.1 and 0.5 FTE, which will vary based on the specific activities (upgrades, repairs, training new employees) at the time.

Recommendation Summary

The recommendations above provide the basis for an extendable and maintainable system that addresses the immediate needs of MATS and enables advanced features to be added. This system will encompass:

- Upgraded on-demand management software
- Driver scheduling software
- MDCs (whether tablet, computer, or other device) on all vehicles, beginning with paratransit vehicles
- GPS/AVL equipment for all revenue vehicles
- Registering fareboxes and electronic payment processing and sales
- Fleet management software for fixed route service
- APC system
- Improvements to IT infrastructure to ensure availability
- Adjustments to staffing to accommodate deployment and maintenance

It is recommended that these solutions be implemented using cloud-based services and an integrated solution from a single vendor or vendor team.

Implementation

The process used to design the system, choose providers and validate the final product has direct bearing on the success of the deployment. By following a stepwise approach, a solution will be defined that addresses the underlying challenges, operates as expected and is maintainable over the long term by MATS.

Process Overview

The overall process for implementation is presented in detail in Technical Memorandum Number Three. A high-level overview consisting of eight steps is summarized here.

1. Define Functional Requirements: Describe in specific terms what the recommended investments should do
2. Issue a Request for Information (RFI) to technology suppliers
3. Issue a Request for Proposals (RFP)
4. Award Contract
5. Pre-deployment Preparation
6. System Build-Out
7. System Cut-Over
8. On-Going Use

Although it is shown as a single step here, item #1 "Describe Functional Requirements" entails a complete process in itself. This is commonly called Systems Engineering and is a standardized way of managing the design and deployment of complex systems. This process may be informed by completing step #2 and gathering information from vendors, or it could be completed beforehand to guide the specific questions to be asked in the RFI.

Systems Engineering

The FHWA has defined a standard process for engineering transportation-related systems. It is most commonly illustrated using a "V" diagram, such as that shown in Figure 1.

This Transit Technology Implementation Plan represents the Concept Exploration phase of systems engineering. The next steps are to develop the Concept of Operations and System Requirements for MATS' technology implementation.

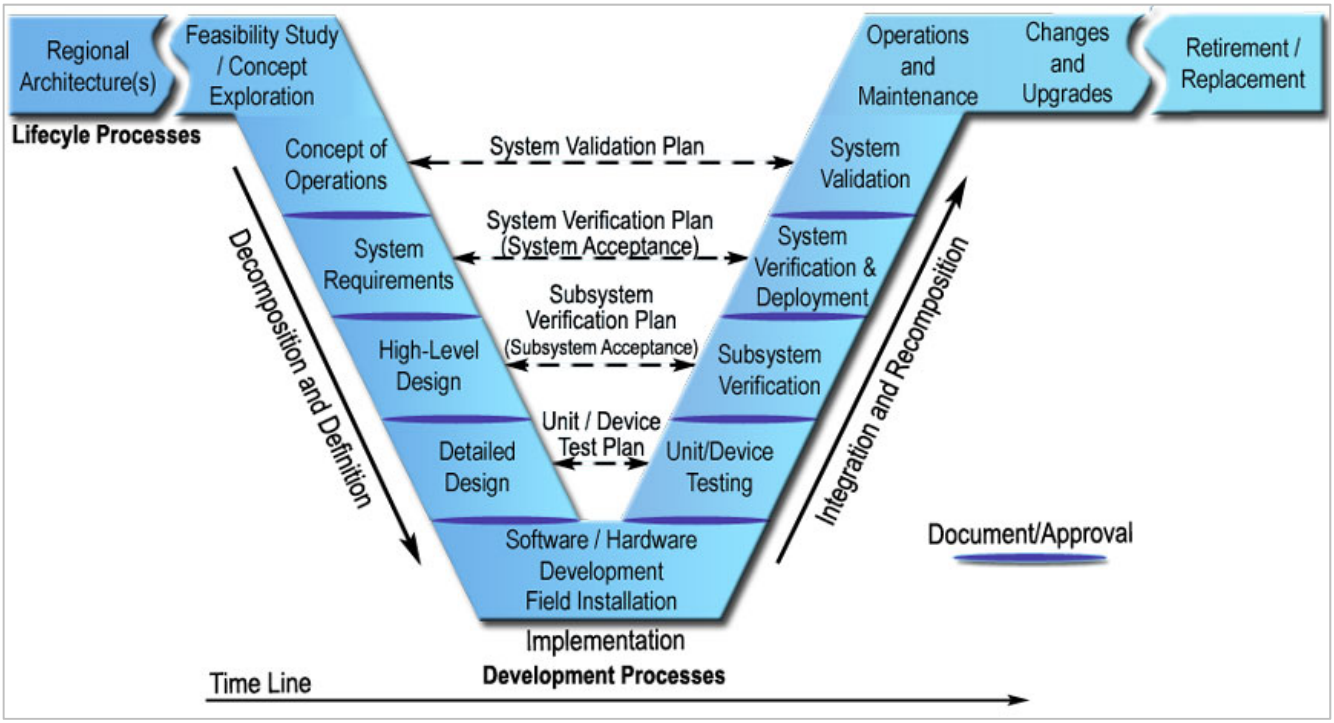
The Concept of Operations (ConOps) will provide a narrative description of the system, the environment where it will be deployed and operational scenarios that describe what the system will look like for each of the stakeholder groups (drivers, operators, managers, and support staff). The ConOps then provides the basis for a comprehensive set of system requirements. The system requirements should be used to create a detailed list of requirements to be included along with the ConOps in an RFP.

After a contract award (step #4 above) high-level and detailed design will be completed in collaboration with the selected vendor(s). The vendor(s) will be required to submit verification and unit test plans as part of their deliverables (step #5 above). By defining test plans prior to deployment, conflicts over requested vs. delivered functionality and products will be minimized.

Following system installation and cut-over (steps #6 and #7 above), the system will be tested and validated to ensure that it conforms to the scenarios described in the ConOps. Finally, the system will enter the operations and maintenance phase as MATS engages in on-going use of the system (step #8 above).

The following the systems engineering process is recommended in order to build systems that perform as desired and have traceability to a well-defined set of requirements.

Figure 1. Systems Engineering Process



Sequencing

The introduction of new technologies into MATS operations should be managed in a stepwise fashion. This will allow an orderly transition for staff and provide an opportunity to make any needed improvements to information technology systems to accommodate the new functions.

There are four phases envisioned for the MATS deployments:

- Phase 1 updates existing paratransit software, adds call center management functionality and introduces a new driver schedule system. The new software will transition to a hosted provider during this phase. Following software configuration, mobile data and MDCs (i.e., tablets, computers, etc.) will be installed on paratransit revenue vehicles. These devices allow the new paratransit and fleet management software to identify vehicle locations in real time (AVL), provide live status updates for scheduled trips and update trip manifests while the vehicle is service customers.
- Phase 1a is concurrent with Phase 1 and introduces any needed upgrades to desktop computers, networking and Internet connectivity.
- Phase 2 Introduces electronic payments and advanced, registering fare boxes. This phase will also introduce mobile communications and GPS/AVL to the fixed route vehicles. It may also provide an MDC for each fixed-route vehicle (could be the same or different than those on paratransit vehicles), depending on specific vendor packages.
- Phase 3 completes the technology upgrades with automatic passenger counters. MATS will now have continuous data collection for fixed route system use, and operators will have access to real time vehicle occupancy data.

When preparing an initial RFP, all phases should be described as the ultimate goal of the MATS technology deployment, even if the initial request covers only the first phase. This approach will allow bidders to provide information on a complete, integrated solution, while allowing MATS to procure systems as budget and technical capacity allows. Future phases can then be procured separately, which will maintain competitive pressure even though a single integrated system is still the goal.

Sequencing is envisioned to take place over a 24-month period, following issuance of an RFP for the initial system deployment. This timeline is illustrated in Figure 2.

Figure 2. Implementation Timeline

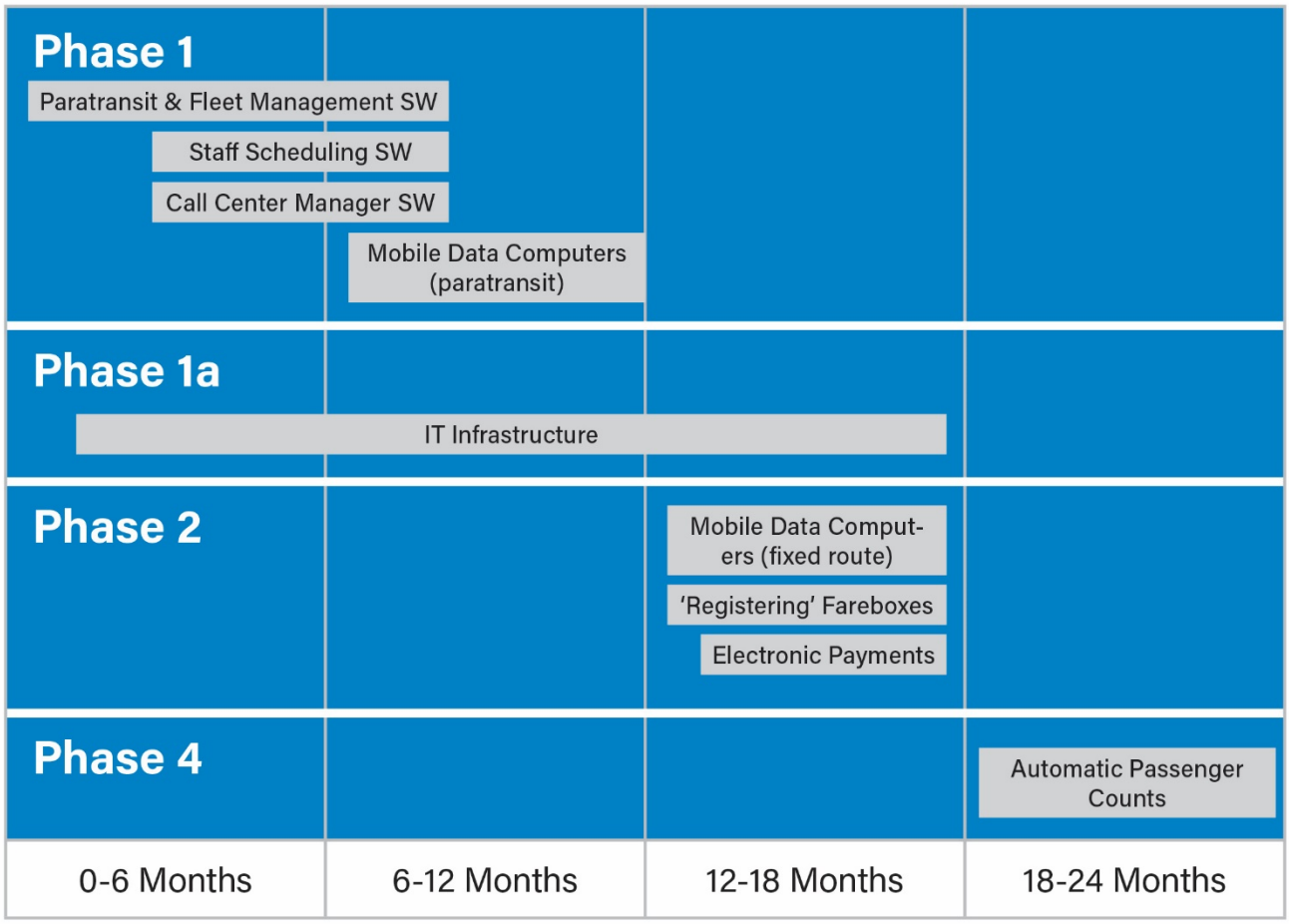


Table 2 organizes the proposed solutions by phase.

Table 2. Solutions – Phase Matrix

Challenges		SOLUTIONS								
		PHASE 1				PHASE 1A	PHASE 3		PHASE 4	ALL PHASES
		Paratransit & Fleet Management Software	Staff Scheduling Software	Call Center Management	Mobile Data Computers *Paratransit	IT Infrastructure	Registering Fareboxes	Electronic Payments	Automatic Passenger Counters	Staffing *Make Adjustments as you go
Fare Handling	Limited payment options				X			X		
	Drivers handle cash & card inventories				X			X		
	Cash management				X		X	X		
Service Improvements	On-demand trip requests	X		X	X					
	Vehicle location and route compliance data	X			X					
	Ridership data	X		X			X		X	
Staff and Organizational	Driver scheduling		X							
	Computer and network reliability					X				X
	Staff availability and expertise limitations			X		X				X

Cost Estimates

As outlined in this report, MATS has many options in selecting technology solutions to address current needs and must weigh many considerations before implementing new technology solutions. Without these details, it can be difficult to estimate the cost of these service improvement hardware and software solutions prior to the RFI and RFP process with great accuracy. The actual costs to MATS will depend on the vendor, specific system elements and support options and level of integration with other MATS systems, among other consideration.

Table 3 summarizes cost estimate ranges for the recommended solutions. These cost estimates are illustrative and are based on per vehicle unit costs developed from research conducted of recent procurement of similar transit technology solutions by multiple transit agencies in North America.

Reliable intelligent transportation systems cost databases have little information available from the last five years on the solutions MATS is considering.[2] In this short period of time, transit technology solutions have evolved significantly and become much more commonly deployed at transit systems of similar size to MATS. Given this, public procurement records were collected through online research to gather several comparable transit technology procurement examples from the last few years for a more appropriate comparison. Additional discussion of the methods and assumptions used to derive these estimates, plus other cost considerations, are listed in the following section.

Table 3. Cost Estimate Ranges for Recommended Solutions

Phase	Solution Element		One-time/Capital Cost (Total for MATS)	Ongoing/Operating and Maintenance Cost (Total for MATS)
System Engineering	Planning and Systems Engineering		250 to 350 person-hours	--
Phase 1	Service Improvements	Paratransit & Fleet Management Software	$50,400 to $201,600	$4,320 to $32,400 annually
		Mobile Data Computers on Paratransit Vehicles	$10,200 to $136,000	$850 to $10,200 annually
	Staff and Organizational	Staff Scheduling Software	TBD. Often included as part of paratransit & fleet management software suite	TBD. Often included as part of paratransit & fleet management software suite
		Staffing	0.5 FTE	0.1 to 0.3 FTE
Phase 1a	Staff and Organizational	IT Infrastructure	TBD	TBD

[2] Often a reliable source, the U.S. Department of Transportation's Intelligent Transportation Systems Knowledge Resource Cost Database (https://www.itscosts.its.dot.gov/its/benecost.nsf/CostHome) includes little information about the solutions MATS seeks to implement that is current and suitable for comparison. Most records for relevant transit technology solutions are more than a decade old; in many instances, enabling technologies and common configurations have changed dramatically, and solutions have become more cost-effective, in this time.

Phase	Solution Element		One-time/Capital Cost (Total for MATS)	Ongoing/Operating and Maintenance Cost (Total for MATS)
Phase 2	Fare Handling	'Registering' Fareboxes	$540,000 to $720,000	$5,400 to $10,800 annually
		Electronic Payments		
	Staff and Organizational	Staffing	0.5 FTE	0.1 to 0.3 FTE
Phase 3	Service Improvements	Automatic Passenger Counters	$26,600 to $32,300	$190 to $5,130 annually
	Staff and Organizational	Staffing	0.2 FTE	0.1 FTE

Planning and Systems Engineering

The systems engineering process can be complex but can be scaled to an appropriate level for each project. For the envisioned MATS system, the system engineering is likely to require between 250 and 350 person-hours, not including the time of stakeholders spent providing input to the ConOps and requirements.

Phase 1

Service Improvements

MATS has many options to pursue the recommended service improvement solutions. Many vendors offer complete packages that include on-demand and fixed route hardware and software, staff scheduling software, and call center management tools, among many other elements. Further, these vendors often provide (or require) integrated mobile data and MDCs that are required to implement the other solutions. For these reasons, it can be difficult to estimate the cost of these service improvement hardware and software solutions prior to the RFI and RFP process. Thus, the following cost estimates are illustrative.

Paratransit dispatch and fleet management system hardware and software with call center management and staff scheduling modules could result in the following costs. These are based on the entire revenue fleet, as both paratransit and fixed route modes would interface with the software (in some way, at some point).

- One-time/capital cost: between $1,400 and $5,600 per vehicle for installation, testing, and project management. Based on MATS' revenue fleet of 36 vehicles[3], this amounts to $54,000 to $201,600.
- Ongoing/operating and maintenance costs: such a system could cost from $120 to $900 per-vehicle, per-year, for ongoing software support and maintenance, hosting services, warranties, etc.; around $4,320 to $32,400 annually.

Onboard equipment such as mobile data and MDCs are costed separately from the software and other hardware specific to the paratransit dispatch and fleet management system described above. Similarly, their cost can vary

[3] 36 vehicles: 19 fixed-route buses, 10 cutaway buses, and 7 mini-vans

drastically. The following assumes hardware for paratransit vehicles[4] only, and that MDCs and/or mobile data aboard fixed route vehicles would be addressed through farebox upgrades.

- One-time/capital cost: between $600 and $8,000 per vehicle for installation, testing, and project management. Based on MATS' revenue fleet of 17 paratransit vehicles, this amounts to $10,200 to $136,000.
- Ongoing/operating and maintenance costs: such a system could cost from $50 to $600 per-vehicle, per-year, for ongoing support and maintenance, warranties, etc.; around $850 to $10,200 annually.

Staff and Organizational

Implementation of additional transit technology systems will require support by either MATS or other Muskegon County personnel. Initial deployment and training should be supported by approximately 0.5 FTE, at least immediately. On-going operations are likely to require between 0.1 and 0.3 FTE, which will vary based on the specific activities (upgrades, repairs, training new employees) at the time.

Phase 2

Fare Handling

Several elements are required to revamp MATS' fare collection processes in order to achieve the desired benefits. As such, procurement of a comprehensive fare payment system – including registering fareboxes, electronic payment reader, mobile ticketing app and web portal, automatic fare collection software – will be complex and unique to MATS.

A modern and comprehensive fare payment system for MATS could result in the following costs:

- Capital cost: between $15,000 and $20,000 per vehicle for installation, testing, and project management. Based on MATS' revenue fleet of 36 vehicles, this amounts to $540,000 to $720,000.
- Ongoing, operating and maintenance costs: such a system could cost from $150 to $300 per-vehicle, per-year, for ongoing software support and maintenance, hosting services, warranties, etc.; around $5,400 to $10,800 annual total.

Staff and Organizational

Initial deployment and training should be supported by approximately 0.5 FTE, at least immediately. On-going operations are likely to require between 0.1 and 0.3 FTE, which will vary based on the specific activities (upgrades, repairs, training new employees) at the time.

Phase 3

Service Improvements

APC systems are often offered by many vendors, including those who provide paratransit and fleet management software and hardware and automated fare collection systems. Given this, it can be difficult to estimate the cost of an APC system for MATS. The following are estimated costs for the hardware and software associated with a stand-alone APC system.

[4] 17 vehicles: 10 cutaway buses and 7 mini-vans

- One-time/capital cost: between $1,400 and $1,700 per vehicle for installation, testing, and project management. Based on MATS' revenue fleet of 19 fixed route buses, this amounts to $26,600 to $32,300.
- Ongoing/operating and maintenance costs: such a system could cost from $10 to $270 per-vehicle, per-year, for ongoing support and maintenance, warranties, etc., or around $190 to $5,130 annually.

Staff and Organizational

Initial deployment and training should be supported by approximately 0.2 FTE, at least immediately. On-going operations may require 0.1 FTE in the first year, which will vary based on the specifics of the system and integration with other elements.