Transit Fare Payment and Computer-aided Dispatch (CAD)/Automatic Vehicle Location (AVL) Review and Recommendations

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List of Abbreviations and Acronyms

ABT	Account-Based Ticketing
AFC	Automated Fare Collection
AFP	Automated Fare Payment
ARTS	Aroostook Regional Transportation System
AVL	Automatic Vehicle Location
BSOOB	Biddeford Saco Old Orchard Beach
CAD	Computer-aided Dispatch
Cal-ITP	California Integrated Travel Project
Caltrans	California Department of Transportation
COAST	Cooperative Alliance for Seacoast Transportation
DOT	Department of Transportation
EMV	Europay, MasterCard® and Visa®
FPaaS	Fare Payment as a Service
FTA	Federal Transit Administration
GMCN	Green Mountain Community Network
GMT	Green Mountain Transit
GPTD	Greater Portland Transit District
GTFS	General Transit Feed Specification
IT	Information Technology
ITS	Intelligent Transportation Systems
KVCAP	Kennebec Valley CAP
MaaS	Mobility as a Service
MSAs	Master Service Agreements
MTA	Manchester Transit Authority
N-CATT	National Center for Applied Transit Technology
NFC	Near Field Communication
NHDOT	New Hampshire DOT
NTS	Nashua Transit System
ODS	Operational Data Standard
POS	Point of sale
RFP	Request for Proposals
RFQ	Request for Qualifications
TCRP	Transit Cooperative Research Program
TNC	Transportation Network Companies
TVM	Ticket Vending Machine
UNH	University of New Hampshire
VMT	Vehicle miles traveled
VTrans	Vermont Agency of Transportation
WMTS	Western Maine Transportation Services
YCCAC	York County Community Action Corporation

Section 1. Introduction

The purpose of this report is to describe the results of the following tasks and subtasks:

- Task 2 – Assist with Transit Fare Payment Review and Recommendations
  - Subtask 2.1: Automated Fare Payment (AFP) Assessment
  - Subtask 2.2: Implementation and Expansion Recommendations
  - Subtask 2.3: Best Practices and Technology Identification
- Task 3 – Assist with Computer-aided Dispatch (CAD)/Automatic Vehicle Location (AVL) System Review and Recommendations
  - Subtask 3.1: CAD/AVL Assessment
  - Subtask 3.2: Implementation and Expansion Recommendations
  - Subtask 3.3: Best Practices and Technology Identification

Besides these tasks being in the Scope of Work for this technology initiative project, they were supported by the technology components of the Maine State Transit Plan prepared by Cambridge Systematics dated March 2023 in that "effective targeted technology" was identified as one of the specific needs that contributes to "Rural Transit Demand and Accessibility." Further, additional technologies, including both computer-aided dispatch (CAD)/automatic vehicle location (AVL) and automated fare payment (AFP) systems, were identified as needs.

Specifically, this Plan recommended that CAD/AVL Systems should be deployed throughout the state. "Computer-aided dispatching/automatic vehicle location (CAD/AVL) systems allow transit operators to know in real time the location of all vehicles in a fleet. This is helpful for dispatching, fleet management, and service planning and is a prerequisite for providing real-time information to customers. CAD/AVL systems allow for integration of [General Transit Feed Specification] GTFS Realtime, which allows trip planning apps to display and predict the actual (rather than scheduled) arrival time of vehicles. This improves customer satisfaction and helps drive ridership." (Plan, pages 52-53).

In terms of automated fare payment, the Plan suggests that this technology can facilitate one of the Plan's strategies – to "remove barriers to riding transit and make transit easier to use." (Plan, page 54). Further, the Plan states that "to respond to the needs of customers and adopt new fare policies, modernized fare payment systems are needed. Policies and practices must also accommodate users for whom automated fare payment systems may be challenging, including older adults, individuals with disabilities, unbanked individuals, and people with limited English proficiency."

While the following sections describe an in-depth review of and recommendations for automated fare payment and CAD/AVL systems, the recommendations were influenced, in part, by interviews that Schweiger Consulting conducted with key stakeholders from several Maine transit agencies. Interviews were conducted with Biddeford Saco Old Orchard Beach (BSOOB) Transit, City of South Portland Transportation Department, City of Bangor Community Connector and York County Community Action Corporation (YCCAC) Transportation Program. Summaries of these interviews are included in Appendix A. Please note that two other agencies, Greater Portland Metro and the

Regional Transportation Program in Westbrook, were contacted for interviews, but interviews were not conducted.

Section 2. Assist with Transit Fare Payment Review and Recommendations

2.1 Automated Fare Payment (AFP) Assessment

Schweiger Consulting began this subtask by conducting a review of automated fare payment (AFP) systems in peer states, which are identified in "Rural Public Transportation and Maine: Review of State Best Practices"[1] as Vermont, New Hampshire and North Dakota. Further, other references that were consulted included the following:

- Federal Transit Administration's (FTA's) Mobility Payment Integration: State-of-the-Practice Scan[2]
- National Center for Applied Transit Technology's (N-CATT's) New Fare Payment Systems and Payment Technology[3]
- California Department of Transportation's (Caltrans') All Aboard! Easier Transit Travel with Standardized Payments[4]
- Transit Cooperative Research Program (TCRP) Synthesis 125: Multiagency Electronic Fare Payment Systems[5]
- TCRP Synthesis 148: Business Models for Mobile Fare Apps[6]
- Public transit websites for agencies in Vermont, New Hampshire and North Dakota
- Course materials from the Intelligent Transportation Systems (ITS) Transit Training Modules that directly address AFP[7]:
  - Module 10: Electronic Fare Payment Systems
  - Module 12: Electronic Fare Payment/Advanced Payment Systems: Open Payments Acceptance
  - Module 21: Mobile Fare Ticketing/Payment

AFP deployment among the peer states and Maine is very similar in terms of the number of deployments and the types of AFP systems. In Vermont, only one transit agency has AFP: Green Mountain Transit (GMT). GMT's AFP has a new AFP system (as of May 20, 2024) that offers three options to pay the fare in addition to being able to pay cash. The three AFP options are shown in Figure 1. Genfare is the vendor that provided this system.

Figure 1. GMT AFP Options

The “Ride Ready by GMT” app allows riders to purchase and activate bus fares instantly. With fare capping, riders will no longer be required to pay the upfront cost of a monthly pass. All riders of any age category can take advantage of fare capping. Riders load money on the app or smartcard as needed and once the trip cap has been reached, riders can continue to ride without paying additional fares. Smartcard users can use the Ride Ready by GMT efares page to manage their smartcard account, add funds, and update their profile information. When a rider registers for a Ride Ready account, their account funds are protected if their card is lost or stolen.

In New Hampshire, the Nashua Transit System (NTS) has an AFP system provided by Token Transit. To purchase fare online, riders can use the Token Transit app or website. Cash fare is accepted as well. Figure 2 shows information on the NTS AFP system.

Figure 2. Nashua Transit System AFP System

Riders can download the Token Transit app to their mobile device and set up their account. This requires creating a personal profile and entering the details of a credit or debit card for electronic payment. Once a rider purchases one or more bus fare tickets, they will activate a ticket and show the ticket or pass to the driver as they board.

In North Dakota, the transit system in Fargo, MATBUS, launched a fare payment system called MATBUS Connect in May 2022. This system, provided by Genfare, includes the Connect Card, Connect App, and Connect Portal. With these features, riders can load money into their account via an internet connection and pay on the bus using a smartphone. Funds in a rider’s account are protected if the Connect Card is lost or stolen. MATBUS Connect is an account-based system, which means that a rider can load their card or app with any amount, rather than paying for a monthly pass upfront. The fare is deducted from the rider’s account each time they ride, and the system provides daily and monthly fare capping. The mobile app and smart card are both free, and the cost of a ride is the same across all payment types.

In Maine, the three public transportation providers in the Greater Portland region, Biddeford-Saco-Old Orchard Beach (BSOOB) Transit, Greater Portland Transit District (GPTD), and City of South Portland Bus Service use DiriGo provided by UMO. Riders can download the UMO Mobility App on their smartphones and register DiriGo Pass mobile app to pay their fare, plan their trip, and track their bus. DiriGo has fare capping and a 90-minute pass. Paying with the DiriGo card or app allows you to transfer between any METRO, South Portland Bus Service, or Biddeford Saco Old Orchard Beach Transit (BSOOB) service within 90 minutes without needed a separate transfer. You may need to pay the net fare difference if transferring to an express route. Fare capping applies to the

whole DiriGo system (METRO, South Portland Bus Service, and BSOOB). Fares paid on any of these services apply to your daily or monthly fare cap. Riders paying cash need to pay again when boarding a second bus - this applies whether you are transferring within one system or transferring to a bus from another system.

What sets this AFP deployment apart from those mentioned above is that the same system is used across these three transit systems, requiring the system to determine the portion of the fare paid that goes to each transit system if a rider is using more than one transit system to make their trip. Currently, this is a complex and time-consuming process due to the fact that the UMO system does not automatically determine the portion of each fare that should be distributed to each transit agency.

Other AFP deployments in Maine include the following:

- citylink in the Lewiston-Auburn area uses both cash and Token Transit; and
- Western Maine Transportation Services (WMTS) started using Token Transit for some of their services as of April 2024.

As part of this initial assessment, Schweiger Consulting reviewed and updated a list of AFP system vendors that is maintained by Schweiger Consulting. The updated list is shown in Table 1. Please note the following:

- Those agencies that are shown in bold are located in the peer states and Maine.
- Agencies can have more than one vendor since selected vendors have integrated services.
- This list is not exhaustive in terms of vendors and transit agencies.

Table 1. Mobile Fare Payment Solution Vendors

Vendor Name	Representative Agencies	Type of System
Bytemark	▪ Capital Metropolitan Transportation Authority (CMTA) (Austin, TX) ▪ Delaware Transit Corp ▪ King County Metro, Sound Transit, Seattle Streetcar and Water Taxi (Transit GO Ticket) ▪ NYC Ferry ▪ Sacramento Regional Transit (SacRT) (ZipPass)	Mobile payment/app
California Integrated Travel Project (Cal-ITP)[8]	▪ Anaheim Transit Network ▪ Capitol Corridor ▪ Coast RTA (South Carolina) ▪ Far North Group ▪ Humboldt Transit Authority ▪ Lake Transit Authority ▪ Mendocino Transit Authority ▪ Monterey Salinas Transit ▪ Redwood Coast Transit Authority ▪ Santa Barbara County Association of Governments: Clean Air Express ▪ Santa Barbara Metropolitan Transit District (MTD)	▪ Support with purchasing the hardware and software needed to accept open-loop payments off the state of CA Master Service Agreements ▪ Implementation support including staff training and marketing assistance ▪ Provide a Payments Data Dashboard that provide insights from open-loop payments

Vendor Name	Representative Agencies	Type of System
Conduent	Southeastern Pennsylvania Transportation Authority. (SEPTA) (Philadelphia)	Open architecture and standards system that accepts smartcards, bank-issued contactless credit, debit or prepaid cards or near field communication (NFC)-enabled mobile devices
Cubic	▪ Chicago Transit Authority (CTA)	▪ Ventra Card
	▪ Maryland Transit Administration (MTA)	▪ CharmCard
	▪ Massachusetts Bay Transportation Authority (MBTA) (Boston, MA) (future)	▪ Automated Fare Collection (AFC) 2.0 (Ticket Vending Machines [TVMs], point of sale [POS], smartcards, contactless credit cards, mobile devices, no fareboxes)
	▪ Metropolitan Transportation Commission (MTC)	▪ Clipper Card
	▪ Miami-Dade Transit (MDT)	▪ EASY Card
	▪ San Diego Metropolitan Transit System (MTS)	▪ Compass Card
	▪ Vancouver TransLink	▪ Compass Card
Enghouse	▪ Within Transdev's operations in the Netherlands	▪ Account-based ticketing ▪ Contactless EMV (Europay, MasterCard® and Visa®) payment
FAIRTIQ	86 public transit agencies in 6 countries[1]	Mobile payment (with no infrastructure)
Flowbird	Minneapolis Metro (MN) (TVMs)	▪ Ticket vending machines ▪ On-board fare validator ▪ Mobile ticketing
Genfare/SPX	▪ Capital District Transportation Authority (CDTA) (Albany, NY) ▪ Connect Transit (Normal, IL) ▪ **Green Mountain Transit (GMT) (Burlington, VT)** ▪ LeeTran (Fort Myers, FL) ▪ **Metro Transit (Fargo, ND)** ▪ Montachusett Regional Transit Authority (Fitchburg, MA) ▪ Porterville Transit (California) ▪ The Wave Transit (Mobile, AL)	▪ Fareboxes ▪ Payment Processing ▪ Mobile ticketing and trip planning app ▪ Ticket Vending Machine ▪ Point of Sale Terminals ▪ Online ticketing platform ▪ Electronic fare media validator

[1] Currently, FAIRTIQ does not have any deployments in North America.

Vendor Name	Representative Agencies	Type of System
Hopthru	▪ Bay Area Transportation Authority (BATA) (Traverse City, MI) ▪ Benzie Bus (Benzie County, MI) ▪ Capital Area Rural Transportation System (CARTS) (Greater Austin, TX) ▪ Columbia Area Transit (CAT) (Hood River, OR) ▪ Envida (Colorado Springs, CO) ▪ GoGeo (Georgetown, TX) ▪ Pierce Transit (Tacoma, WA) ▪ Roscommon County Transportation Authority (RCTA) (Roscommon, County, MI) ▪ San Francisco Bay Ferry (San Francisco Bay, CA) ▪ Seattle Monorail (Seattle, WA) ▪ Sonoma County Transit (Sonoma, CA) ▪ TheBus (San Marcos, TX) ▪ Vine Transit (Napa, CA) ▪ WexExpress (Cadillac, MI)	Mobile payment/app
INIT	▪ Capital Metro (Austin, TX) ▪ Interurban Transit Partnership (Grand Rapids, MI) ▪ Metropolitan Atlanta Rapid Transit Authority (MARTA) (future) ▪ ORCA regional fare system in Seattle, WA: Community Transit, Everett Transit, King County Metro, Kitsap Transit, Pierce Transit, Sound Transit, and Washington State Ferries ▪ Regional System in FL: Hillsborough Area Regional Transit Authority (HART) (Tampa), Pinellas Suncoast Transit Authority (PSTA), Hernando County's The Bus, Pasco County Public Transportation (PCPT), and Sarasota County Area Transit (SCAT) ▪ Rhode Island Public Transportation Authority (RIPTA) ▪ Spokane Transit Authority (STA) ▪ TriMet (Portland, OR)	▪ Europay, Mastercard and Visa (EMV)-capable e-fare validators, integration of Bytemark mobile ticketing app, and option to implement platform validators and TVMs ▪ Open payments fare structure by using EMV standard and account-based smart cards ▪ Account-based smart card, mobile ticketing solution and TVMs ▪ Regional account-based system and open payments
Kontron	Metropolitan Atlanta Rapid Transit Authority (MARTA)	Mobile ticketing solutions with visual or electronic validation
Littlepay	▪ Monterey Salinas Transit (MST) ▪ Sacramento Regional Transit ▪ Santa Barbara County Association of Governments ▪ Santa Barbara Metropolitan Transit District (MTD)	▪ Contactless open loop payments ▪ Mobile payments

Vendor Name	Representative Agencies	Type of System
Masabi	▪ Beaver County Transit Authority (Rochester, PA) ▪ Greater Cleveland Regional Transit Authority (GCRTA) ▪ Greater Dayton Regional Transit Authority (RTA) ▪ Los Angeles Metrolink ▪ MBTA Commuter Rail ▪ Nassau Inter-County Express (NICE) (NY) ▪ NEORide Council of Governments (manages EZfare) (OH) ▪ People Mover (Anchorage) ▪ Regional Transit Service of Rochester-Genesee Regional Transportation Authority ▪ Regional Transportation Commission of Southern Nevada (RTC) ▪ Regional Transportation District (RTD) (Denver) ▪ Southwest Ohio Regional Transit Authority (SORTA) (Cincinnati, OH) ▪ Transfort (City of Fort Collins, CO) ▪ Westmoreland Transit (PA) ▪ Worcester Regional Transit Authority (MA) (future)	▪ Mobile payment/app ▪ EZfare is now available at 15 transit systems in KY, MI, OH, WV: ○ Akron Metro (OH) ○ Ann Arbor Area Transportation Authority (MI) ○ Butler County Regional Transit Authority (OH) ○ Community Action Rural Transit System (OH) ○ GCRTA ○ Kanawha Valley Regional Transit Transportation Authority (WV) ○ Laketran (Lake County, OH) ○ Lancaster-Fairfield Public Transit (OH) ○ Medina County Public Transit (MCPT) (OH) ○ Portage Area Regional Transportation Authority (OH) ○ Sandusky Transit (OH) ○ SORTA ○ Stark Area Regional Transit Authority (OH) ○ Toledo Area Regional Transit Authority (OH) ○ Transit Authority of Northern Kentucky
Modeshift	▪ Monroe Transit (City of Monroe, LA) ▪ Santa Maria Regional Transit ▪ South Central Transit Authority (which comprises Berks Area Regional Transportation Authority (BARTA) and Red Rose Transit Authority (RRTA) in PA)	▪ Account-based fare collection ▪ EMV-Open Loop ▪ Mobile Ticketing ▪ Electronic Fare Validator and Ticket Vending Machines
Moovel	▪ Orange County Transportation Authority (OCTA) ▪ TriMet (Portland, OR) ▪ Valley Metro (Phoenix)	Mobile payment
Passport	▪ Sacramento Regional Transit District (SacRT) ▪ Sun Tran (Tucson, AZ) ▪ The Comet (Central Midlands Transit in Columbia, SC)	Mobile payment

Vendor Name	Representative Agencies	Type of System
Scheidt & Bachmann	▪ Connecticut DOT ▪ MBTA (except Commuter Rail) ▪ Niagara Frontier Transportation Authority (NFTA) (Buffalo, NY) ▪ Port Authority (Pittsburgh)	Multi-modal account-based ticketing system with the aim to reduce cash payment in busses
Token Transit	▪ Alameda-Contra Costa Transit District (AC Transit) (CA) ▪ Athens-Clarke County Transit (Athens, GA) ▪ Big Blue Bus (Santa Monica, CA) ▪ Bloomington Transit (Bloomington, IN) ▪ Capital Area Transit (Harrisburg, PA) ▪ Capital Area Transportation Authority (CATA) (State College, PA) ▪ CENTRO (Syracuse, NY) ▪ Champaign-Urbana Mass Transit District (MTD) (Champaign-Urbana, IL) ▪ Gary Public Transit (Gary, IN) ▪ Golden Empire Transit (Bakersfield, CA) ▪ Greater Attleboro Taunton Regional Transit Authority (GATRA) (Attleboro, MA) ▪ **Green Mountain Transit (Burlington, VT)** ▪ Jacksonville Transportation Authority (FL) ▪ Lehigh and Northampton Transportation Authority (LANTA) (Allentown, PA) ▪ Madison County Transit (Madison County, IL) ▪ Manatee County Area Transit (Manatee County, FL) ▪ Mountain Line Transit Authority (Morgantown, WV) ▪ **Nashua Transit System (Nashua, NH)** ▪ Niagara Frontier Transportation Authority (NFTA) Metro (Buffalo, NY) ▪ rabbittransit (York, PA) ▪ Regional Transportation Commission (RTC) (Reno/Sparks, NV) ▪ Riverside Transit Agency (Riverside, CA) ▪ StarMetro (Tallahassee, FL) ▪ StarTran (Lincoln, NE) ▪ Sunline Transit Agency (Palm Springs, CA) ▪ **WMTS (Auburn, ME)** ▪ Yorktown Transit (Yorktown, VA)	Mobile payment app (requires visual validation)
Transit App (supports mobile ticketing in 67 cities across the US and Canada)	▪ Central Ohio Transit Authority (COTA) (Columbus, OH) ▪ Greater Lynchburg Transit Company (GLTC) ▪ Knoxville Area Transit (KAT) ▪ Metro (St. Louis, MO) ▪ Pierce Transit (Tacoma, WA) ▪ Regional Transportation District (Denver, CO) ▪ SORTA (Cincinnati, OH) ▪ Utah Transit Authority	▪ Mobile fare payment[9] ▪ Trip planning ▪ Real-time tracking

Vendor Name	Representative Agencies	Type of System
Tranzer	▪ National and regional train services in The Netherlands, Austria, Belgium, Germany, Italy, Switzerland ▪ Local public transport (bus, tram, metro) in the whole of the Netherlands, big parts of Belgium and various cities in Germany	Mobile payment system
UMO (Cubic) (formerly Delerrok Inc.)	▪ **Biddeford-Saco-Old Orchard Beach Transit, Greater Portland Transit District, and City of South Portland Bus Service** ▪ City of Shreveport, Louisiana (SporTran) ▪ Piedmont Authority for Regional Transportation ▪ Rogue Valley Transportation District (RVTD)	▪ Account-based ticketing ▪ Contactless payment options ▪ Loyalty rewards programs
Vix	▪ Brussels Intercommunal Transport Company (STIB) (Belgium) ▪ Dallas Area Rapid Transit (DART) ▪ King County Metro (Seattle) ▪ Utah Transit Authority	Multi-modal, multi-operator automated fare collection platform that unifies account-based, closed loop and open payments

The final step in this subtask was to identify and document the advantages/benefits and disadvantages/challenges of AFP systems that are deployed in peer states and regions. Typically, AFP system benefits outweigh the challenges, but challenges such as equity for low income, unbanked and under-banked individuals, and those with digital illiteracy require specific system features that address these challenges (e.g., allowing cash to be easily added to an account at a local convenience store). In any case, the National Center for Applied Transit Technology (N-CATT) Guidebook on New Fare Payment Systems and Payment Technology, which is geared toward rural and small urban transit agencies, identifies benefits and challenges associated with each type of AFP system, including those deployed in Maine and the peer states. This information is shown in Table 2 and Table 3.

Table 2. Benefits and Challenges of AFP[10]

Fare System Type	Benefits	Challenges
Open Payment	▪ Direct fare payment enables the transit agency to capitalize on the expertise of financial institutions and the payments industry ▪ Reduced queuing at stations ▪ Interoperability ▪ Ease of use for visitors or those not familiar with the system ▪ Reduced capital costs compared to contactless smart cards ▪ Potential to reduce transit provider's role in processing fares ▪ Increased operational efficiency by eliminating the need to distribute cards	▪ Complex system requires additional security measures and systems in place to ensure valid payment methods ▪ Serving unbanked populations ▪ Real-time processing can be delayed ▪ Micropayments can result in higher transaction fees ▪ Additional equipment is needed to process the fares

Fare System Type	Benefits	Challenges
Account-Based Ticketing (ABT)	▪ Passengers and transit agencies can easily view accounts and manage them remotely ▪ Compatible with fare capping and reduced fare programs ▪ Simple management by transit agencies ▪ Enables increased data collection	▪ Requires back-end configuration ▪ Needs infrastructure on board the vehicle to allow for quick transactions such as Wi-Fi or a cellular network ▪ Delays or transaction outages may occur in areas without connection ▪ Additional information technology (IT) management required for security, risk management, and speed
Fare Payment as a Service (FPaaS)[11]	▪ Cost-effective by utilizing one off the shelf, cloud-based platform ▪ Quick deployment of technology ▪ Technology upgrades are delivered regularly ▪ Enables the development of Mobility as a Service (MaaS) ▪ Enables ABT ▪ Transit agencies can select from vendors that best meet their needs ▪ Improves rider convenience and accessibility ▪ Security is managed by the cloud providers ▪ Vendors may provide IT customer service support ▪ Easy system maintenance and upgrades	▪ May require bus infrastructure such as Wi-Fi or cellular network ▪ Firmware upgrades, often deployed to the hardware by the vendor automatically, may be buggy resulting in equipment outages ▪ Smaller network of vendors to choose from who may offer this type of service ▪ Transit agency RFP's must explicitly outline requirements and needs from the vendor

Table 3. Fare Payment Benefits and Challenges

Fare Payment Types	Benefits	Challenges
EMV	▪ Eliminates the need and costs for riders to obtain an additional card for transit ▪ Allows riders to take advantage of fare capping if they utilize the same card for each transit trip ▪ The transaction is processed quickly via the financial institution ▪ Financial institution incurs any risks associated with the cost of the transaction ▪ Easily integrates with mobile wallets and other mobile devices, further increasing rider flexibility and convenience ▪ Reduces cost and administrative burden associated with reconciling cash payments	▪ Low-income riders and those below a certain age are less likely to have access to a credit or debit card ▪ Fees for micropayments ▪ Additional equipment is needed to process the fares ▪ Requires the rider to have a bank account that issues EMV compatible debit or credit cards ▪ Requires each rider to have their own card to use on board vehicles (cannot do multiple taps per trip) ▪ First-ride risk ▪ Difficult to implement fare capping and to setup reduced fares or special passes for eligible riders
Smartcards	▪ The transit agency, third party, authorized user, or the rider can easily view the account and manage the stored value on the card ▪ Riders are not required to have a smartphone, smart device, or bank account for physical smart cards ▪ Easily integrates fare capping ▪ Cards can be configured to allow for multiple taps/fare types, including family passes ▪ Can be reloaded at designated retail locations ▪ Increased protection of lost or stolen cards with card registration	▪ The cost to purchase the card is often passed onto riders ▪ Higher capital costs (fareboxes, readers, TVM, cards) ▪ Virtual smart cards require a smartphone ▪ Smart cards are required to be disbursed to riders by the transit agency ▪ Cards are more likely to be lost by passengers ▪ Not interoperable – card serves one purpose ▪ Not environmentally friendly – requires the manufacturing of plastic cards

Fare Payment Types	Benefits	Challenges
Mobile Ticketing	▪ Easily configured to the transit agency's existing fare structure ▪ Increased convenience for transit riders ▪ Reduced fares can be verified easily ▪ Can be white-labeled for the transit agency ▪ Tickets are in one central location ▪ Riders can store multiple tickets in their account ▪ Ability to integrate with trip planning phone apps ▪ Does not require the use of electronic fareboxes, ticket vending machines, or the manufacturing of physical cards ▪ No additional onboard equipment needed with visual validation = quicker to launch	▪ Requires a smartphone or smart device with power ▪ To purchase tickets, Wi-Fi or cell service is required ▪ The vendor often manages the platform, including any changes to the fare structure ▪ Additional customer service support may be needed for those who may not be tech-savvy ▪ Vendor transaction fees ▪ Non-US based smartphones or devices may not work/get service ▪ Not all people own a smartphone or smart device

Additional agency benefits of AFP systems were identified through research conducted by Schweiger Consulting:

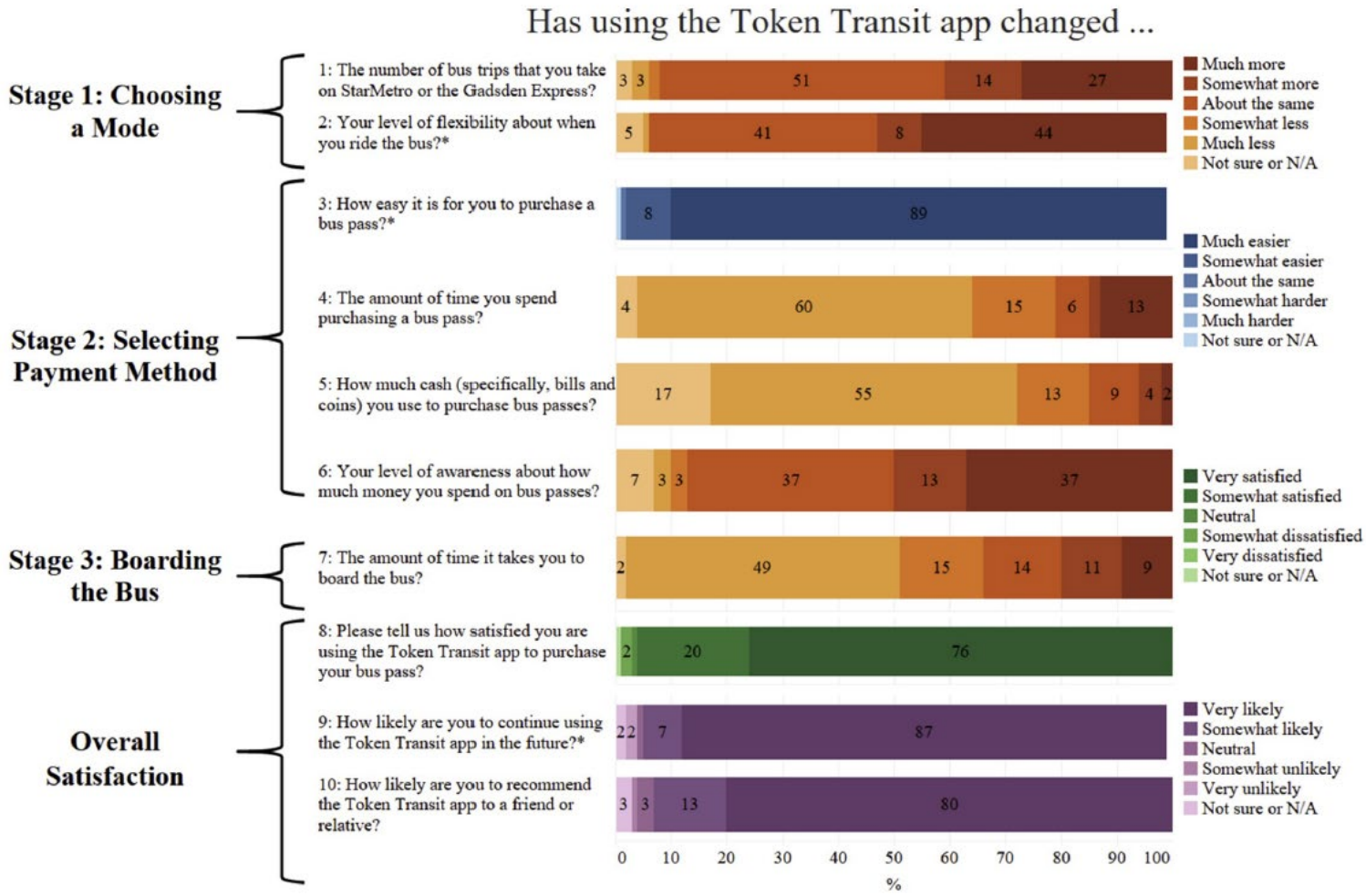
- Dwell time at bus stops can be reduced
- Passenger convenience could be increased
- The following could be minimized:
  - Hardware with moving parts, such as fareboxes
  - Supervisory and clerical support for fare collection and counting activities
  - Producing, purchasing and managing fare media
  - Controlling the distribution and sales of tickets and tokens
  - Transporting cash, credit card and debit card data to accounting facilities
  - Counting cash, transfers and tokens
  - Performing credit and debit card sales accounting
  - Destroying used fare media
  - Providing security for the fare collection process
  - Auditing and controlling fare collection including reconciling readings to cash, credit card and debit card collections
  - Inspecting passes or fare media (a.k.a. fare enforcement), which may result in boarding taking longer
- Additional hardware and software may no longer be needed for riders to purchase fares off-board (e.g., ticket vending machines)
- Equity and economic parity for riders could be improved
- Potentially create an incentive to take public transit over personal vehicles

Research described in Endnote 16 not only confirms the benefits of AFP to transit agencies, but also identifies specific benefits to riders. Figure 3 shows the results of this research.

Given the results of the previous efforts in this subtask, Schweiger Consulting's recommendations for an AFP system that best suits Maine transit agencies' needs are as follows. First, there are three major alternatives for deploying AFP in Maine:

- Expansion of the DiriGo system to other transit agencies in Maine;
- Procurement of open AFP systems based on the Cal-ITP model:
  - Across the whole state; or
  - By select transit agencies;
- Procurement of AFP systems using:
  - A state contract with pre-qualified AFP vendors that transit agencies can use to select the most appropriate system;
  - Individual agency procurements;
  - Multiple-agency group procurements; or
  - Statewide procurement.

Second, these AFP alternatives have benefits and risks as shown in Table 4.



Notes: Numbers rounded to the nearest percent. Numbers less than 2% are not shown. Question wording is exactly as it appeared on the survey instrument.
** Numbers do not sum to 100%*

Figure 3. Rider Benefits of Using AFP

Table 4. Benefits and Risks of AFP Procurement Alternatives

Procurement Alternative	Benefits	Risks
Expansion of the DiriGo system to other transit agencies in Maine	▪ Existing knowledge of system by BSOOB, GPTD and City of South Portland ▪ Consistency of fare collection across the state ▪ Riders can use one app/ smartcard to use multiple agencies' services	▪ Complex fare allocation and distribution among agencies using DiriGo ▪ Being tied to one AFP vendor
Procurement of open AFP system based on the Cal-ITP model:		
Across the whole state	▪ Consistency of fare collection across the state ▪ Will facilitate coordination among agencies ▪ Cal-ITP model reduces the capital and operating costs of an AFP system ▪ Cal-ITP model reduces the amount of time required for procurement ▪ Riders can use one of several payment media to access all transit services throughout the state ▪ AFP Hardware and software is available from multiple vendors, rather than needing to procure from just one vendor	▪ May require on-going coordination among agencies ▪ Unknown how Cal-ITP's model works with agencies that coordinate service with each other to ensure proper fare allocation among agencies ▪ Unknown if State of California's competitively awarded Master Service Agreements (MSAs) can be used by the State of Maine ▪ May not be able to add or modify functionality/ requirements not currently included in the Cal-ITP model

Procurement Alternative	Benefits	Risks
By select transit agencies	▪ Cal-ITP model reduces the capital and operating costs of an AFP system ▪ Cal-ITP model reduces the amount of time required for procurement ▪ AFP Hardware and software is available from multiple vendors, rather than needing to procure from just one vendor ▪ Riders can use one of several payment media to access transit services provided by these selected agencies	▪ Unknown if State of California's competitively awarded Master Service Agreements (MSAs) can be used by transit agencies ▪ Individual procurements needed
Procurement of AFP systems using:		
A state contract with pre-qualified AFP vendors that transit agencies can use to select the most appropriate system	▪ One procurement could be done for the whole state to pre-qualify AFP vendors ▪ Individual agencies can purchase an AFP system from a state contract	▪ Need to identify functionality/requirements that cover all transit agencies in the state ▪ May require riders to use different fare media to access more than one transit service ▪ Could require support from MaineDOT during and after implementation
Individual agency procurements	Each agency can tailor the AFP system functionality/ requirements to meet their individual needs	▪ Each agency will conduct their own procurement ▪ May not have other agencies to confer with during and after implementation ▪ May require riders to use different fare media to access more than one transit service

Procurement Alternative	Benefits	Risks
Multiple-agency/regional group procurements	▪ Similar to DiriGo, multiple agencies procuring the same AFP system will facilitate service coordination ▪ Consistency of fare collection in a specific region of the state ▪ Knowledge of system by multiple agencies will help during and after implementation ▪ Will allow riders to use one fare media to access all the transit services in the region	▪ Need to identify functionality/requirements that cover the agencies in the group procurement ▪ Being tied to one AFP vendor
Statewide procurement	▪ One procurement will minimize administrative overhead ▪ Consistency of fare collection across the state ▪ Will facilitate coordination among agencies ▪ May reduce the capital costs of an AFP system ▪ Knowledge of system by multiple agencies will help during and after implementation	▪ May require on-going coordination among agencies ▪ Need to identify functionality/requirements that cover all transit agencies in the state ▪ Will need to determine if fare allocation among specific agencies is required ▪ Being tied to one vendor across the state

Third, the following considerations were used to identify the recommended AFP system. An AFP system deployment(s) should:

- Facilitate service coordination among regional agencies (or potentially statewide) and the "Complete Trip[12]";
- Establish a community of users who can share experiences of AFP implementation and maintenance;
- Lower the cost of procurement and deployment; and
- Identify different "levels" of sophistication depending on the needs of the agencies.

2.2 Key Recommendations

Based on the benefits and risks associated with the procurement alternatives, Schweiger Consulting recommends that Maine DOT and the Maine Transit Association contact Cal-ITP to determine if the Cal-ITP model for AFP could be used by the state to procure either a statewide AFP deployment or individual/regional agency[13] AFP system. Based on the outcome of consulting with Cal-ITP, if the Cal-ITP model will work for most of the agencies in Maine, it is recommended that either a statewide or regional/multi-agency approach to deploying the Cal-ITP model be pursued.

The reason for this recommendation is that the Cal-ITP model significantly reduces the cost and time associated with implementing an AFP. Further, the riders throughout Maine would benefit from this type of open-loop AFP, meaning that they can use a variety of fare media to access transit services throughout the state (e.g., credit/debit cards, Apple/Google Pay).
If the Cal-ITP model is determined to not be appropriate for Maine transit agencies, it is recommended that Maine DOT pursue pre-qualifying AFP vendors so that individual or multiple/regional agencies can purchase an AFP system from the list of pre-qualified vendors. The reason for this recommendation is that this approach will facilitate the procurement of an AFP so that individual agencies will not have to go through an entire procurement process. Further, with this approach, it is possible that the pricing of each AFP system will be less than if an agency did their own procurement.

One caveat of this state contract approach is that functionality/requirements of an AFP system will need to be agreed to by agencies that want to purchase from the state contract. Given the nature of the transit systems in Maine in terms of location and size, it could be challenging to obtain agreement among interested agencies on the functionality of an AFP system. This approach may need to consider two or more "levels" of AFP sophistication, which will apply to different types of transit systems. Also, this could lengthen the amount of time needed to develop system requirements that will be used to pre-qualify AFP vendors.

If these two approaches (Cal-ITP and state contract approach) are determined to not be appropriate or possible, it is recommended that the statewide procurement approach is conducted. Again, this approach limits that amount of effort required from each agency and will have a great benefit to riders throughout the state.

2.2 Implementation and Expansion Recommendations

Schweiger Consulting conducted a comprehensive analysis of existing and potential technology deployment across 17 Maine transit agencies using a questionnaire. The results of this questionnaire in the area of AFP helped to identify those transit agencies that are most interested in improving or replacing their existing fare collection system, and in a possible statewide AFP system. These agencies include the following:

- Community Connector (City of Bangor)
- York County Community Action Corporation (YCCAC)
- Kennebec Valley CAP (KVCAP)
- Aroostook Regional Transportation System (ARTS)
- Lynx-Penquis Transport Program
- South Portland Bus Service
- WaldoCAP/Mid-Coast Public Transport

It is recommended that a committee with a member from each of these agencies be established to work with MaineDOT to:

- Determine which of the recommended approaches to AFP procurement and deployment should be pursued;
- Assist in the development and identification of AFP system functionality/requirements, if necessary;

- Assist in participating in the AFP request for qualifications (RFQ) or request for proposals (RFP) process (e.g., evaluating RFQ or RFP responses), if necessary; and
- Assist in making a vendor selection, depending on the procurement approach selected.

It is not recommended for DiriGo to be extended to other transit agencies since there are issues associated with the current system. Given that the deployment of DiriGo happened shortly after Cubic acquired Delerrok (which became UMO), there were issues with the system that have not been resolved yet. For example, the complexity associated with allocating the correct portion of fares to each of the three participating agencies is significant. Further, the initial on-board validators[2] were not very durable and were hard to maintain.

2.3 Best Practices and Technology Identification

As mentioned earlier, a questionnaire was completed by 17 transit agencies across the state to determine the level of technology deployment, and needs for technology and assistance with deploying new technology. The overall purpose of this data gathering was to better understand each agency's needs in fare collection and several other technologies. The questionnaire is shown in Appendix B, and the results of the questionnaire are shown in Appendix C.

The N-CATT Guidebook[3] mentioned earlier identified best practices and considerations for the three major types of fare media and systems. The considerations for the three types of fare media are as follows[14]:

Contactless Cards (EMV):
- Supports Visa, Mastercard, and Discover payment methods.
- Utilizes fare aggregation of transactions instead of micropayment transactions that report individual, smaller fares.
- Allows unbanked users to utilize EMV technology through prepaid cards found at retail locations or through payment processors such as CashApp or Venmo.
- Identify if the financial institution or the transit agency will absorb the first ride risk.
- Ensure compliance with PCI DSS.
- Outline in the contract who is responsible for merchant fees.

Smartcards:
- Establish partnerships with retailers to allow cash users to load stored values on cards.
- Avoid setting high reload values for smart cards to promote equitable access, perhaps only requiring the cost of one fare. Agencies should work with community members to determine the right amount.
- Consider offering transit rewards or other promotions when riders use smart cards.
- Decide if the smart cards will allow for account-based back-end administration.

Mobile Ticketing:
- Determine the type of validation:

[2] An on-board fare validator is a device to support closed-loop and contactless open payment programs. Typically, a validator is compliant with international standards for contactless devices and supports reading contactless smart cards and barcodes. It often has a display that shows the validity of fare media and wireless communication, allowing it to communicate via Wi-Fi, Bluetooth or cellular network.

    - If using visual validation, vehicle operators to identify fraudulent tickets
    - If using a validator, select the preferred type (i.e., proximity or Near Field Communication [NFC]/Bluetooth)
- Deploy security measures to avoid fraud, such as unique ticket branding, scrolling images, or specific colors.
- Establish a policy to allow riders to board vehicles without requiring cellular service to activate.
- Select a vendor that meets your specific needs with either simple integrations or complex integrations, including micromobility or transportation network companies (TNCs).
- Consider allowing institutional partners access to back-end systems to manage unique riders via a third party to reduce the administrative burden.

The best practices associated with an AFP system cited in the N-CATT Guidebook are as follows:

Establish Agency Goals
- Set agency goals to guide the planning, procurement, selection, and deployment of the fare technology.
- Align goals with agency policies, priorities, capital needs, and rider demographics.

Consider Leveraging a Joint Procurement

Collaborative procurement with other agencies in the region can be helpful in managing complex technologies, attracting and improving negotiations with vendors, and can lead to a stronger financial arrangement and cost-efficiency.

Prioritize Equitable Access for Riders When Offering Financial Incentives

Riders may be unbanked, underbanked, or without access to a cellphone. If the fare technology only offers riders an alternative way to pay for fares, then continue to provide alternative fare options to ensure access. However, if the technology includes financial incentives such as fare capping or reduced fares, everyone needs to have equitable access to the technology.

Carefully Evaluate Vendors and the Technology Offered
- Identify any potential costs, fee structures, and time commitments.
- Verify that the technology is market-tested and available.
- Outline specific agency needs that need to be met by the vendor (i.e., vehicle equipment, customer service support, data requirements).

Select Fare Technology to Meet Data Needs and Requirements
- Ensure any data collected meet agency goals or Federal reporting requirements.
- Utilize a user-friendly back-end system that can integrate with the existing IT system.
- Confirm back-end system allows for data reconciliations needed for auditing purposes.

Utilize an Evaluation Strategy for Selecting Fare Systems and Fare Payments
- For fare payments, consider the evaluation matrix for compatibility between fare types required by the agency and the type of fare payment, as shown in Table 5.
- When determining which fare technology consider utilizing an evaluation strategy to consider a low, medium, or high level of complexity relative to capital cost and a low, medium, or high level of effort at the agency level relative to operating costs. Examples of these evaluation strategy matrices are shown in Table 6 and Table 7.

Table 5. Compatibility Between Fare Types and Media

Fare Types	Contactless EMV Cards	Smart Cards	Mobile Ticketing
Full Fare	5	5	5
Passes	1	4	5
Reduced Fares	1	3	4
Institutional Fares/Passes	1	4	3
Zonal/Distance-Based Fares	2	2	3
Fare Capping	2	5	5
Trip Planning	0	0	4
Transit Rewards	0	4	4
Retail Partnerships	4	3	4

Matrix Legend:
0 = Not applicable
1 = Hard to implement
2 = Somewhat hard to implement
3 = Neutral
4 = Somewhat straightforward to implement
5 = Straightforward to implement

Table 6. Evaluation Strategy to Consider Level of Complexity Relative to Capital Cost

	Low Capital Cost	Medium Capital Cost	High Capital Cost
Low Complexity	▪ Mobile Ticketing – Visual Validation	▪ 2D Barcode Scanner ▪ NFC/Bluetooth Validators	
Medium Complexity	▪ Physical Smartcard ▪ Mobile Ticketing – setup and onboarding	▪ Smartcard set up and onboarding	▪ Communication modifications for vehicles
High Complexity	▪ Mobile ticketing – set up and onboarding plus trip planning integration	▪ Open Payment ▪ Compliant Validators	▪ Bespoke AFC

Table 7. Evaluation Strategy to Consider Level of Effort Relative to Operating Costs

	Low Operating Cost	Medium Operating Cost	High Operating Cost
Low Level of Effort	▪ Cashless	▪ Mobile Ticketing – vendor fee ▪ Software as a Service (SaaS)/FPaaS	▪ SaaS with Customer Service

Medium Level of Effort	▪ Smart Card Processing	▪ Retail partnerships ▪ Account-based ticketing	
High Level of Effort	▪ Fare-Free	▪ Open Payment Processing	▪ Card-Centric

While Schweiger Consulting recommends contacting Cal-ITP to determine the feasibility of using their model for procuring and implementing a statewide AFP, the following outline identifies the major functionality and requirements that could be considered in an AFP procurement and implementation.

1 Project Overview & Contract Management
- 1.1 Project Overview
  - 1.1.1 Background
  - 1.1.2 Project Goals & Objectives
  - 1.1.3 Scope
  - 1.1.4 General Requirements
- 1.2 Document Organization
- 1.3 Codes, Regulations & Standards

2 System Architecture
- 2.1 General Architecture
  - 2.1.1 Account-Based System
  - 2.1.2 Real-Time Communications
- 2.2 Open Architecture
  - 2.2.1 General Approach
  - 2.2.2 Fare Media Formats
  - 2.2.3 Application Programming Interfaces
  - 2.2.4 Transaction Formats
- 2.3 Open Payment Architecture
  - 2.3.1 General Requirements
  - 2.3.2 Supported Formats
  - 2.3.3 Open Payment Authorization
  - 2.3.4 Payment Aggregation
- 2.4 Required Submittals

3 Design Criteria
- 3.1 Design Review
  - 3.1.1 General Requirements
  - 3.1.2 Conceptual Design Review (CDR)
  - 3.1.3 Preliminary Design Review (PDR)
  - 3.1.4 Final Design Review (FDR)
- 3.2 General Design Requirements
- 3.3 Environmental Factors
  - 3.3.1 Environment & Climate Tolerance
  - 3.3.2 Shock & Vibration
  - 3.3.3 Power & Voltage Requirements
  - 3.3.4 Electrical Noise Requirements

14.8.3 Application Programming Interfaces
14.8.4 Data
14.9 Modifications & Configuration Control
14.9.1 Engineering Changes
14.9.2 Field Modifications
14.9.3 Component Identification & Serial Numbers
14.10 Required Submittals

Schweiger Consulting reviewed the results of the research conducted in the first subtask to identify best practices in AFP deployment. Beside the documents mentioned earlier in Section 2.1, Schweiger Consulting consulted with the following documents in addition to others to identify best practices:

- Applying an Equity Lens to Automated Payment Solutions for Public Transportation[15]
- Advancements in Electronic Fare Payment Contactless and Open Loop Technologies[16]
- An evaluation of the benefits of mobile fare payment technology from the user and operator perspectives [17]
- Business Models for Mobile Fare Apps[18]
- Mobile Fare Ticketing/Payment[19]

Equity issues associated with AFP seem to be the most prevalent in terms of challenges in deploying AFP systems. In addition to the previously-mentioned equity issues associated with AFP implementation, there are several best practices that can be used to address these issues:

- Local conditions and patterns will differ substantially from national averages, so it is recommended doing local survey work to understand particular rider issues with transitions from cash payment to AFP;
- Outreach, education, training and partnerships with community organizations will be important elements of improving adaptation to new fare payment systems;
- To address concern over phone data limits, offering free public Wi-Fi near or on-board transit vehicles could be an important improvement for those who are dependent on Wi-Fi hotspots, especially those who may live or work far from stores, libraries or cafes which offer such services;
- For older adults, a smartphone program and training may be needed to close the gap in smartphone access and use and proficiency, especially if they are going to be using transit more as they phase out of driving themselves as they age.;
- Collecting fares is not free, and for smaller agencies fare collection expenses are very high compared to fare revenue. In these situations, eliminating fare collection entirely may be a prudent financial choice.
- Simple, non-validating cash collection, which seems to be the predominant collection method across Maine transit agencies, is another option to allow for cash fare collection. If the volume of cash fares is low overall, then there is no need for more expensive fare validation machines.
- Integration with retail services is a common strategy to provide options for travelers to use cash. With retail partnerships, travelers can purchase fare media from a variety of providers, such as grocery stores, convenience stores, or public facilities such as libraries. Such partnerships are typically a convenient and low-cost strategy for transit agencies, but the

specific geographic coverage of retail services can vary, and in some cases may not meet the needs of all travelers.

In terms of the technical aspects of future AFP systems, advances in technology that will become commonplace in the future, such as cryptocurrency apps and wallets, which are mobile apps to manage and pay for services using cryptocurrency (e.g., Coinbase, Blockchain), are not recommended for transit fare payment. "Bitcoin, the most popular cryptocurrency, and other Proof of Work (PoW) cryptocurrencies are criticized because they are by design very wasteful of energy both in the initial token creation, known as 'mining'[3] but also transactions (data changes) are very energy intensive to record, reach consensus and distribute to the peers around the world.[4] Instead of completing one bitcoin transaction, the same energy could power 1 million conventional credit card transactions. It would be cost-prohibitive to pay for a small-value transit pass, and also very environmentally destructive, compared to using any other conventional payment option. [Further,] currently users of bitcoin and cryptocurrencies are usually high-technology-using early adopters with access to many other payment options, and bitcoin does not represent a vulnerable minority that requires transit access through this unusual payment method. [Finally,] cryptocurrencies are very complex to access, with plenty of opportunities for the unwary (or even expert) user to be scammed, lose money or even suffer from the volatility of exchange prices between normal national currencies and cryptocurrencies."[20]

[3] Mining consumes over 128 Terawatt Hours of power, which is more energy than Pakistan or the Netherlands use in a year.

[4] Transactions use 1.5 megawatt hours for one bitcoin transaction, the equivalent of 50 days' of energy use for an average USA home (source: https://digiconomist.net/bitcoin-energy-consumption).

Section 3. Assist with CAD/AVL System Review and Recommendations

3.1 Computer-aided Dispatch (CAD)/Automatic Vehicle Location (AVL) Assessment

Schweiger Consulting's approach to this subtask was to conduct a review of computer-aided dispatch (CAD)/ automated vehicle location (AVL) systems in peer states, which are identified in Section 2.1 as Vermont, New Hampshire and North Dakota. Further, other references that were consulted included the following:

- Regional Transit Data Standards Report: Making the Case for GTFS[21]
- New Hampshire DOT (NHDOT) Statewide Strategic Transit Assessment, Appendix H[22]
- TCRP Synthesis 73: AVL Systems for Bus Transit: Update [23]
- TCRP Synthesis 155: Intelligent Transportation Systems in Headway-Based Bus Service[24]
- Green Mountain Community Network, Inc, Request for Proposal: Automated Vehicle Location And Monitoring System[25]
- Transit Service Reliability: Analyzing Automatic Vehicle Location (AVL) Data for On-Time Performance and Identifying Conditions Leading to Service Degradation[26]
- On Bus Hardware, Software, Standards & Interoperability[27]
- Greater Minnesota Public Transit Technology Plan[28]

The Vermont Agency of Transportation (VTrans) conducted three AVL tests throughout the state and needed a vendor to provide the real-time data to the Transit App. With VT being a small state, decisions about AVL; GTFS static, GTFS-realtime, and Flex extensions; and scheduling and dispatching software would be very difficult to procure seven different times rather than fund one statewide approach. So in 2023, VTrans worked with Green Mountain Community Network (GMCN) in Bennington, VT to procure a new statewide CAD/AVL system. Three proposals were submitted and Swiftly was selected as the successful proposer for a one-year term: January 1 – December 31, 2024, with the option to extend for another three years. VTrans and GMCN started with a one-year contract because they wanted to test Swiftly's onboard app to determine if it could improve bus location data. More information will be available on this deployment once the onboard app is up and running in Spring 2024.

In New Hampshire, a variety of CAD/AVL systems have been procured and implemented throughout the state. The New Hampshire transit agencies that have CAD/AVL systems include Advance Transit, Cooperative Alliance for Seacoast Transportation (COAST), Manchester Transit Authority (MTA), and University of New Hampshire (UNH) Wildcat Transit. These are from multiple vendors and have been implemented at different times.

Information regarding CAD/AVL deployment in North Dakota was not available as of April 2024.

In Maine, several transit agencies have CAD/AVL systems already, but a need was expressed early on in this project by members of the Maine Transit Association for recommendations regarding the procurement and deployment of CAD/AVL systems. The most recent procurements of CAD/AVL in Maine are at BSOOB Transit (Swiftly CAD/AVL), City of South Portland Transportation Department (transitioning from Clever Devices to Swiftly CAD/AVL) and City of Bangor's Community Connector (in the process of implementing Strategic Mapping's CAD/AVL). One of the oldest CAD/AVL

systems deployed in Maine is in the Island Explorer in Bar Harbor, Maine (Avail Technologies CAD/AVL).

As part of this initial assessment, Schweiger Consulting reviewed and updated a list of CAD/AVL system vendors that is maintained by Schweiger Consulting. The updated list is shown in Table 8. Please note the following:

- Vendors that are shown in bold have deployed systems in transit agencies in the peer states and Maine.
- This list is not exhaustive in terms of vendors. It contains the vendors that have provided CAD/AVL systems in the U.S. and Canada for the past ten years. Vendors that provide systems primarily outside of North America are not included.

Table 8. CAD/AVL Vendors

Vendor Name
Avail Technologies
Clever Devices
Conduent
Connexionz Limited
EQUANS
ETA Transit
Geotab
GMV ITS North America
INIT
Modeshift
Passio Technologies
Peak Transit
Routematch (now TripSpark)
Samsara
Strategic Mapping
Swiftly
TransLoc
Trapeze
UniteGPS
Vix Technology
Vontas

Third, the advantages/benefits and disadvantages/challenges of CAD/AVL systems that are deployed in peer states and regions were identified and documented. We expect that the following agency benefits will be identified for CAD/AVL systems deployed in peer states and regions[29,30]:

- Decreased passenger late arrival times
- Improved on-time performance
- Reduced emergency incident response time

- Improved emergency communication through a covert alarm feature and alarm monitoring to notify dispatch of emergencies
- Possible savings include:
  - Reduced data-collection costs
  - Decreased staff labor costs for schedule checkers and supervisors in the field
  - Reduction in fleet requirements (i.e., fewer vehicles required) through integration of AVL and CAD
  - Environmental benefits: increased transit ridership can save on personal vehicle miles traveled (VMT)
- Improved data warehousing and reporting tools can provide "dashboards" with real-time displays of key indicators for performance management
- Increased customer satisfaction and more smartphone and internet applications for customer decision making
- Improved fleet situational awareness through route adherence monitoring
- Proactive addressing of operational issues by supervisors and dispatchers
- Improved dispatch efficiency through text messaging between dispatchers and vehicle operators
- Single point operator log in
- Computation of real-time next-vehicle predictions
- Comprehensive historical data collection and incident reporting
- Provide schedule adherence warnings to vehicle operators and dispatchers when vehicles are running early or late based on a configurable threshold
- Facilitates making on-board visual and audible announcements at major stops, intersections and points of interest
- Providing a record of events that can be searched using a text/keyword search feature
- Improved reporting at various levels of detail
- Facilitate planning studies using archived data
- Provide playback feature to review vehicle operation at desired time durations in the past

Based on the results of the previous efforts, including interviews with key Maine transit agencies, Schweiger Consulting identified five alternatives for deploying CAD/AVL in Maine:

- Expansion of the Swiftly CAD/AVL system implemented by BSOOB Transit and City of South Portland Transportation Department to other transit agencies in Maine;
- Procurement of CAD/AVL systems:
  - A state contract with pre-qualified CAD/AVL vendors that transit agencies can use to select the most appropriate system;
  - Individual agency procurements;
  - Multiple-agency/ group procurements; or
  - Statewide procurement;

Second, these CAD/AVL alternatives have benefits and risks as shown in Table 9.

Table 9. Benefits and Risks of CAD/AVL Procurement Alternatives

Procurement Alternative	Benefits	Risks
Expansion of the Swiftly CAD/AVL system implemented by BSOOB Transit and City of South Portland Transportation Department to other transit agencies in Maine	▪ Existing knowledge of system by BSOOB and City of South Portland Transportation Department ▪ Consistency of CAD/AVL across most of the state ▪ Riders can use one app to access trip planning and real-time transit information	▪ Potential that Swiftly's resources are limited based on their current base of implementations ▪ Being tied to one CAD/AVL vendor
Procurement of CAD/AVL systems using:		
A state contract with pre-qualified CAD/AVL vendors that transit agencies can use to select the most appropriate system	▪ One procurement could be done for the whole state to pre-qualify CAD/AVL vendors ▪ Individual agencies can purchase a CAD/AVL system from a state contract	▪ Need to identify functionality/ requirements that cover all transit agencies in the state ▪ May require riders to use different apps to access information about more than one transit service ▪ Could require support from MaineDOT during and after implementation
Individual agency procurements	Each agency can tailor the CAD/AVL system functionality/ requirements to meet their individual needs	▪ Each agency will conduct their own procurement ▪ May not have other agencies to confer with during and after implementation ▪ May require riders to use different apps to access information about more than one transit service

Procurement Alternative	Benefits	Risks
Multiple-agency/regional/ group procurements	▪ Similar to the Swiftly implementation by BSOOB Transit and City of South Portland Transportation Department, multiple agencies procuring the same CAD/AVL system will facilitate service coordination ▪ Consistency of CAD/AVL in a specific region of the state ▪ Knowledge of system by multiple agencies will help during and after implementation ▪ Will allow riders to use one app to access information about all the transit services in the region	▪ Need to identify functionality/requirements that cover the agencies in the group procurement ▪ Being tied to one CAD/AVL vendor
Statewide procurement	▪ One procurement will save time ▪ Consistency of CAD/AVL across the state ▪ Will facilitate coordination among agencies ▪ May reduce the capital costs of a CAD/AVL system ▪ Knowledge of system by multiple agencies will help during and after implementation	▪ Need to identify functionality/requirements that cover all transit agencies in the state ▪ Being tied to one vendor across the state

Schweiger Consulting recommends the following approach to procure CAD/AVL systems that best suit Maine transit agencies' needs:

- A statewide approach to procuring and implementing CAD/AVL, similar to VTrans' approach, could be most effective for those agencies that either want to implement or replace a CAD/AVL system. This recommendation is based on the rural nature of many of the Maine transit agencies as well as the expanded vendor market that can meet the needs of these agencies. Further, it will not require that individual transit agencies have to procure their own system. Finally, having one CAD/AVL system across the state will facilitate better service coordination and riders will only have to use one app to access trip planning and real-time information about multiple agencies.
- The next best approach would be to issue an RFQ to qualify CAD/AVL vendors for implementation by state transit agencies. This would give individual transit agencies an option to purchase a system from a state contract with selected vendors. This approach was taken by

Florida DOT. In 2021, FDOT issued an RFP (# TRIPS-21-APTS) for Intelligent Transportation Systems/Technology Solutions for Public Transit to qualify multiple vendors, allowing transit agencies to purchase technology solutions such as a CAD/AVL system from a state contract. Vendors that qualified to provide CAD/AVL systems were Avail Technologies, CTS Software, ETA, GMV Syncromatics, Strategic Mapping Inc, Transloc Inc., and TripSpark Technologies[31].

3.2 Implementation and Expansion Recommendations

As mentioned earlier, Schweiger Consulting conducted a comprehensive analysis of existing and potential technology deployment across 17 Maine transit agencies using a questionnaire. The results of this questionnaire in the area of CAD/AVL helped to identify those transit agencies that have experience with CAD/AVL systems or are interested in improving or replacing their existing CAD/AVL system, and in a possible statewide CAD/AVL system. These agencies include the following:

- BSOOB Transit
- Community Connector (City of Bangor)
- York County Community Action Corporation (YCCAC)
- Western Maine Transportation Services (WMTS)
- South Portland Bus Service
- WaldoCAP/Mid-Coast Public Transport

It is recommended that a committee with a member from each of these agencies be established to work with MaineDOT to:

- Determine which of the recommended approaches to CAD/AVL procurement and deployment should be pursued;
- Assist in the development and identification of CAD/AVL system functionality/requirements, if necessary;
- Assist in participating in the CAD/AVL RFQ or RFP process (e.g., evaluating RFQ or RFP responses), if necessary; and
- Assist in making a vendor selection, depending on the procurement approach selected.

3.3 Best Practices and Technology Identification

As mentioned earlier, a questionnaire was completed by 17 transit agencies across the state to determine the level of technology deployment, and needs for technology and assistance with deploying new technology. The overall purpose of this data gathering was to better understand each agency's needs in CAD/AVL and several other technologies. As mentioned earlier, the questionnaire is shown in Appendix B, and the results of the questionnaire, including those related to CAD/AVL are shown in Appendix C.

Because CAD/AVL systems have been used in public transit for many years and are commonplace currently, the best practices and considerations for implementing these systems are somewhat limited. However, tools that could assist Maine transit agencies, particularly small and medium size agencies, plan for and implement CAD/AVL include those mentioned in the Greater Minnesota Public Transit Technology Plan. These are mentioned later in this subsection. MaineDOT has the

opportunity to support the statewide deployment of CAD/AVL, including the use of some of these tools.

While Schweiger Consulting recommends procuring and implementing a statewide CAD/AVL using one of two different methods, the following outline identifies the major and minor functionality and requirements that could be considered in an CAD/AVL procurement and implementation.

1 Introduction
2 Project Overview
  2.1 Purpose
  2.2 Agency Background
    2.2.1 Transit Operations and Services
    2.2.2 Transit Fleet
  2.3 Existing Systems Environment - Servers, Desktops, Database, and Networks
  2.4 Technical Scope and Project Phasing
    2.4.1 Technical Scope
    2.4.2 Project Phasing
3 Information Technology (IT) Requirements
  3.1 General
  3.2 Required Infrastructure
    3.2.1 Hardware
    3.2.2 Software
  3.3 Information Security
  3.4 Database
    3.4.1 General
    3.4.2 Data Management
    3.4.3 Data Logging and Retrieval
  3.5 Data Access
  3.6 Customer Support
    3.6.1 Hosted Approach
    3.6.2 Follow-up Analysis
  3.7 Software Updates and Upgrades
4 Wireless Data Communication Requirements
  4.1 General
  4.2 Wireless Data Communications
    4.2.1 On-Board Hardware
    4.2.2 Wireless Communication Gateway Software
  4.3 Wireless Local Area Network (WLAN) Data Exchange
    4.3.1 General
    4.3.2 Access Point Hardware
    4.3.3 WLAN Data Transfer Support Software
5 ITS Functional Specifications
  5.1 General
    5.1.1 Environment
    5.1.2 Installation
    5.1.3 CC Responsibilities
  5.2 On-board Systems
    5.2.1 Vehicle Area Network (VAN)

However, a more streamlined list of functional requirements, adapted from the VTrans/GMCN Statewide AVL procurement, could be used as well in a procurement as follows:

- Software infrastructure to track vehicle positions for all fixed-route vehicles in the State of **[state name here]** utilizing various onboard devices to include global positioning system (GPS) trackers, mobile devices or other supported hardware.
  - Required:
    - Vendor will supply a list of preferred GPS hardware devices to provide vehicle location based on cell coverage and signals for all fixed-route vehicles in the State of **[state name here]**. Alternatively, the vendor will define a technical plan to integrate with existing GPS devices. **[Describe existing GPS devices here]**
    - All services necessary to provide ongoing information about the vehicle location including latitude, longitude, direction of travel, speed and historical data. In addition, the proposal should detail but not be limited to the following:
      - Device software
      - Device support
      - Hardware and software warranty information with a minimum of one year with option for extending warranty for up to **[number of years here]** years
      - Specify installation time, location poll rate, and system latency in proposal response.
      - **[List functional requirements here]**
  - Desired:
    - Easy installation (**[number of minutes here]** or less per vehicle) by local staff
    - Vehicle location poll (sample) rate of [number of seconds here] seconds or better
    - Latency of less than **[number of seconds here]** seconds from vehicle location poll to GTFS-real time data feed
- Provide functions for configuration and schedule loading.
  - Required:
    - System should provide the capability for loading schedule data through GTFS (static) datasets, provided by a third party.
    - Provide documentation for system configuration, including any system-specific requirements for GTFS (static) data that are not listed at gtfs.org.
- Provide application programming interface (API) endpoints and historical archive of vehicle information, synced with current and historical local agency GTFS feeds and with outputs owned by local agencies.
  - Required:
    - API endpoints open for free use by any developer, providing the following data formats for each fixed route agency in the state of (state name here).
      - GTFS-real time Trip Updates, synced with the agency's current GTFS feed (provided by a third party).
      - GTFS-real time vehicle positions, synced with the agency's current GTFS feed (provided by a third party).
      - All GTFS-real time feeds must be of proven quality to allow integration into Google Maps.
    - Portal through which to download past data from a certain time period, in a .csv or other spreadsheet format.
    - All hosting, support, server expenses, etc. necessary for the continued operation of these items with 99% or greater uptime, for the duration of the contract period.
    - All data in any format retrieved from these endpoints and portal must be fully owned by the agency or licensed in such a way that the agency has free, unrestricted, transferrable, and irrevocable rights to use, store, and edit said data.

    - Desired:
        - A well-documented JavaScript Object Notation (JSON) or eXtensible Markup Language (XML) API giving various useful endpoints, for example, Current location by vehicle, Upcoming arrivals by stop, etc.
        - The highest possible arrival estimate accuracy, demonstrated through quantitative research, and the capability to produce retrospective indicators of arrival prediction accuracy.
- (Required) Provide a dashboard that gives dispatchers and system managers tools to analyze fixed-route performance.
    - Vendor to define approach and features in their submission. On-time performance tracking is the most important concern and feature request.
    - List available reports in proposal submission.
    - Support for dashboard application.
- (Desired) An option for using Apple or Android tablets for AVL tracking purposes
- (Desired) Application which informs driver of arrival and departure times from scheduled stops
- (Desired) Application that allows driver tracking
- (Desired) Application that allows the driver to manually assign their duty/route at the beginning of their shift and following extended deviations
- (Desired) Digital Pre-Trip Inspection Reports
- (Optional) Support for integration into and communication with third-party app developers for public integration. **[Maine DOT or agency name here]** seeks to integrate real-time information for all fixed route agencies in the state into Google, Transit app, GO MAINE and other free-to-use apps available on the App Store and other public app marketplaces. **[Maine DOT or agency name here]** is interested in a vendor able to perform the communication with these developers necessary to complete those real-time integrations.

Schweiger Consulting reviewed the results of the research conducted in the first Task 3 subtask to identify tools that can be used in CAD/AVL deployment. Besides the documents mentioned earlier in Section 3.1, Schweiger Consulting consulted with the following documents in addition to others to identify best practices:

- Promising Practices Guidebook: Transit Technology Adoption[32]
- On Bus Hardware, Software, Standards & Interoperability[33]
- TransitWiki.org[34]
- Technology Support for the Arizona Rural Transportation Incubator[35]
- Transit Technology Toolkit[36]
- Transit Operational Data Standard (ODS)[37]
- Greater Minnesota Public Transit Technology Plan References: Peer Agency and Industry Experts Interview Results, Transit Agency Survey Results[38]

While “Regional Transit Data Standards Report: Making the Case for GTFS” (Endnote 21) describes the use and importance of GTFS in addition to its role in CAD/AVL systems, it is crucial that Maine transit agencies recognize the development and use of another CAD/AVL-related standard, Operational Data Standard (ODS). ODS, which was developed by Cal-ITP, “is an open standard for describing how to operate scheduled transit operations which can be used to port scheduled operations between software products (e.g. scheduling systems and CAD/AVL systems), agencies, and more. ODS leverages the existing General Transit Feed Specification (GTFS) and extends it to

include information about personnel and non-revenue service." Currently, the CAD/AVL and scheduling system vendors that are using it include Swiftly and Equans Navineo, and The Master Scheduler, Remix by Via and Giro Hastus, respectively.

Next, in the Technology Support for the Arizona Rural Transportation Incubator (Endnote 36), a specific recommendation for small and rural transit agencies is relevant to Maine. "For agencies that are ready to start applying technology to solve their problems but [do not] have the resources to undertake the work of undergoing a systems engineering process, there are still options available using tools that [are not] specifically designed for rural transportation."[39] These tools related to vehicle tracking/AVL are two low-cost software as a service (SaaS) packages Samsara and Geotab.

Further, recommendations for considering CAD/AVL systems are documented in the Greater Minnesota Public Transit Technology Plan. Figure 4 "lists the various transit technology systems and uses size categories of less than 10 vehicles, 10 to 29 vehicles, and over 30 vehicles. The chart identifies technology systems that have long-proven value for a specific size agency, those that are likely not appropriate, and those that warrant additional questions and perhaps consideration. Due to the complexities of transit services, some agencies may not fit the size classifications when determining the best technology fit. For example, an agency with nine vehicles providing complex services may be more like the medium sized agencies in respect to technology needs."[40]

KEY: ○ = NO ● = YES ◑ = MAYBE NA = Not applicable

	FLEET SIZE					
	1 to 9 vehicles		10 to 29 vehicles		30+ vehicles	
	DR	FR	DR	FR	DR	FR
Customer-Facing Trip Planning						
Trip planning for riders	◑	◑	◑	●	◑	●
GTFS	NA	●	NA	●	NA	●
GTFS-Realtime	NA	◑	NA	◑	NA	●
GTFS-Flex	◑	NA	●	NA	●	NA
In-Vehicle Technology						
Automated voice announcements	NA	◑	NA	◑	NA	●
Cameras	◑	◑	●	●	●	●
Automatic vehicle location or GPS	◑	◑	●	●	●	●
Automated passenger counters	NA	○	NA	◑	NA	◑
Collision avoidance systems	◑	◑	◑	◑	◑	◑
Mobile data terminal/computer	◑	◑	●	◑	●	●

Figure 4. Excerpt of Baseline Technology Reference Chart[41]

Finally, in the Minnesota Plan "Another resource to assist transit agencies in designing effective technology systems is the transit technology flowchart. These flowcharts, also known as transit stacks, illustrate the technology tools and processes used by transit agencies. These diagrams show the relationship of different transit technologies to each other and show the dependencies between them, illustrating what can be free-standing (such as on-vehicle cameras) and what may require foundational technologies to be in place. For example, Automatic Vehicle Location (AVL) is needed for several technologies. These dependencies can assist in identifying where it will be useful to integrate two or more systems." (Endnote 28, page 43)

The flowcharts for small and medium size transit agencies are shown in Appendix D.

Appendix A – Interview Summaries

Interview with Laurie Linscott, Bus Superintendent, Community Connector, Bangor, Maine

Community Connector (CC) in Bangor is just beginning the implementation of a CAD/AVL system as of January 2024. It has taken quite a while to get to this point in that CC started considering this technology since 2017. The reasons for the delay are mostly because CC's staff is significantly resource constrained. As a result of technical assistance provided by the National Center for Applied Transit Technology (N-CATT), CAD/AVL specifications were developed for CC at the end of 2021 and an initial Request for Proposal (RFP), RFP No. P22-37, was issued by the City of Bangor on May 18, 2022. There were two responses to this RFP.

After this, CC decided to revisit the specifications and re-issue the RFP. Modifications were made to the specifications and the RFP, RFP No. P23-07, was re-issued on September 22, 2022. Two responses were received. Passio Technologies was awarded the contract and is in the process of implementing CC's CAD/AVL system. Grant funds were used for the CC CAD/AVL implementation, which will include automated voice announcements (AVA), automatic passenger counters (APCs) and a white label app that will be tailored to CC. Eventually, real-time information will be provided via the app and on signage at the new Transit Center, both at the bus bays and outside the Center. Further, CC is hoping that Downeast Transportation fare payment and the University of Maine's student IDs can be used on CC vehicles.

In terms of lessons learned, CC indicated that it was helpful to have technical assistance from N-CATT as this served as having a consultant on-board to help. Further, CC hired a transit technician to be in charge of the CAD/AVL project.

However, upon feedback after the RFPs were issued, it was felt that the CAD/AVL specifications were too long and too specific. CC felt that this limited the number of responses to both RFPs primarily because vendors could not meet the system and RFP requirements.

CC conferred with other Maine transit providers, specifically Biddeford Saco Old Orchard Beach (BSOOB) Transit and Greater Portland Metro. CC felt that the system specifications should have been less detailed – this would have resulted in more RFP responses. CC felt that would have been more advantageous for CC in terms of the CAD/AVL implementation. Specifically, CC felt that the use of the Compliance Matrix, which identified the CAD/AVL system requirements, should have been optional[5].

Another lesson from the procurement is that the evaluation of the proposals had to be postponed because the new Transit Center opened and CC's Superintendent was single-handedly running the new facility as well as the procurement. Again, there was a lack of staff to assist with the technology procurement. It took six months for CC to hire someone into the technician position, and it took time for this new staff person to become familiar with the CAD/AVL project and assist in evaluating the proposals.

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5 Proposers were required to indicate their compliance, non-compliance or compliance with modification with each requirement listed in the Compliance Matrix.

Another lesson was that if Maine DOT had staff who could have provided technical assistance, they could have shared their existing expertise and experience to help with the procurement and implementation. Further, they could share their experience with the CC CAD/AVL deployment with other transit agencies in Maine. Maine DOT having the right skills and resources to help CC would have been valuable.

Another lesson from CC was that with a small transit agency, it may be necessary to hire just one firm to provide multiple technologies rather than procuring the technologies separately. This is analogous to having a general contractor for home repairs, rather than individually hiring a plumber, electrician and woodworker separately and having to manage all of them separately.

Another lesson is that some CC staff are not computer-savvy, so training on the new technology system will be significant. Further, because of the small staff at CC, the staff who need to be trained cannot be trained all at the same time – the training needs to be staggered to coordinate with the timing of operational shifts. Finally, buy-in from staff on the technology is critical to a successful deployment.

CC feels that the State will have to provide funding if they want transit agencies to adopt new technologies. The funding commitment from the State level is critical for on-going technology adoption.

Another lesson is that technology does not mean that an agency can reduce or maintain the number of staff – it typically requires an increase in staff (e.g., statistician, software analyst, data scientist). This ties back to the need for support and funding from the State level.

Finally, CC feels that it may take a while before the benefits of the technology are measurable, especially since there are other activities that CC is conducting (e.g., moving from flag to fixed stops, union contract negotiations, operator bidding/rostering process, schedule changes).

CC would like to eventually implement an automated payment system, but will need to consider this after the CAD/AVL implementation. CC's hope is that Maine DOT will determine that a statewide automated fare payment system such as DiriGO is appropriate and will be supported throughout the state.

Interview with Chad Heid, Executive Director, Biddeford Saco Old Orchard Beach (BSOOB) Transit

Biddeford Saco Old Orchard Beach (BSOOB) Transit has deployed both Swiftly CAD/AVL and UMO (Cubic) DiriGO. As of the end of 2023, BSOOB deployed their real-time feed to Google Transit and a new real-time map on their website using the new CAD/AVL feed, began reporting in-time performance to their Board and the public. Further, they are live on the Transit app as well. It took nearly two years to source the funds, and procure and implement the CAD/AVL system. The procurement yielded a number of competitive and high quality proposers.

Swiftly was selected for a few reasons: cost and the ability for BSOOB to leverage open technology, particularly if Swiftly ceases to exist several years down the road. Swiftly's CAD/AVL system is more of a software as a service (SaaS) with several features similar to other CAD/AVL vendors.

BSOOB went from using a very simple fleet tracking tool, Unite GPS, which has a very small footprint in the transit space to Swiftly. Unite GPS did not have enough data on the backend, and it is based on JavaScript Object Notation (JSON) protocols as opposed to the General Transit Feed Specification (GTFS) which is a widely-accepted standard in the transit industry.

BSOOB considers itself a more mature CAD/AVL user as compared to other transit agencies in Maine, with the exception of Greater Portland Metro and South Portland. They both have Clever Devices, but that system has been sunset. South Portland may have done a one-year extension for the Clever Devices hardware as of the end of 2023. BSOOB allowed South Portland to join their CAD/AVL procurement, if they wanted to do that. It was BSOOB's understanding that if South Portland adopted Swiftly, it would be for the basic system without automated voice announcements (AVA), on-board real-time signs and APCs. Also, it was BSOOB's understanding that South Portland would take advantage of the existing Cradlepoint routers to use Swiftly.

Regionally, the Southern Maine transit tracker was deployed when Clever Devices was implemented by South Portland, Greater Portland Metro and Casco Bay Lines. This allowed them to have one regional map showing all services in real-time as well as allowing some text-based real-time information at the stop level. Because of the Clever Devices systems being sunset, BSOOB has an interest in regional unification based on the Swiftly system or at least CAD/AVL standards, but the various transit agencies all have different timelines and priorities when a new CAD/AVL procurement and implementation can be funded and conducted.

One critical point made by the Executive Director is that leveraging technology for good decision-making is a very important focus in a transit agency.

The automated fare payment system was deployed at BSOOB before the current Executive Director started working there. The DiriGo system has been in place almost four years now, although it was not really "turned on" until October 2020. BSOOB is exploring the regional DiriGo system so that Greater Portland Metro, South Portland and BSOOB can have direct credit or debit transactions using a regular debit or credit card to pay the fare. Cubic, the owner of UMO has told BSOOB that this feature is in development, but as of the end of 2023, BSOOB still does not have a specific and firm timeline for when that feature will be available. However, Cubic has provided BSOOB with a price per unit of around $3500 per reader. Further, BSOOB was told by Cubic that the necessary

hardware might be available in April, with a go-live date in June. Prior to go-live, BSOOB would have to modify its fare policy. That has created challenges for BSOOB, especially when their experience with the Swiftly application programming interface (API) pushing real time information, including vehicle and route assignment, took a very short period of time. BSOOB understood that Swiftly and Cubic indicated that they had some examples where they already have integrated with each other. On the Cubic side, BSOOB was told by an engineering team that said that they were already digesting the APIs, but they would prefer that it just be a link to the real-time feed, not an API based feed. This conversation should have happened when the possibility of having the Swiftly API be digested by UMO, but it happened much later.

For BSOOB, this integration among technologies was one of the last touch points for the operations team because every morning when the Unite product was being used, operations staff manually had to go in and assign a vehicle to a route and then manually had to go into DiriGo and assign the vehicle to a route so that the correct fare policy would be used. Now BSOOB operators are doing a single signin on the vehicle for all of the technology, but they still have to manually assign the vehicles to a route because the integration is not done yet. In the off-season when the pullout is only six vehicles at peak time, this is not a significant issue. But during the high season, this becomes a much bigger issue. If this manual effort is not done, it is necessary to do post-processing to make sure that the three agencies' revenue distribution is accurate.

For other agencies in Maine, BSOOB has some lessons learned. One is based on the CAD/AVL procurement that the Community Connector (CC) in Bangor went through. First, BSOOB feels that a broad approach to a request for proposals (RFP) is needed to obtain the maximum number of proposers who can provide a turnkey or SaaS solution. For example, BSOOB received six proposals as a result of their CAD/AVL RFP and CC received two proposals. Further, agencies need to understand what the technology landscape looks like. In Maine, there may not be enough folks who have that perspective or awareness. Also, there is some apprehension around technology in Maine. This may be due to either a lack of skills within this segment of the market or an awareness that it is going to be an additional burden in the day to day management. Further, there may not be an alignment about the investment in handling that burden.

Prior to the procurement phase, BSOOB feels that there is no well-programmed and well-ordered funding to onboard new technology. BSOOB's experience is that it was a challenge to obtain funding for the technology – they were able to leverage some CARES Act funds in addition to other funding to ensure that we had enough for the deployment. While in the bigger cities, they may have funds from at least a 5307 program which can be considered for allocating to that capital project. But rural providers typically do not have the budget strength to consider a strong technology component.

BSOOB feels that low-budget technology options should be considered because they can be better than having nothing. For example, the Unite GPS product has weaknesses but it was better than BSOOB having nothing. Sometimes that low-budget alternative is a good first step. Anything that shows an investment in technology and the customer experience and understanding is valuable. But that requires the technical capability to write a broad and attractive RFP for those firms that can satisfy the requirements. More importantly, BSOOB feels that there needs to be either an incentive program for adopting new technology or just outright mandating it. It would be particularly useful if

Maine DOT could provide funding if technology is being encouraged whether it is across the whole state or for individual agencies.

In Maine, it would be helpful for all passengers to know if their trip is on time given the varying levels of transit service throughout the state. If Maine DOT considers this customer-facing approach, it may give transit agencies throughout the state an opportunity to consider technology. Further, in considering having technology be an integral part of a transit operation, having an information technology (IT) technician on staff is critical. Without IT staff, it becomes very difficult for a small transit agency to move forward with technology deployment. Also, this shows an investment in the workforce to leverage technology in transit operations.

BSOOB feels that holding vendors accountable when things are not going well is another lesson learned. For example, cabling was done incorrectly to mount tablets in the vehicles. This problem may not have been found if BSOOB did not have an IT technician. Another example is when Cubic told BSOOB that they would be doing the in-vehicle installations but did not end up doing them.

Another lesson learned from BSOOB is that in a region where there is not a lot of experience onboarding technology or with technology firms, transit agencies should somewhat push back and be skeptical. The bottom line is that there have to be project management and oversight tasks so that there is vendor oversight throughout a technology deployment.

There are many benefits from the customer side. BSOOB feels that being able to display customer information is a game-changer. For example, BSOOB invested in bus stop signs that reduce anxiety and encourage people to use transit more. Prior to this there were no signs at bus stops, but now having the bus being tracked in real-time and being able to communicate that to passengers has led to increasing ridership. On the backend or operations side, BSOOB was not reporting on-time performance (OTP). At that time, BSOOB was only conducting audited trip checks, so they did not know how they were performing against the timetables. Now they are able to use information to validate making service adjustments. Having all of the data available to an agency prepares the agency to defend and advocate for service changes. Given that transit operates in a resource-constrained environment, they now have the rationale for making a decision about modifying service.

Another benefit of the technology can be equity. For example, DiriGo allows riders to take advantage of fare-capping. (Cash users [typically unbanked] do not have access to fare-capping.) However, given that 60% of riders were using cash, DiriGo needed the capability for passengers to go to Walgreens, for example, to add cash to their farecards. But that has not happened yet. Fortunately, BSOOB's commuter service had a larger adoption rate for the new fare system.

Another benefit is that technology has provided onboard voice announcements and corresponding onboard digital signs – riders are very positive about this system along with real-time departure boards at key locations. BSOOB is considering the deployment of e-paper digital signs. This enhances people's awareness of transit and adds value to non-users as well.

Interview with Donna Tippett, former Director, City of South Portland Bus Service

The City of South Portland Bus Service deployed the Clever Devices CAD/AVL system. Prior to that, they had Nextel mobile phones using the Bridgewater State College AVL system - it was basically a flip-phone on the bus that was tracking the bus' location - a very rudimentary AVL system. The Clever Devices system has an on-board vehicle logic called Intelligent Vehicle Network (IVN) which is a hardware unit that controls the complete Clever Devices ITS technology package on the vehicle, and the BusTime® application, which provides real-time information for passengers on the web, mobile devices and digital signage.

Clever Devices created a custom application for South Portland, Greater Portland Metro and Casco Bay Lines that displayed all of these agencies' real-time information on one map. This map was popular with customers. However, the downside was it that it took about five years for the full deployment of the CAD/AVL system. The system went live in 2016. But where South Portland differed from, Greater Portland Metro, and where Metro and South Portland were different from Casco Bay Lines, was in fleet size. The fleet size was so small at South Portland that the Clever Devices implementation did not include integrating with destination signs, an emergency/panic button, and the wheelchair ramp. This integration was creating small glitches in the system. For example, a bus would have to be taken out of service because the system showed that the wheelchair ramp does not work when it actually was working. The minor benefits of accounting for that integration in the system and utilizing those data points were not worth it. Further, the lack of destination sign integration was not worth addressing the glitches. These minor integrations could potentially malfunction and then the bus had to be taken out of service. When you only have seven buses, the system could not afford to have any buses out of service. It was not enough of a benefit to the agency or the drivers to have these integrations.

South Portland was able to log drivers in and out remotely from the back end of the Clever Devices system, and could use the playback feature. And what else did we use? South Portland did not end up using the reports because they always seemed to have some kind of problem that created erroneous information. South Portland expected to get useful data out of the system, but it did not produce that - it did not prove to be that useful. But South Portland did use the CAD system daily to see where the buses were and if they were off-route. Further, South Portland used the BusTime® supervisor for their dispatchers because there were not multiple workstations set up. All the dispatchers really needed was to know where the buses were – they did not need to be able to do playbacks and on-time performance. South Portland felt that it was very likely underutilized compared to what the system could do. So the Clever Devices system had many features that South Portland never used. However, the one feature that South Portland did like was the real-time map that the public could use.

So one of South Portland's lessons learned was that because they were so small, they procured a system that they really did not need - it was bigger than what they needed.

In terms of DiriGo, it took a while to deploy it in South Portland. There have been issues from the beginning of the implementation. South Portland feels that the biggest drawback to the DiriGo system is that on the back end, for billing or revenue sharing purposes, it is complicated to determine which agency gets how much revenue. This stems from having one shared system across multiple agencies that collects revenue into one bank account, requiring the manual

development of spreadsheets to determine the actual revenue sharing. This is a very cumbersome process. It takes the AVL system login to determine where the money was collected and which route which agency is operating. So if the AVL system was down and South Portland ended up with a number of defaults, it is extremely difficult to determine how the revenue is split up among the agencies. Thus, South Portland feels that the DiriGo system is not user friendly. The system was not built to do revenue sharing. A regional fare collection system being used by multiple transit agencies must have the capability to perform revenue sharing without significant manual effort. It takes a considerable amount of time to determine the accuracy of this manually-determined revenue sharing, and to trust that the agencies are getting the right amount of money. However, South Portland recognizes that revenue sharing has always been the hardest thing for an automated fare collection system to do based on experiences in San Francisco and Seattle. San Francisco has 25 transit agencies utilizing the same fare collection system.

Another lesson learned is that often, technology companies will develop a product specifically for smaller agencies, but it will take just as much time to implement that specialized product. This is true with the UMO product in that it was originally a Delerrok product and then bought by Cubic. The same is true with Trapeze paratransit scheduling and dispatching software – they re-branded a scheduling product for smaller agencies called TripSpark. The technology has to work whether it is for a huge region or just one small agency. Cubic's strong suit is with some of the largest transit systems in the world, such as Transport for London and the Metropolitan Transportation Authority in New York City. In addition to San Francisco and Seattle. The solutions for smaller agencies still have to have some of the same functionality as for the larger agencies, such as the revenue sharing.

Another issue with DiriGo is that the readers that were deployed in 2019-2020 were being phased out, so South Portland was forced to buy new readers. The readers are not very durable and there was no maintenance on them – they had to be removed and replaced if there was a fault. South Portland did purchase spares but they had to be used in new buses. The new readers were offered at $1,250 per reader, which was a reasonable price. Further, the new readers were supposed to be able to work with Apple Pay and Google Pay. That will be an improvement but that does not change the fact that revenue still needs to be distributed among the agencies – it will continue to be cumbersome.

South Portland feels that it will be challenging to accomplish a statewide deployment of an automated fare system if it does not include revenue sharing functionality.

Also, South Portland feels that technology is changing so quickly that agencies needs to plan more for the technology. But they feel that an agency can get paralyzed by planning too much, and by the time a technology is deployed, it has changed so much that it has limited support from the vendor. For example, in South Portland, the Clever Devices system was hosted locally. But in 2024, it can only be hosted on the cloud. So Greater Portland had to invest in moving their system to the cloud. South Portland decided to stop investing in the Clever Devices system at the end of five years because the IVNs were at the end of life. South Portland decided to transition to Swiftly, which was deployed in three months vs. the five years it took to deploy Clever Devices. South Portland's buses are being tracked by Swiftly using Cradlepoint routers (which were procured to access cellular data when 3G was phased out).

South Portland is using Remix (a Via product) to create schedules (they used Sched21 previously). There has been an issue in Swiftly with routes 24A and 24B. They are separate routes and operate on different blocks, but are being combined in Swiftly and the Transit app. South Portland was working on resolving this issue as of February 2024.

South Portland received grant funding for new dynamic message signs. The display at the transit hub was turned off as of February 2024. Further, when South Portland received three new buses, the cost to equip them with Clever Devices IVNs and BusTime® was too high so those buses are not being tracked.

South Portland feels that DiriGo could work as a brand but it needs a different platform. It is important that Apple Pay and Google Pay will work, but the revenue sharing issue will be the biggest problem to solve. However, Cubic has limited abilities to change anything on the backend.

South Portland feels that being in touch with the riders is very important especially when technology is being considered. For example, there was an impact to riders when the 10-ride pass was going to be discontinued. This was going to significantly impact lower-income riders. Discontinuing this paper pass would require that every rider would have to have a smartphone app or smartcard. No passback would be allowed. So now you can use one app to pay for the whole family's trip. This type of issue could be faced with a statewide deployment of automated fare collection.

Interview with Thomas Reinauer, Director of Transportation, York County Community Action Corp, Sanford, Maine

YCCAC ridership is back to around 70% to 75% of pre COVID ridership as of January 2024.

YCCAC is still using Easy Rides (now from GMV) and getting adequate support. However, this software will not be updated. So YCCAC is looking at deploying QRyde from HBSS or CTS TripMaster. YCCAC's agreement with GMV expires in February 2024, but they may extend their agreement for a year for the following reason.

YCCAC teamed up with Penquis to bid on Region Eight for brokerage service. As of January 2024, YCCAC was in the appeals process, because DHHS awarded all regions to Modivcare. As of the end of January, YCCAC was in this limbo because if the Penquis team was successful appealing, YCCAC would get QRyde because that is what Penquis uses. But if YCCAC loses the appeal, they may obtain CTS TripMaster primarily because TripMaster has a real-time interface with the Modivcare Portal. CTS TripMaster has done a lot of work with Modivcare on their software. So as of January 2024, that is an issue for YCCAC scheduling staff because they have to physically go into the portal to see if there are any changes because they do not receive any notifications in real time. So if Modivcare is operating for another 10 years, then YCCAC will use CTS TripMaster so that they can at least strengthen that real-time connection with the with the Modivcare trips and make it a lot easier for YCCAC.

If YCCAC ends up procuring CTS TripMaster, and fare payment comes back, it is possible that they would include TripMaster's fare payment module rather than procuring a separate fare payment system. Although YCCAC is not opposed to another fare payment platform, such as the one being used by Western Transportation Services (WTS)[6]. This particular system is attractive to YCCAC because it does not require much in the way of administration. YCCAC is still assessing what fare payment system would work best for them, and would like to have it in-place when YCCAC begins to charge fares again. They do not plan to completely eliminate cash fares, but would like to limit the use of cash as much as possible. Further, they would like to reduce the number of fare types (e.g., charge one fare for everything, one monthly pass fare).

YCCAC is not considering purchasing a separate CAD/AVL system as either QRyde or CTS TripMaster have an AVL component.

YCCAC has gone through the process of creating a GTFS feed using RTAP's GTFS Builder, but are now using Remix's automatic GTFS builder to create the feed. As of January 2024, there were two outstanding issues with YCCAC's GTFS feed that were being addressed.

YCCAC feels that it was very helpful to look at technology planning, procurement and deployment at other transit agencies when planning their own technology. For example, they share information on pricing and features of software with three or four other Community Action Program (CAP) agencies. All of these agencies discuss what they like about the software, what they do not like and how the software could be setup.

[6] WTS is using Token Transit.

YCCAC procured their camera system along with KVCAP, Waldo County CAP, Penquis, Aroostook Regional Transportation System and Downeast Transportation. They all conducted a collective interview with three camera system companies. This does not mean that they all made the same decision, but this collective process allows them to compare notes and obtain feedback from agencies that they are quite familiar with. Also, using this collaborative process makes it easier to document the reason(s) why a particular firm's product was selected and use the documentation for funding requests.

From YCCAC's perspective, it would be helpful to have a technical assistance person on-call at Maine DOT who can assist the agencies throughout Maine. YCCAC could have used such assistance during their camera procurement. Technology planning, procurement and deployment can be daunting, especially for small agencies, so this type of assistance would be ideal, especially when it takes some time to get support from vendors.

YCCAC feels that they are doing a disservice to their customers if they do not migrate toward using technologies. For example, if they begin using a trip request app on a smartphone (which YCCAC would like to do eventually), they expect a saturation rate of 60%, but that means that 40% still want to call on the phone to make a reservation. Those who can use the technology will, but YCCAC has to account for those who cannot. Another example is YCCAC staff setting up geo-fences for their routes within a quarter-mile – while this was a small step, setting up the geo-fencing means that the route will be displayed in the Go Maine platform.

YCCAC says this is the same thing with using an AVL system – it will allow customers to see where their bus is located via a "where's-my-bus" app. YCCAC receives a lot of calls from customers asking where their bus is – on average, there are 20 to 30 calls per day asking where their bus is. This is a lot of time that could be well-spent on other activities. Customers would be appreciative of knowing where their bus is located in real-time. With Google Transit, it will show up in that app as well.

YCCAC is in the process of trying to eliminate their 48-hour advance notice policy for reserving rides. This has been challenging for staff since that constraint has existed for many years. YCCAC developed a strategic plan, including vision and goals - input from staff including drivers was obtained. This development forced YCCAC to take a hard look at their policies and procedures to see if they meet customer needs.

Further, YCCAC has been exposing staff to both QRyde and CTS TripMaster meetings so that they can become familiar with these scheduling systems. An example of this was finding out that CTS TripMaster has the capability to provide text trip reminders – this would help greatly with trip cancellations and no-shows.

Finally, YCCAC thinks that having Maine DOT involved in some meetings with vendors could be helpful to show that other agencies in Maine may be interested in deploying that system (e.g., UMO/DiriGo). (Unfortunately, even though Maine DOT was involved in meeting with Cubic, Cubic was not prepared to deal with any other type of service than a fixed-route system. A provider like YCCAC could not go with that platform since most of their services are not fixed routes.)

Appendix B – Technology Questionnaire

Request for Technology Information

The purpose of this questionnaire is to collect and review information about technologies that you are using to support operations, customer service and other vital functions. While the focus of the project is on fare collection and computer-aided dispatch (CAD)/automatic vehicle location (AVL), it is helpful for us to understand all of the technologies your agency is using. It would be most appreciated if you can complete this questionnaire by close of business on Monday, May 1, 2023. If you have any questions, please feel free to email me at carol@tech4transit.com or call me at 781-424-2208. Thank you very much for your help!

* Indicates required question

1. Email *

Additional Agency Information

In this section, we are collecting a few additional pieces of information about your agency.

2. How many vehicles does your agency operate? *

Check all that apply.

- [ ] 1 - 9 paratransit vehicles
- [ ] 10 - 29 paratransit vehicles
- [ ] 30+ paratransit vehicles
- [ ] 1 - 9 fixed route vehicles
- [ ] 10 - 29 fixed route vehicles
- [ ] 30+ fixed route vehicles

3. Does your agency have its own Information Technology (IT) staff? *

Mark only one oval.

- Yes *Skip to question 6*
- No
- I don't know *Skip to question 6*

Untitled Section

4. If your agency does not have its own IT staff, do you have an outside contractor provide IT services? *

Mark only one oval.

- Yes
- No *Skip to question 6*
- I don't know *Skip to question 6*

Untitled Section

5. If you use an outside IT contractor, have they helped your agency implement transit technologies, such as automatic vehicle location (AVL) or paratransit scheduling software? *

Mark only one oval.

- Yes
- No
- I don't know

Technology to Support Agency Operations: Fleet Operations and Management

In this section of the questionnaire, we are exploring those technologies that support your day-to-day work and help to meet regulatory requirements

6. **Transit communications systems** are technologies that transfer information from one user to another via wired, wireless, radio, the internet or other means. **Communications technologies** facilitate interaction among drivers, dispatchers, emergency responders and other personnel involved in transit and transportation operations. Which of the following communications technologies is your agency currently using? *

Check all that apply.

- [ ] Conventional land mobile radio system using analog radios for voice and/or data communication
- [ ] Conventional land mobile radio system using digital radios for voice and/or data communication
- [ ] Cellular communication/Voice over Internet Protocol (VoIP) for voice and/or data communication
- [ ] Wireless local area network (WLAN) (e.g., to download data collected on-board vehicles to a central database)
- [ ] Dedicated short-range communications (DSRC) (e.g., used for transit signal priority)
- [ ] Other
- [ ] None of the above

7. Which In-Vehicle/On-board Technology does your agency have/use? *

Check all that apply.

- [ ] Automated voice announcements
- [ ] On-board message signs that display next stop or other information
- [ ] Public address system for announcements
- [ ] Cameras
- [ ] Digital video recorder(s)
- [ ] Automatic vehicle location
- [ ] Automated passenger counters
- [ ] Collision avoidance system
- [ ] Mobile data terminals/computers or tablets
- [ ] Global positioning system (GPS) receiver/antenna
- [ ] Radio system to communicate between driver and dispatch
- [ ] Other communication system (voice over internet protocol [VoIP])
- [ ] Public Wi-Fi
- [ ] Vehicle/remote component monitoring (e.g., low transmission oil message)
- [ ] Mobile gateway router/mobile access router and/or cellular data modem
- [ ] Covert alarm switch
- [ ] Vehicle area network
- [ ] Event Data Recorder (to monitor driver performance)
- [ ] Other
- [ ] None of the above

8. Which of the following fare payment technologies does your agency have/use? *

Check all that apply.

- [ ] Non-registering fareboxes (also know as a simple dropbox for cash)
- [ ] Registering fareboxes (these accept and count coins and dollar bills)
- [ ] Electronic fare reader or validator (can accept a magnetic-stripe card or smartcard)
- [ ] Account-based fare system (that uses a contactless smartcard or smartphone app)
- [ ] Reporting interface with financial software
- [ ] External fare/ticketing equipment (e.g., ticket vending machines)
- [ ] Tickets/farecards available from outside vendors (e.g., convenience stores)
- [ ] Magnetic stripe farecards
- [ ] Contact or contactless smartcard farecards
- [ ] Fare payment smartphone app
- [ ] Other
- [ ] None of the above

9. Which of these Customer-Facing Trip Planning items does your agency have/use? *

Check all that apply.

- [ ] Trip planning for travelers/riders on agency website
- [ ] Trip planning for traveler/riders on smartphone application
- [ ] General Transit Feed Specification (GTFS) data
- [ ] GTFS-realtime data
- [ ] GTFS-Flex data
- [ ] OpenStreetMap or OpenTripPlanner use
- [ ] Other
- [ ] None of the above

10. How does your agency communicate with riders and the public? *

Check all that apply.

- [ ] Website
- [ ] Facebook
- [ ] Twitter
- [ ] Instagram
- [ ] YouTube
- [ ] Business telephone system
- [ ] Interactive voice response (IVR) system to provide "callouts"
- [ ] IVR system that traveler/rider can call in to
- [ ] Dynamic or electronic message signs at bus stops or other locations
- [ ] Texts/short message service (SMS) for alerts
- [ ] Other
- [ ] None of the above

11. Which Asset Management Systems does your agency have/use? *

Check all that apply.

- [ ] Vehicle maintenance software (including generating and monitoring work orders, managing inventory, etc.)
- [ ] Facility maintenance software
- [ ] Pre- and post-trip inspection hardware or software
- [ ] On-board vehicle component monitoring (that provides alerts if a component is out of tolerance)
- [ ] Other
- [ ] None of the above

12. Which of these Scheduling/Dispatch Software and Related Management Systems does your agency currently have/use? *

Check all that apply.

- [ ] Client management and scheduling demand response/paratransit trips
- [ ] Scheduling fixed route vehicle runs
- [ ] Algorithm to optimize schedules
- [ ] Driver and vehicle scheduling and management
- [ ] Runcutting software for fixed-route transit operations
- [ ] Reporting/Business Intelligence software
- [ ] Interfaces and export/import ability
- [ ] Driver manifests on tablets or mobile data terminals (MDTs)
- [ ] Reminder "callouts" to paratransit/demand-response travelers
- [ ] Microtransit scheduling software
- [ ] Other
- [ ] None of the above

13. Which of the following Service Planning tools does your agency use or have access to? *

Check all that apply.

- [ ] Geographic information system (GIS)
- [ ] Spreadsheets for demand analysis or fixed route runs
- [ ] Fixed route planning software (e.g., Remix, Optibus, TransLoc)
- [ ] Data warehouse to facilitate service or other analysis
- [ ] Other service planning tools
- [ ] None of the above

14. Is your agency in the process of implementing any technologies? If so, which ones and when do you expect them to be implemented? *

15. Do you plan to replace any of your current technologies? If so, which ones and when do you plan to replace them? *

Tools for Travelers to Discover Your Agency's Services

In this section, we are asking about how travelers discover your services and your interest in using new tools to ensure that your agency's services can be easily discovered.

16. How do travelers currently discover the services that your agency provides? *

Check all that apply.

- [ ] “One-call/one-click” system
- [ ] Statewide directory of transit and paratransit services
- [ ] Statewide trip planning service (e.g., GO MAINE)
- [ ] Use GTFS, GTFS-realtime and/or GTFS-Flex data
- [ ] Your agency's website
- [ ] A link to your website on other websites
- [ ] Other
- [ ] None of the above

17. How would you like travelers to discover the services that your agency provides? *

Check all that apply.

- [ ] Your agency's one-call/one-click system
- [ ] A statewide one-call/one-click system
- [ ] Statewide directory of transit and paratransit services
- [ ] Statewide trip planning service (e.g., GO MAINE)
- [ ] Use GTFS, GTFS-realtime and/or GTFS-Flex data
- [ ] Your agency's website
- [ ] A link to your website on other websites
- [ ] Using Mapnificent (an open source interface for creating maps that show service accessibility)
- [ ] Using OpenStreetMap and/or OpenTripPlanner
- [ ] Other
- [ ] None of the above

Needs for Assistance and Technology

This section covers your agency's needs regarding technology assistance and technology(ies) that could help your agency.

18. Please identify how useful each item would be to your agency? *

Mark only one oval per row.

	Not at all	Moderately useful	Very useful	Not sure/not applicable
Assessing your agency's technology needs				
Assistance with technology procurement				
Understanding electronic data security options				
Understanding scheduling and management software options				
How to use technology to improve operations				
Understanding customer information system options				
How to facilitate service coordination with other Maine transit providers				

Understanding maintenance management software options				
Cross-training staff in multiple technologies				
Ways to help customers plan trips that use multiple transit providers				
Assistance with technology implementation				
Understanding alternate transit services such as microtransit				
Understanding transit technology standards (e.g., GTFS)				

19. How beneficial would each of these items be to your agency? *

Mark only one oval per row.

	Not at all	Moderately beneficial	Very beneficial	Not sure/not applicable
Improved phone system				
Improved internet access				
Rider app to schedule demand response rides either on your agency's website or on a smartphone				
Collecting data (e.g., passenger counts, non-revenue mileage)				
Improved access to data generated by existing systems (e.g., for analysis)				
Optimizing paratransit schedules				
Optimizing fixed route schedules				
Coordinating service with other Maine transit providers				
Accommodating same-day paratransit reservations/trips				
Automated reminder calls for next-day or upcoming paratransit trips				
Improved fare collection				

Rider app that displays "Where's my bus?"				
Improved paratransit scheduling software				
Cameras on vehicles				
Automated on-board stop announcements/signage				
Electronic signs at bus stops or other facilities indicating when the next two vehicles will arrive				
Statewide mobile fare payment system				

20. If you have any additional thoughts or comments on the technology support that could be provided by Maine DOT or another entity (e.g., a Maine transit technology user group), please let us know here. *

Regional Coordination

This section explores the existing and desired tools for your agency to coordinate your services with other Maine transit providers.

21. Which tools does your agency currently use to coordinate your services with other agencies? *

Check all that apply.

- [ ] Manual methods of coordination (e.g., telephone other agencies)
- [ ] Real-time messaging to coordinate trips
- [ ] Automated method of coordination
- [ ] Scheduling software that has the capability to automatically coordinate service with other agencies
- [ ] Regional fare collection/coordination
- [ ] Other
- [ ] None of the above

22. Which tools does your agency wish to use to coordinate your services with other agencies? *

Check all that apply.

- [ ] Manual methods of coordination (e.g., telephone other agencies)
- [ ] Real-time messaging to coordinate trips
- [ ] Scheduling software that has the capability to automatically coordinate service with other agencies
- [ ] Regional fare collection/coordination
- [ ] Other automated method of coordination
- [ ] Other
- [ ] None of the above

Appendix C – Results of Questionnaire

Request for Technology Information

17 responses

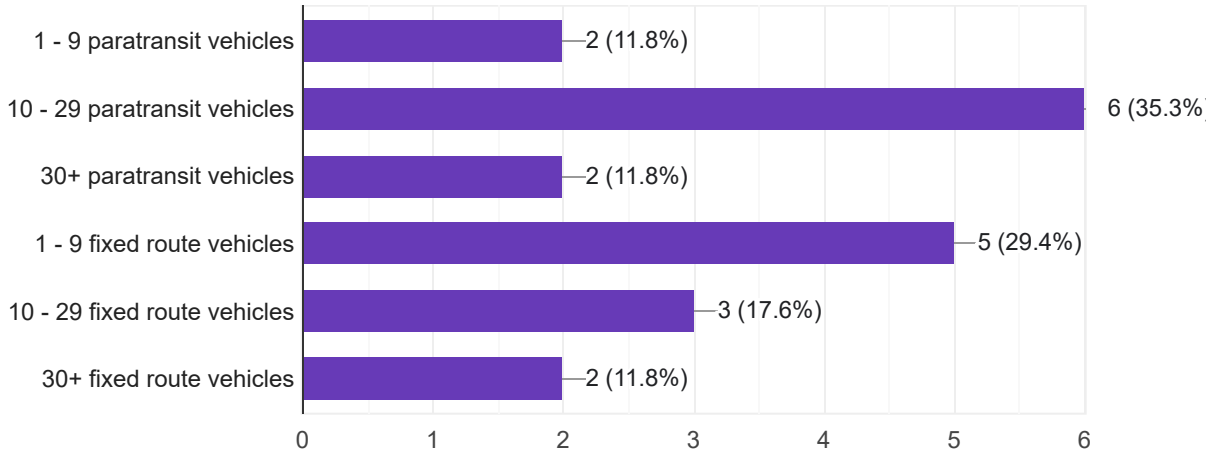
Publish analytics

Additional Agency Information

How many vehicles does your agency operate?

Copy

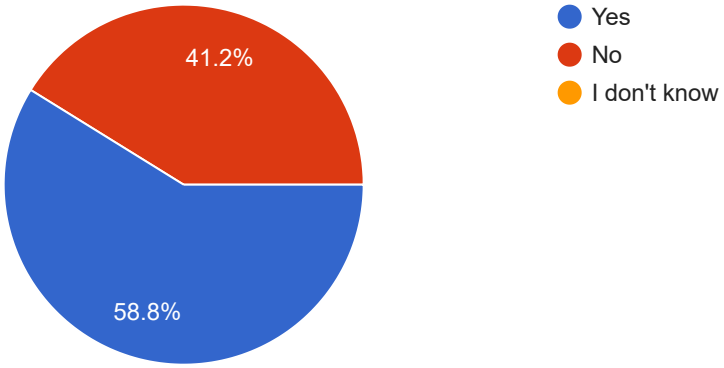
17 responses



Does your agency have its own Information Technology (IT) staff?

Copy

17 responses



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If your agency does not have its own IT staff, do you have an outside contractor provide IT services?

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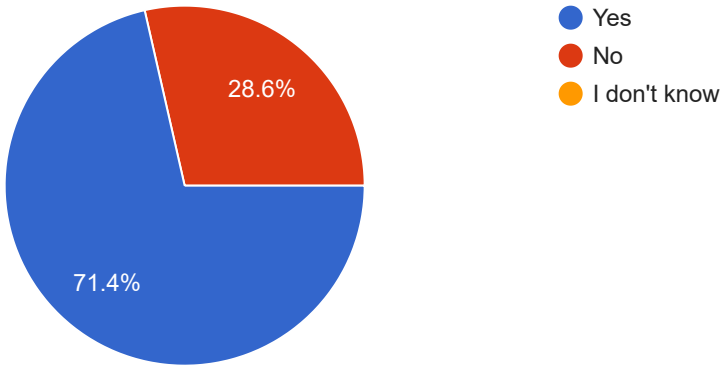
7 responses



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If you use an outside IT contractor, have they helped your agency implement transit technologies, such as automatic vehicle location (AVL) or paratransit scheduling software?

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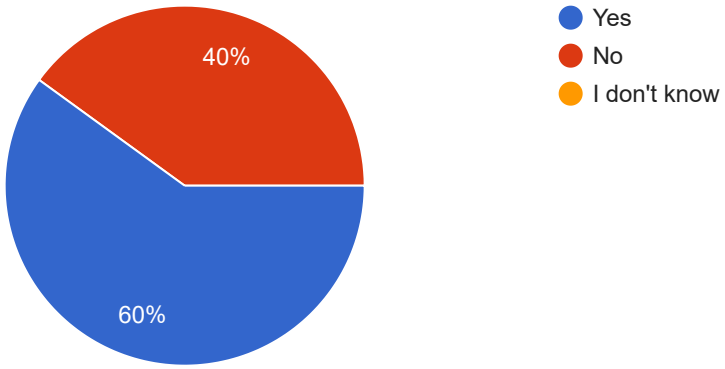
5 responses



Technology to Support Agency Operations: Fleet Operations and Management

Transit communications systems are technologies that transfer information from one user to another via wired, wireless, radio, the internet or other means. **Communications technologies** facilitate interaction among drivers, dispatchers, emergency responders and other personnel involved in transit and transportation operations. Which of the following communications technologies is your agency currently using?

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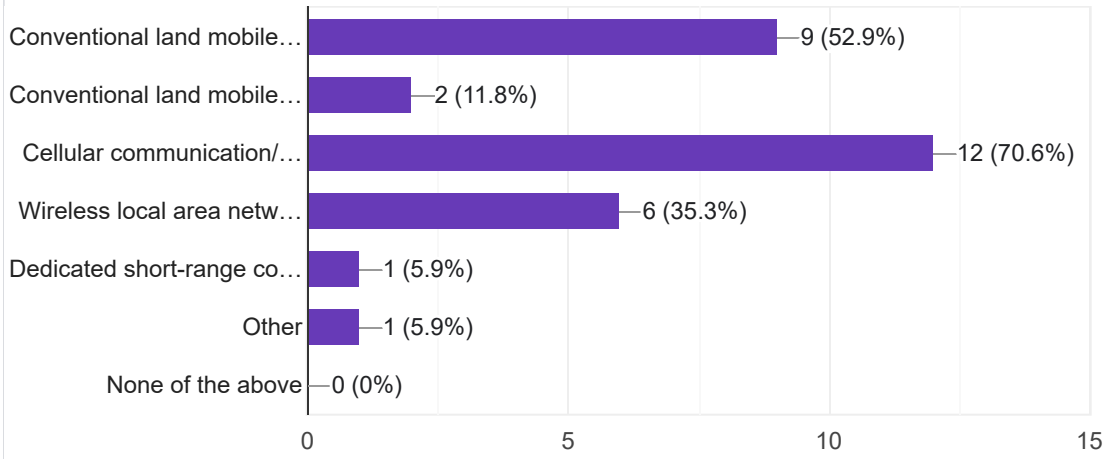
17 responses



Which In-Vehicle/On-board Technology does your agency have/use?

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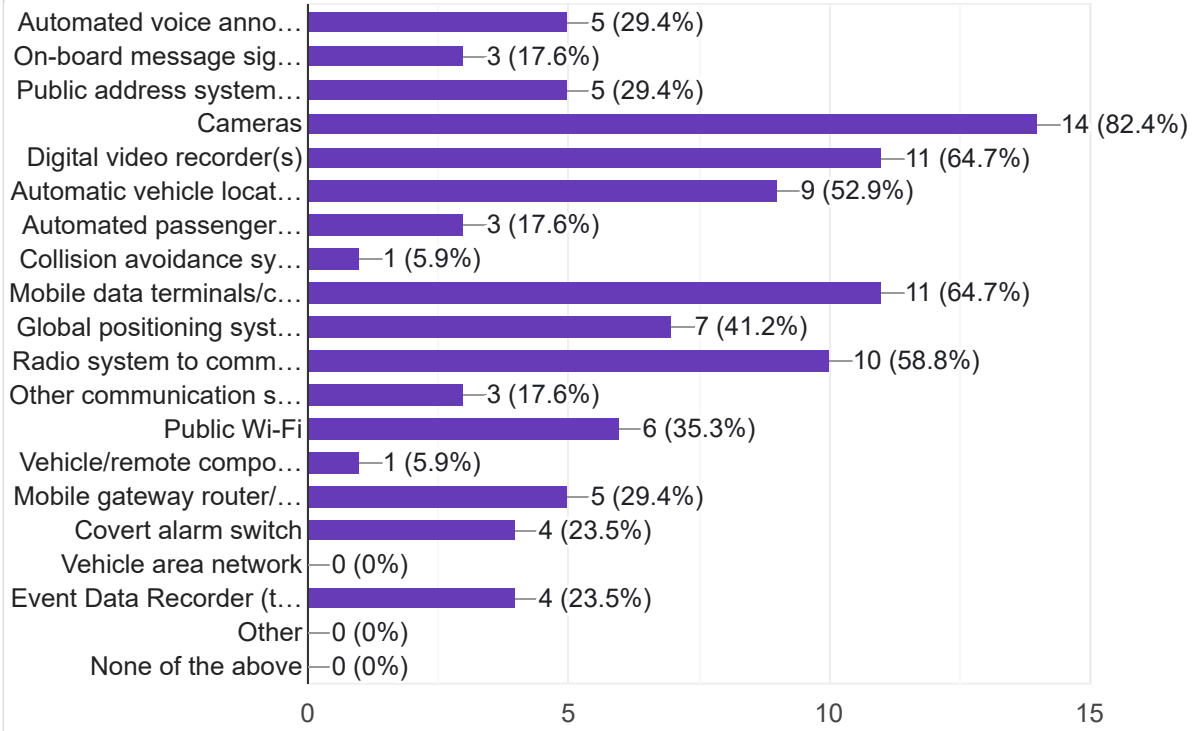
17 responses



Which of the following fare payment technologies does your agency have/use?

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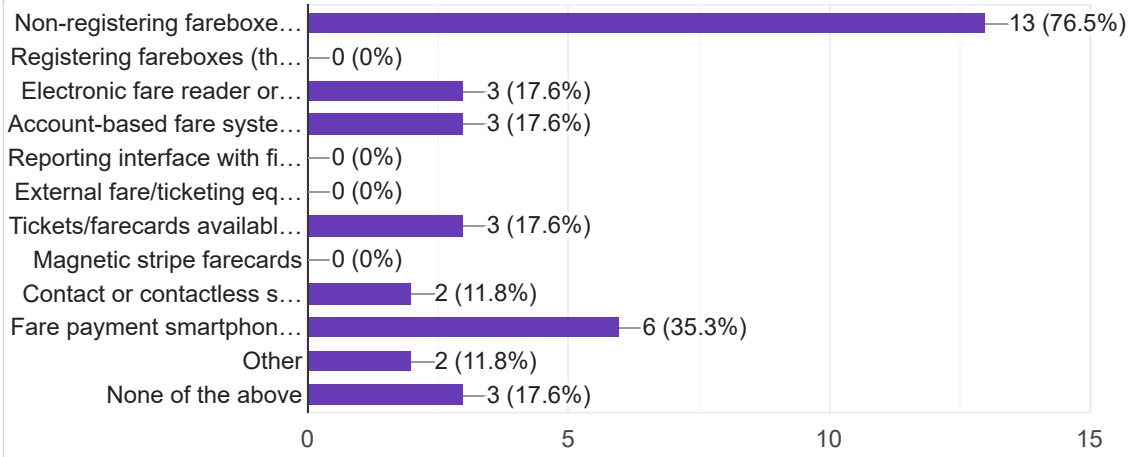
17 responses



Which of these Customer-Facing Trip Planning items does your agency have/use?

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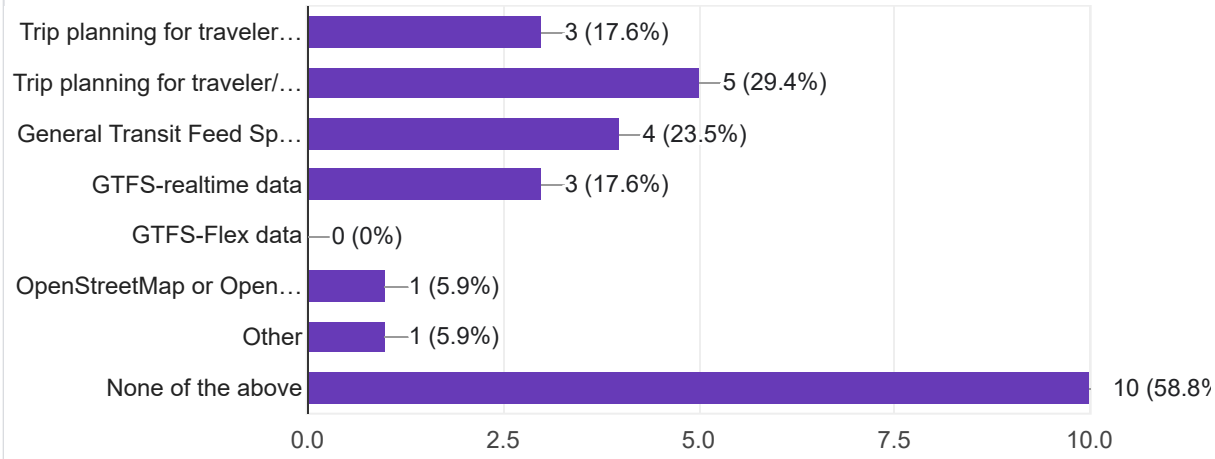
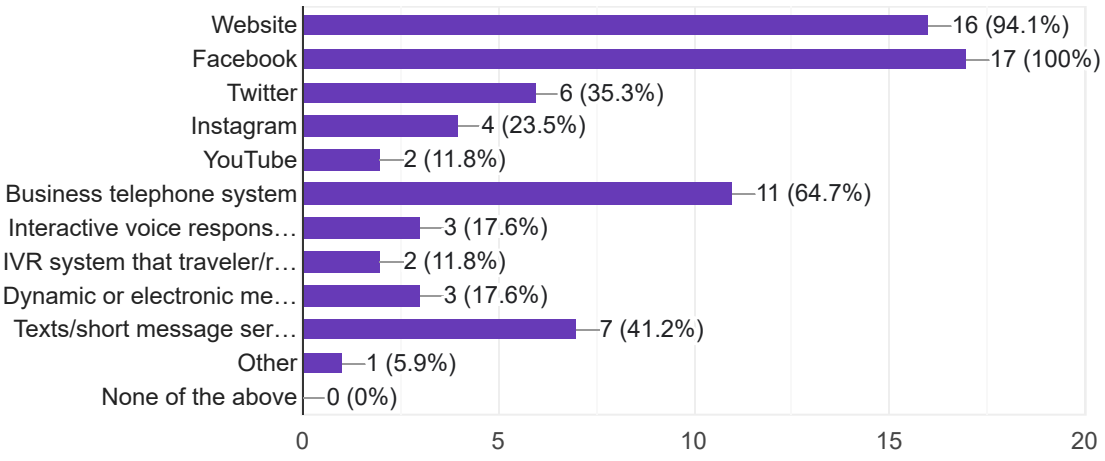
17 responses



How does your agency communicate with riders and the public?

Copy

17 responses



Which Asset Management Systems does your agency have/use?

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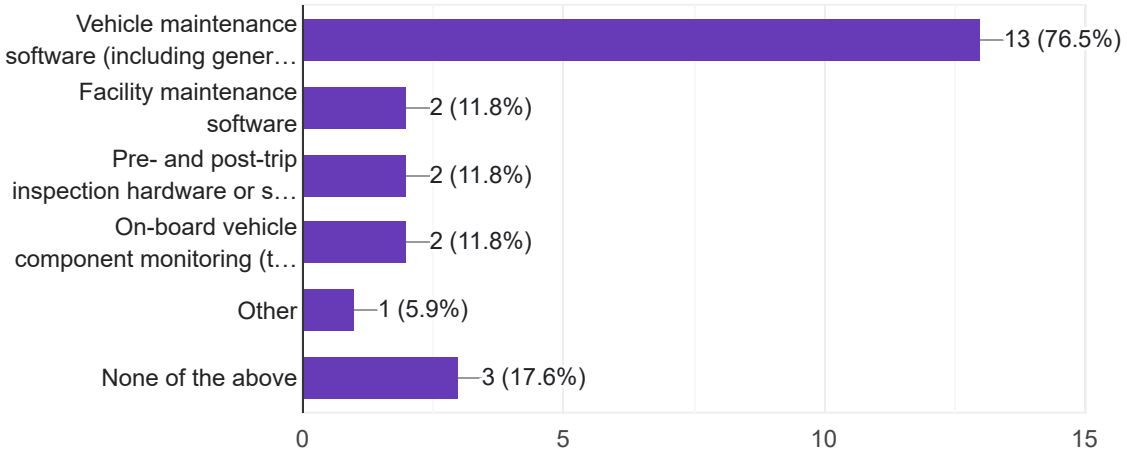
17 responses



Which of these Scheduling/Dispatch Software and Related Management Systems does your agency currently have/use?

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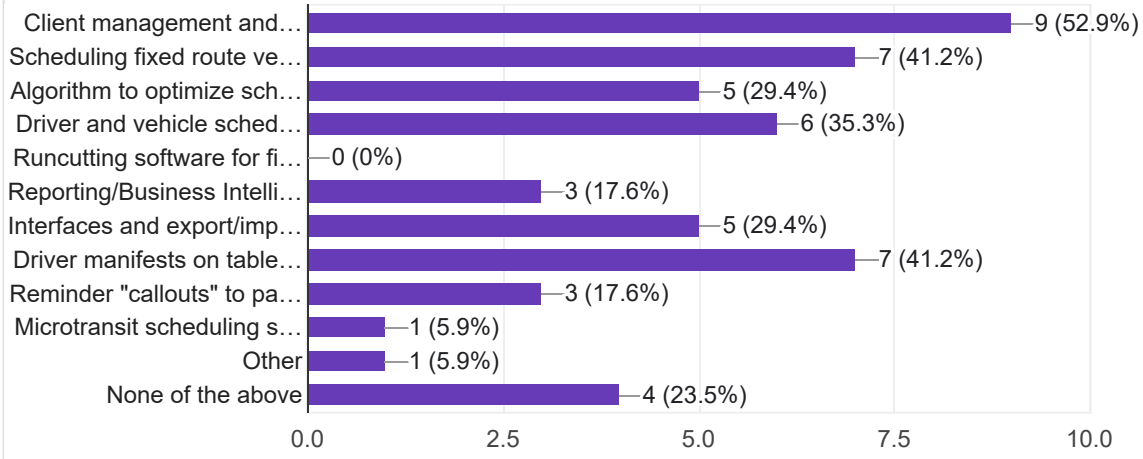
17 responses



Which of the following Service Planning tools does your agency use or have access to?

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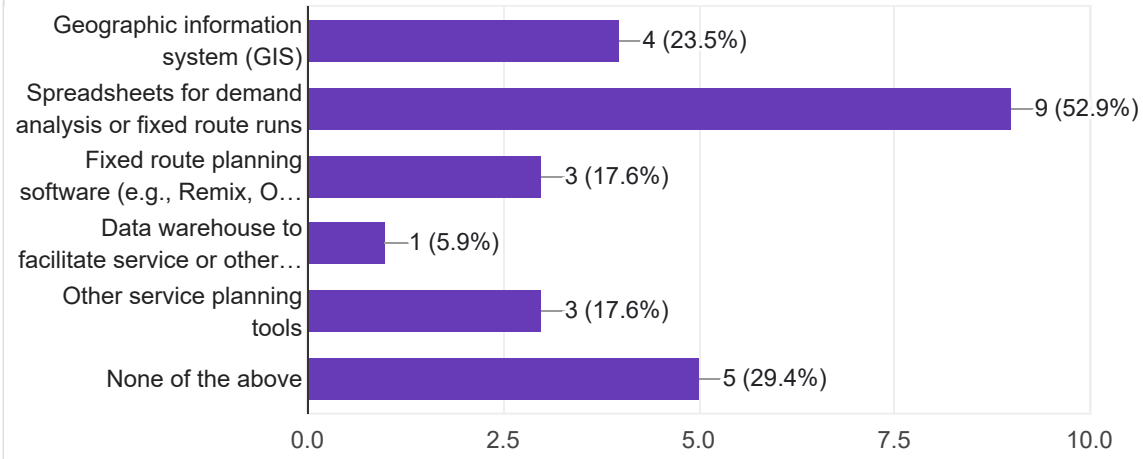
17 responses



Is your agency in the process of implementing any technologies? If so, which ones and when do you expect them to be implemented?

17 responses

yes and soon very soon

No

none

Beginning the process of changing scheduling software vendor/platform. Looking into AVL options, either on our own or through a collaborative process with other providers in the Portland MPO area.

Real-time vehicle cameras with live view, new bus tracking application, microtransit software

Exploring if our current software (HBSS) will work for the Micro Transit model we are going to unroll this year

no

Planning on replacing scheduling software and adding time-keeping software.

barcoding for fleet maintenance, looking for new dispatching and scheduling software(s), connecting maintenance, dispatching &scheduling, and payroll for increased efficiency options.

NO

AVL for marine vessels and programmable electronic signs

None at this time

Yes, We will be implementing new scheduling software soon.

Automated Fare Collection System

Most of the items I have checked as currently having are actually part of a Swiftly CAD/AVL implementation project that is underway. The full suite of components and solutions should be finalized by September 2023.

CAD/AVL, Scheduling, GTFS editor, onboard AVA, RTPI displays for Hub/major stops, Planning, Microtransit

Automated trips scheduling software integration between on demand, micro transit and deviated flex - 2023 implementation (Q3/Q4). Automated WIFI fleet video download, 2023. Fleet Asset Management software, 2023. GIS platform, 2023 Fleet Maintenance. Trip planning for traveler/riders on smartphone application, 2023/2024.
General Transit Feed Specification (GTFS) data management software, 2024. Passenger ride request automation, 2024

Do you plan to replace any of your current technologies? If so, which ones and when do you plan to replace them?

17 responses

no

We need Vehicle GPS location and maintenance data.

Scheduling software - hopefully in early 2024

Replace existing cameras in the vehicles with live view, new fare box system, new tracking application for fixed route system

Just switched from GeoTab to Fleetio. Will consider making another switch if HBSS cannot accommodate our plans

Yes, replace CAD/AVL system

We need to find better dispatching & scheduling software(s)that will support multiple modes of transit better than what we are using now.

NO

AVL

Yes, Software for facility, asset, and maintenance plans

We will soon have AVL, tablets, and software the will interact with our drivers.

Not aware of any changes at this time

See previous comment.

CAD/AVL, Scheduling

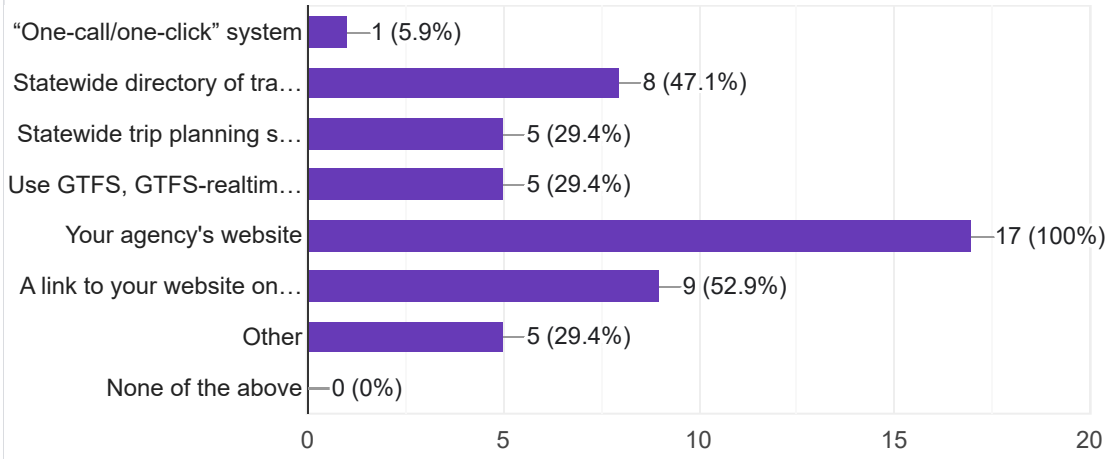
Trips scheduling software.

Tools for Travelers to Discover Your Agency's Services

How do travelers currently discover the services that your agency provides?

Copy

17 responses



How would you like travelers to discover the services that your agency provides?

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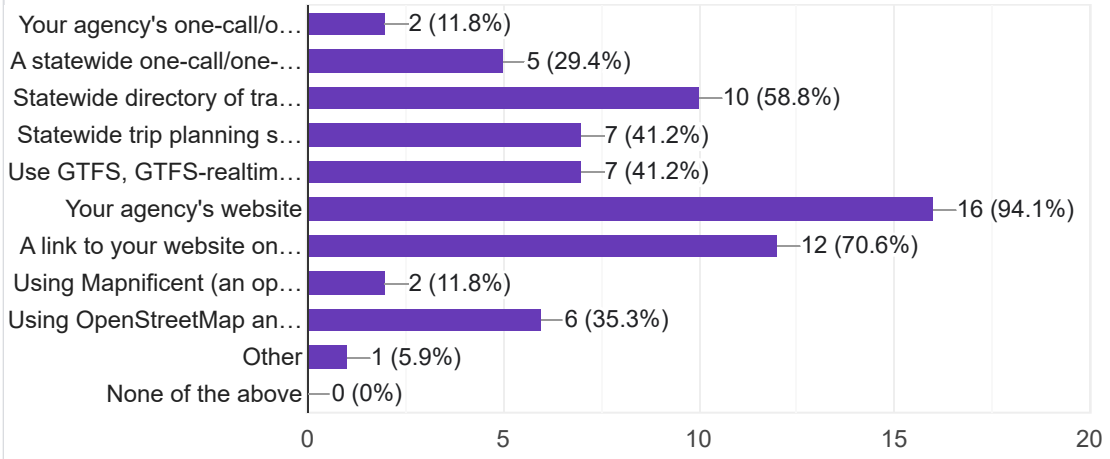
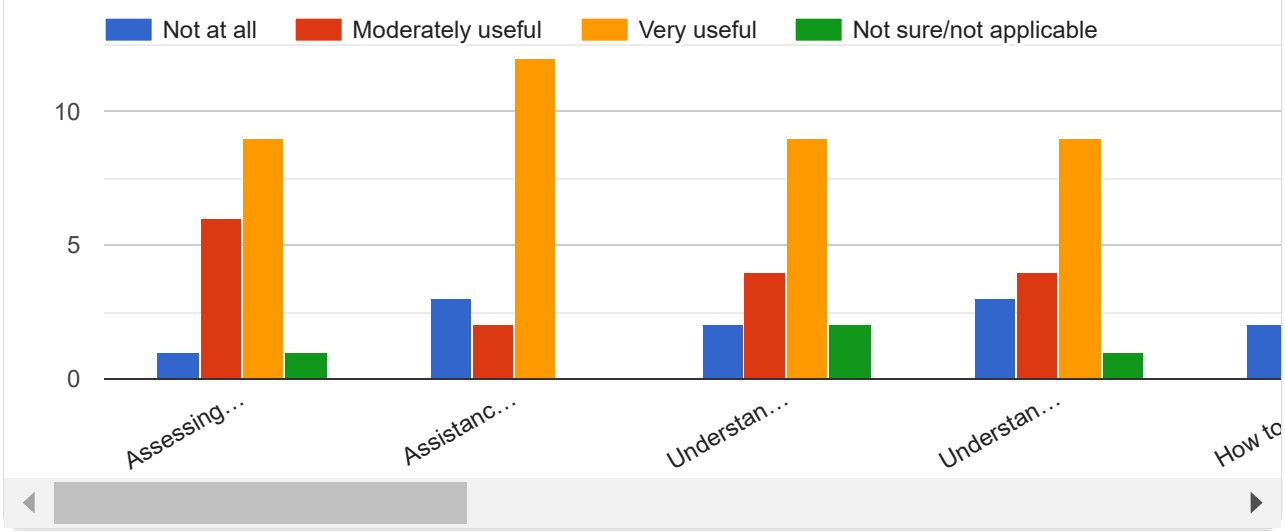
17 responses



Needs for Assistance and Technology

Please identify how useful each item would be to your agency? (continued on next page)



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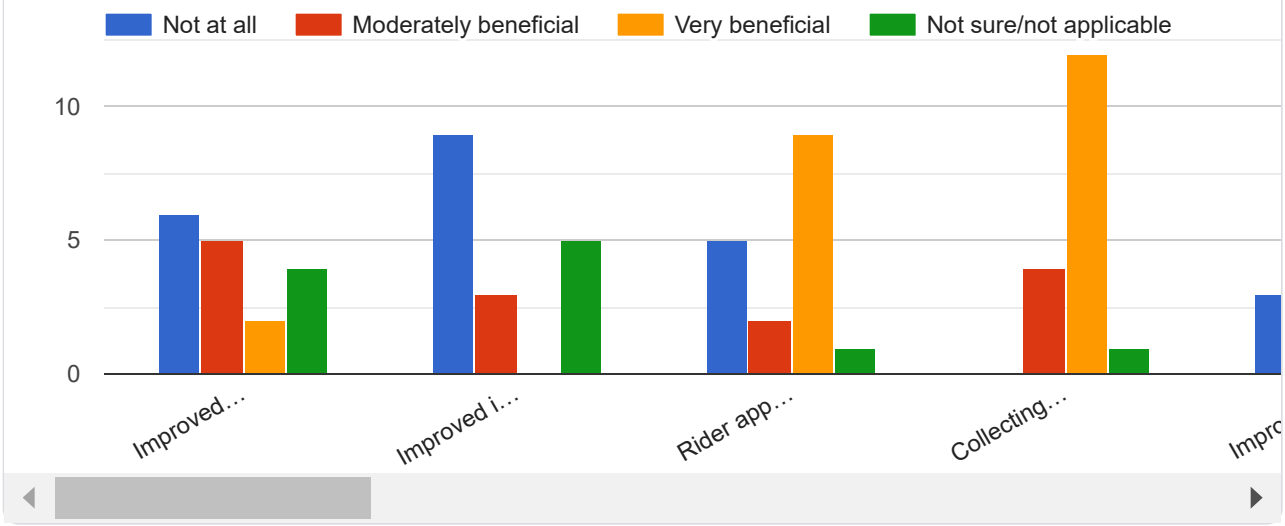

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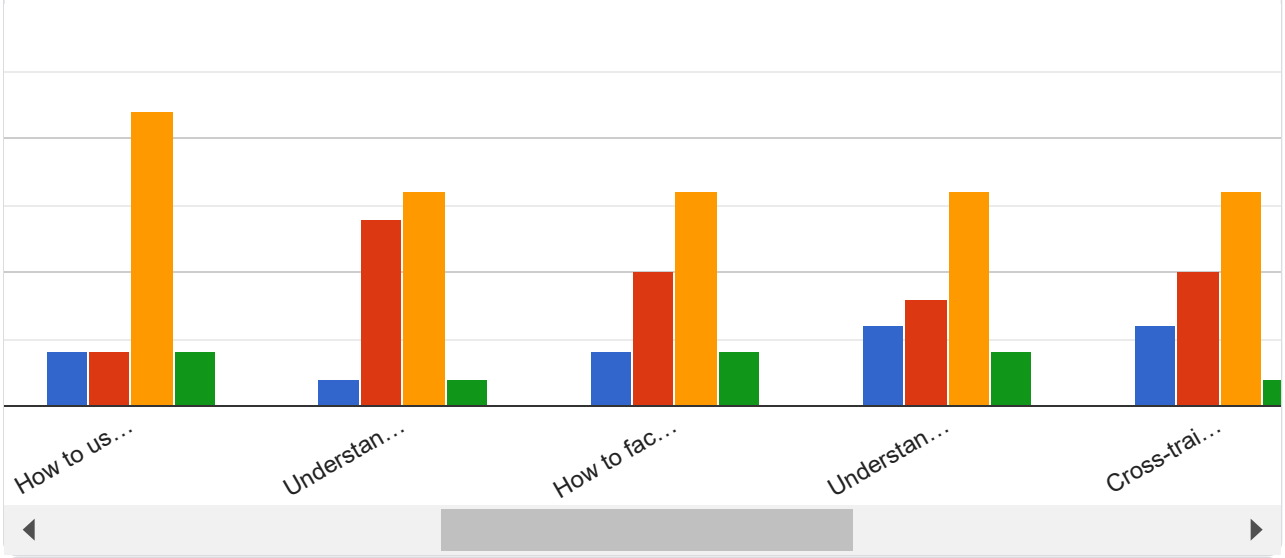

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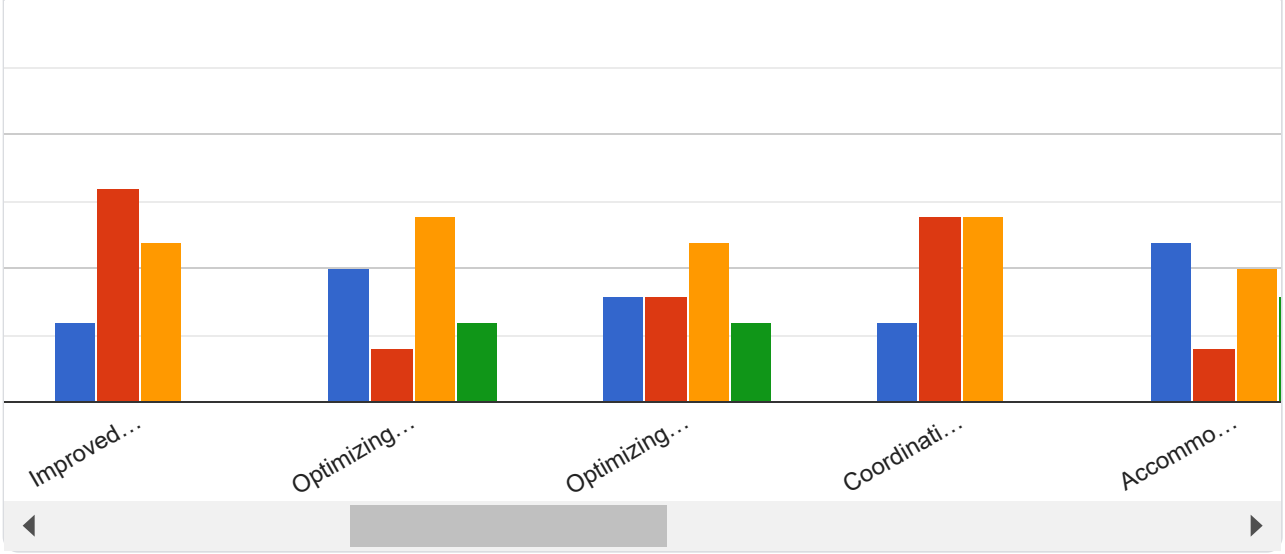
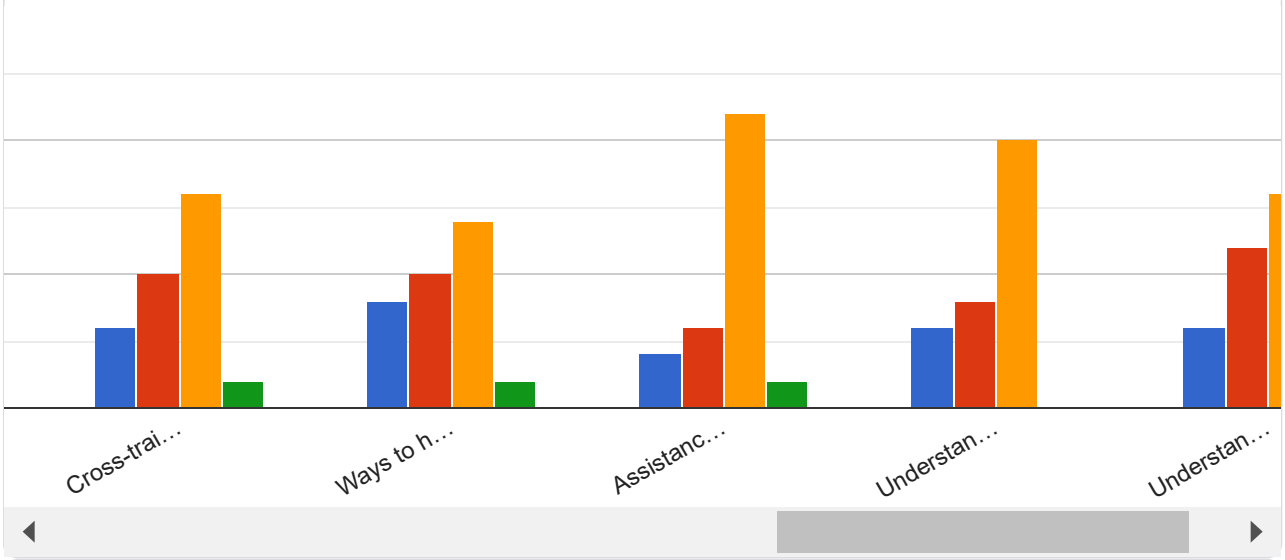


Please identify how useful each item would be to your agency? (continued on next page)



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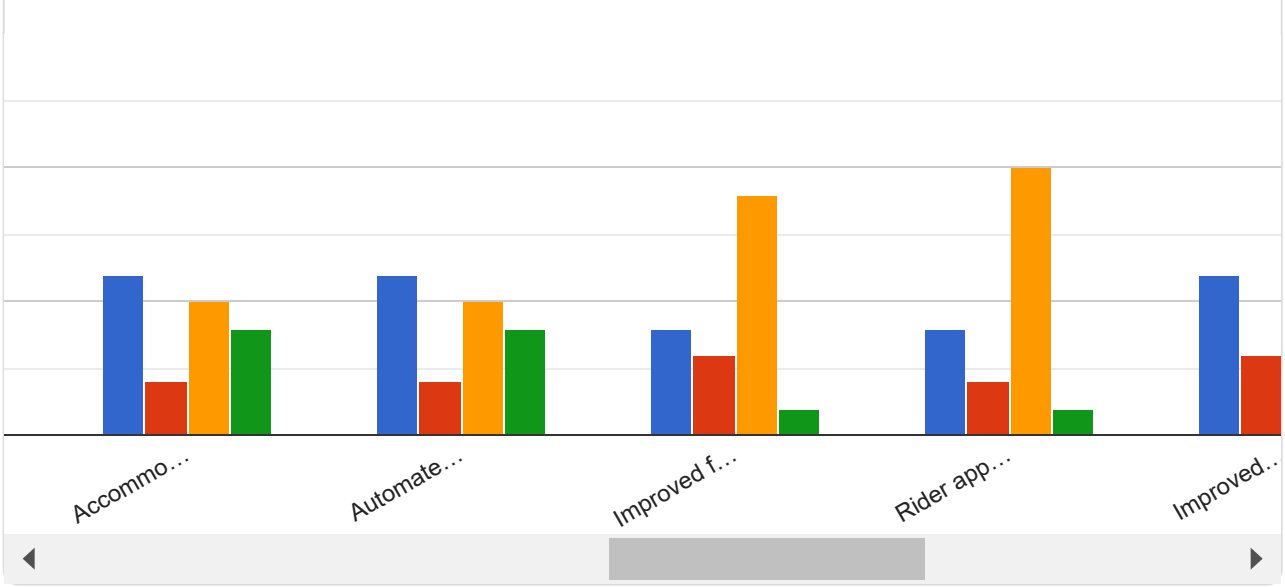
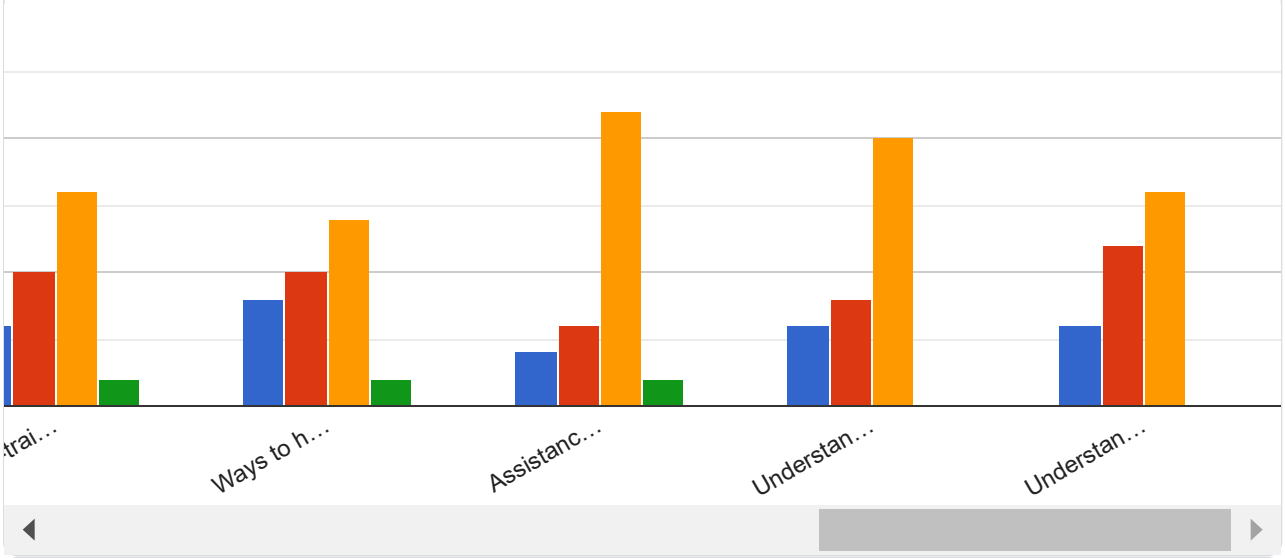


Please identify how useful each item would be to your agency?



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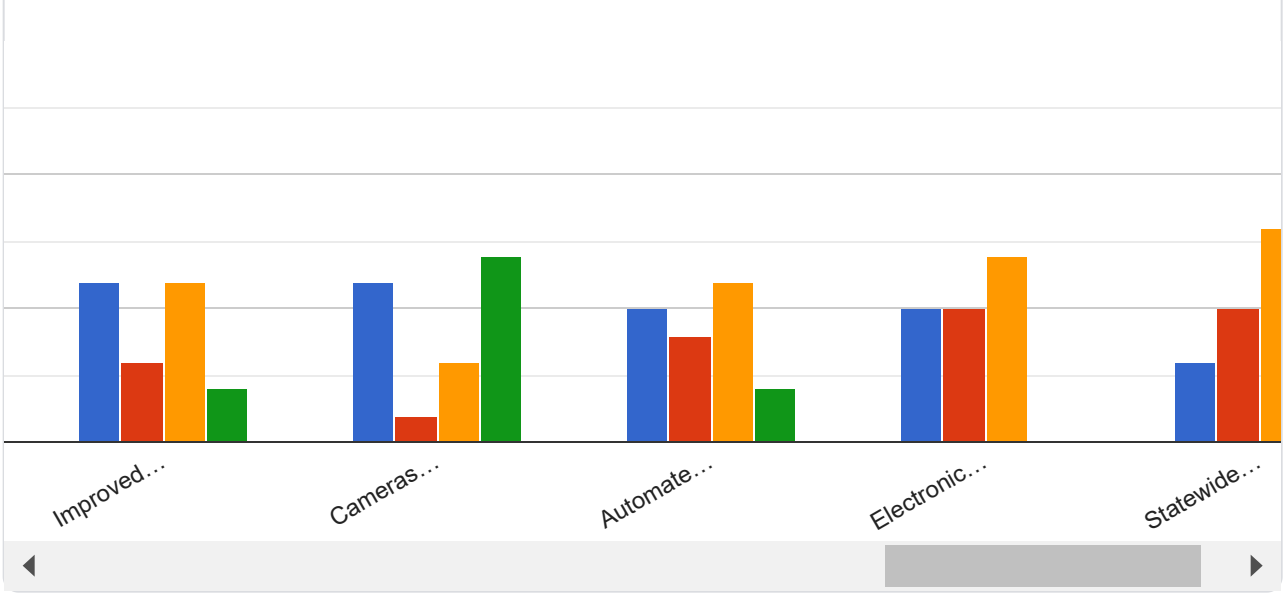
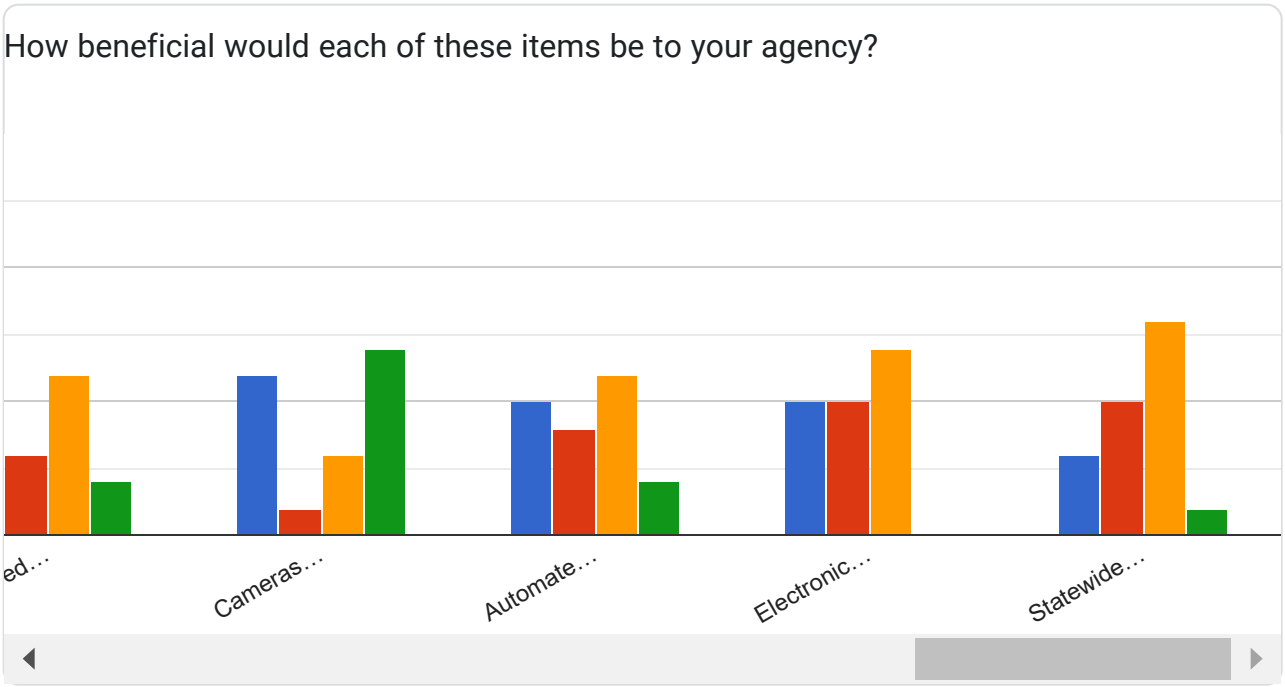


How beneficial would each of these items be to your agency?



If you have any additional thoughts or comments on the technology support that could be provided by Maine DOT or another entity (e.g., a Maine transit technology user group), please let us know here.

17 responses

none

making transit more access able

Our system needs a lot more technology solutions.

Not at this point, thanks

n/a

Funding assistance

Regional website integrating GTFS feeds and maps.

WMTS is presently using MDT's and tablets that are at the end of their useful life. Additionally we need to improve our dispatching & scheduling capabilities as we have increased the demands on our Demand response (Easy Rides) software to support fixed route and commuter services however we think there must be better options that would increase efficiency and link our fleet maintenance software (RTA) to work with our operations software.

NONE

None. Please note we do not have any busses; only 5 boats. (Thanks)

For small rural transit providers any and all technology assistance would be an extreme help to improve service to our communities and move us in the direction of serving more people in need.

We are currently in the process of updating or system

Thank you for this survey

None at this time.

There are some shades of gray to the last few questions. Also we do have an IT department, but they are small and not very helpful when it comes to bus tech. Thanks for your work on this.

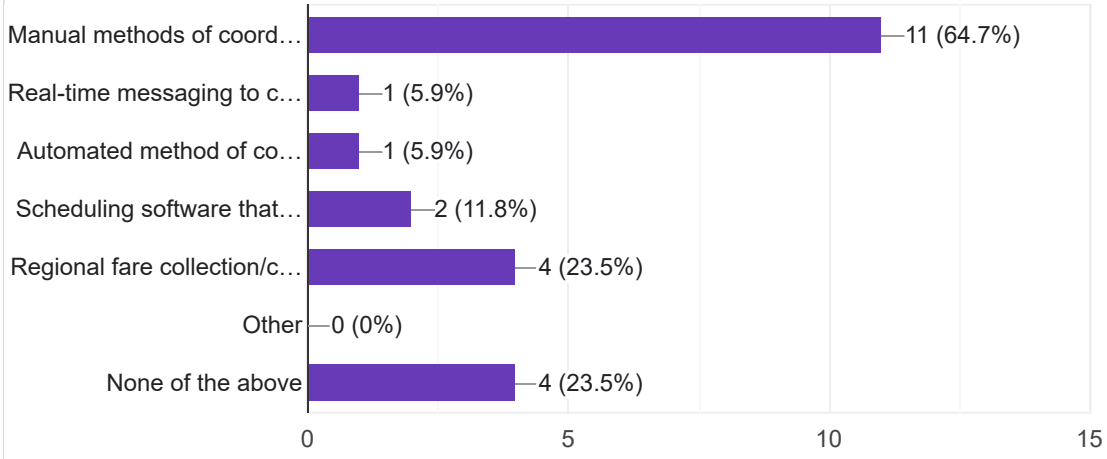
Thank you for the survey. 1: The largest barriers we face to improving services and service availability through technology is lack of understanding and knowledge of available options. 2: Implementation, integration and training / optimization of solutions. 3: Statewide coordination of unified technology platforms and technologies.

Regional Coordination

Which tools does your agency currently use to coordinate your services with other agencies?

Copy

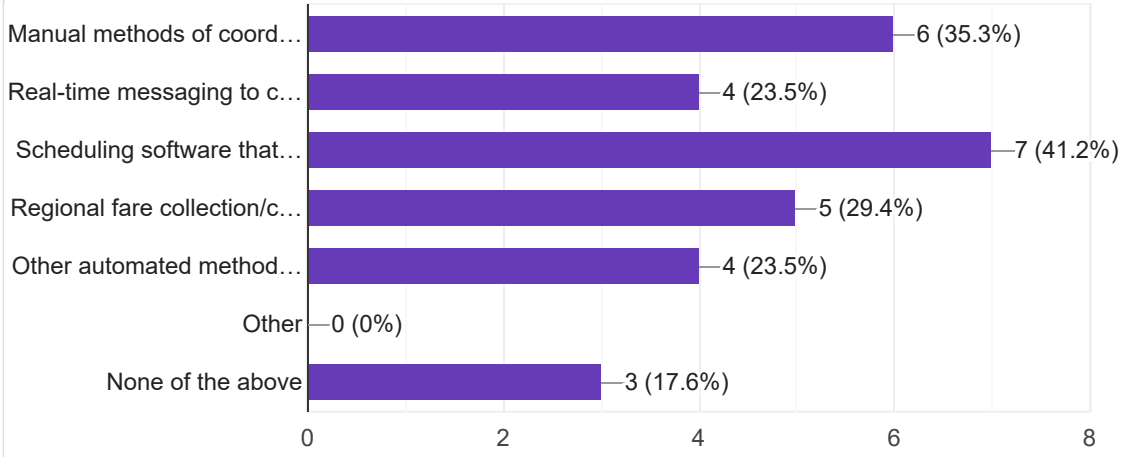
17 responses



Which tools does your agency wish to use to coordinate your services with other agencies?

Copy

17 responses



Appendix D – Technology Flowcharts for Small and Medium Size Transit Agencies

INTRODUCTION

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

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

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

OVERVIEW OF TRANSIT TECHNOLOGY FLOWCHARTS

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

Service Planning and Scheduling

Customer Information and Service

In-Vehicle Technology

Back Office

Reporting

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

SAMPLE FLOWCHARTS

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

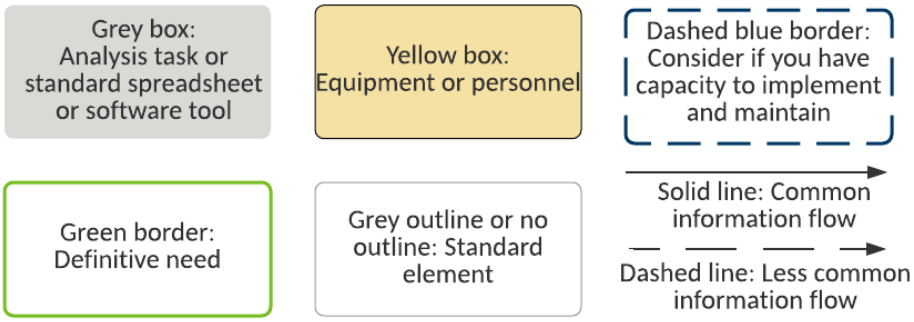
These typical flowcharts are intended to guide transit agencies and identify the relationships between technology systems and how they may develop the technology that is right for their agency. The reader is cautioned to keep in mind the diversity that exists between transit agencies. Even within a given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

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

Flowchart Legend

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

Figure 1: Legend for Transit Technology Flowcharts



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

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

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

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

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

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

Small Agency Technology Flowchart

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

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

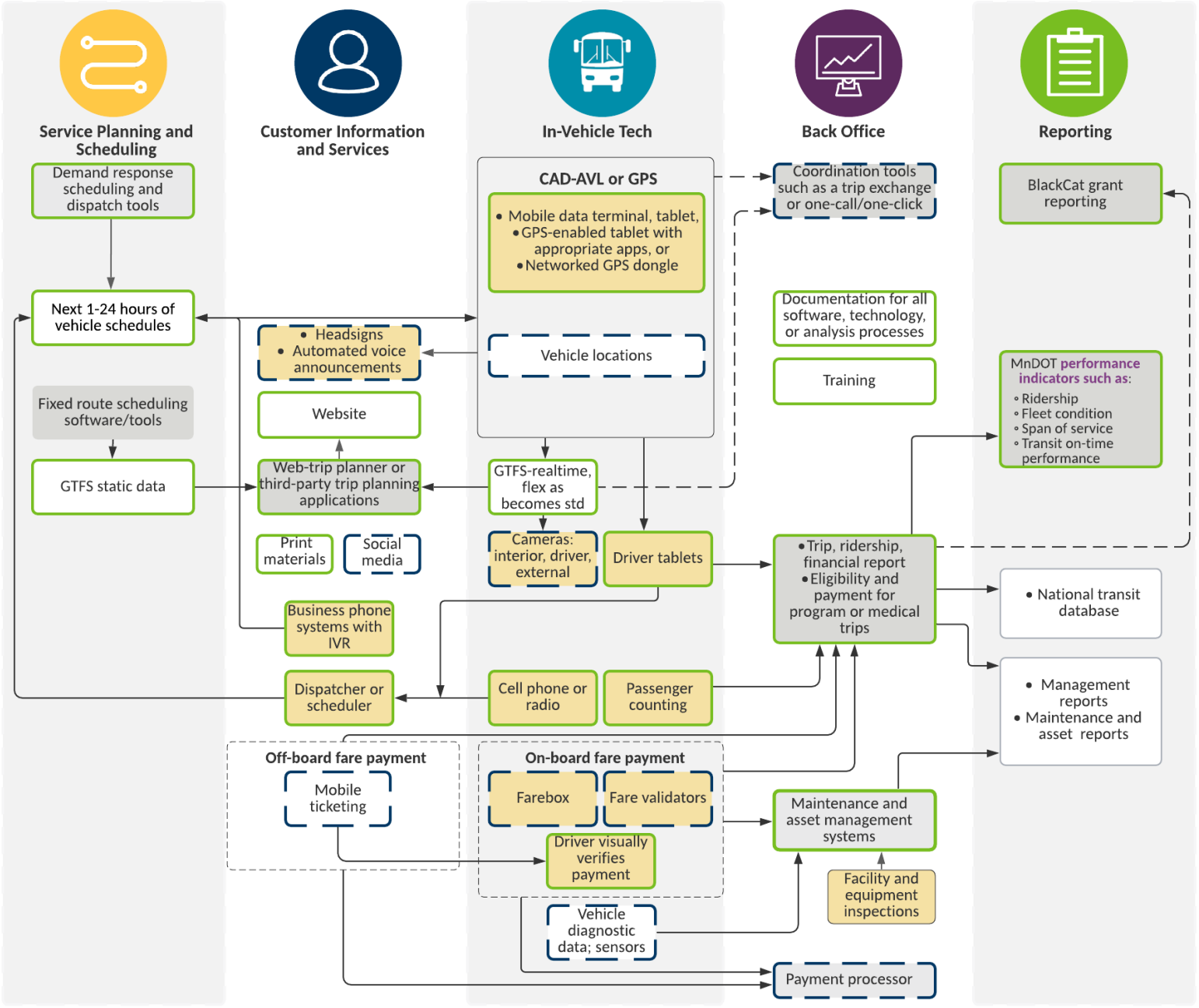
Customer Information and Service. A website that provides customers with accurate and updated information is a critical technology system for all agencies. Another important item for small transit agencies is a telephone system, preferably capable of making automatic calls to riders using interactive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

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

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

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

Figure 2: Small Agency Technology Flowchart



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

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

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

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

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

Figure 3: Example of Lightweight Card-Reader and Smartphone In-Vehicle Technology[9]

Medium Agency Technology Flowchart

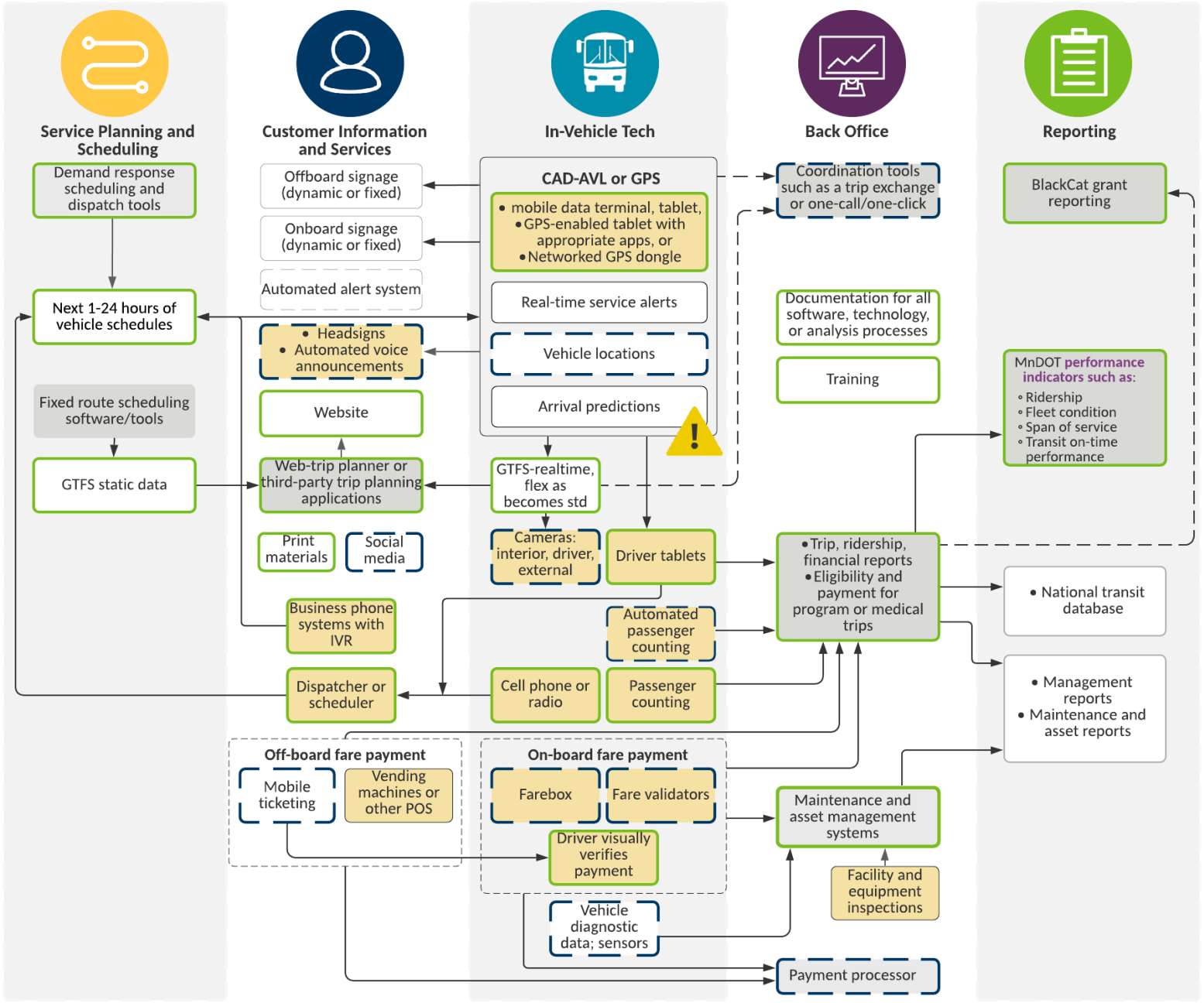
For agencies that have between 10-29 vehicles, service might be primarily fixed-route, primarily demand response, or a mix of the two. From an operating standpoint, this can be challenging because these are distinct services, and the products/software tools available for one do not necessarily translate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

	Service Planning and Scheduling. A medium-sized agency is more likely to benefit from scheduling and dispatch software for demand response trips and less likely to find spreadsheet tools to be adequate.
	Customer Information and Service. These larger fixed route systems are also likely to find GTFS-realtime information to be a valuable addition for customers, a supporting a web-based or third-party trip planning application. At this juncture, it is important to consider if the scheduling and dispatch software accurately generates GTFS-realtime data streams.

[9] Source: https://www.ubitransport.com/wp-content/up- loads/2018/09/ubitransport-quipe-la-ca-privas.jpg

	**In-Vehicle Technologies**. Advances in this area include having a more sophisticated CAD-AVL system, integrated headsigns and automated voice announcement systems, and automated passenger counters. Integration of CAD-AVL systems is an important technological step involving significant staff time and likely the service of a domain expert.
	**Back-office**. Agencies of this size might support ticket vending machines or other points of sale, such as grocery stores that keep fare media available for sale. Most medium-sized agencies will have maintenance software in place that generates and tracks work orders, allocates mechanic time, and maintains an inventory. They may also have a module for asset management functions. Many components of the transit flowchart can inform administrative, operational, and reporting activities if data is exported and manipulated in support of those functions.
	**Reporting**. While there are no significant additions, the larger and more complex the transit agency, the more complex the reporting requirements will be. While all agencies have back office and reporting responsibilities, full integration of these systems may not be a priority except for the larger agencies. It is useful for medium-sized agencies to begin considering where back office and reporting responsibilities may link to other activities. For example, all agencies need documentation of technology systems.

Figure 4: Medium Agency Technology Flowchart



CAD/AVL

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

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

INTEGRATED HEADSIGNS AND AUTOMATED VOICE ANNOUNCEMENTS

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

AUTOMATED PASSENGER COUNTERS

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

ENDNOTES:

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[9] Transit is working with Token Transit, which is the first mobile ticketing provider with which it's integrating Apple Pay and Google Pay, but Transit is working with its other partners to offer this ability as well. Since the Transit app-Token integration launched in December 2021, about one-third of users across 36 transit systems accepting Google Pay and Apple Pay have used these mobile wallet payment methods to purchase mobile tickets. The U.S. transit systems now supporting Apple Pay and Google Pay in the Transit app include AC Transit (Oakland, CA); Big Blue Bus (Santa Monica, CA); GET (Bakersfield, CA); Omnitrans (San Bernardino, CA); Champaign and Urbana MTD (IL); JTA (Jacksonville, FL); The COMET (Columbia, SC); and EMBARK (Oklahoma City, OK)

[10] Adapted from https://n-catt.org/guidebooks/new-fare-payment-systems-and-payment-technology/benefits-and-challenges/

[11] "Fare Payments-as-a-Service" is a term that was coined by a fare vendor (Masabi). It is described as a "better way of providing fare payment services. Agencies can sign up to a multi-tenant fare payments platform which is already live. This enables agencies to deliver the latest innovations to riders extremely quickly and then grow capabilities as they get regularly released onto the platform, helping keep up with the pace of technology change and doing so far more cost-effectively than building and maintaining a bespoke fare collection system."

[12] The Complete Trip Concept is that the success of a complete trip can be defined in terms of an individual's ability to go from origin to destination reliably and efficiently without gaps in the travel chain.

[13] This approach could be modeled after the deployment of Cal-ITP's model at four transit agencies in Northern California - Humboldt Transit Authority, Lake Transit Authority, Mendocino Transit Authority, and Redwood Coast Transit Authority. "Four Northern California transit agencies join forces to buy contactless open-loop fare payment systems off of California's purchasing agreements," Press Release, August 18, 2023, https://www.calitp.org/press/four-northern-california-transit-agencies-join-forces-to-buy-contactless-open-loop-fare-payment-systems-off-of-californias-purchasing-agreements

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