Regional Technology Plan 2025

Transit Technology in the Triangle Region

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WAKE TRANSIT PLAN

Durham Transit Plan

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Regional Technology Plan Executive Summary

The Triangle Region's transit agencies and regional transit partners have worked together toward a unified vision of mobility, efficiency, and improved rider experience through technology integration and regional collaboration. The Regional Technology Plan (Technology Plan) serves to identify recommendations that can be followed by regional stakeholders with respect to the following transit technology priority areas:

1. Passenger Real Time and Trip Planning Applications;
2. Transit Service Planning Tools;
3. Transit Signal Priority (TSP);
4. Regionally Integrated Payments;
5. Regional GTFS Publishing Standards; and
6. Open Transit Data Portal

The Technology Plan presents regional transit solutions to enhance a rider's ability to travel by transit within *and* across Durham, Orange, and Wake Counties. Separate chapters address each priority area outlined by stakeholders in the Triangle Region.

The purpose of the Regional Technology Plan is to guide the future deployment of technological solutions for transit agencies that are scalable, interoperable, and sustainable for the region. Each chapter addresses current conditions, opportunities, and challenges current to transit agencies in the region. Discussions illustrate case studies of other US transit agencies that have found solutions to challenges addressed. A roadmap budgetary cost estimate of potential technologies for consideration concludes each chapter. Recommendations present features and capabilities that agencies should consider when procuring transit technologies.

Each chapter identifies technology tools, standards, and recommendations to use as a resource when considering technology procurements. Existing transit technologies are identified in the chapters only to highlight current deployments by transit agencies in the region. Recommendations are not intended to direct agencies towards any specific technology vendor, but rather to provide guidance on how specific technologies present opportunities for interoperability between transit systems in the region over time. The chapters also include budgetary recommendations to guide planning decisions for the County Transit Plans over the next 4-5 years. The Regional Technology Plan is written for audiences with an understanding of modern account-based fare collection systems based on the current deployments of technology at the agencies in the region.

Challenges, Opportunities, and Recommendations

The summary below lists the notable challenges, opportunities, and recommendations with respect to transit technologies discussed within each chapter of the Technology Plan. The planning-level budget summary follows the overview of the Challenges, Opportunities, and Recommendation of this Technology Plan.

Chapter 1: Passenger Real Time and Trip Planning Overview

Challenges	Inconsistent real-time transit information across trip planning apps Limited integration between CAD/AVL systems and trip planning tools Variability in data quality and vendor support
Opportunities	Promote a single source of real-time transit information for regional travel Expand Transit Royale features to improve trip planning and rider experience Standardize CAD/AVL systems for disruption and detour reporting
Recommendations	Establish GTFS-RT as the standard for real time transit data Monitor data quality in real time feeds using various tools Provide passengers with multiple options for accessing real-time transit information Enhance trip planning with detour notifications and service updates

Chapter 2: Transit Service Planning Tools Overview

Challenges	Disparate service planning tools Limited regional coordination for service changes and data sharing Lack of standardized metrics for regional tracking
Opportunities	Adopt scalable service planning tools Standardize GTFS to align service planning metrics regionally Integrate microtransit and paratransit services into regional planning
Recommendations	Commit to interoperability in service planning tool integration Develop workflows for regional service planning coordination Leverage statewide contracts Enhance trip planning with integrated data from multiple sources

Chapter 3: Transit Signal Priority (TSP) Overview

Challenges	Multiple TSP vendors and proprietary systems limit interoperability Inconsistent adoption of standards (e.g., NTCP 1211 for controllers) Limited funding for expanding TSP system
Opportunities	Use NTCIP 1211 to standardize TSP operations across the region Integrate service planning software with cloud-based TSP system for real-time schedule adherence Collaborate with NCDOT on signal controller upgrades
Recommendations	Adopt NTCIP 1211 for future TSP deployments Establish regional TSP working group for interagency collaboration Identify corridors for test TSP interoperability Expand TSP system to support Bus Rapid Transit (BRT) routes

Chapter 4: Regionally Integrated Payments Overview

Challenges	Variability in fare collection systems and policies across agencies Limited adoption of open payment solutions Minimal integration between fixed-route and microtransit payment systems
Opportunities	Implement open payment solutions for contactless fare collection. Update GTFS to include GTFS-Fares information for each agency Integrate payment system to include multimodal journeys
Recommendations	Maintain equitable cash payment options Adopt open payment solutions for fixed route and BRT services Consider validation configuration for BRT routes (on-board/off-board) Explore integration of microtransit and TNC payments into regional payment systems

Chapter 5: Regional GTFS Publishing Standards Overview

Challenges	Inconsistent stop naming conventions and IDs Lack of standardized workflows for GTFS updates Limited integration between GTFS and GTFS-RT feeds
Opportunities	Develop a standard operating procedure for shared stops and naming conventions Schedule quarterly coordination meetings to align GTFS updates Implement best practices for GTFS creation and validation
Recommendations	Create SOPs for coding shared stops in GTFS Use tools like a Mobility Data Validator to ensure GTFS quality Procure planning software to streamline GTFS generation Separate planning and scheduling tools from CAD/AVL systems for resiliency

Chapter 6: Open Transit Data Portal Overview

Challenges	Variability in data readiness across agencies Lack of centralized access to regional transit data Concerns about cyber security and data maintenance
Opportunities	Build a centralized portal for GTFS and GTFS-RT feeds Develop interactive dashboards for performance metrics and analysis Collaborate with universities and nonprofits to support research and innovation
Recommendations	Leverage existing data feeds to create a centralized portal Develop a regional open data portal with dashboards and analytics Establish a regional steward to manage the portal Implement cyber security measures to protect data integrity

Triangle Region Planning-Level Budget Recommendations for Transit Technologies

A summary of the budgetary recommendations from each chapter is presented in the table below. Cost ranges are provided where alternative approaches could be taken by transit agencies in the region. These planning-level cost estimates can support initial planning efforts and guide agencies as they take next steps with procuring and implementing technologies that can meet the recommendations of the plan to enhance regional interoperability over time.

Each chapter of the Regional Technology Plan contains additional detail on budget estimates for agencies to consider in budgeting to support the recommendations and technologies discussed within each chapter.

Regional Technology Plan Chapters	Budget Recommendations	Notes on Estimates
1. Passenger Real Time and Trip Planning	Year 1 Costs: $533,770 Annual Costs (Years 2-5): $370,210	Based on applications for providing real-time updates of various impacts to transit operations
2. Transit Service Planning Tools	Year 1 Costs: Range from $894,750 to $1,072,890 Annual Costs (Years 2-5): Range from $409,925 to $779,365	Ranges include options for use of separate tools or combination of planning tools under one platform
3. Transit Signal Priority (TSP)	Total Costs (Years 1-5): Range from $7,894,325 to $9,129,710	Range reflects spread of costs for two different approaches to regional TSP
4. Regionally Integrated Payments	Total Costs (Years 1-5): Range from $6,468,360 to $9,408,185	Range reflects low and high end of three different options for the region
5. Regional GTFS Publishing Standards	Total Costs (Years 1-5): Average cost of $907,140	Average cost is based on prior data from other transit agencies and size of agency vehicle fleets
6. Open Transit Data Portal	Year 1 Costs: Range from $22,775 to $40,490 Annual Costs (Years 2-5): Range from $93,625 to $217,615	Range includes costs for alternate approaches to deployment of Open Transit Data Portal in region

The Regional Technology Plan reinforces the need for interoperability across agencies in the region to address regional mobility goals. Regional mobility rests on each agency's ability to foster an interoperable transit network. Interoperability aligns with agreed upon, policies, processes, and technological procedures that impact riders. Interoperability can enhance regional transit system efficiency and enhance the overall rider experience traveling across the region.

The report concludes with a coordinated roadmap of actions that are organized by type: policy, processes, and people (riders) to emphasize that technology changes to help people must be paired with changes in policy and process. Industry research and case studies demonstrate that the change toward interoperable technologies can enhance system efficiency with improved coordination, reduced redundancies, optimized resources, and improved experiences for both riders and agencies. It creates a more cohesive and reliable network that is better equipped to meet regional mobility needs now and in the future.

Glossary

Term	Definition
ADA	Americans with Disabilities Act
AFC	Automated Fare Collection: Systems enable transit agencies to collect, process, and manage revenue collection activities.
AI	Applied Information (Vendor)
AI	Artificial Intelligence
APC	Automated Passenger Counter: electronic device on transit vehicles that accurately records boarding and alighting data.
API	Application Programming Interface: an interface or communication protocol between a client and a server.
APTA	American Public Transportation Association
ASC/3	Advanced System Controller, version 3
ATC	Advanced Traffic Controller
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
Bundled fare	A single fare product that contains multiple fare products.
Business Rules	Transit Agency guidelines that govern operations are in compliance with regulations, safety standards and delivery of transit services.
CAD	Computer-Aided Dispatch
CAD/AVL	Computer Aided Dispatch/Automatic Vehicle Location: the use of computers and Global Positioning Systems (GPS) in dispatching and tracking a fleet of transit vehicles.
Cal-ITP	California Integrated Travel Project
CAMPO	Capital Area Metropolitan Planning Organization
CapMetro	Capital Metropolitan Transportation Authority
CATT	Cybersecurity Assessment Tool for Transit
CDOT	Chicago Department of Transportation
cEMV	Contactless Europay, Mastercard and Visa: cEMV is the open-loop token container for account-based ticketing. (virtual credit card)
CHT	Chapel Hill Transit
CMS	Content Management System
COMET	Central Midlands Regional Transit Authority (CMRT)
COOP	Continuity of Operations Plan
Core Technology	Suite of hardware, software, and communications tools used by transit agencies in a technology stack to aggregate data from different sources.
COTS	Commercial Off-the-Shelf: used to describe products that are ready-made and service proven. Typically requires fewer custom integrations.
CSF	Cybersecurity Framework
CSV	Comma-Separated Values. This is a typical format for data export.

Term	Definition
CTA	Chicago Transit Authority
CTDOT	Connecticut Department of Transportation
CTfastrak	Connecticut Fastrak
CTtransit	Connecticut Transit
CV	Connected Vehicle
CV2X	Connected Vehicle-to-Everything
DART	Dallas Area Rapid Transit
Deadhead	Deadhead is the movement of a transit vehicle without passengers aboard; often to and from a garage or to and from one route to another.
Demand-Response	Demand Response or on-demand, refers to a transit mode that is a non-fixed route service using vans or buses with passengers boarding and alighting at pre-arranged times at any location within the system's service area. Sometimes referred to as dial-a-ride.
EMV	Europay, Mastercard, and Visa
ETA	Estimated Time of Arrival
EVP	Emergency Vehicle Preemption
Fare media	A physical card, device, or application that can be used to store purchased fares or fare products, or to pay for fares directly.
Fare product	Purchasable fare products that can be used to pay for or validate travel (e.g., single-ride, 10-fare bundle, student monthly pass).
FHWA	Federal Highway Administration
Fixed Route	Service provided on a repetitive, fixed-schedule basis along a specific route with vehicles that deliver passengers to specific locations.
FTA	Federal Transit Administration
GIS	Geographic Information System
GMV	GMV Innovating Solutions
GOFS	General On-Demand Feed Specification: Lightweight specification provides real-time information on point-to-point, on-demand, or zonal based transit.
GPRS	General Packet Radio Service
GPS	Global Positioning System
GTFS	General Transit Feed Specification: a common format for public transportation schedules and associated geographic information.
GTFS-Flex	General Transit Feed Specification – Flexible Services extension
GTFS-Ride	General Transit Feed Specification – Ridership
GTFS-RT	General Transit Feed Specification – Real Time
Headway	Time interval between vehicles moving in the same direction on a particular route.
IDOT	Illinois Department of Transportation
IL	Illinois
IT	Information Technology
ITRE	Institute for Transportation Research and Education (North Carolina State University)

Term	Definition
ITS	Intelligent Transportation Systems: a variety of technology-based systems, techniques, and methods used to relieve congestion, improve road and transit safety, and increase economic productivity.
ITxPT	Information Technology for Public Transport
IVR	Interactive Voice Response
JSON	JavaScript Object Notation
JTA	Jacksonville Transportation Authority
KPI	Key Performance Indicator
MaaS	Mobility as a Service: platform for riders to select from private and public provider transportation services.
MDIP	Mobility Data Interoperability Principles
MDOT MTA	Maryland Department of Transportation Maryland Transit Administration
MDT	Mobile Data Terminal. Facilitates communication data exchange, and operational management between vehicle and central dispatches.
Microtransit	A form of Demand Response Transit (DRT) that offers flexible routing and/or scheduling of urban bicycle or scooter options or more generally minibus vehicles to supplement rural service areas.
MMCVP	Multi-Modal Connected Vehicle Pilot
MOD	Mobility on Demand
MOUs	Memorandums of Understanding
MPO	Metropolitan Planning Organization: the organization designated by local elected officials as being responsible for carrying out urban transportation and other planning processes for the area.
NC	North Carolina
NCDOT	North Carolina Department of Transportation
NEMT	Non-Emergency Medical Transportation
Network-as-route	A group of routes that can be transferred between freely, behaving as a single, composed route for purposes of determining transfer cost.
NFC	Near Field Communication
NIST	National Institute of Standards and Technology
NSBRT	North-South Bus Rapid Transit
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
NTD	National Transit Database: a federal reporting program for transit agencies receiving Federal Transit Administration funding that serves as the primary repository for all transit-related data and statistics in the United States.
OBU	On-Board Unit
OCPT	Orange County Public Transportation
ODOT	Oregon Department of Transportation

Term	Definition
On-demand	On-demand transit is also known as demand response transit. Demand responsive mode of transport for customers who are unable to use the conventional fixed-route bus service due to a disability pursuant ADA regulation of 1990.
Operating Partners	For the purpose of this Plan, operating partners reference agencies that operate transit in the region. MPOs and other regional stakeholders often assist in planning with operating partners.
OTD	Open Transit Data
OTP	On-Time Performance
Paratransit	Comparable transportation service required by the ADA act of 1990 for individuals with disabilities who are unable to use fixed-route transit.
PART	Piedmont Authority for Regional Transportation
PC	Personal Computer
PCI	Payment Card Industry. The PCI Security Standards protect cardholder data in credit card transactions.
PM	Project Management
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QR	Quick Response
R&D	Research and Development
RATP-Dev	Régie Autonome des Transports Parisiens – Développement. Private vendor operating bus services.
RDU	Raleigh–Durham International Airport
RFI	Request for Information
RFID	Radio Frequency Identification: Tracking system that uses electromagnetic fields to automatically identify, and track tags attached to objects.
RFP	Request for Proposals
Ridesharing	A form of transportation, other than public transit, in which more than one person shares the use of a vehicle, such as a van or car, to make a trip. Also known as 'carpooling' or ' vanpooling'.
ROM	Rough Order-of-Magnitude
RSU	Roadside Unit
RTA	Regional Transportation Authority (Chicago)
RTAP	Rural Transit Assistance Program
RTC	Regional Transportation Commission of Southern Nevada
RTMC	Regional Transportation Management Center
RTTSPIP	Regional Transit Signal Priority Implementation Program
SaaS	Software-as-a-Service
SAE	Society of Automotive Engineers
SEPTA	Southeastern Pennsylvania Transportation Authority

Term	Definition
Service Planning Tools	Suite of tools to aggregate data from different sources and on bus to produce usable information that can be analyzed. Software solutions can analyze scheduling and plan transit services.
SMS	Short Messaging Service
SOGR	State of Good Repair: an asset is considered to be in a state of good repair if it is in a condition sufficient for the asset to operate at full performance.
SOP	Standard Operating Procedure
SORTA	Southwest Ohio Regional Transit Authority
TARC	Transit Authority of River City
TBD	To Be Determined
TIDES	Transit Integrated Data Exchange Specification is developed by APTA to encourage secure real-time data sharing and interoperability among transit systems including CAD/AVLs, MDTs, and other technologies.
TMC	Traffic Management Center
TNC	Transportation Network Company
TNExT	Transit Network Explorer Tool
TODS	The Transit Operational Data Standard (TODS) is an open standard for describing how to operate scheduled transit operations.
TSP	Transit Signal Priority includes a set of operational improvements that reduce the time of transit vehicles at traffic signals by holding green lights longer or shortening red lights.
TVM	Ticket Vending Machine: an electronic vending machine that allows riders to purchase single fares, add value to fare media, or generate proof-of-payment tickets from passes.
Umo	Closed loop account-based ticket system used in the region by Cubic Corporation.
UNC	University of North Carolina
USDOT	United States Department of Transportation
UTA	Utah Transit Authority
VMS	Variable Message Signs: Deployed in transit stations, hubs, and bus terminals to provide travelers with information.
VOMS	Vehicles Operated in annual Maximum Service: A statistic reported to the National Transit Database.
VPTA	Vermont Public Transit Association
VTrans	Vermont Agency of Transportation
WLAN	Wireless Local Area Network: a local area network that allows devices to connect and communicate wirelessly.
WMATA	Washington Metropolitan Area Transit Authority
Zone Fares	A system of fares where a transit system's service area is divided into zones within which specified rates or fares apply.

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Chapter 1. Passenger Real-Time and Trip Planning

Vision: Riders from across the region can easily navigate fixed-route transit options, access real-time information, and plan trips. Transferring between transit providers is seamless and easy.

Objective: Identify recommended steps that transit agencies can take that allow them to provide passengers with real-time information and fixed-route trip planning tools that make regional travel on transit a seamless travel experience.

1.1 Initial Findings and Opportunities

1.1.1 Summary of Current Conditions

Transit riders in the Triangle Region can currently access real-time transit information from multiple transit providers that are provided through different contracts and systems using various mobile phone applications.

A summary description of how transit agencies currently provide this information through mobile phone applications is listed below. Table 1-1 presents a summary listing with hyperlinks for reference.

- GoTriangle and GoCary provide a mobile application developed by their Computer Aided Dispatch (CAD)/Automated Vehicle Locator (AVL) vendor (TripSpark).
- This application is known as MyRide and is branded for the public as the GoTriangle App and GoCary App for customers to download on their mobile phones.
- GoDurham routes are visible through a MyStop App that is provided by their CAD/AVL vendor known as Avail Technologies, though this is not promoted to passengers by Durham.
- GoRaleigh, GoDurham, and Chapel Hill Transit provide Transit Royale as a premium service of the Transit App for passengers and make the Transit Royale service free to all users. In addition to real-time transit information to passengers, the Transit Royale feature allows users to look at future departure times and schedules for all transit lines without any daily limits. This feature also launched for Raleigh riders in January 2025.
- Trip planning and route information is also available through the Umo app that is provided by Cubic. The Umo App has two interfaces:
    - A trip planner interface and,
    - A payment interface.

Figure 1-1: GoCary App Images

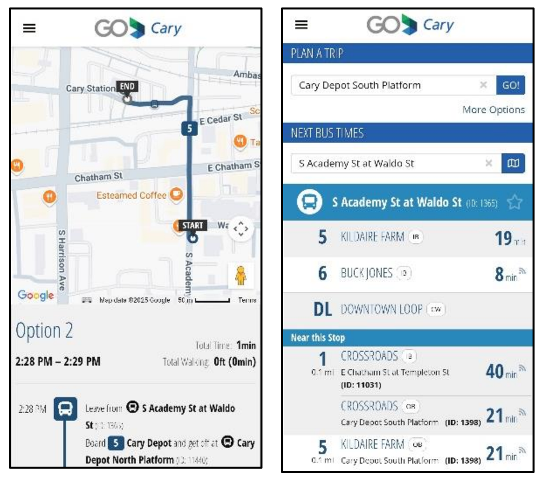


Figure 1-2. Google Maps Images of Chapel Hill

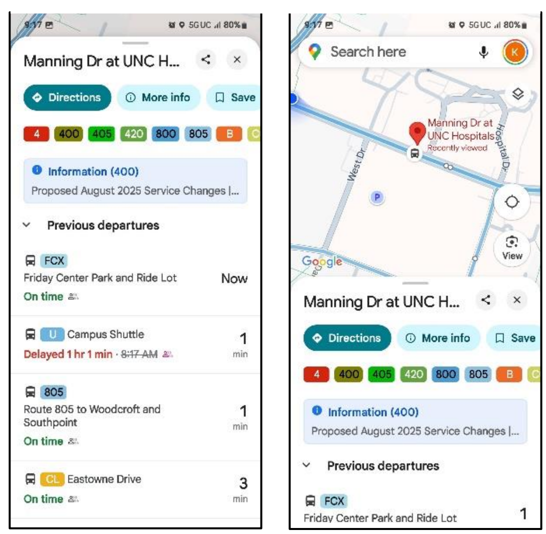
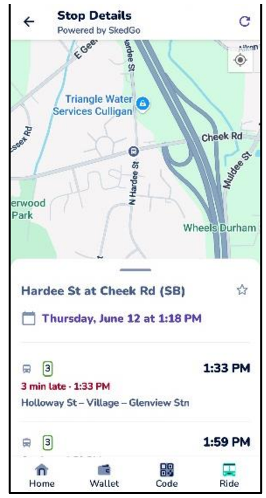


Figure 1-3. Umo App Images in Durham



- Chapel Hill Transit and GoDurham do not have active contracts with Umo mainly due to the agencies not collecting fares. However, Chapel Hill and Durham static trip information is available in the UMO trip planner interface.
- All agencies have shared their General Transit Feed Specification (GTFS) and GTFS-Realtime (GTFS-RT) with Google so that their transit service is discoverable in Google Maps. Submitting the GTFS to Google requires signing up to participate, does not require a contract with Google, and has no fee.
- GoRaleigh and Chapel Hill Transit both provide real-time information in Apple Maps. Publishing GTFS data in Apple Maps requires directly contacting Apple Support and requesting that the GTFS be included and providing the necessary links. Inclusion in Apple Maps is free.
- Real-time transit information on desktop interfaces is also provided by all agencies as noted in Table 1-1 below. For example, Chapel Hill Transit provides real-time transit information through GMV system on the Town of Chapel Hill website.
- TextMarks is utilized by GoTriangle and GoRaleigh in the region for Short Messaging Service (SMS) text messaging to gather real-time transit information for people without smartphones and access to mobile applications. TextMarks reads GoRaleigh's GTFS feeds to provide the SMS service, which is a pilot project that TextMarks is doing with GoRaleigh.

Table 1-1. Summary of Real-time Transit Information on Mobile Applications and Desktop Websites in Region

	GoTriangle	GoCary	GoRaleigh	GoDurham	Chapel Hill
Real-Time Transit Information through Mobile Applications			Transit App/Transit Royale	Transit App/Transit Royale	Transit App/Transit Royale
	GoTriangle App (Vendor: MyRide)	GoCary App (Vendor: MyRide)		MyStop App (Vendor: Avail Technologies)	
	Google Maps	Google Maps	Google Maps	Google Maps	Google Maps
	Apple Maps	Apple Maps	Apple Maps	Apple Maps	Apple Maps
	Umo app (Cubic)	Umo app (Cubic)	Umo app (Cubic)	Umo app (Cubic)	
Real-Time Transit Information on Desktop Interface	GoTriangle Regional Web Interface	GoCarylive.org Web Interface	GoRaleighlive.org Web Interface	MyStop Web Interface	Chapel Hill Transit page (Vendor: GMV/Syncromatics)
Real-Time Trip Planner Websites	GoTriangle Trip Planner Site	GoCary Trip Planner Site	GoRaleigh Trip Planner Site	GoDurham Trip Planner Web Interface	GoTriangle Trip Planner Site
SMS Messaging	TextMarks		TextMarks	TextMarks	TextMarks

1.2 Noted Challenges

The most notable challenge for transit agencies in the region is ensuring that passengers are viewing accurate real-time transit information, especially on applications that the transit agencies do not have control over. This includes third-party applications that are not contracted with the transit agencies, such as Google Maps and Apple Maps, and transit agencies in the region do not have control over the algorithms that produce real-time predictions in those applications. This is also especially important when there is a recent transit service change or an update to an agency's GTFS feed that is ingested by these third-party providers.

Other challenges noted from transit agencies include the following:

- Although most mobile applications have the capability to display GTFS-RT information in the trip planner interface, the level of details can vary among vendors. For example, some applications may not display a moving bus icon to indicate that a bus is moving along a corridor, which can provide passengers with more confidence/comfort about the reliability of bus tracking and reporting of bus locations.
- Proprietary solutions for real-time transit information provided by technology vendors may become unreliable if the vendors become unable or unwilling to support continued operations. GoTriangle, GoRaleigh, GoDurham and GoCary had previously used a technology solution from a vendor that aggregated real-time location feeds from the agencies to provide an SMS text messaging service. This service (along with others provided by the vendor) was eventually discontinued by the technology vendor, and passengers were unable to obtain real-time information using the SMS text messaging service as the technology vendor no longer supported the aggregated real-time feeds that the SMS depended on to function. As a result, the agencies had to procure an entirely new SMS system (TextMarks).
- Given that CAD/AVL systems and onboard vehicle hardware are the source for real-time transit information, improvements in how real-time transit information is provided to passengers in the region are dependent upon improvements in those CAD/AVL systems and hardware. For example, announcing each stop is a functionality that GoRaleigh is exploring as an improvement that needs to be supported by CAD/AVL system.
- Developing an accurate schedule and calendar can also be a challenge with real-time transit information. Nuances in transit schedules have to be captured in the scheduling process. The GTFS-RT relies on the underlying static GTFS to determine arrival predictions. If the underlying GTFS is not scheduled/calendared properly due to inaccurate data entry by the personnel responsible for its development, then it results in issues with the GTFS-RT feed.

1.3 Opportunities for Innovation and Collaboration

While transit agencies have made real-time transit information available through multiple different mobile applications, an opportunity may exist for transit agencies to promote a single source of real-time transit information for passengers traveling across the region on multiple transit agencies. From a transit agency customer service perspective, it may become easier if the transit agencies can point to one source of transit information instead of the different sources that are available currently. However, customers can obtain real-time transit information from multiple sources through mobile phones and applications, and providing these options to customers can allow them to choose the application that they are most comfortable with for getting transit information.

From the review of current conditions, the Transit Royale service from Transit App is offered by many transit agencies in the region for free to its customers, though an expansion of this service to other transit agencies would come with an added cost to those agencies. Transit Royale is a premium subscription service within the Transit App that can provide customers with additional features and customization beyond the free service offered through the Transit App. This service can be paid for individually by passengers, or transit agencies can pay an annual fee to cover the cost of the premium service on the Transit App for their passengers.

The Transit App provides several features that are not available through Google Maps or Apple Maps, including automatic detour detection, in-app rider surveys, and the ability to include GTFS-Flex and General On-Demand Feed Specification (GOFS). Detour detection senses patterns in real-time data to identify and display detours directly in the app. The survey feature enables transit agencies to gather feedback on rider experience or collect public input on proposed service changes. GTFS-Flex and GOFS allow for the inclusion of on-demand and flexible transit as an option for trip planning.

Transit Royale unlocks advanced features that enhance the rider experience. These include:

- Unlimited transit schedules for planning trips days in advance, whereas the base Transit App only allows for planning an immediate trip to see the next real-time departure.
- Access to multiple transit systems, allowing users to track real-time vehicle locations and departure times across agencies that publish GTFS-RT data. Individuals using a device within a service area that has procured Transit Royale will automatically be upgraded to Transit Royale while traveling in that area. Note that routes from different agencies can appear in different colors to differentiate between the agencies. Also note that the base Transit App only shows departures for transit routes in close proximity to the user, whereas Transit Royale shows all routes from all agencies in Transit App, even those that are 100's of miles away.
- Expanded trip results and the ability to view routes beyond a rider's immediate area
- Customization features, such as the ability to personalize route icons

Expanded use of Transit Royale could help to deliver consistent, high-quality rider experience and improve coordination across the region's transit network. This would allow individuals to plan trips seamlessly across the region, be alerted to detours and stop closures, have access to real-time information, and allow agencies to collect feedback and survey riders.

One drawback to this approach may need to be considered for transit agencies that do not provide the Transit Royale features for its passengers, in that passengers would need to pay for the service in the absence of the transit agencies providing the funding for the service.

Another opportunity for the region can be to standardize how CAD/AVL systems are used in reporting detours and disruptions to transit service. The use of a "disruptions" feature on CAD/AVL systems allows transit dispatchers to actively use the CAD/AVL software in real-time to manage transit trips, blocks, and routes that are not going as planned. The process of how this "disruptions" is used varies by CAD/AVL vendor, but the use of this feature by dispatchers in real-time will improve the quality of the information provided to passengers. One example of disruption to transit service could be a special event that requires closing a road for an extended period of time. However, smaller events such as a broken down car blocking the road for a small period of time may not be considered a disruption if it only impacts a single trip.

The use of this type of feature should be guided by a standard process for regional agencies and their CAD/AVL dispatchers, and training of those dispatchers can help ensure the use of sending out detour information is done on a consistent basis. Policies could be defined for the amount of time a disruption is estimated, so that CAD/AVL dispatchers are using the feature properly within their CAD/AVL system. For example, if a major detour is known well in advance, then this disruption (likely a detour) can be built into an agency's GTFS and a new GTFS can be published. If a disruption is found less than a month in advance by an agency, then agencies will need to work with their CAD/AVL vendor for determining the best method for using the "disruptions" in the CAD/AVL system.

From a passenger perspective, agencies should also monitor how information on transit route disruptions is presented to the general public through various mobile applications used by the public. Some applications can ingest disruption data and accurately report it to the public, but some applications may require additional work to send this information through their platform.

Examples of one service detour for Durham Station Construction are provided as an example in Figures 1-4 and 1-5 below. In this example, the Route 400 will use Gate K, and the Route 405 will use Gate J at the station.

Figure 1-4. Example Differences of Detour Information on Mobile Applications

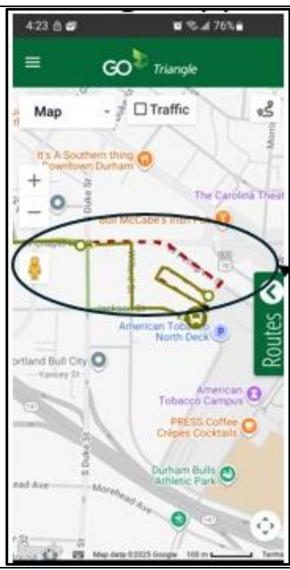
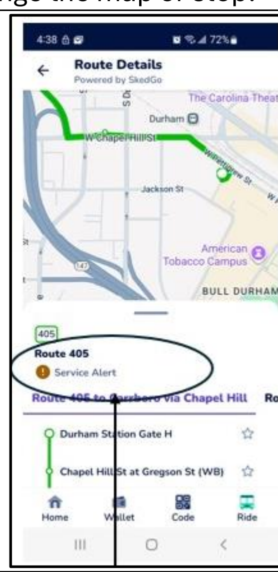
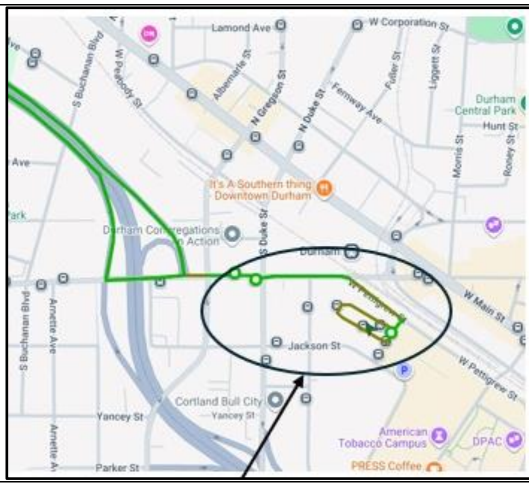
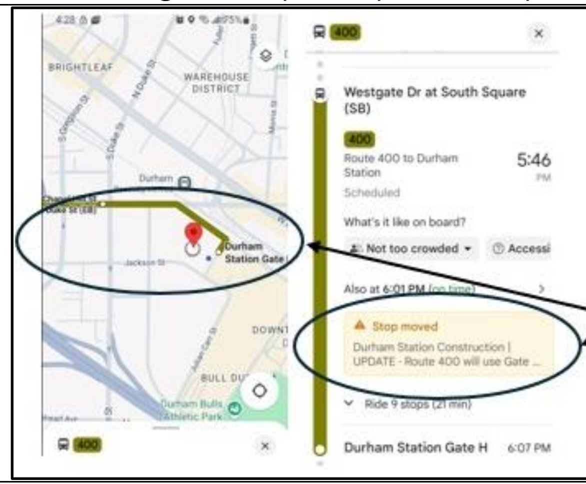
GoTriangle App – Shows the change in routing in red dash line with detour.	Umo App – Shows the alert on the website, but does not change the map or stop.	Apple Maps – Does not show a service alert, or that map or stop is changed.
		

Figure 1-5. Example Differences of Detour Information on Web-Based Desktop Applications

Web-based Map (gotransitnc.org) – Shows the GTFS data, but no detour and no alert	Google Maps – Shows an alert on the website but doesn't change the map or stop on the map.
	

1.3.1 Case Study: Connecticut Department of Transportation (CTDOT)

In 2023, the Connecticut Department of Transportation (CTDOT) published their Customer Experience Action Plan after two years of extensive public outreach. The plan is aimed at improving public transit for riders across Connecticut. One of the top customer priorities identified was the need for a simpler way to plan trips. Shortly after CTDOT partnered with Transit App to offer Transit Royale—a premium version of the app—free to all residents for one year as a pilot program. Given the success of the app, CTDOT renewed the one-year contract in 2024 and again in 2025.

The Transit App allows users to plan trips across multiple transit systems statewide. The initial rollout included information from all eight CT*transit* divisions, CT*fastrak*, five of the nine fixed-route Transit Districts, CT*rail* services, and the Metro-North Railroad's New Haven Line. Two months after launch, a deep link to Token Transit—the mobile ticketing app used by many Connecticut transit providers—was added to streamline fare payments.

In 2024, additional fixed-route transit districts were integrated, and by 2025, all fixed-route providers in the state were included in the app. The microtransit zones for one transit district were also added to the Transit App with a link to the ride request app. Real-time schedule information became available for half of the CTtransit-branded services and four Transit Districts. Rider alerts and detour notifications were also made available for CTtransit routes.

Within the first year, Transit App usage in Connecticut surged by 95%. In 2024 alone, the app saw 90,000 monthly users, was opened 38 million times, and facilitated the planning of over 5 million trips. That same year, CTDOT introduced a quarterly Ridership Happiness Benchmark survey within the app, enabling users to rate their satisfaction and provide feedback—helping to shape future transit improvements.

Lessons learned include the following:

- A champion is needed to lead the effort and work with smaller agencies that may not have the technological capabilities.
- If a system does not have AVL then only static GTFS can be used; those with an AVL must be able to provide a GTFS-RT, not all systems could with their existing vendors. Transit App offers GO Crowdsourcing that allows App users to share their transit trip and provide vehicle tracking, even in areas where there is no GTFS-RT feed.
- Microtransit and on demand services (with apps) can be integrated with Transit App either through a deep link or using the new General On-Demand Feed Specification (GOFS)[1]. Both options allow microtransit to show up as potential trip options. Note this is an add-on cost.
- It is possible to integrate certain fare payments app directly into Transit App.
- Implementing as a pilot project allows for testing proof of concept and satisfaction before rolling out to a wider area, adding additional features or committing to longer contractual periods.

1.4 Recommendations for Real-Time Information and Trip Planning in Region

Given the existing real-time transit information systems in the region, the following are recommendations for the region.

Recommendation #1: Establish GTFS-RT as Standard for Making Real-Time Transit Information Available

GTFS Realtime (GTFS-RT) is an open standard developed by Google as an extension of the General Transit Feed Specification (GTFS). It enables transit agencies to share real-time information such as vehicle locations, predicted arrival times, and service alerts. Built on protocol buffers, GTFS-RT provides a standardized format that third-party applications can access via an Application Programming Interface (API).

GTFS-RT has become the global standard for delivering real-time transit information. Because it uses a common data format, any app—such as Google Maps, Apple Maps, or Transit App—can ingest and display transit updates without needing to tailor their systems to individual agencies.

There are three core GTFS-RT feed types:

- Vehicle Positions – Shows real-time vehicle locations.
- Trip Updates – Provides delays, detours, and adjusted schedules.
- Alerts – Communicates service disruptions, temporary stops, and crowding levels.

These feeds allow third-party applications to display accurate vehicle tracking, predict arrival times based on actual conditions, and keep riders informed of service changes.

Adopting GTFS-RT as the standard for real-time transit data empowers riders to use the app of their choice for up-to-date travel information. Best practices for implementing GTFS-RT feeds have been developed by CAL-ITP, MobilityData, GTFS.org and others, and include the following:

[1] GOFS is an open data standard for demand response services

- Real-time data feeds (APIs) published at a public, permanent URL with an uptime of 99% or greater.
- Follow all the official [GTFS Realtime Best Practices].
- Realtime trip data should be provided for all routes.
- Realtime feeds should be provided for Trip Updates, Vehicle Positions, and Service Alerts.
- The transit agency must provide dependable information about trips and routes. Canceled trips, unscheduled trips, and detours must be provided. Additional information on this topic is provided in Recommendation #3 below.
- Create a documented process for improving data quality and supporting processes and technology.
- Update the Trip updates and Vehicle Positions feeds at least every 20 seconds.
- Known service disruptions should be published in advance. If it is a longer-term disruption and known in time to update the next published GTFS, it should be built into the GTFS. For short-term disruptions, those impacting the current published GTFS, or those without enough notice to update the next GTFS, the CAD/AVL systems disruption management tools should be used to relay the detour information to the public. Additional information on this topic is provided in Recommendation #3 below.
- Include the GTFS-RT feed on websites so they are easily discoverable.
- Publish links to global GTFS aggregators such as Transitland and the Mobility Database.
- Provide a way for individuals to report errors or inconsistencies within the GTFS.
- If an API key is required to access GTFS- RT feeds, the registration process should be available to everyone, straightforward, automated and transparent.
- Static GTFS are the backbone on which predictions are made, high quality accurate data is necessary.

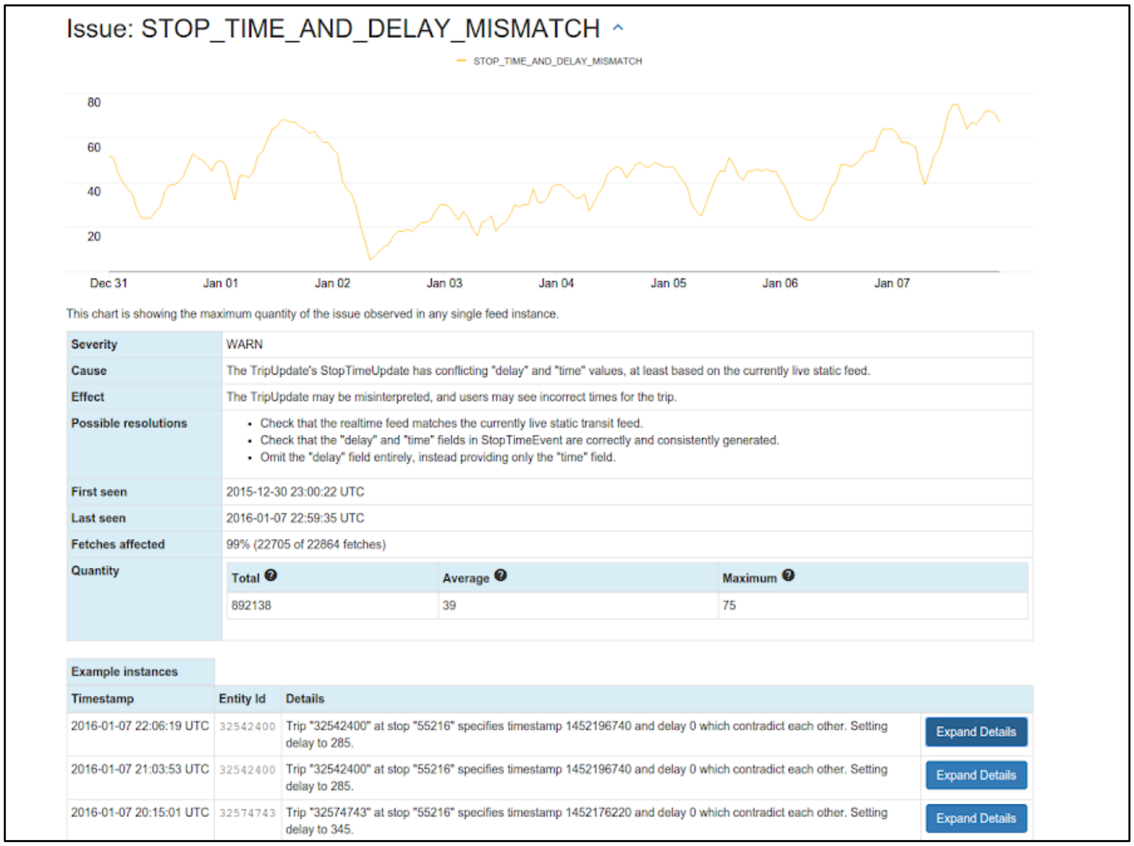
Once a GTFS-RT is initially published the agency is responsible for notifying trip planning applications such as Transit App, Google Maps, Apple Maps, Umo and others that it is available. Each application has its own process.

Recommendation #2: Monitor the Data Quality in Realtime Feeds

A challenge the transit agencies face is ensuring that passengers are viewing accurate, real-time transit information, especially on applications that the transit agencies do not have much control over. This includes third-party applications that are not contracted with the transit agencies, such as Google Maps and Apple Maps. While these apps utilize the feeds provided, each one uses different algorithms to predict arrival times. Transit systems should be monitoring their feeds for quality, stability, and coverage. The GTFS Realtime specifications must be consistent with the underlying static feed, required fields completed, and data must be pushed consistently. Google has a Transit Partner Dashboard that allows agencies to monitor the quality of their real-time feeds over time, refer to Figure 1-6 on the following page. Daily and weekly reports can identify feed issues that are categorized by severity, that can be used to identify causes and effects, possible solutions, when they occur, and how widespread the issue is. Often the issues identified have to do with underlying issues with the schedule data, hardware issues, modified routes, canceled trips, or not entering in detours.

Figure 1-6. Example of Feed Issue Summary from Google

Source: [Monitor the data quality in real-time feed]



Recommendation #3: Contact CAD/AVL Vendors to Determine System Upgrades and Configurations Needed

All five systems offer open access to GTFS and GTFS-Realtime (GTFS-RT), with feeds available directly through the GoTriangle Developer Resources page[2]. The method of feed generation varies by agency and depends on the CAD/AVL provider. Issues with the feeds often result from software configuration settings. Systems using Software-as-a-Service (SaaS) platforms receive automatic updates and always run the latest software version. In contrast, legacy systems require manual updates by the agency, which may involve additional costs. Running outdated software can limit access to new features, security patches, and performance improvements. Agencies should ensure they are operating on the latest version and work closely with their vendor to optimize settings and configurations for the most accurate and reliable GTFS-RT feed.

One example of a CAD/AVL system upgrade discussed under the Opportunities section of this chapter was related to a "disruptions" feature that allows dispatchers to actively use the CAD/AVL

[2] GoTriangle Developer Resources page available at: https://gotriangle.org/developer-resources.

software in real-time to manage transit trips, blocks, and routes that are not going as planned. Agencies can determine how this feature is provided from their CAD/AVL vendor and identify any system upgrades and/or configurations that may be needed to enable the use of this feature.

Also as noted earlier, the use of this feature should be guided by a standard process for how it is used, and training of those dispatchers can help ensure the use of sending out detour information is done on a consistent basis. This can help to improve the quality of information received by passengers who use a variety of mobile and desktop applications to perform trip planning and receive real-time transit information.

Recommendation #4: Provide Options to Passengers for Real-Time Transit Information

To encourage transit ridership in the region, transit agencies should identify various applications for passengers to obtain real-time transit information in the region. Communicating to passengers about the availability of this premium service is one way to provide an incentive for passengers to utilize the application for obtaining real-time transit information.

Other options for real-time transit information are available to passengers as noted within this document. Identifying those options as listed in Table 1-1 of this report for passengers on the agency websites may help to increase transit ridership given the options for how the information can be obtained.

Recommendation #5: Monitor Potential for Integration of Applications that Can Improve the Ease of Use of Transit Operations for Passengers

Agencies should continue to monitor opportunities to increase the integration of various transit software packages that are utilized by their agencies. These would be integrations that could increase the ease of using transit by passengers in the region.

Some example types of integrations that could be monitored by transit agencies for potential use in the region include the following:

- The Transit App could be integrated with Umo as an existing mobile fare collection system in the region. This integration with Umo could increase the ease of use of transit across the region for passengers using Transit App, but this approach may depend on whether the integration is successful in other areas of the country. It is recommended to monitor how this integration is performed in other areas of the country prior to considering this integration.
- The Transit App could also integrate with Swiftly as a Transit Service Planning tool, in which Swiftly provides real-time transit data, including vehicle locations and service disruptions, to the Transit App for it to present real-time transit information to passengers that use the Transit App. GoDurham has already completed this integration of Swiftly with the Transit App, which enables accurate, real-time transit information to be shared through the Transit App to passengers. GoTriangle has also been reviewing the potential to subscribe to the Transit App as well.

Recommendation #6: Enhance Trip Planning with Detour Notifications and Service Updates

Effectively communicating service changes—such as detours, stop closures, canceled trips, and last-minute updates—across multiple platforms is a persistent challenge for transit agencies. However, it is essential to ensure passengers receive timely, accurate, and dynamic information. While some service disruptions are planned, many occur unexpectedly.

Although dispatchers typically have tools to document these disruptions, the ability to relay this information in real time often depends on the capabilities of the agency's CAD/AVL system. In the context of GTFS-RT, such changes are communicated through the Trip Modifications feed.

To improve responsiveness and passenger communication, transit agencies should consider implementing tools that streamline the process of inputting detours, stop closures, canceled trips, and other real-time updates. Ideally, these tools would automatically integrate with the GTFS-RT Trip Modifications feed, ensuring affected stops and detours are properly displayed and canceled trips are removed from public-facing information systems.

Recommendation #7: Adopt Standards and Minimum Requirements for Location Sensing Components

A Global Positioning System (GPS)/Cellular Antenna is the most common onboard location sensor used to transmit a vehicle's location. The sensors accuracy depends on three components: location precision, polling rate, and latency. The location precision is how accurate the GPS is and is impacted by the antenna placement and the surrounding environment (buildings can reduce accuracy). The polling rate is how often the GPS pings the location, and higher polling rates equate to more frequent updates of the vehicle's location. Latency is the delay time between data collection and its display to users, such as a mobile app. A low latency provides information quicker and depends on system components, such as the GTFS-RT data publishing rate. Together, polling rate and latency determine how current the displayed data is, a high polling and low latency yield the most up-to-date information. Common standards used for these variables are as follows:

- Location Precision – GPS antennas should be mounted on the vehicle's exterior, be able to withstand a wide temperature range, various environmental conditions, and be able to go through an automatic bus washer. Antennas should have an accuracy of 10 feet, 95% of the time or more.
- Polling Rate – The minimum polling rate required by various real-time integrators is 30 seconds or less, with ideal polling rates closer to every 5 seconds. A minimum of 10 seconds or better should be adopted.
- Latency – 8 seconds or less from the time the vehicle is polled to when it gets to the GTFS-RT data feed.
- GTFS Realtime Publishing – GTFS-RT feeds should be refreshed at least every 30 seconds, with lower values more desirable. A study published through the Transit IDEA Program[3] showed that CAD/AVL systems were publishing real-time vehicle locations on average once every 15 seconds.

[3] https://onlinepubs.trb.org/onlinepubs/IDEA/FinalReports/Transit/Transit93.pdf

1.5 Roadmap and Resiliency Plan for Future Years

A roadmap with phased implementation steps is presented in Figure 1-7 below.

Budgetary considerations are provided in Table 1-2.

Table 1-2 presents a recommended split of the budgetary cost estimate among Wake, Durham, and Orange Counties based on a percentage of 2024 NTD hours within the region. The Year 1 total and subsequent annual yearly costs in Table 1-2 is multiplied by the percent of all NTD hours for each agency to arrive at the totals presented in Table 1-3. Note that these are planning-level cost estimates to guide Counties in planning for updates to the provision of real-time transit information in the region.

Figure 1-7. Roadmap of Implementation Steps for Real-Time Transit Information in the Region

Step 1: Establish GTFS-RT as Standard for Making Real-Time Transit Information Available Adopting GTFS-RT as the standard for real-time transit data empowers riders to use the app of their choice for up-to-date travel information.		**Step 2: Monitor the Data Quality in Realtime Feeds** Utilize Google Transit Partner Dashboard to monitor the quality of real-time feeds through daily and weekly reports to identify issues and possible solutions.		**Step 3: Contact CAD/AVL Vendors to Determine System Upgrades and Configurations Needed** Agencies should ensure they are operating on the latest version and work closely with their CAD/AVL vendor to maintain the most accurate and reliable GTFS-RT feed.
Years 0-1		**Years 1-2**		**Year 1-2**
Step 4: Provide Options to Passengers for Real-Time Transit Information Provision of value-added options for real-time transit information by all transit agencies allows for consistent, high-quality rider experience and improves coordination across the region's transit network.		**Step 5: Monitor Potential for Integration of Applications that Can Improve the Ease of Use of Transit Operations for Passengers** Can provide additional integration opportunities with other transit software packages, such as Umo and Swiftly, that agencies are familiar with in the region.		**Step 6: Enhance Trip Planning with Detour Notifications and Service Updates** Review the GTFS-RT Trip Modifications feed and capabilities of CAD/AVL vendors to implement tools that can streamline the process of inputting detours, stop closures, canceled trips, and other real-time updates.
Years 1-2		**Years 2-3**		**Years 3-5**
Step 7: Adopt Standards and Minimum Requirements for Location Sensing Components Identify common GPS/Cellular antennae that can be used to communicate vehicle location while meeting requirements on location precision, polling rate, and latency.				
Years 3-5				

Table 1-2. Budgetary Planning-Level Cost Estimates for Real-Time Transit Information

	Buses in Fleet	Value-Added Application per Vehicle (1)	Detour Notifications per Vehicle (2)	Service Update Alerts per Vehicle (2)	One-Time Costs (2)	Year 1 Costs	Annual Cost Estimate After Year 1
GoTriangle	82	$300	$550	$290	$405	$126,690	$93,480
GoCary	20	$300	$550	$290	$405	$30,900	$22,800
GoDurham	63		$550	$290	$405	$78,435	$52,920
GoRaleigh	135		$550	$290	$405	$168,075	$113,400
Chapel Hill Transit	99		$550	$290	$405	$123,255	$83,160
						$527,355	**$365,760**
1 - Average value based upon multiple existing contracts held by Cleveland RTA, SORTA, Utah Transit Authority, and Champaign-Urbana Mass Transit District. Contract values vary based on economies of scale for larger agencies and the Transit App features purchased beyond the core offer of Royale (fare payment integrations, Passenger feedback/Rate-My-Ride, automatic detour detection & Display, APIs for web-based trip planning, push notifications, network change previews)							
2 - Values based on the listed annual price per vehicle provided from a transit vendor to Citibus in Lubbock, Texas							

Table 1-3. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Real-Time Transit Information Updates

	2024 NTD Hours **	Percent of All NTD Hours
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		
Note: Cost estimate split is based upon percent of all NTD hours in region. GoTriangle hours are split 55/30/15 among counties.		

	Year 1 Total	Annual Total (Years 2-5)	Totals
Wake County Total	**$316,049**	**$219,204**	**$1,192,863**
GoRaleigh Estimate	$253,274	$175,665	$955,933
GoCary Estimate	$29,897	$20,736	$112,840
GoTriangle Estimate	$32,878	$22,803	$124,090
Durham County Total	**$133,591**	**$92,655**	**$504,213**
GoDurham Estimate	$115,658	$80,217	$436,528
GoTriangle Estimate	$17,933	$12,438	$67,685
Orange County Total	**$84,129**	**$58,350**	**$317,528**
Chapel Hill Transit Estimate	$68,748	$47,682	$259,476
OCPT Estimate	$6,414	$4,449	$24,209
GoTriangle Estimate	$8,967	$6,219	$33,843

Chapter 2. Transit Service Planning Tools

Vision: Enable staff across the region to have access to a suite of high quality, cost effective, and interoperable tools that facilitate the service planning process, and includes tools for scheduling, run-cutting, optimizing run times, optimizing on time performance, implementing service changes, publishing schedules and General Transit Feed Specifications (GTFS), and rider engagement.

Objective: The objective of this chapter is to address service planning technology recommendations for standards and features for regional interoperability.

2.1 Initial Findings and Opportunities

2.1.1 Summary of Current Conditions

Agencies in the Triangle Region rely on service planning technologies to analyze transit service data inputs from various sources. Service planning functions used by agencies in the region rely on quality information and systems to analyze transit data for route planning, scheduling, and tracking routes. These tools can also analyze ridership information and demographic data when making improvements to network efficiency, and system equity.

Technology Used for Service Planning

Core service planning software tools are visualization tools that allow for planning new services and analyzing operational data. Service planning tools rely on quality data and substantial systems to validate, manage, and report the data. Tools can range from spreadsheets to dedicated scheduling and simulation software. There are four core service planning areas that agencies and MPOs use to improve operational efficiencies, especially reporting. Service planning technologies perform:

- **Fixed route scheduling:** software to schedule fixed route bus service or change service.
- **Run-cutting:** software converts schedules into bus operator schedules.
- **Performance Analysis:** tool integrates historical data to analyze trends, aggregate information.
- **Integrated Planning Platform:** live dashboards and geospatial analysis tools analyze historical data and route scenarios for planning; leverage GTFS to reduce data integration.

Service planning tools are increasingly interoperable and subscription-based Software-as-a-Service (SaaS) products. Optional modules can supplement the base product offering. These modular add-on packages give agencies scalable options to meet the size and complexity of an agency. The ability to add Swiftly's module for APC (Hopthru) is a modular approach example.

Figure 2-1 illustrates a functional model that shows the technology interconnects and data flow for service planning.[4] Service planning technologies get on-board input systems such as Computer Aided Dispatch (CAD)/Automated Vehicle Location (AVL) systems, Automatic Passenger Count (APC) systems. This illustration shows the information required for the planning activity and the anticipated outputs presented by service planning technologies. In planning for technology upgrades, it is critical to capture the purpose for each data or information exchange. Vendors will want to understand the need for the information being communicated to ensure data is integrated.

[4] https://doi.org/10.1016/J.TRANPOL.2015.02.004

Figure 2-1. Service Planning Functional Model

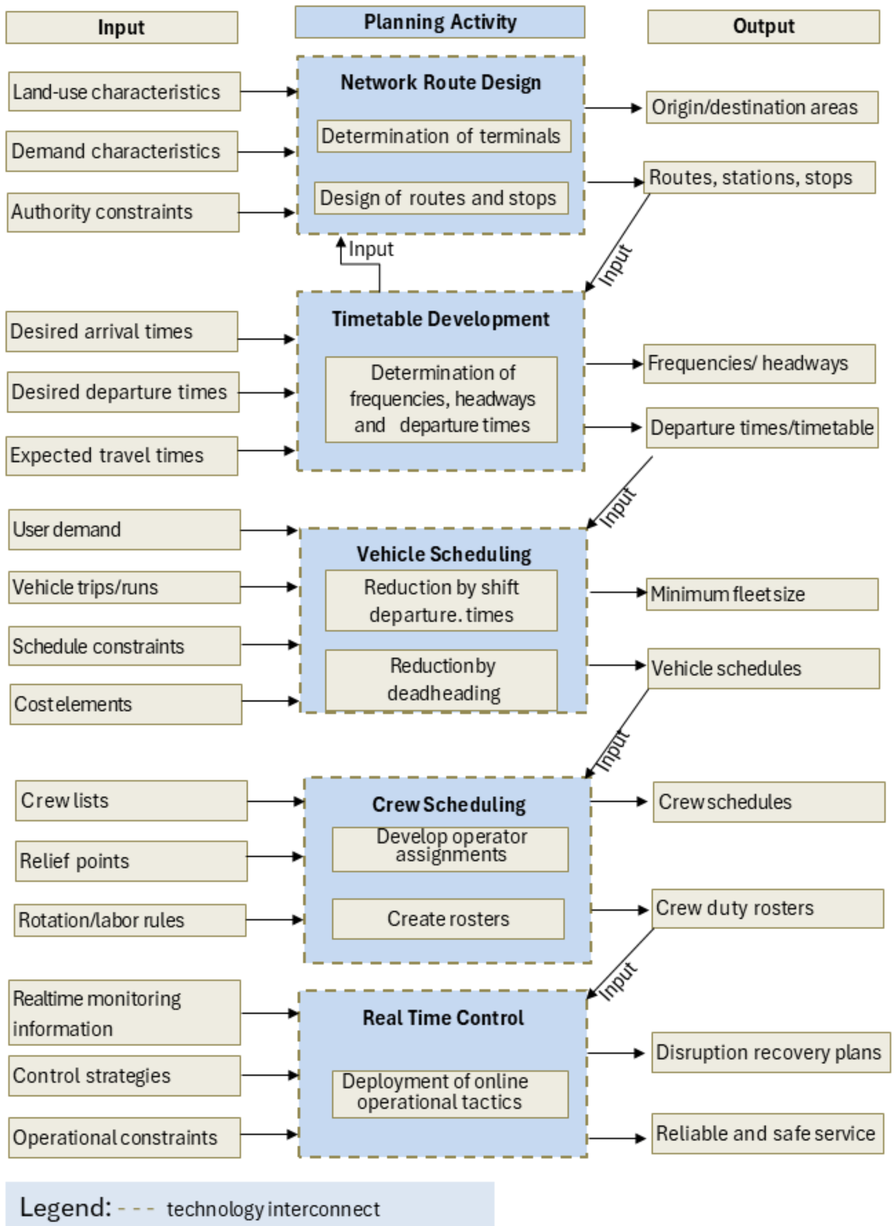


Figure 2-2 illustrates types of information that service planning tools rely upon for usable outputs. are complemented by on-board technology inputs and outputs in the Triangle Region. Since real time information and visualization dashboards are the forefront of robust service planning tools, on-board technologies like CAD/AVL and APC can also be considered inputs.

The potential for service planning to improve transit performance in conjunction with real time and on-board technologies is based on a foundation of integrated data from systems that are interoperable by design or by custom integrations like well documented advanced programming interfaces (APIs). Conditions for regional interoperability present when data from one agency can be seamlessly consumed by other agencies without requiring custom integrations like APIs. Others can be manual workarounds like data 'scrubbing' or uploading GTFS feeds two or more times to ensure it is properly replicated any consumable for the GTFS-RT feed.

Figure 2-2. Survey Responses: Service Planning Software Tools by Agency and Function

Agency	Transit Service Monitoring Tools	Service Change Planning Tools	Run-cutting/blocking tools
CAMPO	--	Remix	--
GoTriangle	CAD/AVL system- -TripSpark ViewPoint from TransTrack for analysis and dashboards APC ridership counts-UTA	Swiftly and Remix	TripSpark and Trapeze systems
GoRaleigh	CAD/AVL reports-Clever Devices APC ridership counts-UTA	Remix	Optibus used by RATP-Dev for run-cuts
GoRaleigh MicroLink	Proprietary platform operated by Via Transportation. (RATP-dev)	Proprietary platform operated by Via Transportation.	Proprietary platform operated by Via Transportation.
GoDurham	APC ridership counts-UTA OTP- Swiftly	Remix Swiftly	Optibus used by RATP-Dev for run-cuts
GoWake Access	*GoCary provides:* CAD/AVL System-TripSpark Hopthru (Swiftly) *GoTriangle provides:* CAD/AVL system- TripSpark APC ridership counts – UTA	*GoCary provides:* TripSpark streets report Remix *GoTriangle provides:* Swiftly and Remix	*GoCary provides:* TripSpark streets report Remix *GoTriangle provides:* TripSpark and Trapeze systems
GoCary	CAD/AVL System– TripSpark Hopthru (Swiftly)	TripSpark Streets report Remix	TripSpark Schedule MV (service operator) makes run-cuts- Optibus
Morrisville	*GoCary provides:* CAD/AVL System– TripSpark Hopthru (Swiftly) Via platform for real-time data dashboard tracks and manages trips. Send updates through app (push/in-app notifications)	*GoCary provides:* TripSpark streets report Remix	*GoCary provides*: TripSpark schedule MV (service operator) performs run-cuts- Optibus. Via to manage driver's shifts
Apex	*GoCary provides:* CAD/AVL System- TripSpark Hopthru (Swiftly) Apex: Spreadsheets	*GoCary provides*: TripSpark streets report Remix Apex: Spreadsheets	GoCary provides TripSpark streets report Remix Apex: Spreadsheets
Orange County	EcoLane TransTrack for analysis and dashboards	Remix - GIS	EcoLane
Chapel Hill Transit	CAD/AVL System- GMV (OTP) APC ridership counts- UTA	Optibus	Optibus
UNC-Chapel Hill	CAD/AVL System- GMV (Fixed route buses)	Vendor GMV and Spare (pilot for on-demand service)	Operator uses GMV and Spare pilot for on-demand service with point-to-point app with a built-in trip planner
GoWake Forest	Proprietary platform operated by Via Transportation.	Proprietary platform operated by Via Transportation.	Proprietary platform operated by Via Transportation.
NC State Wolfline	CAD/AVL System- Passio (data reports, fleet status, GTFS-RT) APC ridership data-Hopthru (Swiftly) NTD ridership data-UTA	Passio	Operator, Transdev, uses Hastus

Types of Service:

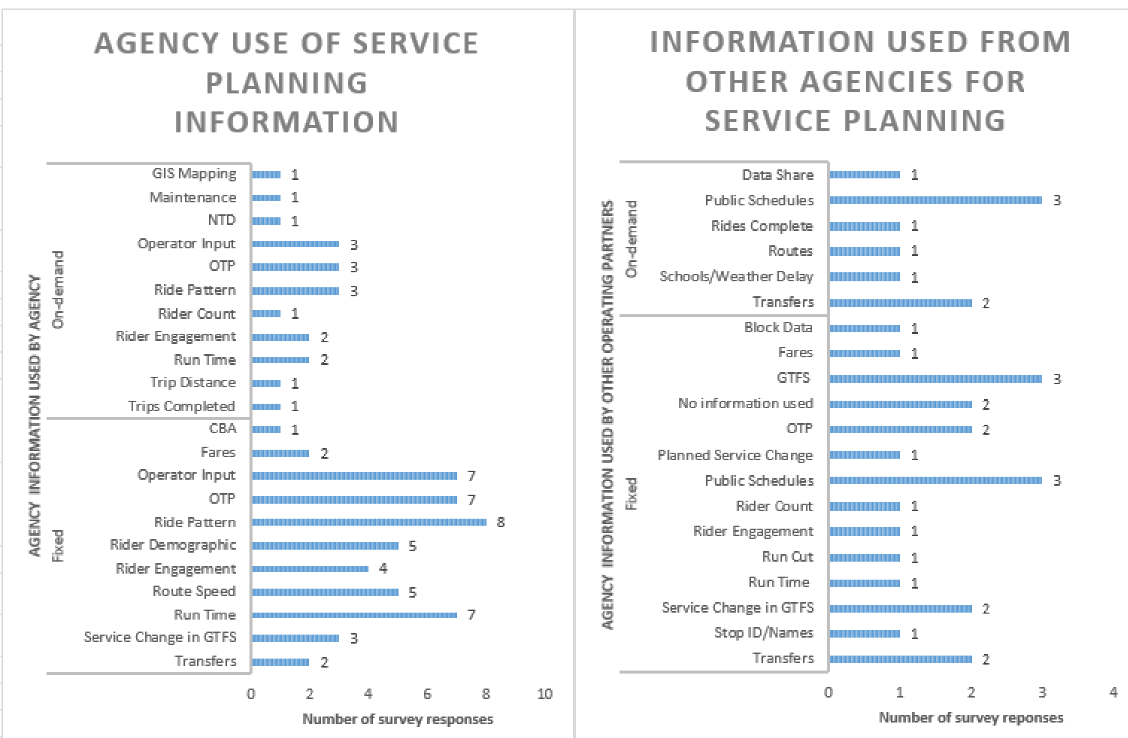
Fixed and on-demand services used in the region traditionally benefit from different service planning tools. Fixed route services feature repetitive trips, fixed stops, and scheduled arrival/departure times. The dynamic nature of on-demand services leans heavily on routing algorithms. On-demand transit is often characterized by dynamic changes, dispatching, and vehicle location information. Examples in the region are microtransit, curb-to-curb shuttles, senior shuttle, non-emergency medical transit (NEMT), and paratransit services.

Information Used for Service Planning

The size of the agency and the service types provided can help determine the need for automated analysis and advanced planning tools. For example, analyzing performance issues for a two-route service is less complex than performance analysis for an urban, larger scale service.

When surveyed, most agencies use information from other agencies such as public schedules, GTFS feeds, timed transfers, and service change proposals Some agencies also incorporate data like on-time performance, fare use, rider engagement, and geographical demand. Figure 2-3 classifies the type of information that agencies use when planning transit service. The bar chart on the left highlights the most common types of information agencies use for their own service planning. The bar chart on the right shows the types of information that agencies seek from other agencies.

Figure 2-3. Types of service planning information used by agencies in the region by service type



The responses are classified by service type (fixed and on-demand) to reveal different informational needs. Fixed routes include university shuttle services, Chapel Hill Transit, Orange County Public Transportation, GoDurham, GoRaleigh, and GoTriangle. The on-demand service classification groups GoRaleigh Microtransit, GoWake Access, GoWake Forest, GoCary, and the Morrisville Smart Shuttle service.

Criteria for Making Service Changes

Agencies consider multiple factors when making service changes. Factors like ridership patterns, on-time performance, run times, fare use, rider demographics, operator input, and proposed service changes in GTFS help to analyze service. Some agencies, like Wake Forest, focus on monitoring travel patterns to identify areas for improvement. Others, such as GoTriangle, follow comprehensive evaluation processes, including cost-benefit analysis and collaboration with service providers. Figure 2-4 builds upon initial survey findings presented in 2025. It presents a summary of the items considered by transit agencies when making service changes.

Figure 2-4. Information used for Transit Service Change Decisions

Transit Agency	Ridership patterns	OTP	Run Times	Fare Data	Timed Transfers	Operator Input	Other
GoCary	X	X	X			X	Rider engagement data
GoRaleigh	X	X	X		X	X	
GoDurham	X	X	X		X	X	Rider engagement data Ridership demographics Proposed service changes in GTFS Route/segment speeds CBA Guidelines
GoTriangle	X	X	X	X	X	X	Rider engagement data Ridership demographics Route/segment speeds
Chapel Hill Transit	X	X	X			X	Ridership demographics Rider engagement data, Route/segment speeds
Town of Apex	X	X	X			X	
NCSU Wolfline	X	X	X			X	Route/segment speeds Road closures on campus
UNC-Chapel Hill	X					X	Rider engagement data Proposed service changes in GTFS
Orange County	X	X	X	X		X	Ridership demographics Route/segment speeds

Time-Consuming Activities and Time Spent Using and Troubleshooting Tools

Agencies reported a wide range of time commitments for using and troubleshooting transit service planning tools. Agencies like NCSU Wolfline, Morrisville, GoCary, and UNC Chapel Hill reported moderate usage, with time spent on service monitoring ranging from 10 to 60 hours per month, service changes requiring 4 to 120 hours per change, and run-cutting averaging 4 to 15 hours per run. Troubleshooting for these activities typically required 2 to 20 hours per month.

On the other hand, agencies such as GoRaleigh, GoTriangle, and GoDurham reported significantly higher time investments. Service monitoring for these agencies ranged from 160 to 560 hours per month, service changes took 120 to 160+ hours per change and run-cutting required 270 to 600 hours per run. Troubleshooting hours for these higher-use agencies were generally within the same range as others, averaging around 8 to 20 hours per month. This contrast reflects differences in operational scale and complexity, with some agencies managing more extensive or resource-intensive planning activities.

The limits of the survey do not cover the specifics of the troubleshooting reported by agencies. Still, the operational toll on continued troubleshooting should be considered when assessing the value that a service planning tool delivers to an agency. In one instance, GoRaleigh reported that troubleshooting necessitates additional database updates from its provider. GoRaleigh must balance between updates for changes that are required and updates to service changes due to troubleshooting.

Whether the agency operates the service or whether the agency has a private operator also factors into use and scale and type of service planning tools. Private operators for agencies in the region typically have national contracts with service planning vendors. Due to these company-wide partnerships/contracts, agencies using private operators are typically tethered to operator's products like service planning tools.

Still, agencies can then leverage innovations and service planning dashboards or software as part of the private operator contracted services. Agencies surveyed indicate having access to the service reporting (OTP, APCs) and others have dashboards to plan and monitor service. Depending on the future agency needs, there may become a time to take control of the analytic sources that drive the Key Performance Indicator (KPI) metrics.

2.2 Noted Challenges

The most notable challenge for transit agencies in the region is **ensuring service reliability**. Operator staffing coverage and recruitment, exposure to delay from long, cross-county routes, and peak traffic patterns impact service in the Triangle Region. The area's rapid growth compounds the challenge even as agencies program for transit infrastructure like enhanced bus stops and sponsored capital projects like the Raleigh Union Station Bus Facility and the Triangle Mobility Hub.

Agencies noted challenges and desired improvements related to service planning tools, including:

- **Lack of customization and usability**: Develop a more simplified processes, flexible data customization, and real-time traffic integration (GoCary, GoTriangle).
- **Better integration and accuracy**: Improve integration between tools like Optibus, Remix, and AVL platforms to ensure timely updates and accurate information (GoRaleigh, Chapel Hill Transit, GoTriangle).

- **Greater regional collaboration**: Currently, operating partners have independent service planning solutions and contracts that are not necessarily aligned in scope, terms, and duration with others in the region. Agencies in the region have differing contracting mechanisms that are specific to that agency. Regional members have expressed interest in a regional standard and centralized platform for inputs from service providers to enhance coordination and regional impacts. (CAMPO).
- **Enhanced visualization and analysis**: Improve web-based visualization and integration with transit tools for TSP, BRT, and microtransit (GoTriangle).

Other notable challenges include:

- **Technologies vary by service type:** There are different technological offerings used in the region for fixed and on-demand (demand response) service. However, the industry's push for greater mobility is starting to suitably combine on-demand and fixed-route, within service planning solutions. Some even offer visibility into taxis, bike and other TNCs.
- **Third parties:** Solution providers and private operators often provide dashboards and reports, but flexibility that comes with true interoperability remains a challenge. Data may or may not be fully available to agencies. Also, private operators may have revenue-based considerations that may conflict with optimal scheduling for rider convenience on local routes or for regional connections.

The task of reviewing and coordinating data for consumption is a key step in service planning across multiple agencies. Naming conventions for routes, cost structures, contract durations, workflow efficiencies, adaptability, and intra-agency coordination are required tasks when moving towards an interoperable service planning solution for the region. Still, there are many opportunities for innovation in the region.

2.3 Opportunities for Innovation and Collaboration

A high-quality selection of service planning tools with modular solutions is available today. There is healthy vendor competition with Software-as-a-Service (SaaS) solutions that are cloud-based, scalable and increasingly interoperable. First-adopter lessons are abundant, and it is known that structured data drives interoperable systems that enhance transit reliability. **Riders have greater trust in reliable transit**. Section 2.3.3 illustrates how data and interoperable service planning tools were key to improving reliability of BRT routes in Seattle alongside capital improvements.

2.3.1 Improved Analysis

Interoperable technology software gives agencies the ability to consider more data for better decisions about service planning by accessing data from other agencies/MPOs. Regardless of the technology and how it is integrated, service planning tools used by agencies in the region must reflect their own unique needs of urban, suburban, or rural areas, to continue improving reliability, efficiency, and equity.

Service Planning technologies provide a range of functionalities that can be scaled to agency needs, such as:

1. **Integration Capabilities:** Promotes data sharing with other service planning tools that are used in the region. These integrations could be natively interoperable or by APIs.

They serve to increase data flow related to services between agencies in the region or even within the agency itself.

2. **Service Schedules:** Assists with the creation of timetables, route drawings, and bus stop locations/shapes.
3. **Data inputs-outputs:** Ingests and processes GTFS data for static schedules, routes, stops, and fares; ingest and process GTFS-RT for vehicle location and service updates.
4. **Route and schedule planning:** Visualizes transit network for service planning staff to use in reviewing potential impacts to routes, stops, and schedules.
5. **Service Analysis:** Simulates a full range of service planning options from full network redesigns to small service adjustments. Recommendations can be made for optimal fuel efficiency, minimal travel times, or other coverage outcomes. Visualization of arrival times allows agencies to see which routes are not performing as expected at various times of the day, which helps diagnose transit issues in a more efficient manner.
6. **Demand forecasting:** Uses data from mobile apps, APCs sensors, or ticketing systems to analyze future demand.
7. **Flexible timetables:** Uses real-time conditions to create a flexible, adjusted timetable in response to unexpected events/disruptions so expected bus arrival times can be maintained.
8. **Passenger flow:** Collects data from on-board cameras, APC, smartcard taps, and other inputs to analyze passenger flow.
9. **Real-time monitoring:** Integrates with traffic cameras and bus GPS systems to suggest alternate routes in the event of disruption.
10. **Visualization of real-time:** Presents historical data to guide service planning staff by estimating vehicle arrival times along routes and provides visual insights into overall system performance.

2.3.2 Interoperability:

Interoperability refers to tools that exchange information between independently built systems typically by following standards to "talk" to one another to maximize visibility while minimizing data silos. Interoperability results in greater agency coordination opportunities, better analysis of service route efficiencies, and increased reliability to customer-facing tools.

Strategic state, regional, and local goals are in alignment for greater interoperability of transit services in North Carolina (e.g., NCDOT's Strategic Plans, NCDOT's Integrated Mobility Division, and Short-Range Transit Plans in the region). Interoperability goals are mirrored nationally with FTA circulars, APTA working groups, and coalitions like Mobility Data Interoperability Principles (MDIP).

MDIP promotes idea that that open standards for non-sensitive transit data are key to keeping up with the fast pace of technology. It helps connect service planning data, allows systems to work together, and allows agencies to grow as needs grow. Essentially, since GTFS is a common standard to format transit data feeds, future tools can be developed using that same standard for data integration with existing systems.

For example, service planning technologies that are interoperable demonstrate operational resiliency to changes in components that may occur over time (like CAD/AVL systems). Interoperability standards like a static GTFS feed providing real-time GPS coordinates should allow service planning tools to produce the same type of visualizations and dashboards for staff regardless of the hardware vendor chosen for CAD/AVL operations.

2.3.3 Service Planning Multiple Service Types

There is an opportunity for agencies throughout the region to use GTFS beyond schedules, routes, and fares for fixed route service. In 2024, GTFS Flex was folded into the base GTFS standard to facilitate discovery of on-demand transit services. There are now specific fields to populate on-demand information into the static GTFS data feed. Another data feed standard is the General On-Demand Feed Specification (GOFS). GOFS is an open data standard that provides real-time information for on-demand services like taxis and ride hails alongside on-demand offerings by transit agencies. As of September 2025, Mobility Data will continue development of the General On-Demand Feed Specification (GOFS) originally developed by Transit App as GOFS-lite. Reporting GOFS data to NTD is unlikely in the near term given the interface with private transportation network companies and focus on real-time data.

Sharing Real Time Information:
Real time information communicated through the CAD/AVL is output in a GTFS format so that GTFS can be consumed by service planning tools. When this common data (e.g., GTFS, GTFS Flex GTFS-RT) is regionally consistent and complete, it is useful data. Creating a reliable data feed means agencies must ensure data is consistent. For example, two separate agencies may have slightly different coordinates for shared bus stops or shared facilities. The shared area must be a complete match for machine language to provide a correct output.

Agencies have an opportunity to consume and analyze it to better understand performance trends in a regional transit ecosystem. Reliability, visualization, and predictive arrival time rely on GTFS data feeds that are provided by robust on-board AVLs that regularly report vehicle location. Real-time information is helpful to agencies for:

- **Performance** data for scenario planning is available to create more accurate and reliable transit schedules. Staff will also see travel speeds and dwell times for different routes, which in turn allows them to create more accurate transit schedules that better reflect actual travel times. The peer example below discusses creative way Sound Transit partner, King County Metro, helped restore reliability of service to BRT lines in Seattle.
- **Information** to trip planning apps can be facilitated through production of a data feed following GTFS-RT). This real-time data can be used to provide next-vehicle arrival information to passengers. Trip planning data can also be analyzed by service planning tools to generate statistics about trip performance for service planning improvements.
- **Locations** of vehicles along a route as part of a future Transit Signal Priority (TSP) implementation in the region. Integration with cloud-based TSP vendors can allow for sending TSP requests when buses meet a schedule adherence threshold to cloud-based TSP software systems.

Advantages of using shared real-time data in planning and operating services are documented by a recent pilot study by Sound Transit partner, King County Metro. In 2023 they performed a service change because of operational challenges resulting from lack of operators. They reduced service on BRT lines to curtail the unplanned trip cancellations and restore a sense of service reliability to passengers. Metro used technology along with these strategies to help restore consistency and frequency of BRT service. In 2024 they launched a new scheduling scheme and 'Advanced Service Management' (AMS) pilot on two BRT lines flagged for reliability.

AMS is a combination of transit infrastructure improvements and street design, staff collaboration, and transit technology. Much like service in the Triangle Region, Metro's AMS BRT pilot used a headway-based system where buses were scheduled to arrive at a set interval (e.g., every 30 minutes), not an arrival time scheduled to the clock (e.g., 3:54 pm). With on-board communication inputs and outputs, Metro staff coached operators in real time to solve problems like re-routes, detours, break times, etc. to keep bus headways properly spaced. Operators along the pilot routes could slow or increase speed to prevent 'bus bunching.' [5]

Metro synchronized its real-time technology so that bus operators and passengers waiting at stops could receive information relayed by the Metro team. The pilot also showed improvements in the rider-experience. The success of the pilot means that Metro will continue to invest in technology that will support active headway management for BRT since it can increase headway-based schedule reliability without adding service hours.

In this example, complementary strategies are used in combination to help to improve reliability across the system. Metro's reliability with its Advanced Management System practice described above and infrastructure investments like queue-jumping designs are factors in reducing the need to invest in additional service hours.

2.3.4 Capital investment insights

A regional service planning analysis backed by measurable data could inform operating partners, as a region, about where capital investments should be made to maximize capital budgets. The tools can analyze data and inform agencies about the:

- number of buses needed for revenue service,
- estimates of in-service costs and vehicles hours,
- visualization of service routes in different scenarios for OTP and impact to travel times,
- analysis of demographics and Title VI impacts when considering route changes,
- data collection to help long range planning,
- analysis of station passenger flow and of strategies to optimize, and
- use of micromobility/on-demand service modes as part of service planning.

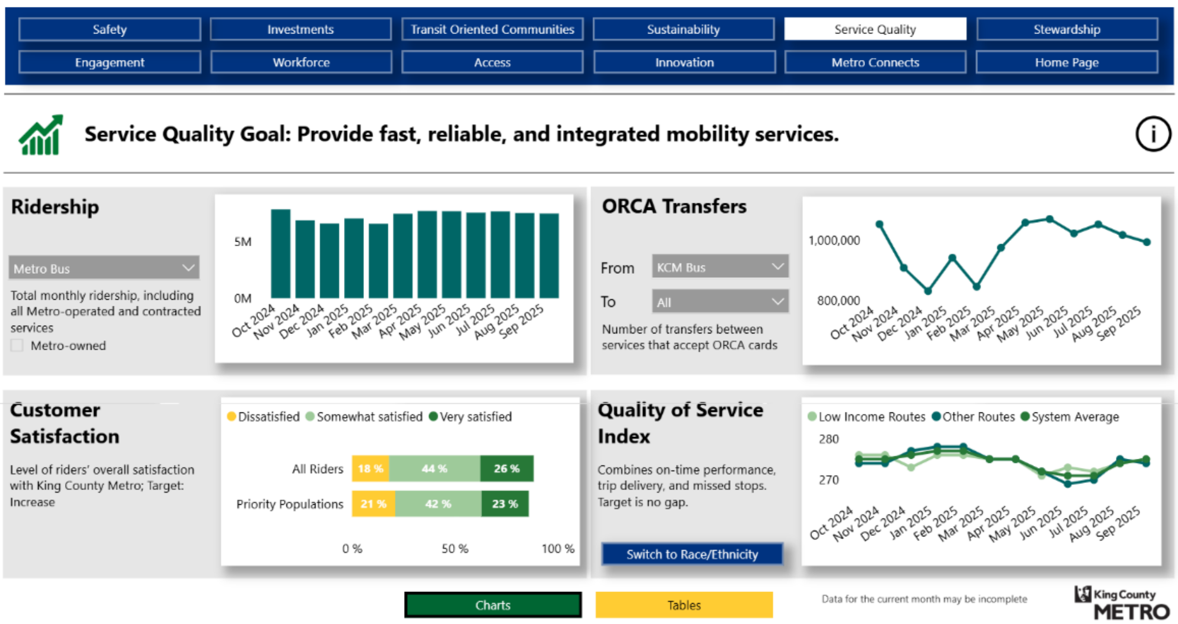
Individual agencies use tools to analyze service change scenarios, arrival/departure times, and ridership metrics to drive decisions. The ability to display information that is aggregated from individual agencies has the potential to give *local* planners *regional* visuals of route scenarios when analyzing their service.

In a broader application, King County Metro budgets for operation costs to cover Power BI dashboard to demonstrate progress on strategic goals in region. Each area measures the successes of their King County Metro long range vision Plan, known as *Metro Connect*. Figure 2-5

[5] https://cdn.kingcounty.gov/-/media/king-county/depts/metro/documents/about/data-and-reports/2024/2024-system-evaluation.pdf

shows the aggregated data from strategies developed to improve mobility in the region[6]. Service Quality is one of twelve strategies that Sound Transit partners use to gauge continued improvements identified in *Metro Connect*.

Figure 2-5. King Metro Dashboards



Link

Observations noted in King County Metro Connect open data portal include:

- Align service with existing workforce capacity, even if there is a reduction in service.
- With SaaS delivery, commercial 'off the shelf' (COTS) tools give agencies options to 'right-size' service planning tools with optional modules. Once deployed, agencies will need to budget for specialized data management staff to maintain in-house service planning expertise.
- Include technology as an operational necessity in long range plans, keeping reliability as a key indicator to attract ridership.
- Service planning tools that consume another agency's routes can show planners any potential route conflicts or redundancies when designing routes or modifying service. Agencies are in a better position to revise or design their own routes if other agency routes are visible. For example, the route expansion described in the Wake County Bus for 2030 plan extends service into areas that may potentially have competing services in the future.
- Educate stakeholders about the full development cost of interoperability. Upfront costs have future operational benefits like fewer manual or automated workarounds that risk

[6] Microsoft Power BI

system reliability and customer satisfaction. Interoperability is globally recognized as a cornerstone for transit mobility.

2.4 Recommendations for Service Planning Tools in the Region

Given the existing service planning technologies and tools, agencies in the region have a workable path to greater service planning interoperability while keeping existing systems in place. Depending on agency need, age, and the remaining useful life of the system in place updates to service planning technologies may or may not make financial sense. Agencies in the region may benefit most from adopting a blended approach. For instance, core service planning functions such as route design and service performance tracking can be managed locally with a combination of service planning tools used by agencies independently, much like is the case today.

This hybrid strategy maintains access to specialized agency features, while still building a foundation for regional transit network. In environments where resources are limited and service expectations are high; such an approach not only reduces risk but also improves scalability and resilience as transit systems evolve in the region. Interoperability between software presents data to provide knowledge about options that make transit more attractive.

Recommendation #1 Consider Modular Service Planning Tools

Service planning software that supports modular phased growth with open data standards is recommended. Both characteristics provide flexibility for the region. Since open data is standardized for consumption, service planning tools that use open data are interoperable in almost all cases. Modular service planning solutions are typically Commercial-off-the-shelf (COTS) solutions which are products that have been built, tested and optimized to meet typical service planning needs. COTS products tend to require less time for agencies to deploy and generally offer a more economical solution. Products are scalable and supported by regular updates. Standardized interfaces between existing agency software and hardware and assuring interoperability are common terms in vendor agreements.

Recommendation #2 Commit to Interoperability

NCDOT is part of a co-author coalition responsible for the Mobility Data Interoperability Principles (MDIP) where open standards drive interoperable technology components that work together in real time and with standard data formats. Following MDIP, the main focus in the region is the continued effort to standardize data from disparate platforms used by operating partners. Without a clear commitment to interoperability, stakeholders in the region are restricted from realizing the full benefit of achieving a regional approach to service planning.

Currently, each agency currently uses a combination of policies, processes, and software tools to provide information about designated service routes and perform their respective service planning activities. To some extent, agencies and MPOs consume data from the others to visualize the region's network of transit services to the extent possible.

During the planning of service changes, insights into another agency's services could minimize the potential for route overlaps which could lead to cannibalization or rider confusion. In a rapidly growing region, ability to visualize and plan from the perspective of multiple agencies in a transit network gives *regional* insights to *local* transit planners.

Interoperability between service planning tools requires less of a customized integration effort (APIs) when data is presented in a format that is ready for consumption (e.g., standards like GTFS, GTFS-RT, GOFS, etc.). Interoperability through integration between Transit App and Swiftly was discussed in Chapter 1. It is another example where information that one software provides can be used in another software tool to inform planners of options that make transit more attractive.

Further, without standardized data in a common format, tools lack the ability to function in a reliable manner without tedious work-arounds to transform data or by a process that is not automated. In these cases, there is little value in investments like modules that use artificial intelligence or machine learning since the module relies on data that appears in a standardized, consistent format.

Benefits of greater interoperability and fewer integration efforts to make disparate technologies work together are evident in operational costs. Although setting up an interoperable region using open standards might lead to higher initial spending, such investments generally pay off over course of time by significantly reducing operational costs. For instance, when systems are interoperable, there is less need for additional tools used to manage data transformation, which can lower expenses related to data conversion processes. Additionally, open standards simplify staff manual work tasks by eliminating the need to perform tasks that should be automated. For example, manual entry of GTFS/GTFS-RT feeds into multiple systems for trip planners to ingest. Operational incentives to move towards increased interoperability include:

- Integration costs can be upfront or ongoing; however, open standards and interoperability typically lead to long-term cost savings.
- Reductions occur in areas such as data conversion tools, staff onboarding, maintenance, and repetitive manual data entry.
- The gains in system flexibility and reduced error rates can further contribute to operational savings and improved revenue potential over time.
- Educating decision-makers about these benefits is essential to avoid sacrificing long-term advantages for short-term cost concerns.

Recommendation #3: Principled Approach to consider new technology

It is likely that agencies seeking service planning technologies will have greater and perhaps different technological solutions available in the near term. To help with this, the Mobility Data Interoperability Principles Coalition developed five principles of interoperable transit technology to help navigate technology decisions. [7]

1. All systems creating, modifying, or consuming mobility data should be interoperable.
2. Interoperability should be achieved through the development, adoption, and widespread implementation of open standards that support the efficient exchange and portability of mobility data.
3. Transit agencies and other mobility service providers should have access to tools that present high-quality mobility data accessibly, equitably, and in real time to assist travelers in meeting their mobility needs.

[7] https://www.interoperablemobility.org/

4. Transit agencies, other mobility service providers, and travelers should be able to select the transportation technology components that best meet their needs.
5. All individuals and the public should be empowered through high-quality, well-distributed mobility data to find, access, and utilize high-quality mobility options that meet their needs as they see fit, while maintaining their privacy.

The principles quoted above MDIP serve as guideposts for current technologies or future technologies yet to be developed. Still, new, or break-out technologies should be carefully vetted, especially those that lack competition or interoperability features.

Recommendation #3: Use procurement strategies to align technology

It is recommended that agencies in the region consider using a conformed RFP so functionalities, requirements, terms (e.g., service level agreements), and metrics (e.g., KPIs) are consistent in the region. Procurement documents should clearly outline the requirements and remedies to ensure scope is met.

The State's Integrated Mobility Division established four vendor purchasing contracts[8] for ride scheduling software for the following vendors, RideCo Us, Inc., Spare Labs, Inc., Via Mobility, and TripMaster. This statewide contract option aims to lessen the administrative burden of agencies having to develop an RFP. That way the agency can focus on other parts of their own procurement. Towns and municipalities throughout the Triangle Region could leverage a statewide contract to support service planning and scheduling fixed route and on-demand transit service in their areas.

Alternatively, agencies can explore The California Integrated Travel Project (Cal-ITP)[9], an industry collective that offers vetted procurement resources for transit agencies and templated contracts with vendors. Cal-ITP has a marketplace to allow transit agencies to join group procurements. Even if agencies do not join procurements, Requests for Proposals (RFPs) and contracts are available with agency registration. If a unique RFP is required, the Mobility Data Interoperability Principles Coalition provides example language to include interoperability in a transit technology procurement.[10]

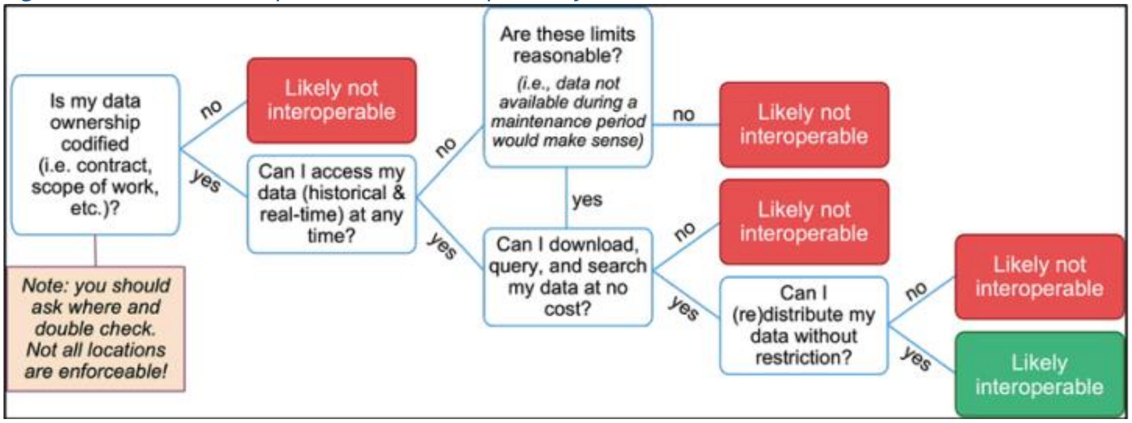
Recommendation #4 Service Planning Vendor Discussions

Vendor discussions that leverage existing tools are an opportunity to implement a common core set of service planning technologies throughout the region. In the beginning of this chapter, Figure 2-1 shows many of the same service planning technologies are used by multiple agencies today. Agencies could have a consistent platform throughout the region while still being able to configure individual software setups unique to their operating requirements. It is important to remember that each product (or module) of vendor's offering may not have the same level of interoperability and conversations for each module should occur. Inquire directly with vendors about how interoperability is achieved with their solution or solutions.

[8] https://connect.ncdot.gov/business/Transit/Pages/Transit-Procurement.aspx.
[9] https://www.camobilitymarketplace.org/contracts/
[10] https://www.interoperablemobility.org/

Should agencies elect a different technology set up, it is recommended that integration with disparate systems be included as a requirement in the procurement documents to ensure the data is consumable and available to use by others.

Figure 2-6. Data ownership/access and Interoperability



Finally, before procurement starts, it is important to clarify that agencies can use service planning data without restriction. Vendors or even private operators for service may have a data policy with limitations with, for example the number of reports provided or ability to customize for ad-hoc reports. The logic flow chart illustrates one of many series of questions developed by the National Center for Applied Transit Technology (NCATT) to be asked by agencies when interviewing vendors. Figure 2-6 shows the line of questions is specific to understanding the use and ownership of data service planning tools can provide.[11]

Recommendation #5: University feedback loop

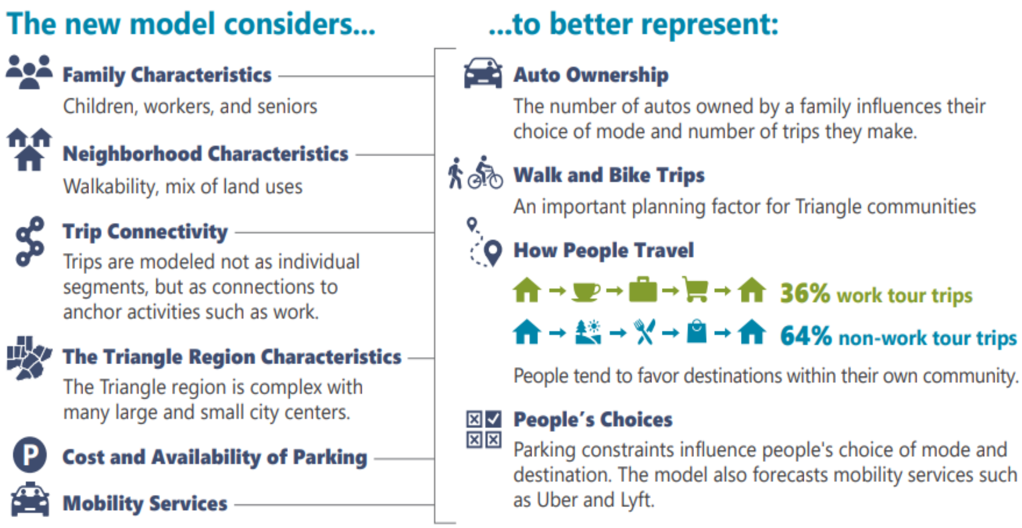
Transit is increasingly reliant on a data-rich environment to accomplish efficient and smart transit. The region has major universities and colleges. The Institute for Transportation Research and Education (ITRE) is a source for potential internships or studies given their institutional insight into NCDOT and regional technology studies they perform.

University partnerships can be an opportunity to further develop a feedback loop for regional data points that are studied at the university and used in the region for service planning. The Triangle Regional Model Generation 2[12] now includes a regional aspect and trip connectivity, as shown in Figure 2-7. These advances lead to improved visualization and scenario planning to help inform decisions in the region. This is an example of the potential synergies between universities, the State, and the transportation planners in the region since 2021 funding started. Cooperation with the Triangle Regional Model effort complements precluding agency modeling currently performed. It would not replace it.

[11] https://n-catt.org/guidebooks/mobility-data-interoperability-principles-mdip-translation-guide/

[12] https://itre.ncsu.edu/wp-content/uploads/2023/05/Triangle-Regional-Model-Factsheet-4-24-23.pdf

Figure 2-7. Triangle Regional Model Generation 2 improvements



Recommendation #6: Service Planning Technology Integration

Currently, agencies in the region use many of the same vendors for service planning activities. The use of these modular SaaS solutions here is efficient and should continue since they are designed to grow with agency need. However, variables like types of service (fixed route, on-demand), agency size, and contractual agreements with private operators greatly influence the function, scope and even interfaces with other operational technologies (i.e., APC and CAD/AVL). Because of the sizes and different services agencies provide, the technological solutions should be tailored to each agency while still having the ability to share information with the region.

Transit service planning tools are used in conjunction with one another to fulfil service planning tasks. It is for that reason that adopting new technologies for service planning must be able to integrate with legacy systems that would remain operational in the region. Efforts to integrate legacy or new service planning tools are less complex when data is presented in standardized, interoperable format that is ready for consumption (e.g., GTFS, GOFS, etc.). Integration is facilitated by using service planning products that have APIs with open licenses and that are compatible with open-standard terminology and fields. In doing so, service planning tools use transit data to analyze operations for route efficiencies, run cut scenarios, and capacity planning.

As noted earlier, surveys, strategic plans, and investments indicate that agencies are aligned with goals to promote a rider-centric transit system. However, adopting a rider-centric focus in a multi-agency region promotes a change in internal agency workflows and greater data sharing of operations data, with technologies that are inherently interoperable or made to be interoperable by integration efforts like APIs. A multi-agency approach to service planning efforts at a regional level often includes processes and working groups to ensure stakeholder engagement before, during and after technology is implemented.

2.5 Roadmap and Resiliency Plan for Future Years

A roadmap with phased implementation steps is presented in Figure 2-8 below.

Budgetary considerations are provided in Table 2-1.

2.5.1 Service Planning Tools Roadmap

Figure 2-8 presents a roadmap that takes into consideration existing service planning tools and ongoing efforts to standardize and then integrate data. The steps are proposed over five years of time but may stretch into shorter or longer periods based on progress made by transit agencies with respect to service planning and regional operations.

Figure 2-8. Roadmap of Recommendation Strategies for Service Planning Tools

<u>Step 1:</u> Inventory Existing Systems **Partners Coordination** • Existing contract terms and specs • Identify data needs. • Rank needs and capabilities. • Establish rules of engagement. **Coordinate with MPOs** • Planning, metrics, processes • Investigate 'sister city' agencies for insights, metrics, gaps, KPIs.	**<u>Step 2:</u> Determine Connectivity Goals** • Identify data needs for each agency (master data map) • Rank data needs and goals. • Identify APIs present or needed. • Develop regional data reporting standards. • Develop regional approach to data sharing and methods	**<u>Step 3:</u> Identify Staff Resources** **Current Service Planning** • SOPs for each Agency • Staff • Processes • Tools • Staff roles **Coordinate Regional Solution** • Resource interaction • Role and workflow changes • Additional needs
Years 0-1	**Years 1-2**	**Year 2**
Step 4: Identify Potential Regional Solutions **Advertise Industry RFI** • Hardware upgrades • Software upgrades • Open payments • Interoperability **Determine level of effort** • Lead agency or individual procurements. • Separate tools or unified platform **Coordinate regional interface efforts** • TSP signal priority upgrades • Emergency responder protocols • Triangle Regional Model feedback loop	**<u>Step 5:</u> Identify Service Planning Approach as a Region** • Develop rider-data journey map. • Total Cost of Ownership study over 5 years. • Submit competitive grants. (NCDOT grant application cycle April – June).	**<u>Step 6:</u> Consider Opportunities for Economies of Scale** • Revisit or update the regional Origin-Destination study. • Confirm regional alignment of data and process to facilitate planning as a region. • Joint procurements • Statewide pre-vetted contracts from NCDOT. • Continued development of procurement assistance from industry collectives like Cal-ITP
Years 2-3	**Years 4-5**	**Years 3-5**

Table 2-1, below, presents an example cost estimate that assumes one (1) primary agency and five (5) additional agencies which are using a combination of the eight tools listed. The cost estimate also assumes the unified platform approach will include service planning tools currently used by at least 3 partner agencies.

Table 2-1. Cost Estimate Comparison of Multiple Service Planning Tools and Consistent Service Planning Tools

Cost Element	Separate Tools (across 6 agencies) *Estimated Range*	Unified Platform Adopted by all Agencies (same combination of tools) *Estimated Range*
Licensing & Subscriptions (Year 1)	\$470,000 – \$510,000	\$325,000 – \$490,000
Initial Training & Onboarding	\$150,000 – \$170,000	\$96,000 – \$180,000
Data Integration & Management (Annual)	\$230,000 – \$270,000	\$165,000 – \$275,000
Interagency Planning and Coordination (Annual)	\$140,000 – \$180,000	\$92,000 – \$145,000
Year 1 Total Estimated Cost	**\$990,000 – \$1,130,000**	**\$678,000 – \$1,090,000**
Annual (Multi-Agency) Cost	\$740,000 – \$800,000	\$390,000 – \$420,000

Note: Costs in this figure are aggregated and blended from a review of the USDOT ITS Costs and Benefits database available at: https://www.itskrs.its.dot.gov/costs/

In addition to the capital and operating costs, agencies must consider key factors such as workflow efficiency and inter-agency collaboration requirements.

Table 2-2 and 2-3 on the following page present a recommended split of the cost estimate among Wake, Durham, and Orange Counties based on a percentage of 2024 NTD hours within the region. The average amount of the range of figures provided in Table 2-1 is multiplied by the percent of all NTD hours for each agency to arrive at the totals presented in Tables 2-2 and 2-3. Note that these are planning-level cost estimates to guide Counties in planning for the two approaches described within this chapter.

Table 2-2. Wake /Durham/Orange County Split of Planning-Level Cost Estimate Under Approach #1 of Separate Tools Across All Agencies

	2024 NTD Hours **	Percent of All NTD Hours
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		
Note: Cost estimate split is based upon percent of all NTD hours in region. GoTriangle hours are split 55/30/15 among counties.		

	Year 1 Total	Annual Total (Years 2-5)	Totals (Years 1-5)
Wake County Total	**$635,268**	**$461,468**	**$2,481,142**
GoRaleigh Estimate	$509,089	$369,810	$1,988,330
GoCary Estimate	$60,094	$43,653	$234,707
GoTriangle Estimate	$66,085	$48,005	$258,105
Durham County Total	**$268,523**	**$195,059**	**$1,048,758**
GoDurham Estimate	$232,476	$168,874	$907,974
GoTriangle Estimate	$36,046	$26,185	$140,784
Orange County Total	**$169,102**	**$122,838**	**$660,455**
Chapel Hill Transit Estimate	$138,186	$100,380	$539,708
OCPT Estimate	$12,893	$9,365	$50,355
GoTriangle Estimate	$18,023	$13,092	$70,392

Table 2-3. Wake/Durham/Orange County Split of Planning-Level Cost Estimate Under Approach #2 of Unified Platform Adopted by All Agencies

	2024 NTD Hours **	Percent of All NTD Hours
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		
Note: Cost estimate split is based upon percent of all NTD hours in region. GoTriangle hours are split 55/30/15 among counties.		

	Year 1 Total	Annual Total (Years 2-5)	Totals (Years 1-5)
Wake County Total	**$529,790**	**$242,720**	**$1,500,671**
GoRaleigh Estimate	$424,561	$194,511	$1,202,604
GoCary Estimate	$50,116	$22,960	$141,958
GoTriangle Estimate	$55,112	$25,249	$156,110
Durham County Total	**$223,938**	**$102,596**	**$634,321**
GoDurham Estimate	$193,876	$88,823	$549,170
GoTriangle Estimate	$30,061	$13,772	$85,151
Orange County Total	**$141,025**	**$64,610**	**$399,463**
Chapel Hill Transit Estimate	$115,242	$52,797	$326,432
OCPT Estimate	$10,752	$4,926	$30,456
GoTriangle Estimate	$15,031	$6,886	$42,575

Chapter 3. Transit Signal Priority

Vision: Transit vehicles are able to benefit from Transit Signal Priority (TSP) across various jurisdictions in the region, regardless of home agency and the Computer Aided Dispatch (CAD)/Automated Vehicle Locator (AVL) system installed on the vehicle.

Objective: Identify recommended steps that allow transit agencies to procure TSP solutions that provide a future path to interoperability of multiple TSP systems.

3.1 Initial Findings and Opportunities

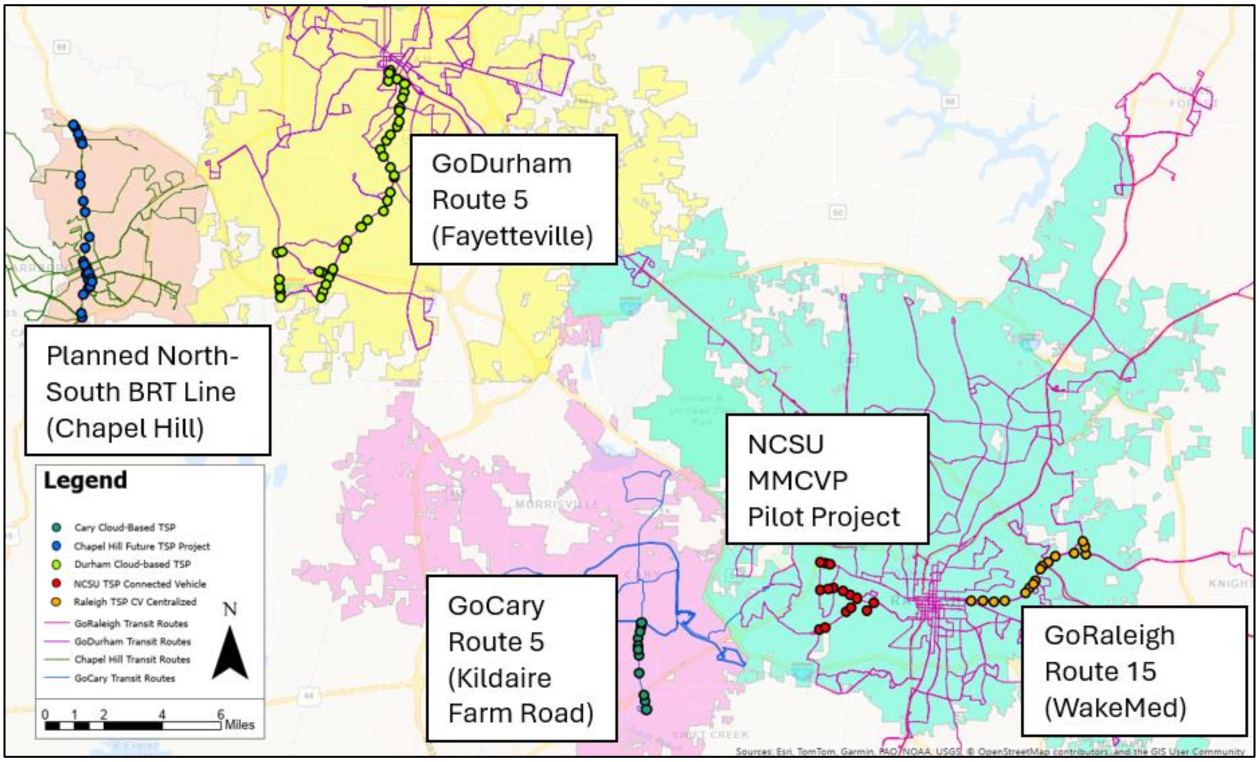
Summary of Current Conditions

Transit Signal Priority (TSP) systems have been deployed in the Triangle Region along several different transit routes and corridors. These routes are summarized in Table 3-1 for reference. Figure 3-1 illustrates the locations of the routes and TSP deployments in the region.

Table 3-1. Summary of Existing and Planned TSP Deployments in the Region

Transit Agency/TSP Routes	Traffic Agency	TSP System Vendor	Signal Locations	# of Buses	TSP Conditions
GoCary Route 5 (Kildaire Farm Rd.)	Town of Cary	Applied Information	Along Route 5	Total of 5 buses on Route 5	Behind schedule by 1 minute
GoDurham Route 5 (Fayetteville St.)	City of Durham	Applied Information	Along Route 5	Route 5 buses	Behind schedule
GoRaleigh Route 15 (WakeMed) – Future Bus Rapid Transit (BRT) on New Bern Avenue	City of Raleigh	EMTRAC	16 signals along Route 15	Route 15 buses	Behind schedule by 1 minute
NCSU Wolfline (All campus buses)	City of Raleigh	Yunex Traffic for CV devices	27 signals on campus	35 buses in fleet	Behind schedule by 4 minutes
Planned - North-South BRT	Town of Chapel Hill	TBD	Along NSBRT Route	NSBRT Buses on Corridor	TBD

Figure 3-1. Locations of Existing and Planned TSP Deployments in the Research Triangle Region



These systems and their locations are described in detail in the following sections.

3.1.1 Existing TSP System: Applied Information (AI)

Locations: GoCary Route 5 (Kildaire Farm Road); GoDurham Route 5 (Fayetteville Street)

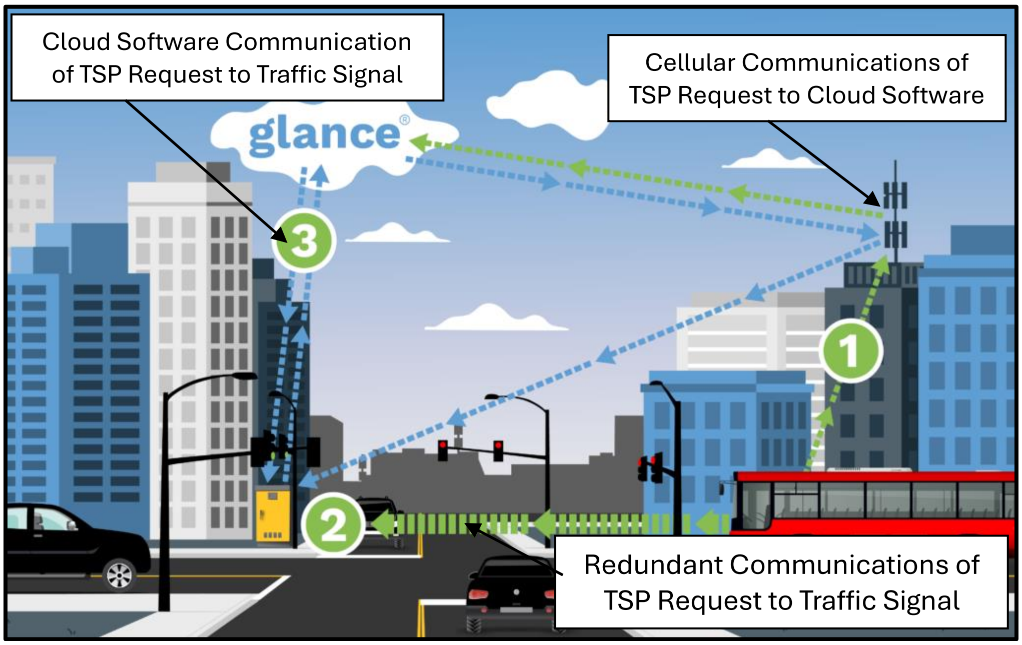
Description: Applied Information (AI) has provided a traffic management system solution for Cary, Durham, Apex, and Morrisville that allows central office staff to remotely monitor traffic signal operations through cloud-based software and cellular communications with traffic signals in those jurisdictions. This system allows for TSP operations that require hardware installed on a select number of buses to facilitate the communication of TSP requests through the cloud-based software management system. All traffic signals in Cary, Durham, Apex, and Morrisville are equipped with the intersection equipment from the vendor (AI) that can enable TSP operations.

TSP hardware on buses is integrated with the existing Automated Vehicle Locator (AVL) hardware for the purpose of receiving schedule adherence-based activations requests to enable TSP requests. Town of Cary has installed an AVL system known as TripSpark, while City of Durham has installed an AVL system from Avail Technologies. Once a bus is behind schedule, the AVL system will send a signal to the TSP hardware which will then use cellular communications to send a TSP request to the next traffic signal on the route to the cloud-based TSP software, which will, in turn, relay the TSP request to TSP hardware in the appropriate traffic signal cabinet.

The AI TSP system also has a redundant communications feature for both Cary and Durham that allows TSP hardware on the bus to send TSP requests directly to traffic signal cabinets using a 900

MHz radio installed on buses. This redundancy is beneficial in the event of a loss in cellular signal or reception along the transit routes. Refer to Figure 3-2 for an illustration of the communication paths for TSP requests made from buses to intersections in Cary and Durham.

Figure 3-2. Communications Overview Diagram of Cary and Durham TSP Systems



Source: Applied Information

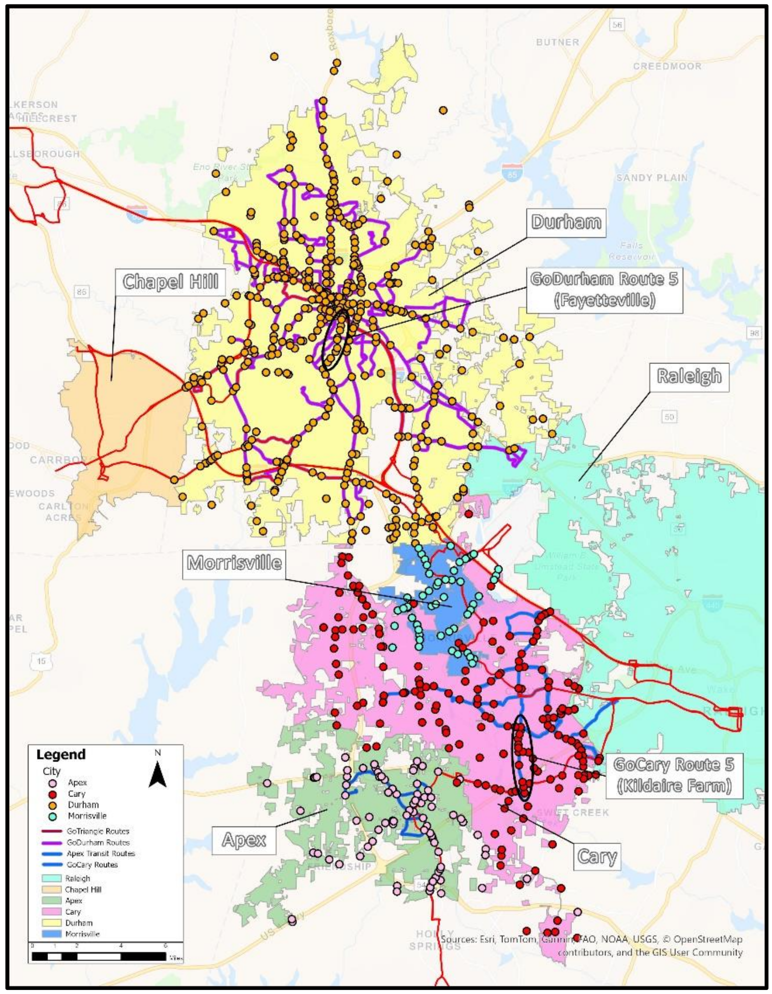
The Town of Cary has installed TSP equipment on five buses as part of a pilot project along the Route 5 (Kildaire Farm Road), which is a high ridership route in Cary. These five buses are programmed to make TSP requests when AVL system has detected the buses running at least 1 minute behind schedule. These five buses are also interlined with other Cary routes, so not all buses along the Route 5 corridor are necessarily equipped with the on-board TSP hardware that will enable them to make TSP requests.

However, even with this limitation, Cary has seen a 3% improvement in On-Time Performance and a 1-minute reduction in transit running times along Route 5 through review of transit data from its AVL vendor (TripSpark) in April and May 2025. While these improvements are relatively small, the time is still important for passengers that may be making transfer connections to other routes at the Town of Cary Depot that are tightly scheduled to arrive at the Depot within minutes of each other.

The Town of Cary will continue to review transit On-Time Performance (OTP) and running time data gathered from their AVL vendor prior to making future decisions about installing additional on-board TSP hardware on more buses. While there is hardware currently installed at all signalized intersections in Cary to provide for both TSP and Emergency Vehicle Pre-emption (EVP), there would need to be TSP signal timing parameters developed by the Town of Cary and input onto the controllers that would provide sufficient time for buses to traverse those intersections during TSP requests. This process can be done remotely by traffic staff with the appropriate traffic software that allows them to communicate with traffic signal controllers.

In addition to these TSP systems, the vendor, Applied Information (AI) has also equipped all traffic signals in the Towns of Apex and Morrisville with intersection equipment that enables Emergency Vehicle Pre-emption (EVP) for all police vehicles in those two jurisdictions. The same AI system that provides emergency vehicles with pre-emption can also provide transit vehicles with signal priority requests. Refer to Figure 3-5 later in the document for an overview map of the signals at which TSP has been implemented, and the other signal locations that are capable of TSP within these jurisdictions.

Figure 3-3. Deployment of Applied Information Cloud-Based System for TSP / EVP



There is also a planned project from FY 2028 through 2030 that proposes an annual traffic signal system operation and maintenance agreement between the Towns of Apex, Holly Springs and Fuquay-Varina. This will help support additional responsibilities of signal maintenance staff in the area as TSP operations expand to additional transit routes in the area.

The Applied Information (AI) cloud-based TSP system in Figure 3-3 has a large deployment in the region that covers all traffic signals in the City of Durham and the Towns of Cary, Morrisville, and Apex, given that the vendor's equipment is also used to support traffic signal operations and Emergency Vehicle Preemption in those jurisdictions.

3.1.2 Existing TSP System: Multi-Modal Connected Vehicle Pilot (MMCVP)

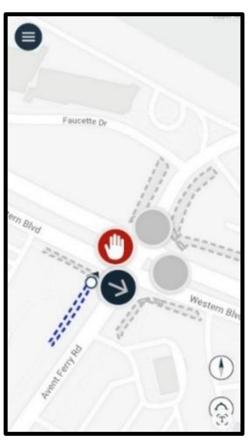
Locations: North Carolina State University (NCSU) Campus at 26 traffic signals

Description: This is a pilot project led by the North Carolina Department of Transportation (NCDOT) in partnership with NCSU Wolfline buses, the City of Raleigh, and other agency stakeholders in the area. This project features the installation of Connected Vehicle (CV) technology on NCSU Wolfline buses that will send TSP requests that follow a message format defined by Society of Automotive Engineers (SAE) under a J2735 standard to CV Roadside Unit (RSU) equipment installed at traffic signals. TSP requests are only activated when the AVL system on NCSU buses detects the bus to be behind its posted schedule by more than 4 minutes, and TSP requests conforming to an NTCIP 1211 standard for signal controllers are sent from the RSU down to the controller. The CV hardware vendor for the pilot project is from Yunex Traffic, and the project will be evaluated by the NCSU Institute for Transportation Research and Education upon its completion in summer/fall of 2026.

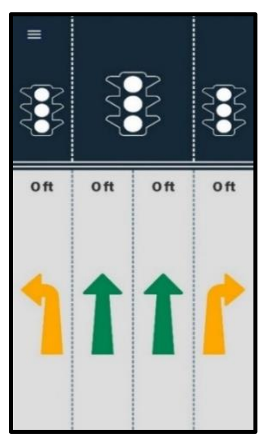
The MMCVP Project is also using CV equipment at a select number of traffic signals with high pedestrian crossings to communicate alerts to pedestrians about vehicles traveling along the roadway on the NCSU campus. These alerts are provided through a mobile application that was developed for the MMCVP project to demonstrate the potential of providing notifications to pedestrians through smartphones about approaching vehicles that pedestrians may not see at an intersection. Figure 3-4 presents a view of the CV equipment and mobile application, and Figure 3-5 presents a map of the 27 intersections at which CV equipment has been installed.

Figure 3-4. MMCVP Project Equipment and Mobile Application at Western Blvd. and Avent Ferry Road Intersection on NCSU Campus

Western Blvd. and Avent Ferry Rd. Traffic Signal and CV Equipment for TSP Operations and Mobile Application for Pedestrians/Motorists



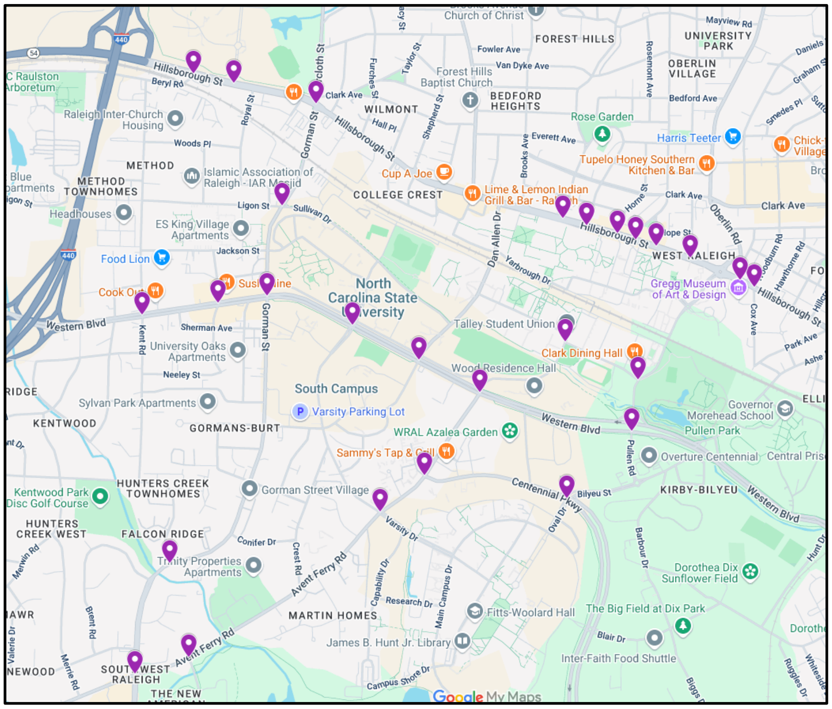
Pedestrian View of Mobile Application at Intersection



Motorist View of Mobile Application at Intersection

Source: Yunex YU2X.

Figure 3-5. Locations of MMCVP Project Equipment on NCSU Campus in Raleigh, NC



Source: [NCDOT Multimodal Connected Vehicle Pilot]

3.1.3 Existing TSP System: EMTRAC Cloud-Based TSP System

Location: GoRaleigh Route 15 (New Bern Avenue)

Description: The TSP system deployed along New Bern Avenue at 16 intersections is a cloud-based approach to TSP operations from the City's TSP vendor known as EMTRAC. The following are key parts of the system:

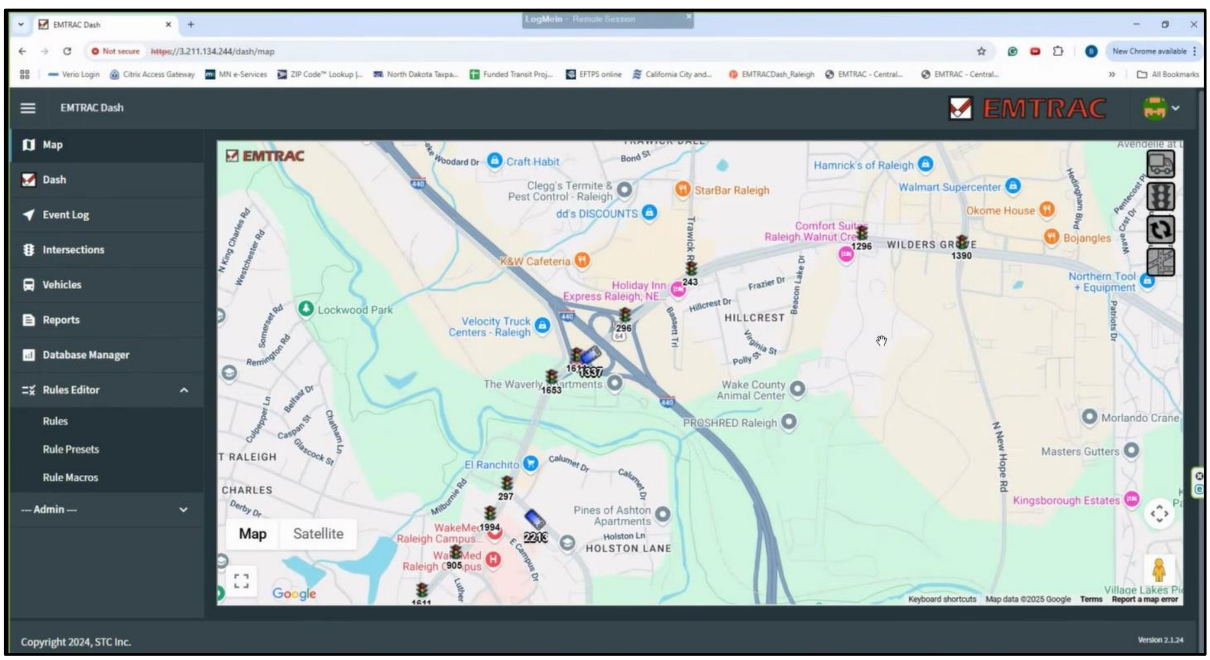
1. The existing AVL hardware on City of Raleigh buses is hosted on a small PC computer on-board the bus which collects data on vehicle location, bus route, vehicle heading, and other variables, sending the data (at a frequency of at least once every 1-2 seconds) to a TSP software application from EMTRAC that is installed on the AVL hardware. This integration required an Application Programming Interface (API) be created by the AVL vendor to facilitate data transfer with the TSP application installed on the AVL hardware, all of which is hosted on the same small, on-board PC computer.
2. The PC computer with AVL hardware (and the EMTRAC TSP software) is connected to a cellular modem that sends data from the on-board TSP application to a cloud-based TSP software (from EMTRAC) that processes the data to determine when buses should receive TSP at intersections on the corridor. The logic within the cloud-based TSP software allows for TSP to be requested when buses are behind schedule by at least one minute, though this is configurable by Raleigh staff. Geographic zones are also defined in the virtual, cloud-based TSP software so that TSP calls are made at an appropriate distance from the intersection.
3. The cloud-based TSP software communicates a TSP request through a server at Raleigh's traffic management center to the appropriate traffic signal controller where TSP is being requested.

Fiber-optic cable connects Raleigh's Traffic Management Center (TMC) with the signal controllers on the corridor to enable TSP requests to signal controllers. The TSP request is made using an NTCIP 1202 standard, which is how the traffic signal controllers are configured to enable TSP operations.

The City of Raleigh has noted that while funding is secured for this approach only along the New Bern Avenue BRT corridor, the City of Raleigh would like to apply this approach to future BRT corridors in the southern and western areas of Raleigh. Additional funding has yet to be identified to support the expansion of the cloud-based TSP approach to those corridors.

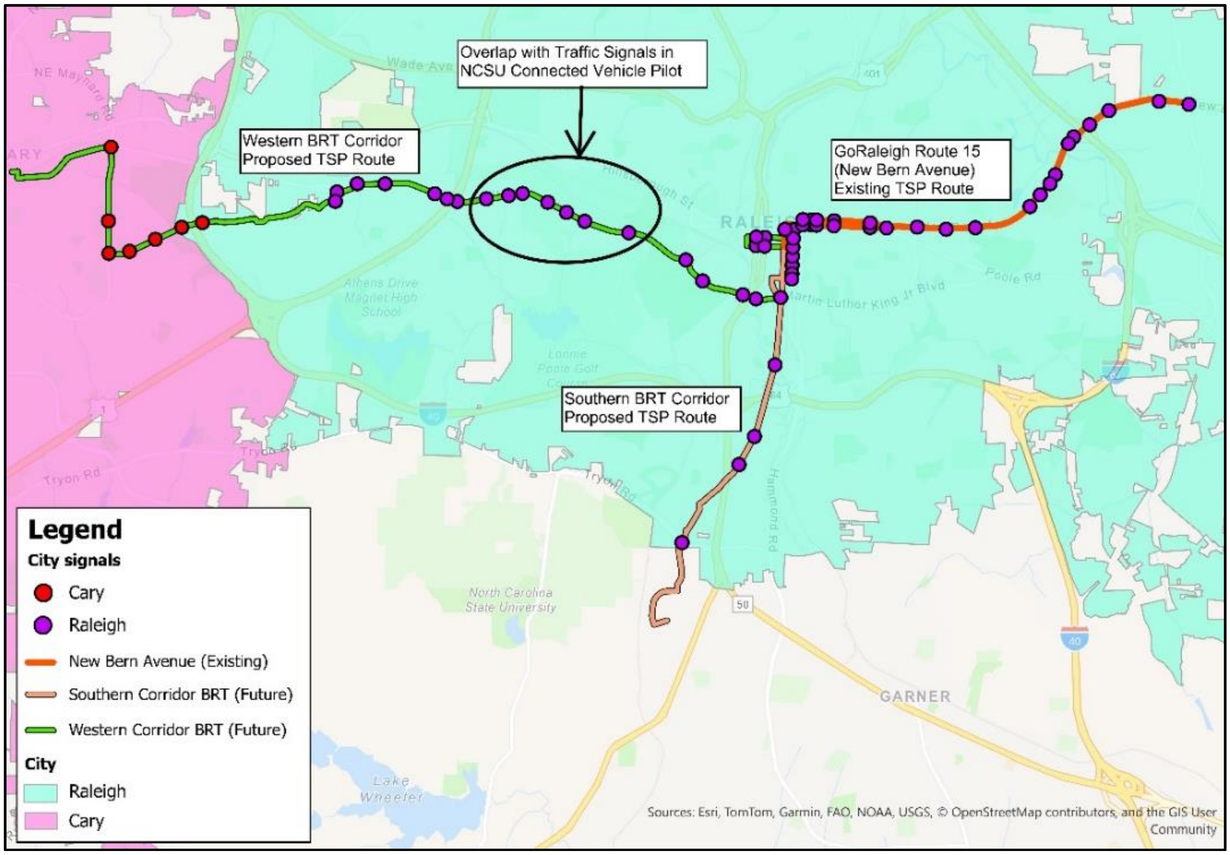
This approach also requires the integration of the AVL system with an on-board TSP application from the TSP vendor through a custom API created by the AVL vendor. While this approach requires no new hardware to be installed on buses or in the field to enable TSP operations, Raleigh TMC staff have noted that licensing fees are being paid based on the number of transit vehicles that have this integration completed. Additional license fees are paid to the TSP vendor for the use of the cloud-based TSP software on the corridor that can provide a real-time view of TSP operations and also provide performance measures on TSP operations. Refer to Figure 3-6 for a corridor view of the EMTRAC TSP system through the cloud-based software for the system.

Figure 3-6. Corridor View of EMTRAC TSP System along New Bern Avenue



The EMTRAC cloud TSP system has been implemented at 16 traffic signal locations along New Bern Avenue, but the City of Raleigh has plans to expand BRT service to future southern and western BRT lines in the coming years as shown in Figure 3-7. Note that there is also overlap with existing intersections that are a part of the current Multimodal Connected Vehicle Pilot show in Figure 3-7.

Figure 3-7. Deployment of EMTRAC Cloud-Based System for Existing and Proposed TSP Routes



For future BRT corridors where TSP will be implemented in Raleigh, station locations in relation to traffic signals should be reviewed to identify where TSP can have the greatest impact on transit performance. It is more beneficial to have transit stations on the far side of a traffic signal so that it can stop to allow passengers to board and alight from buses after it has passed through the traffic signal.

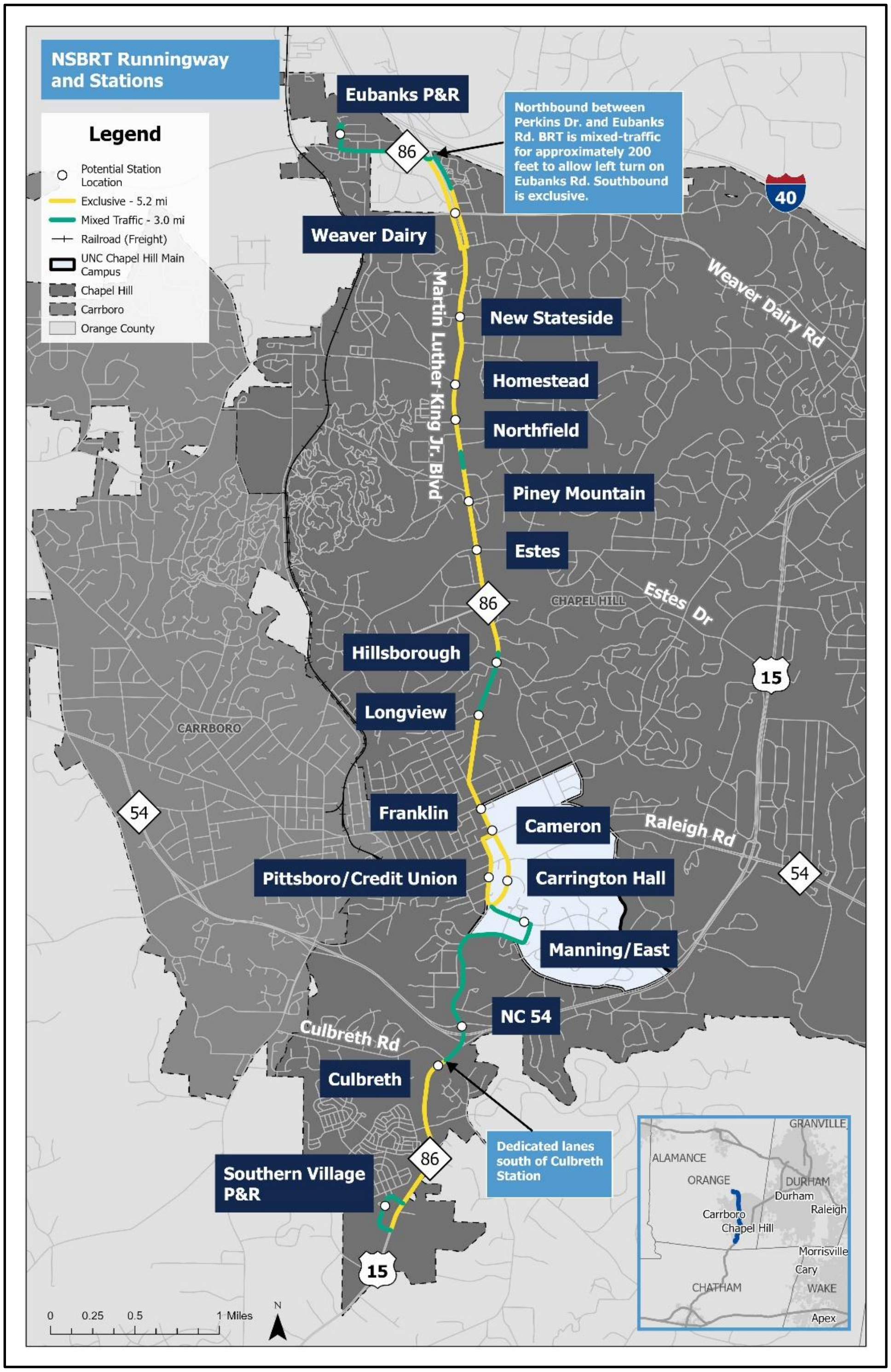
3.1.4 Planned TSP System: North-South Bus Rapid Transit (NSBRT) Corridor

Locations: Chapel Hill (State Route 86/MLK Jr. Blvd.)

Description: The NSBRT project is planning for traffic signal system upgrades that will be needed to enable TSP system operations along the corridor. The desired technology for TSP operations will be decided upon by the project team and Town of Chapel Hill during the design/construction phase of the project. It is anticipated that BRT operations would commence in 2029 on the corridor from the Eubanks Park-and-Ride lot on the north side to the Southern Village Park-and-Ride lot on the south end.

A proposed route map with BRT station locations for the NSBRT project is presented on the following page in Figure 3-8.

Figure 3-8. Proposed NSBRT Route Map and Station Locations



Source: Chapel Hill NSBRT, Octo. 26th, 2025. https://engage.chapelhillnc.gov/nsbrt.

3.2 Noted Challenges

One challenge to accomplishing the vision of transit vehicles benefiting from TSP across various jurisdictions, regardless of transit agency or CAD/AVL system, is the presence of multiple different TSP system vendors and approaches taken in the region. While there are available standards that have been developed to facilitate interoperability among TSP vendors, the acceptance of these standards by industry vendors is not widespread. TSP vendors often prefer their established method of communications for sending TSP, which is often a proprietary solution that would not be operable with other vendors.

One available standard to guide TSP operations on traffic signal controllers is NTCIP 1211[13], which is part of the National Transportation Communications for Intelligent Transportation System (ITS) Protocol (NTCIP) family of standards[14]. The purpose of NTCIP standards is to enable interoperability between hardware and software produced from different vendors of that equipment. NTCIP 1211 defines how messages can be communicated to traffic signal controllers to enable TSP operations. The use of this standard could help to enable future TSP interoperability of signal controllers in multiple jurisdictions.

The MMCVP project on the NCSU campus in the City of Raleigh includes signal controllers that are providing for TSP operations by following an NTCIP 1211 standard on the controller. The MMCVP project is also using a separate standard defined by the Society of Automotive Engineers (SAE) known as an SAE J2735 standard that defines how On-Board Units (OBUs) communicate various types of information with Roadside Units (RSUs). TSP requests are only communicated using the SAE J2735 standard when the AVL system on NCSU buses detects the bus to be behind its posted schedule by more than 4 minutes. TSP requests are then translated into NTCIP 1211 by the RSU at the intersections on the NCSU campus and sent down to the signal controller that uses NTCIP 1211 to manage the TSP request.

Multiple different signal controller software manufacturers and central software systems are in place throughout the region. A summary of these software details gathered from the NCDOT during an interview on the project is provided in Table 3-2 below.

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[13] NTCIP 1211 standard available at: https://www.ntcip.org/file/2018/11/NTCIP1211v02A-SE03.docx.
[14] Standards available at: https://www.ntcip.org/document-numbers-and-status/.

Table 3-2. Summary of Signal Controllers and Central Software in Triangle Region

Jurisdictions	Traffic Signal Controller Hardware/Firmware	Central Office Traffic Software	Notes on NTCIP 1211 Compliance for Region
Durham/ Cary	Econolite ASC/3 Signal Controller with ASC/3 firmware	Econolite Centracs and Applied Information	Would need to investigate the potential for upgrading signal controllers to be capable of TSP under the NTCIP 1211 standard.
Raleigh	Yunex Traffic signal controllers with SEPAC firmware, operating on Linux platform	Tactics central software	Use of NTCIP 1211 for TSP is being tested on NCSU campus for MMCVP project.
Chapel Hill	Econolite ASC/3 Signal Controller with mix of ASC/3 and Oasis firmware	Econolite Centracs	Currently not compatible with NTCIP 1211. Controllers along the planned NSBRT line will be updated with that project with new central software, and new controllers will be capable of NTCIP 1211.

3.3 Opportunities for Innovation and Collaboration

From 2024 through 2029, the NCDOT will make a statewide upgrade of approximately 6,000 traffic signal controllers that it operates and maintains on its own with new signal controllers running MaxTime software. These controller upgrades in the field will allow the NCDOT to remotely manage and communicate with traffic signals from a new traffic central software known as Kinetic Signals. For signal controllers owned by the NCDOT, but operated and maintained by a municipality, the NCDOT has noted a number of these controllers could also be upgraded to a pre-approved signal controller with MaxTime software under the current statewide controller upgrade project.

From an interview with the NCDOT for this project, a few potential opportunities were discussed in relation to future TSP system operations. These are noted below:

1. A potential opportunity may exist for a type of centralized TSP deployment if agencies in the region were interested in an integration of their CAD/AVL system with the Kinetic Signals traffic management software. This would only be possible in locations where MaxTime software is operational on signal controllers in the field. NCDOT has also noted that they would only want to perform one CAD/AVL software integration with Kinetic Signals to reduce the amount of maintenance and updates that may be needed to the software over time. In the Triangle Region, traffic signal locations would be those outside of Raleigh, Cary, Durham, Apex, Morrisville, and Chapel Hill.

2. There may be an opportunity for the Town of Chapel Hill to collaborate with the larger NCDOT signal controller upgrade project during the construction phase of the NSBRT

project. This will need to be further investigated with the NCDOT and with the Town of Chapel Hill prior to construction efforts on the corridor.

Another potential opportunity for TSP operations is the potential integration of Swiftly as a service planning software with future cloud-based TSP systems. Swiftly has noted that they can use GPS coordinates sent from buses at a high frequency (once every 1-3 seconds) in order to make an accurate determination of where buses are in relation to their posted schedule along the route. This will help identify when buses are behind schedule by pre-determined threshold in Swiftly, which can be used to send TSP requests to cloud-based TSP systems in operation along a route.

Swiftly has integrated with other cloud-based TSP vendors to send TSP requests to cloud-based TSP software vendors when buses meet a behind schedule adherence threshold defined in Swiftly by *x* minutes or more. A potential future integration of Swiftly with cloud-based TSP systems provides an opportunity for TSP interoperability with other transit partners that utilize Swiftly.

3.3.1 Case Study: Regional Transportation Authority Interoperable TSP System

To reduce bus delays at traffic signals and improve bus service reliability, the Regional Transportation Authority (RTA) of Chicago, IL designed a regional program for an interoperable TSP system across the different transit and highway jurisdictions in Chicago and its suburbs.[15] The program is known as the Regional Transit Signal Priority Implementation Program (RTSPIP) and involved the Chicago Transit Authority (CTA) and Pace Suburban Bus transit agencies.

The goal of the program was to develop and implement a regionally interoperable TSP system that works for both CTA and Pace buses traveling on roadways maintained by the Chicago Department of Transportation (CDOT), the Illinois Department of Transportation (IDOT), and other local DOT's in northeastern Illinois. Where possible, existing bus and roadside equipment was to be used, as well as utilizing off-the-shelf hardware for bus-to-intersection communication.

The agencies followed a systems engineering approach that is recommended by FHWA and FTA beginning in 2013 to develop regional TSP standards and implementation guidelines that have been utilized to guide TSP deployment on multiple corridors throughout the region.

The CTA then started design engineering activities in 2014 and 2015, which included new Advanced Traffic Controllers (ATC's) and wayside communication equipment to facilitate vehicle-to-intersection communications. The CTA also worked with their AVL system to update the on-board software on the buses and at the intersections to utilize the Regional TSP Message Set. Pace Suburban Bus worked separately with a consultant team beginning in 2015 to manage TSP systems integration and design engineering services for wayside equipment along Pace corridors and also engaged their AVL system vendor to modify the existing on-board equipment to accommodate the Regional TSP Message Set.

Proof-of-concept testing began in 2018 for one corridor that included transit service from both Pace and the CTA, as well as signal controllers managed by multiple DOT's, to test the interoperability of

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15 https://rtams.org/sites/default/files/digital_documents/Evaluation%20Report%20for%20the%20Regional%20Transit%20Signal%20Priority%20Implementation%20Program%20%28RTSPIP%29.pdf

the Regional TSP Message Set in the region. The RTA assisted with baseline data collection and analysis for performance measures before and after TSP system installation along multiple other corridors in the region. The following are lessons learned on the project:

- The creation of a Regional TSP Message Set allowed for regional interoperability, but this was a new approach for AVL and traffic signal controller vendors. Testing required the creation of virtual testing tools to demonstrate compliance with the message set. This testing resulted in additional time and resources from agencies and vendors. Agencies should consider off-the-shelf hardware, such as CV2X hardware now available.
- Systems Engineering documentation laid the groundwork for program requirements to be followed by transit agencies during design engineering and implementation stages. This was helpful to gather buy-in from regional transit and traffic agencies.
- Developing a regionally interoperable TSP system took longer to develop than other approaches that might have relied upon vendor-provided, off-the-shelf TSP systems. Agencies may want to consider working with existing TSP vendors that may be able to implement on a faster timeline versus developing a standards-based approach that TSP vendors will need to adapt to over time.

3.4 Recommendations for TSP in Region

Given the existing cloud-based approaches from multiple TSP systems in the region and potential for use of available standards to guide TSP operations, the following recommendations can be followed to enable the future interoperability of TSP systems across the region.

Recommendation #1: Include NTCIP 1211 Standard in Future TSP Deployments in Region

The NTCIP 1211 standard noted earlier in this document contains the technical details for how traffic signal controllers can manage and provide TSP requests. The use of this standard in future TSP deployments in the Triangle Region can establish a level of consistency in how signal controllers from different manufacturers manage TSP requests within signal controllers.

The use of NTCIP 1211 on existing signal controllers in City of Raleigh is being tested as part of the NCDOT MMCVP pilot project. An evaluation of the project will be performed by the NCSU ITRE and is expected to be completed in summer/fall of 2026. Lessons learned from the project can be reviewed to determine if there were any issues in TSP operations on signal controllers with the NTCIP 1211 standard.

Other traffic agencies in the region will need to review whether NTCIP 1211 can be implemented on their existing traffic signal controllers. Upgrades to some traffic signal controllers may be necessary if transit agencies require their TSP system vendor to utilize NTCIP 1211 as a standard for how signal controllers should provide for TSP operations. Gathering support from traffic agencies to implement NTCIP 1211 can be an early step in the planning process for expanding this approach to traffic signals throughout the region.

Recommendation #2: Establish Stakeholder Contact List for Future TSP Working Group

In contacting traffic agencies to discuss NTCIP 1211, a list of TSP agency stakeholders can be created to include traffic engineers and emergency management staff that operate EVP at traffic signals in the region. This stakeholder contact list can support future efforts to implement TSP across additional corridors in the region.

A TSP Working Group can be established in the region that could meet on a recurring basis to support interagency collaboration on the recommendations included within this plan. This working group can also include transit agency partners that do not have TSP systems implemented in their service areas. Transit agency staff can meet with traffic agency staff in discussing how TSP operations are progressing in the region, and how a recommended approach for NTCIP 1211 can be implemented in the region.

Members of this TSP Working Group can also join a national-level peer agency TSP Working Group that includes transit agencies that have implemented TSP systems throughout the country. The purpose of the peer agency working group is for transit agencies to learn about past TSP System deployments and current efforts with respect to TSP operations. Agencies that are using NTCIP 1211 could be consulted from this group to also gather best practices and lessons learned.

Recommendation #3: Review Connected Vehicle Approach for TSP with NCSU MMCVP Pilot Project

As an alternative to the cloud-based TSP software approach, this approach includes CV hardware on buses and at intersections to facilitate direct communications with traffic signals for TSP requests. The Connected Vehicle-to-Everything (CV2X) standard has been created to define the TSP messages that can be communicated between CV hardware on-vehicle and at intersections. This type of configuration allows for the procurement of CV hardware from multiple vendors that can meet this standard.

Transit agencies that may desire to follow this approach should consult with an evaluation report to be prepared by the NCSU Institute for Transportation Research and Education (ITRE) as part of the larger MMCVP project. This evaluation may influence the spread of CV technology to additional areas in the region, and transit agencies should consult the report for any potential lessons learned with regards to TSP operations. A timeline for an evaluation report is anticipated in summer/fall of 2026 for the project.

This CV approach would utilize an SAE J2735 standard for communications of TSP requests between On-Board Units (OBUs) on buses and Roadside Units (RSUs), as well as a conversion of the TSP request into an NTCIP 1211 standard format for traffic signal controllers. This is being tested under the larger MMCVP project and can be reviewed for its potential to be installed in other areas of the region.

It should also be noted that this approach requires new CV communications hardware to be installed at traffic signals and on buses, which must be configured, maintained, and eventually replaced over time. These are considerations to be weighed in considering how best to expand TSP service in the region given existing cloud-based systems. Tables 3-4 and 3-5 present a comparison of planning-level cost estimates of these two approaches if implemented for all transit agencies in the region. Additional considerations with respect to CV equipment are listed below:

1. Verify that any selected vendor of CV hardware has been certified by the Omni-Air Consortium to support future interoperability with other vendors. An overall goal of the Omni-Air Consortium is to assist with the interoperability of devices as more manufacturers

develop and produce more devices for CV2X deployments. This listing can be found at: https://omniair.org/.

2. Coordinate with transit agency AVL vendors to enable the integration of future on-board CV hardware with existing on-board AVL hardware, so that TSP requests can be made when buses are detected as being behind schedule. NCSU Wolfline buses completed this on-board integration through working with their AVL vendor (Passio Go) for the MMCVP Project.

3. Consult with City of Raleigh traffic operations staff if CV technology is desired to be installed at other traffic signal locations in Raleigh outside of the MMCVP project area on the NCSU campus. Traffic operations staff will be able to identify any additional signal cabinet hardware or communications infrastructure that may be needed to support TSP operations, and whether maintenance staff can provide longer term support for the equipment.

4. For other jurisdictions in the region where the cloud-based TSP system from the vendor Applied Information (AI) has been installed, it is possible that Connected Vehicle hardware can be installed at those intersections to facilitate TSP operations for other transit agencies. The transit agency should consult with the jurisdiction responsible for traffic signal operations and the vendor for cloud-based TSP operations to identify any additional steps that may be needed to allow for a CV approach to co-exist with the cloud-based TSP system at those locations. It is possible that some traffic signal controllers may need to be updated in order to receive and process TSP requests using CV equipment.

Recommendation #4: Determine Potential for Existing Cloud-Based TSP Systems to Accommodate NTCIP Standard for TSP and/or SAE J2735 Standard for CV Communications

A cloud-based TSP system has been implemented by two separate vendors (Applied Information (AI) operating in Cary, Durham, Apex, and Morrisville and EMTRAC operating in Raleigh). Given the investment in these systems and the recommendation to implement a standards-based approach for future TSP operations in the region, transit agencies should consult with their TSP vendors to identify how existing systems could be updated to accommodate the NTCIP 1211 standard for signal controllers, as well as SAE J2735 standards for communications between buses and intersections.

It is possible that equipment hardware and software upgrades would be required for these existing cloud-based TSP systems. TSP system vendors will need to understand what is required to determine the feasibility of the upgrades and estimate the potential costs of those upgrades. Future meetings with transit and traffic agencies responsible for maintaining these systems and the TSP vendors can occur over time to determine these potential upgrades.

Recommendation #5: Review Transit Routes and Identify Candidate Corridors for TSP Service

Given the existing use of schedule adherence as a measure to enable TSP requests by buses, transit agencies should identify transit routes that have relatively lower on-time performance metrics than others. TSP operations could help to improve these on-time performance metrics through sending TSP requests when buses are behind schedule as measured by the existing on-board AVL system. The Town of Cary has seen an initial improvement in on-time performance along their Route 5 (Kildaire Farm Road) by initiating TSP requests when behind schedule by 1 minute, and they will continue reviewing data through 2025 to determine any adjustments that may be needed.

This step of reviewing transit routes will require coordination with transit service planners to review candidate transit routes for TSP operations. Service planning staff can determine the types of AVL system data that can be collected before and after TSP implementation to help with an evaluation of TSP operations that are enabled by schedule adherence thresholds set by AVL systems. Bus operators can also be consulted about which traffic signals in the region present challenges for them to pass through, perhaps due to near-side bus stops or signal timing that could be improved to provide more for buses to clear through the intersection.

Recommendation #6: Identify Potential Corridor for Testing of Regional TSP Interoperability

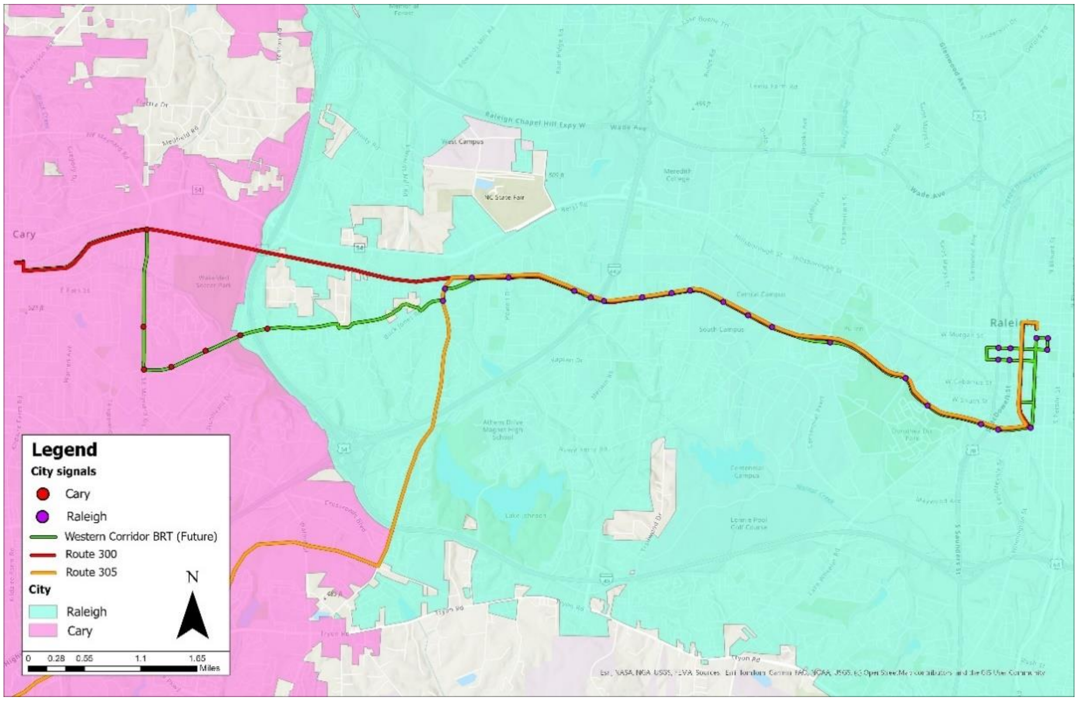
Given the vision of providing buses from multiple transit agencies the opportunity to benefit from TSP across various jurisdictions in the region, a future corridor can be identified where multiple TSP systems could provide TSP to transit agencies utilizing the recommended NTCIP and/or SAE J2735 standards from the plan.

One potential corridor could be the test location for the current NCDOT MMCVP which is along Western Boulevard. This corridor includes a future Raleigh BRT line (Western BRT Corridor) from Raleigh into Cary and could potentially contain the following systems for a future interoperability demonstration of TSP operations:

1. City of Raleigh may extend the use of the existing EMTRAC cloud-based TSP System to support BRT operations, and if so, BRT buses from Raleigh may need to interface with traffic signals in Cary. This would allow for Raleigh BRT buses to perform TSP operations at the identified traffic signals in Cary.
2. The Raleigh BRT buses would also be traveling through signals that are currently a part of the NCDOT MMCVP pilot project that include CV equipment being used for TSP operations with NCSU Wolfline buses. Future discussion with City of Raleigh traffic agency staff will be needed to determine how TSP could best be provided in this area of overlap.
3. GoTriangle also operates the Route 305 along this area of Western Boulevard and could benefit from use of either the existing EMTRAC cloud-based TSP system that communicates TSP requests to traffic signals in Raleigh or from the CV equipment installed as part of the NCDOT MMCVP pilot project.

Given the overlap of transit services in the area, this corridor could serve as a potential area of TSP interoperability testing, but would require coordination between transit and traffic agencies in the region to enable system interoperability on the corridor. The recommended TSP Working Group could assist with identifying the key stakeholders that would need to be involved in working towards TSP interoperability along the proposed corridor. Figure 3-9 presents an overview of the area along Western Boulevard where a potential future interoperability test of TSP operations could be performed.

Figure 3-9. Potential Future TSP Interoperability Test Corridor along Western Boulevard



3.5 Roadmap and Resiliency Plan for TSP in Future Years

A roadmap with phased steps for TSP implementation in the Research Triangle region is presented in Figure 3-10 that takes into consideration the recommendations provided in the prior section. The steps are proposed over five years of time but may stretch to shorter or longer periods based on progress made by transit agencies with respect to expansion of TSP operations.

The use of the NTCIP 1211 standard can support future interoperability of TSP system operations across multiple transit agencies and jurisdictions. A TSP Working Group will need to be developed for the region to guide discussions and meetings with transit and traffic agency staff so that the standard can be adopted and used in future TSP deployments.

Budgetary considerations are provided in Table 3-3 for transit agencies to plan for funding if TSP projects are advanced throughout the region. Budget estimates are provided for vehicle, intersection, and other project items to be accounted for by transit agencies in future years.

Planning-level cost estimates are provided in Table 3-4 and Table 3-6 for each of the two TSP system approaches presented in Table 3-3. An estimate of buses in each agency fleet is multiplied by the vehicle cost estimate in Table 3-3. In addition, an estimated number of traffic signals along transit routes at which TSP could be provided for each agency is provided in Table 3-4 under the Connected Vehicle approach for TSP operations. This intersection count was gathered from use of ArcGIS in reviewing the number of traffic signals along transit routes for each transit agency.

Table 3-6 includes a planning-level cost estimate that accounts for the use of cloud-based TSP systems expanding from the current base in the region. Notes are placed in the right column to indicate differences from the planning-level cost estimate presented in Table 3-4.

The planning-level cost estimates include anticipated vehicle and intersection-based cost items. Other overall project cost items are estimated, but these may vary based on the vendor providing TSP equipment for each agency. Additional cost items due to updates in Connected Vehicle equipment and cloud-based TSP systems may be identified as future TSP deployments by transit agencies advance into a more detailed design and deployment stage with TSP vendors. Integration costs may also be identified in future design and deployment efforts by TSP vendors in areas where interoperability between TSP systems is desired.

Each planning-level cost estimate also includes a split of the funding by Wake, Durham, and Orange Counties to guide the counties in planning for how much budget could be set aside over the next five years within each County's transit plan. This is presented in Tables 3-5 and 3-7 for each approach.

Figure 3-10.Roadmap of Implementation Steps for Transit Agencies for Regional TSP Operations

Step 1: Include NTCIP 1211 in Plans for TSP Operations/Expansion Discuss the use of the NTCIP 1211 standard with transit and traffic agencies to identify potential upgrades that may be needed on traffic signal systems along future TSP corridors in the region. Review operation of NTCIP 1211 in Raleigh on NCSU campus.	**Step 2: Establish Stakeholder Contact Listing for Future TSP Working Group** Develop list of TSP agency stakeholders (traffic engineers emergency management staff, transit staff, etc.) that would be involved in future TSP projects. Create a TSP Working Group to meet on recurring basis to support interagency collaboration on the recommendations from the plan.	**Step 3: Review CV Approach for TSP with NCSU MMCVP Pilot Project** NCSU ITRE will evaluate the project and identify lessons learned with respect to TSP operations for NCSU at traffic signals with CV equipment. Recommendations from the report may lead to the expansion of CV equipment in the region. Evaluation of TSP operations with NTCIP 1211 standard can also be reviewed.
Years 0-1	**Years 0-1**	**Years 1-2**
Step 4: Determine if Existing Cloud-Based TSP Systems can use NTCIP 1211 Standard/SAE J2735 Standard Identify hardware and software upgrades that may be needed to existing cloud-based TSP systems that could accommodate interoperability of TSP from multiple transit agencies. Meet with existing vendors of TSP systems to understand potential approaches and costs of upgrades.	**Step 5: Review Transit Routes and Identify Candidate TSP Corridors** Identify routes with on-time performance issues that could benefit from TSP system operations. Ensure integration between AVL system and TSP system to enable schedule adherence-based TSP requests. Identify AVL system data that can be collected before and after implementation to help with TSP system evaluations.	**Step 6: Identify TSP Approach along North-South BRT Corridor** Identify technology approach to TSP along the north-south BRT corridor. Coordinate with other transit agencies on the approach to enable interoperability of TSP operations where possible on the corridor.
Years 1-2	**Years 1-2**	**Years 2-3**
Step 7: Identify TSP Approach along Raleigh BRT Corridors Raleigh will identify funding sources to support expansion of cloud-based TSP system along the southern and western Wake BRT corridors. The traffic department will identify any traffic signal hardware updates needed to enable TSP along corridors.	**Step 8: Identify Corridor for TSP System Interoperability Testing** Raleigh will identify funding sources to support expansion of cloud-based TSP system along the southern and western Wake BRT corridors. The traffic department will identify any traffic signal hardware updates needed to enable TSP along corridors.	**Step 9: Coordinate with Signal System Expansion in Region** Traffic signal operations in Holly Springs and Fuquay-Varina are to be expanded to allow for Emergency Vehicle Preemption. NCDOT will evaluate location of signal operations center in Holly Springs for monitoring of signals.
Years 3-4	**Years 4-5**	**Years 4-5**

Table 3-3. Budgetary Planning Recommendations for Transit Agency Consideration

TSP System Approaches	Vehicle Budget Items	Intersection Budget Items	Other TSP Project Items
Use of Connected Vehicle (CV) Approach for TSP Operations	**$5,000** per OnBoard Unit (OBU) for purchase, installation, and integration with existing AVL hardware on vehicles	**$5,000** per Roadside Unit (RSU) for purchase, installation, and setup at traffic signal	**$30,000** for communications backhaul from intersections to central software. **$25,000** per year for vendor PM costs, warranty, and central software access for monitoring
Use of Existing Cloud-Based TSP Software	**$5,000** per OnBoard Unit (OBU) for purchase, installation, and integration with existing AVL hardware on vehicles	If expanding to signals outside of current deployment, **$10,000** for new equipment and integration with traffic signals	**$25,000** per year for vendor PM costs, warranty, and central software access for monitoring

Table 3-4. Planning-Level Cost Estimate for Use of Connected Vehicle (CV) Approach for TSP Operations

	Buses in Fleet	Vehicle Cost Estimate	Intersections on Transit Routes	Intersection Cost Estimate	Other TSP Project Items*	Total Costs	Notes
GoTriangle	82	$5,000	203	$5,000	$55,000	$1,480,000	Assumes 7 intersections on Western Blvd. with CV RSUs
GoCary	15	$5,000	78	$5,000	$55,000	$520,000	
GoDurham	0	$5,000	291	$5,000	$55,000	$1,510,000	Assumes all Durham buses capable of TSP
GoRaleigh	135	$5,000	506	$5,000	$55,000	$3,260,000	Assumes 7 intersections on Western Blvd. with CV RSUs
Chapel Hill Transit	99	$5,000	87	$5,000	$55,000	$985,000	
* See notes in Table 3-3 above.						**$7,755,000**	

Table 3-5. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Connected Vehicle (CV) Approach for TSP Operations

	2024 NTD Hours **	Percent of All NTD Hours		County Estimates with Transit Agencies	Totals	Notes
GoTriangle	146,063	11%		**Wake County Total**	**$4,647,646**	Five-year total amount
GoCary	73,052	6%		GoRaleigh Estimate	$3,724,517	
GoDurham	282,605	22%		GoCary Estimate	$439,650	
GoRaleigh	618,864	48%		GoTriangle Estimate	$483,479	55% of GoTriangle NTD Hours
Chapel Hill Transit	167,983	13%		**Durham County Total**	**$1,964,521**	Five-year total amount
				GoDurham Estimate	$1,700,805	
Totals	1,288,567	**100%**		GoTriangle Estimate	$263,716	30% of GoTriangle NTD Hours
** Annual Vehicle Revenue Hours from 2024 NTD Reporting				**Orange County Total**	**$1,237,156**	Five-year total amount
Note: Cost estimate split is based upon percent of all NTD hours within region. GoTriangle hours are split 55/30/15 among counties.				Chapel Hill Transit Estimate	$1,010,974	
				OCPT Estimate	$94,324	
				GoTriangle Estimate	$131,858	15% of GoTriangle NTD Hours

Table 3-6. Planning-Level Cost Estimate for Use of Existing Cloud-Based TSP Software

	Buses in Fleet	Vehicle Cost Estimate	Intersections on Transit Routes	Intersection Cost Estimate	Other TSP Project Items*	Total Costs	Notes
GoTriangle	82	$5,000	140	$10,000	$25,000	$1,835,000	Intersection total accounts for signals in Durham and Cary areas already equipped for TSP.
GoCary	15	$5,000	0	$10,000	$25,000	$100,000	5 buses already using TSP. Intersections in Cary ready for cloud-based TSP.
GoDurham	0	$5,000	0	$10,000	$25,000	$25,000	Assumes all Durham buses capable of TSP
GoRaleigh	135	$5,000	497	$10,000	$25,000	$5,670,000	Intersection total accounts for 16 signals on New Bern with cloud-based TSP
Chapel Hill Transit	99	$5,000	87	$10,000	$25,000	$1,390,000	
* See notes in Table 3-3 above						**$9,020,000**	

Table 3-7. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Use of Existing Cloud-Based TSP Software

	2024 NTD Hours **	Percent of All NTD Hours		County Estimates with Transit Agencies	Totals	Notes
GoTriangle	146,063	11%		**Wake County**	**$5,405,773**	Five-year total amount
GoCary	73,052	6%		GoRaleigh Estimate	$4,332,063	
GoDurham	282,605	22%		GoCary Estimate	$511,366	
GoRaleigh	618,864	48%		GoTriangle Estimate	$562,344	55% of GoTriangle NTD Hours
Chapel Hill Transit	167,983	13%		**Durham County**	**$2,284,975**	Five-year total amount
				GoDurham Estimate	$1,978,242	
Totals	1,288,567	**100%**		GoTriangle Estimate	$306,733	30% of GoTriangle NTD Hours
** Annual Vehicle Revenue Hours from 2024 NTD Reporting				**Orange County**	**$1,438,962**	Five-year total amount
Note: Cost estimate split is based upon percent of all NTD hours within region. GoTriangle hours are split 55/30/15 among counties.				Chapel Hill Transit Estimate	$1,175,885	
				OCPT Estimate	$109,710	
				GoTriangle Estimate	$153,367	15% of GoTriangle NTD Hours

Chapter 4. Chapter Four Regionally Integrated Payments

Vision: The agencies in the Triangle Region have developed a vision for regionally integrated payments where riders are able to easily manage transit payments for mobility services across the region with equitable options for unbanked/cash-based riders.

Objective: This chapter examines technologies available to collect transit fares. Further integrating payments in the region serves existing riders, attracts new riders, and improves rider experience. Regional priorities for integrated payments are recognized as a payment solution that:

- Accepts cash.
- Performs mobile ticketing.
- Integrates with current GoPass program.
- Incorporates fare capping.
- Considers transfers between systems.
- Processes open payments.

4.1 Initial Findings and Opportunities

4.1.1 Summary of Current Conditions

Since 2024, three transit agencies have returned to fares including GoTriangle, GoRaleigh, and Orange County Public Transportation (OCPT). GoDurham and GoCary have not yet returned to fares. Chapel Hill Transit has had fare-free public transit in place for over 20 years. Other fare-free services operate in the towns of Apex, Morrisville, and Wake Forest as well as Wake County. They use a mix of mobility service types to meet the needs of the area. Paratransit services sometimes co-mingle with microtransit services to improve mobility of the region's rural population[16]. North Carolina State University, University of North Carolina Chapel Hill, and Duke University provide free campus transit and are GoPass Partners to benefit students and staff.

Fixed Route Fare Collection

Agencies use fareboxes for cash payments and electronic validation systems with fare media for electronic payments with a closed loop card (Umo GoPass), or the Umo mobile ticketing app. Currently, GoTriangle and GoRaleigh buses collect fares with older Umo validators for electronic payments and Genfare fareboxes for on-board cash payments. OCPT riders use the Umo smartcard, or Umo mobile ticket app at validators. Cash is not accepted on board OCPT fixed route buses.

Cash fareboxes (Genfare Odessey or FastFare) were procured at various times by agencies in the region and are used alongside the Umo validators on board. Neither Umo nor Genfare products are able to process or accept open-loop payments in the region today. **Open loop payment systems** permit third party media as the fare media (eCMV virtual wallets, bank cards, wearables, etc.) with real time authorization for each transaction. Open Payments, sometimes referred to as mass transit open payments, use the same fare media as open loop payments but differ in that the transactions are smaller amounts, such as a single tap and ride, and are settled in batches. **Closed loop payment systems** accept a specific fare media unique to a particular transit system.

Validators currently reading Umo cards or app QR codes will require replacement since they cannot be upgraded to be compatible with open payment technology.

[16] Agency websites are the source for service types and accepted payments in Figure 4-3.

Aging Equipment

GoTriangle Odyssey fareboxes rely on older technologies that are fast becoming obsolete. Fareboxes on fleets today will mostly require replacement to achieve the regional goal of accepting open payments. Odyssey models have reached the end of product lifecycle and will have software updates for major bugs only through 2025.[17] Agencies report increasing reliability and maintenance issues with the Odyssey box. The exception is the Genfare FastFare farebox. GoRaleigh has invested in the FastFare farebox and should have all FastFare boxes by December 31, 2025. GoRaleigh FastFare fareboxes are not currently configured to be able to accept open payment, but GoRaleigh could elect to upgrade the existing FastFare software and integrations to allow for accepting open payments. In doing so however, GoRaleigh would break with the current Umo smartcard system used by other agencies in the region.

Upgrading Fare Payment Systems

Most agencies do not plan to upgrade their payment systems in the near future. Exceptions include GoRaleigh and GoTriangle, which are exploring improvements. GoRaleigh aims to integrate open payment systems, such as tap-to-pay with credit or with debit cards, while maintaining cash options and potentially pursuing integrations such as bike-share fare. GoTriangle is considering open payments and simplified cash collection systems, since farebox reliability has decreased, and maintenance costs are on the rise. Agencies already operating fare-free services, such as Chapel Hill Transit, reported having no plans to implement upgrades.

Desired Updates for Fare Payment Services

Survey responses emphasize the importance of seamless payment integration across transit providers to improve regional mobility and ease of transfers. Even while fare free, the Town of Morrisville highlighted the importance of maintaining both electronic and cash payment options. Fare-free agencies like Chapel Hill Transit have no planned updates but ensure fare-free services for affiliated riders through systems like Single Sign-On for user verification. Meetings, survey results, and interviews conducted with agencies mirror many of the same regional priorities:

- Calculate fare caps.
- Integrate with existing systems (i.e., Umo GoPass cards and validators, Genfare fareboxes).
- Purchase fare products using a mobile app for other service types like BRT, or microtransit.

Electronic Fare Collection Footprint in the Region

Umo's platform provides agencies with configurable fare policies, validator management, and custom integrations. As shown below in Figures 4-1 and 4-2, Umo accountholders in the region significantly outnumber cash riders.

Riders register with Umo to create an account to which riders add money. Riders must choose between one of the two ways to validate their fare since one disables the other. Simply put, riders cannot use both the app and a smartcard. Riders can pay fares by tapping an account-based, closed loop[18] Umo card or with the Umo app. Riders can tap a smartphone with the Umo app generated Quick Response

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[17] Odyssey® And Odyssey Plus® Product Discontinuation Notification | Genfare

[18] Umo has the potential to function like an open payment system with hardware replacement and custom work with Cubic Umo system integrators.

(QR) code, to pay. Each on-board validator tap deducts fares from a rider's Umo account. After a predetermined number of rides, fares are capped.

The flexibility of configurable fare policies allows agencies to provide rider benefits like fare capping. Fare technologies used today can track and then cap the maximum amount that a rider pays within a defined period (day, week, or month). Once a cap is met, remaining travel for that period is free. This strategy makes frequent travel by transit more equitable and affordable. It encourages use of transit without the upfront payment of a paper pass for multiple rides to get a discount. Qualified riders also benefit from configurable fare policies since fare discounts can be applied to a ridership category such as youth, veterans, seniors, or low-income.

Figure 4-1. Passenger Count by fare type for GoRaleigh

GoRaleigh FY 25 Passengers fare data by fare type	Number of Passengers	Percentage of APC
Stored Value (Self-Pay) (Umo)	140,064	2.2%
Partner GoPass (Umo)	197,560	3.2%
TAP Pass (Umo)	3,342,929	53.6%
Youth Pass (Umo)	71,521	1.1%
Cash on Bus	186,821	3.0%
Total all fare types	3,938,895	

GoRaleigh reports that the fare data in Figure 4-1 represents only 63% of the APC totals for GoRaleigh. Reasons for this data gap may range from registered riders that don't tap or inconsistent operator validation (e.g., Senior Pass are not accounted for by operators). Fare data and APC discrepancies are not uncommon and can be lessened by either a policy (e.g., change in fare rules that all riders must tap) or technological solution (e.g., confirm APC hardware state of good repair). Despite the variance, the number of riders that are registered with an Umo account is significant.

The Umo solution has a significant footprint in the Region.

Figure 4-2 shows the October 2024 data from fixed route revenue sources that GoTriangle presented at the February 2025 Board of Trustees Meeting. Umo GoPasses represent a majority of transactions reported for GoTriangle Fixed Route Revenue Sources. The GoTriangle *Budget Message Fiscal Year 2025* anticipates revenue to be greater with the return to fares in FY25.[19]

Figure 4-2. Revenue percentage by fare type for GoTriangle

GoTriangle FY24 Revenue by fare	Revenue	Percentage of Revenue
Umo Self Pay	$28,000.	16%
Partner GoPass	$63,000.	37%
TAP Pass (Umo)	$58,000.	35%
Youth Pass (Umo)	$2,000.	1%
Cash on Bus	$18,000.	11%
Total revenue of **all fare types**	$170,000.	

[19] https://gotriangle.community.highbond.com/home/public/document/9124

TAP Pass and Youth Pass benefits are available to eligible riders. Riders must open an Umo account to receive these free and low-fare benefit types. An important current condition to note for fare-free and low-fare riders that tap their UMO cards on a validator is that each tap does cost the transit agencies for providing that service to their riders, which is not a common practice among other fare vendors that provide this type of technology.

Figure 4-3 lists the transit agencies in the Triangle Region, the forms of payment taken, service types provided, and if the agency collects fares for services. In Figure 4-3, the term fixed-route refers to the region's bus fleets that operate on a predetermined route and schedule. On-demand or 'demand-response' refers to transportation services that riders can schedule. Micromobility solutions take many forms and are typically scheduled by the rider, on-demand, by telephone call or by an app. The smaller on-demand vehicles can bridge the first-mile/last-mile gap, improve rural coverage, and provide paratransit service for equitable access to transit.

Figure 4-3. Fare Collection by Transit Agencies in the Triangle Region

	Transit Agency	Payments	Collect Fares	Service Type
1	GoTriangle Link	• An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) • Cash (exact change) • ID cards for reduced or free fares	Yes	Fixed Route
2	GoRaleigh Link	• An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) • Cash (exact change through change cards to passengers) • Physical Paper Bus Pass (cash/credit card) • ID Cards for reduced or free fares	Yes	Fixed Route
3	Orange County Public Transportation Link	• An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) • ADA/Low-income, Senior free fares with ID • Loop routes are free; connector routes have a fare	Yes	Fixed Route
4	GoCary Link	• Fare Free for rider	No	Fixed Route
5	GoDurham Link	• Fare Free for rider	No	Fixed Route
6	Chapel Hill Transit Link	• Fare Free for rider	No	Fixed Route
7	Town of Apex Link	• Fare Free for rider	No	Fixed Route
8	Town of Morrisville Link	• Fare Free for rider	No	On-Demand
9	GoRaleigh MicroLink Link	• Fare Free for rider	No	On-Demand
10	GoWake SmartRide Link	• Fare Free for rider	No	On-Demand

	Transit Agency	Payments	Collect Fares	Service Type
11	GoWake Forest* Link	• An account-based smartphone app • Call to customer service for purchase • In person purchase at the town hall • ADA/Low-income free fare eligibility with ID	Yes	On-Demand Microtransit Paratransit
12	UNC Chapel Hill – Point to Point (P2P) Link	• Fare Free available for students and staff • An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) for unlimited rides on GoTriangle routes by students, staff, and faculty	No	On-Demand University provides access to transit
13	NC State Wolfline Link	• Fare Free for rider, open to public	No	Fixed Route
14	Duke Link	• Fare Free for rider • An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) for unlimited rides on GoDurham, GoTriangle and GoRaleigh buses by students, staff, and faculty	No	Fixed Route University provides access to transit
15	GoCary Door-to-Door Link	• Cash • Ticket Booklets for purchase	Yes	Paratransit Tiered premium services
16	GoWake Access Link	• Cash	Yes	General on-demand and Paratransit
17	GoApex Link	• Fare-free for eligible riders	No	Paratransit
18	GoTriangle Access Link	• Cash (exact change) • Physical Punch Card (10 rides) • Physical Monthly Pass • An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) • ADA/Low-income free fare eligibility with ID	Yes	Paratransit
19	GoRaleigh ACCESS Link	• Cash (exact change) • Access tickets: each ticket is good for one trip, one way only • ADA/Low-income fare-free eligibility with ID	Yes	Paratransit
20	Orange County Public Transportation Link	• An Umo account tied to the Umo mobile app or to a physical GoPass card (not both) • ADA/Low-income, Senior fare-free eligibility with ID • Cash (pay each driver for each trip)	Yes	Paratransit On-demand MOD Rural Service
21	GoDurham Connect Link	• Fare free for rider	No	On-demand
22	GoDurham ACCESS Link	• Fare-free for eligible riders	No	Paratransit
23	Chapel Hill EZ-Rider Link	• Fare-free for eligible riders	No	Paratransit Fixed route Sr. Shuttle

*Wake Forest indicates return to fares 2/26: www.wakeforestnc.gov/transportation/go-wake-forest

For transit, interoperability is the ability for different technologies, systems, and agencies to work in concert with processes in place that rely on common definitions in a standard format for reliable data exchange. Some examples include alignment of fare systems, harmonization of fare rules, and elimination of duplicative fare products. Agencies so far have taken steps to prioritize accessibility and regional integration of payment systems. They adopted contactless payments which included mobile ticketing and have put considerable investment into this rider-facing electronic payment integration.

4.2 Noted Challenges

Challenges to integrate payments for the region originate from the variety of agency sizes, fare structures in place, and fare policies/business rules active in the region. Differences in fare products and fare policy are summarized in Figure 4-3, above. Figure 4-4 below highlights agency alignments to expose potential gaps in multi-agency integration efforts.

Figure 4-4. . Regional standards for interoperable payment systems

Regional Standards	Agency alignments demonstrate rider benefits
Equitable and inclusive	Cash payments, rural service coverage, ADA.
Seamless and integrated	Consistency for riders, easy to pay and ride across the region.
Flexible and scalable	Modular systems as foundation for future growth, open design.
Reliable	Timely local connections to regional destinations make transit simple for riders. Zone definitions are consistent. Fare products and policy are mostly the same.
Resilient	Redundancies in event of operational, technical, or power outages.
Secure	Data privacy for account holders and PCI compliance for secure open payment transaction.
Transparent and accountable	Accurate information across transit websites that are easy to understand, GTFS fares v2 for consumption.

The standards listed above promote a regional payment integration effort because each relies on simple, predictable, and equitable fare policies that are delivered through a unified technology solution. Collective commitment to align systems while still maintaining autonomy remains a priority for agencies. Standardized practices and policy changes often affect organizations and transit agencies are not an exception. Fare policies and business rules are living documents that change over time. A regional Working Group or augmenting specialized in-house staff are ways the region can coordinate fare rules for the network of approximately 20 transit, microtransit, paratransit, and mobility on-demand options. The intent of the working groups is to maintain a regional approach to fares that is simple, reliable, and predictable for riders.

Streamline Fare Policies and Products

Regional payments are governed today by established fare policy percentages for stored values, fare reciprocity, and alignment on other common caps- like ages. Agencies that collect fares have achieved regional 'shared mobile ticketing' by the significant use of the Umo GoPass. This milestone allows agencies to potentially integrate payment of different service types and even modes.

In fact, Orange County offers Umo as a payment option for their demand response service for riders living outside Chapel Hill and Carrboro town limits.[20] Still, the variety and number of fare products for different service types present a challenge to integrate regional payments. The multiple fare rules/policies and eligibility requirements that exist in the region today create a complex regional fare table. For example, the GoRaleigh website lists daily, weekly and monthly passes for purchase.[21] Purchasing these physical passes gives riders a discount, much like fare capping would. It would appear there is potential to consolidate fare products since the physical pass fare type could be replicated as an electronic fare type by the Umo GoPass. Consolidation becomes a challenge if these fare products serve another function that cannot be replicated with an account-based Umo GoPass or mobile app QR code.

Upgrade or Replace Current System with Open Payment Technology

Many agencies around the world are adopting open payments as a natural extension of account-based-ticketing. Open payment systems use Near Field Communications (NFC) from smart phones, wearables to pay fares without registering an account with an agency in the region. Common fare media that operate within similar technology, processes, and commitments is often a catalyst for interoperability.

The term 'open payments' describes the ability to purchase fares by tapping a 3rd party payment method that is not necessarily linked to a customer's account. When coupled with on board cellular technology, fare payment can be a contactless and secure transaction.

It is important to note that when an 'anonymous' open payment is <u>not</u> linked to a registered rider account (e.g., Umo account) a rider would not, for example, benefit from the reduced or free fare associated with their rider account (i.e., TAP, youth, or senior riders).

Fare capping, however, can be applied to anonymous open payments. Riders who do not have a rider account (like an Umo account) or choose *not* to link their open payment form to their rider account can still accumulate a fare-capping benefit on an unlinked open payment form so long as it is the *same* open payment used at each tap.

Riders that have an account (like Umo) can enjoy using open payment forms available to them as an alternate payment form. Open payments also encourage infrequent riders to board transit. They can explore transit without the commitment of account registration and can use a familiar form of payment to ride transit in the region.

Options to implement open payments in a region typically start with the decision to retain or replace the existing system. It is becoming increasingly possible with back-office integration to retain and augment an existing payment system that is not at the end of their useful life. The challenge is determining if the legacy equipment supports integration with the open payment solution selected by the agency.

Given the current age and capabilities of fare equipment, replacement of validators is a potential path to open payments in the region. Umo smartcard system is regionally in place to collect non-

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[20] https://www.orangecountync.gov/DocumentCenter/View/30462/TRANSPORTATION-GUIDE-FOR-OLDER-ADULTS?bidId=
[21] https://goraleigh.org/find-your-fare-goraleigh-ticketing-options

cash fares however the model in place does not have the open payment functionality. Another option is to consider replacing older smart fareboxes (Genfare Odyssey) with a newer model that accepts open payments. The newer model is currently on board GoRaleigh buses and can be upgraded with an open payment configuration for non-cash fares. A third option maintains status quo and adds open payments as a third system that is secure and open payment ready. It would seem likely the agencies would continue to prefer a common electronic fare system throughout the region with a common ability to reconcile fares.

This third option for open payments in the region is to explore is an additional installation of a payment overlay solution. The third vendor solution integrates with multiple and existing fare collection systems to overlay the ability to pay with credit cards in a secure manner. Recently, WMATA began an integration effort of such an open payment overlay solution from one vendor with a validator from another vendor.

Transfers

From a regional perspective, transfers help riders use local transit options to access the regional system. When riders transfer from one to the other mode in a regional system, money between the agencies changes hands. An aligned regional fare policy facilitates fare reconciliation of transfer rules. For example, for WMATA and others, like Maryland MTA, fare collection starts on the line on which the rider first travels. This rule applies throughout the journey. Each of the agencies' Memorandums of Understanding (MOUs) and business rules are applied in the back office to simplify the rider journey. Those responsible for the back office oversee the central system for fares where performance reporting, processing fares, reconciliation of accounts, and application of transfer rules.

In the Triangle Region, transfers are provided to GoRaleigh riders. Yet other agencies notice the public that the cash fareboxes do not provide transfer receipts.[22] Also, the fare policy rules for transfers indicate that fare-free systems like Durham provide transfer receipts so riders can enjoy fare-free rides, even upon transfer to a bus that collects fares. There are exceptions like upcharges when transferring to the GoTriangle longer express type routes. The challenge for interoperability in the region arises if only a portion of the trip with transfer is captured in the system. For cash riders, solutions for their transfer activities should be considered. The continued ability to print receipts from the farebox could be a regionally uniform policy consideration which will inform procurement decisions for equipment. Another challenge is capturing data (for analysis and service planning) related to transfers to free systems. Data may not capture a rider's complete origin or destination. Figure 4-5 covers typical topics covered when developing a bus transfer policy.

[22] https://gotriangle.org/fare-faqs?q=return-fare-faqs

Figure 4-5. General Bus Transfer Guidelines

Considerations when formulating bus transfer guidelines for multiple transit agencies
1. Definitions and Scope: First validation, Modes covered
2. Eligibility: Initial fare, Number of transfers permitted, Revalidate each boarding
3. Transfer Window: Duration, Grace period, Last trip of the day
4. Number of Transfers: Number of boardings within transfer window
5. Fare Upcharges: Cross agency credit, Premium services, Zone base credit
6. Fare Media: Cash time stamped ticket, Phone, Smartcard automatically applies each tap
7. Reduced fares: Reduced or better transfer rate
8. Fare Capping: Applied to no cash fares, across agencies
9. Proof of Payment: Needed when validate fare before boarding bus
10. Service Disruption: Extend window, honor missed connections
11. Special Cases: Airport services, Paratransit, Microtransit
12. Communication and Signage: Post rules on website, trip planners, onboard
13. Interagency Reconciliation: Settlement, Standards, Policy
14. Refunds: Policy, Periods for refunds

4.3 Opportunities for Innovation and Collaboration

4.3.1 Station Opportunities to Improve Payment Integration

Stations are locations where riders will congregate to start, continue or complete a trip. Stations in the region include GoRaleigh Station, the new Raleigh Union Bus Station, Durham Station, RTC, UNC Hospital Station, Cary's Multimodal Facility, as well as the future GoRaleigh BRT Station, the Triangle Mobility Hub, and Chapel Hill BRT Station. Since each facilitates regional movement, consider maximizing opportunities for fare payment integration in these areas by pointing infrastructure, equipment, and technology toward a single payment for transit, mobility on demand, micromobility, transportation network companies (TNCs) like Uber or Lyft, and other first-mile/last-mile solutions. A few examples follow below.

- **Infrastructure:** Integrating parking payments with a transit trip for commuters who drive to the station "park and ride" is an option to create a seamless journey. Account-based fare systems can be used for products other than fares. At WAMTA stations, parking garages accept the fare card (SmarTrip) to pay for parking. Other properties like MARTA in Atlanta allow riders to use its fare card (Breeze) to enter gated station parking and unlock free or reduced rate parking benefit. Patrons must use another form of payment to exit since the Breeze card is limited to fares.

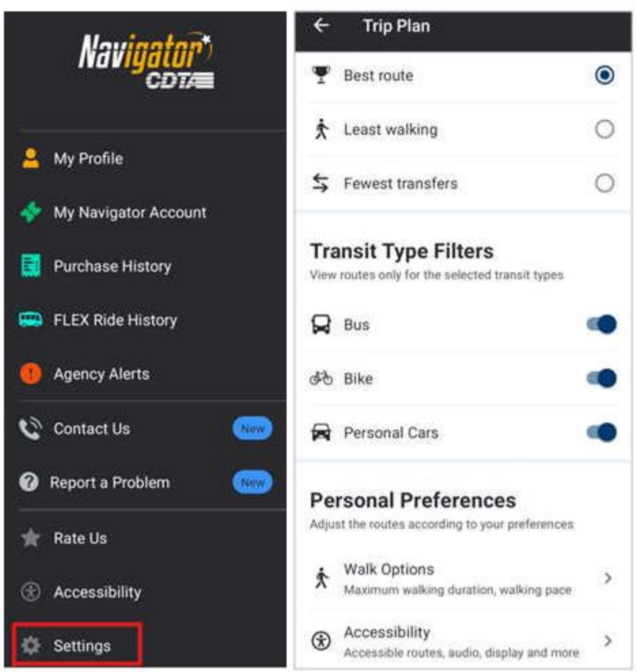
- **BRT Fare Equipment:** Stations and enhanced stops or platforms should have fare validation equipment and payment options for routes and modes. Agencies should come to full agreement on the validator location for Bus Rapid transit vehicles. On-board validation with the same fare system permits a quick vehicle swap if a fixed route bus needs to be put into BRT revenue service or vice-versa. Off-board validation is a common solution since it typically has lower implementation efforts. Validation can be done prior to boarding and with typically less delay than on-board validation. Cash payment for BRT routes will likely be off-board at a TVM or customer service desk.

- **Micromobility**: Transit riders and micromobility users pay fares and rent microtransit options like bikes, scooters, and ride-shares. Free micromobility offers are available under the right criteria. Promoting the options surrounding the region's mobility is another opportunity to increase ridership and garner interest in new stations underway. Agencies could have promotions that encourage riders to use micromobility. Similarly, nearby transit-oriented developments could also consider outreach marketing or even promotional 'first ride free' discounts to encourage a shift in rider behavior.

4.3.2 Fixed route fare payment integrations with first-mile/last-mile solutions

As with other regional payment integrations, alignments of policy, technologies and operational processes are required. Integrated, open payment solutions accommodate payment of the multiple modes that may be required of a trip. Technologies that promote open payments without needing an account are often solutions where riders can pay for micromobility and transit fares in an integrated system. Fares could be bundled to give the impression that the rider is processing a single transaction. Fare payment and mobility payments could also be separated. In the case of Los Angeles, The TAP pass integrates with Metro bike share and offers reduced rate for low income or student transit users. Chicago is known for the Ventra card where riders can link the bike share service to the Ventra account and pay for with the card or a wallet. Clipper card is used by multiple agencies in the San Francisco region. It is integrated so riders can pay with the Clipper bike share service that is operated by Lyft. In the case of Albany, NY, the Capital District Transit Authority (CDTA), has a mobile app platform that shows multiple modes of available transit. The 'Navigator' app has integrated trip planning payment for CDTA buses, and FLEX On Demand Transit. It also shows complementary mobility options during trip planning for bike shares and electric car-sharing programs. Figure 4-6 shows the Navigator mobile ticket and trip planner app interface with Bus and on-demand Flex service types in addition to a rider's ability to select routes on select transit types.

Figure 4-6. CDTA Navigator App for Fixed, On-demand, and Microtransit



Micromobility is increasingly convenient as a last-mile solution for transit riders. Conversely, transit should be just as convenient for micromobility users who arrive at stations on rented devices or on their own bike or scooters. Stations with docking areas or other micromobility infrastructure like secure bike shelters or lockers with clear payment options make the first-mile or last-mile simpler. With proper integration, there is an opportunity for riders to pay for their bike storage with a registered transit account. Pilots, if considered, should occur at stations that are located near the future Triangle Bikeway.

Open payments encourage infrequent riders to board transit. Tourists can be nudged towards transit with a comfortable form of payment without the need for account registration, exact change, or customer service interactions. Routes to and from RDU Airport could serve as a pilot for open payments given likely concentration of non-local riders. A phased approach which includes a pilot just prior to implementation is considered industry best practice.

4.3.3 First-Mile/Last-Mile Fixed Route Trip Planning

Transit planning apps integrate with first-mile/last-mile providers to create Mobility-as-a-Service (MaaS). Depending on the solution, riders can pay for services in one app and occasionally a single payment. MaaS links Transportation Network Company (TNC) fleets, bike rentals, scooters, etc. with fixed routes and final destinations.

Since TNC fleets like Lyft, Uber, and Lime, have developed working integrations with the leading trip planning apps Apple Maps, Google Maps, and Transit App, riders are starting to have a deep link connecting riders to another area to pay for the different modes. Booking and payment for both transit and TNCs can be paid together on a handful of occasions in metropolitan areas.

The Umo app has an optional trip planning feature with payment, transfer, and last-mile capabilities so long as agencies select to purchase the module is in addition to the base offering as part of their agreement with Cubic. While Umo for fare collection and real-time trip planning information in one application was designed to simplify travel within a specific agency or county, it is less apparent when planning a trip in the region. Regional trip planning in the Umo app with fare payment should offer a complete picture of transit options that the regional agencies provide. However, testing several use cases for regional travel shows a journey across more than one agency is more time consuming to plan. This was especially true for the Chapel Hill – Apex/Cary journeys where planned trips were over 3 hours. Appendix A shows the trip planning test cases. Depending on the origin-destination, riders get Umo trip planning results that are only enhanced when they consult local origin or destination agency routes, schedules, and on demand options.

In an account-based fare system, agencies today have various degrees of support for back-office system. For operations that do not have budgeted staff, vendors can provide reporting capabilities to agencies with features to adjust and monitor the fare system.

Automating the process of purchase and validation with an account-based solution has proven to improve customer experience and simplify transit. Adding the ability for account holders to receive a discount or a fare cap has further improved the fare payment experience for riders.

Seamless transit at these first mile or last mile junctures should feature a regionally unified payment system that regular and infrequent users can navigate with ease. Open payments are a clear strategy to accomplish a common form payment.

4.4 Market Analysis of Fare Collection Systems

Figures 4-7 and 4-8 compare features for regionally integrated fare systems to quickly visualize common software and functionalities available from Software-as-a-Service (SaaS) system integrators and Mobility-as-a-Service (MaaS) providers.

SaaS is a cloud computing model where clients just access the product but are not responsible for the hardware and its maintenance. Its subscription pricing model makes for simple scaling and stays current with the latest updates and security features.

MaaS from a rider's view is a platform, mobile app, website, and/or a phone number that provide(s) a source of information. MaaS at its most basic, provides riders with available transportation in the general area. The platform includes eligibility, pricing, schedule, and payment options. Realtime alerts and information are also part of a typical MaaS technology platform. For an agency, transit modes are at the center of the network. With MaaS, fixed route and on-demand transit are part of a larger transportation network made up of mobility options like, micromobility, ride hailing, or other transit routes to get from point A to point B. From this viewpoint, all providers of transportation are not in competition with one another, they are part of one ecosystem. MaaS solutions incorporate modes from the private sector, from transit like fixed routes, and on-demand services.

As summarized below, SaaS payment system integrators have different configurations. Some back-end solutions rely on third-party services to process funds, while others manage accounts internally. Certain vendors have a third-party cash option – such as mechanical fareboxes for cash, while others have third party partnerships to distribute or load contactless smartcards at third party retailers. Most have a mobile application to access services. Since a seamless transit journey usually starts with the app, there is a compelling argument for agencies to start investigating potential vendors early by reviewing app ratings found on mobile app store platforms. This cursory review can serve as an early indicator of rider satisfaction and enlighten agencies on improvement needed. Figure 4-7, on the next page, compares several transit payment integrator SaaS offerings with the key features present in a regionally integrated payment system. Data was gathered from publicly available sources such as industry reports, websites, or transit agency publications.

Figure 4-7. Key Software-as-a-Service (SaaS) Integrators Providing Integrated Systems

Vendor *Available offerings noted by a ☒*		Description
INIT ☒ Cash on-board (integration) ☒ Mobile app *and* GoPass Card ☒ Cash substitute on-board ☐ Mobile app *or* GoPass Card ☒ Trip Planning	☒ Underbanked Solution ☒ Single app to pay and plan ☒ Interoperable Payments-Fare Capping ☒ Open Payments ☒ First-mile/Last-mile Integration with micro-transit/micro-mobility providers	INIT is a systems integrator of cloud-based fare management and real-time insights ridership. INIT supports multiple services and contactless EMV payment technology and fare capping. Supports mobile apps and real time trip planning. Features interoperability between fare collection, fleet management, and other systems for an **open mobility platform**.
Conduent ☒ Cash on-board (integration) ☒ Mobile app *and* GoPass Card ☒ Cash substitute on-board ☐ Mobile app *or* GoPass Card ☒ Trip Planning	☒ Underbanked Solution ☒ Single app to pay and plan ☒ Interoperable Payments-Fare Capping ☒ Open Payments ☒ First-mile/Last-mile Integration with micro-transit/micro-mobility providers	Conduent is a smart mobility technology solutions company that designs and implements contactless payment systems with payment processing and reconciliation. Supports mobile app, bank card, and cash payments. Robust reporting for real time insights. Interoperable **connections to existing systems.**
Genfare ☒ Cash on-board (native) ☒ Mobile app *and* GoPass Card ☒ Cash substitute on-board ☐ Mobile app *or* GoPass Card ☒ Trip Planning	☒ Underbanked Solution ☒ Single app to pay and plan ☒ Interoperable Payments-Fare Capping ☒ Open Payments ☒ First-mile/Last-mile Integration with micro-transit/micro-mobility providers	Cloud-based software service with validating **fare boxes for cash**. FastFare model upgrades software for open payments. Farebox APIs ready for other vendors to develop integrations. The Mobile Link™ rider application which features trip planning and e-Fare® for mobile payment. API integration helps riders plan and pay for combinations of transit, first-mile/last-mile modalities, and even parking. The system solution provides back-office support and reporting (transactions, reconciliation, ridership, device monitoring, field equipment monitoring, etc.).
Vix Technology ☒ Cash on-board (integration) ☐ Mobile app *and* GoPass Card ☒ Cash substitute on-board ☒ Mobile app *or* GoPass Card ☒ Trip Planning	☒ Underbanked Solution ☒ Single app to pay and plan ☒ Interoperable Payments-Fare Capping ☒ Open Payments ☒ First-mile/Last-mile Integration with micro-transit/micro-mobility providers	Open-loop payment provider for digital mobility payment systems. Solution is more than an overlay. The core offer focuses on **supporting open payments.** Offers solutions for account-based fare collection, contactless smartcard, mobile ticketing, and MaaS solutions.
Cubic (Umo) ☒ Cash on-board (integration) ☐ Mobile app *and* Go Pass Card ☒ Cash substitute on-board ☒ Mobile app *or* GoPass Card ☒ Trip Planning	☒ Underbanked Solution ☒ Single app to pay and plan ☒ Interoperable Payments-Fare Capping ☒ Open Payments ☐ First-mile/Last-mile Integration with micro-transit/micro-mobility providers	**Used for contactless smartcards, mobile tickets, and trip planning.** Third-party integration is required for cash solutions; agency subscription unlocks premium trip planning in Umo. Retail network for cash loading on GoPass is possible. Newer, compatible validator models have available APIs for open payment capability with Umo.
Littlepay ☒ Cash on-board (integration) ☐ Mobile app *and* GoPass Card ☒ Cash substitute on-board ☐ Mobile app *or* GoPass Card ☐ Trip Planning	☐ Underbanked Solution (custom) ☐ Single app to pay and plan (custom) ☒ Interoperable Payments-Fare Capping ☒ Open Payments ☐ First-mile/Last-mile Integration with micro-transit/micro-mobility providers	Scalable transit payment platform that overlays on existing fare system, provides open payment solution. Hardware agnostic approach. Google Transit Insights Integration to access fare tracking and journey information directly into mobile wallets. **Supports multi-agency fare capping.** Reporting tools and fraud prevention.

While all vendors have APIs that can exchange functionality between systems, each API will need to be investigated to ensure features can be supported *after* the final architecture selection. For each vendor, characteristics of the MaaS solution are marked with an "X." The nuances of each base product are important to compare when the regional fleets are composed of different services. Notable agency integrations with vendors are italicized in Figure 4-8 below. Data was gathered from publicly available sources such as industry reports, websites, or transit agency publications.

Figure 4-8. Key Vendors Providing MaaS fare collection solutions

Vendor ***Integration examples***	**Single app for pay and plan trip**	**Open payment**	**First-mile/ Last-mile Integration**	**Unbanked solution**	**Interoper-ability payment fare cap**	**Description**
Reach Now (Moovel) *Cubic integration (CTA)*	☒	☒	☒	☒ cash to digital option	☒	MaaS solution offers **trip planning for transit modes both public and private** (TriMet). Mobile tickets (MDOT MTA). App integrates virtual cards (rider virtual wallet) with Apple Pay; Google Pay prepaid cards for digital payment.
Via Transportation	☒	☒	☒	☐ custom solution	☐ custom solution	Provides mobility solutions primarily focused on dynamic routing to serve **on-demand, paratransit and microtransit** services. Riders can choose destinations, review multimodal options, and pay for travel. Integrates with existing fare system- First-mile/ last-mile solution integrates with public transit to bridge gaps in fixed route networks.
Token Transit *Genfare/FastFare integration TARC, COMET, JTA*	☒	☐ Roadmap 9/2025	☐	☒ cash to digital option	☐ custom solution	Scalable mobility solution lets rider purchase, activate and board by mobile app. Provides mobile ticketing for public transit and **integration with CashApp for unbanked.**
Transit (Transit App) ***Used in the region*** *today along with Transit Royal premium subscription.*	☒	☐	☒	☐	☐ custom solution	Provides transit information specific to a rider location. Provides departure times, track buses, and plans trips with a trip comparison tool. Payment for fares when **integrated with other mobile ticketing platforms (i.e., Token Transit).** The ability to pay for multiple modes is only open to cities where Transit has partnerships with agency and Transportation Network Companies (TNCs). Subscription unlocks premium features.
Spare Technology Labs *Token Transit Integration DART*	☒	☒	☒	☐ custom solution	☐ custom solution	Microtransit and Paratransit platform that facilitates payment for on-demand and first-mile/last-mile transit. Integrates payment systems for seamless fare collection. **Fare management system can support fare capping rules.** Riders can book, manage, and pay for trips.

4.5 Recommendations for the Region

Recommendation #1: Delay single app for trip planning and payment

Part of "meeting riders where they are" means letting riders choose more than a payment type or service mode. It also means having the choice to use their preferred app to plan the journey. For example, MaaS providers that specialize in on-demand and mobility can activate ticket purchases when agencies provide APIs and agree to deep link integration.

An important consideration for trip planning, tracking, and purchase is the dependence on smartphones. If there is no cellular service in the area or a rider does not have a mobile phone, another payment option should be in place so riders can purchase fares. Similarly, for those that cannot or do not want to use app-based services, another payment option should be available.

While it is often beneficial to adopt modern app-based solutions to streamline rider experiences, trip planning alongside fare purchase in a *single* app may be premature. Agencies can first consider the rapid growth in the SaaS/MaaS industry and the current specifics of the region like:

- The momentum of electronic fare collection solutions for system integration is gaining speed with each agency implementation. SaaS, MaaS integrations are cost effective solutions, so deployment of new features is modular and does not require custom development for efficiencies like trip planning.
- At present, GoTriangle, GoRaleigh, and OCPT collect fares on fixed routes, while GoCary, GoDurham, Chapel Hill Transit, and others remain fare-free.
- Communities throughout the Triangle Region are served by on-demand services alongside micromobility and paratransit options. Providers in these on-demand scenarios already 'plan' trips and give riders a time window for arrival.
- Other agencies in the US (e.g., CapMetro in Austin, Texas) are currently exploring the integration of trip planning systems with separate trip payment applications.

It is the recommended approach that agencies monitor and learn from ongoing, successful integrations first, before committing to a single app that provides both trip planning and trip purchase now. Trip planning tools available in the region are addressed in Chapter 1.

Recommendations #2: Regional integration of payments

Interoperability standards to promote a regional payment integration effort are at the core of many of the topics in this Technology Plan. Agencies should find commonalities and identify current system configurations, age of software and equipment, product lifecycle, and state of good repair as a first step to payment technology integration.

Consider the ability for the region to adopt an automated fare collections system that accepts each operating partner's fare rules that work with mobile ticketing applications, smartcards, and open payment solutions such that riders have options for payment (e.g., fare media, credit cards, and mobile wallets (Apple pay, Google pay)). This would imply that physical fare media, mobile ticketing, and open payment options could be securely read by validators or fareboxes throughout the region. Software updates for newer fareboxes and a full replacement for older farebox models would be required for current fareboxes in the region to accept open payments. Validator replacement would be required should the current smartcard system be retained. A typical approach to regional payment integration includes the following elements:

- Standardized payment processing
  - Data architecture is common, scalable
  - Revenue sharing across agencies
- Technical Architecture
  - Open APIs
  - Account-based ticketing growth
  - Standardized and formatted data
  - Real-time information exchange
- Future Readiness
  - Multi-modal integration
  - MaaS platform
  - Integrate third parties
  - Mobility partnerships
- Implementation Strategy
  - Potential use of existing GoPass infrastructure
  - Agencies coordinate technology upgrade
  - Establish regional data standards

Recommendation #3: Maintain a Cash Option for Riders

Agencies in the region should maintain the current equitable approach to transit with a cash option that includes equipment for riders to pay fares in coins or dollars. Riders who choose not to download apps, create an account, or do not accept an app's terms and conditions should still be able to ride transit and cash provides riders with that option.

This approach also allows the unbanked to ride transit without an account, pass, or fare card and typically involves an on-board farebox to collect fares. Eliminating cash fare collection would likely require further evaluation including Title VI fare equity analysis to document cash removal would not impact one demographic over another. A common way is to demonstrate no impact is for service nodes to be near third-party retail networks that sell or reload GoPass fare cards by a cash transaction. CashApp has developed a cash app card that riders can load with cash and add to a mobile wallet or transit mobile app to pay for transit. The solution allows unbanked riders to load funds for contactless payments into a mobile wallet or into mobile ticket app.

Recommendation #4: Develop KPIs for system performance and reliability.

Establishing uniform key performance indicators (KPIs) for the region helps to measure efficiency, cost, reliability, and accuracy rates of a fare collections system. The selected solution for future procurements should meet the identified KPI thresholds to hold vendors to desired standards and contracted requirements. KPI thresholds are set according to a desired outcome defined by the agencies in the region. Examples of events where accuracy thresholds are set for KPI metrics include:

- Critical System Failure Issue Resolution Time
- Mobile App Availability

- Mobile App Crash Rate
- Farebox Availability Time – Mean Time Between Failures When in Service
- Revenue Processing Accuracy
- Fare Transaction Processing Accuracy
- Average Validator Transaction Time
- Ticket Vending Machines (TVM) Availability Time

KPI performance measures give agencies the ability to enforce high performance levels from vendors who are contracted to provide the payment system. In absence of robust KPIs, vendors typically fall short of delivering the functionalities promised at the expected time threshold or failure rate that were bid upon. For example, when developing procurement documents for open payments, it is recommended that transaction threshold times are a requirement in the Request for Proposal (RFP). One reason to advertise expected transaction rates is to contractually set data delivery expectations (i.e., currently between 300-500 milliseconds). Another reason is to ensure the vendor's equipment provides sufficient bandwidth to complete the transaction within that threshold.

Recommendation #5: Standardize fare data with GTFS Fares(v2)

Agencies have the opportunity to conform with existing data standards like GTFS and Fares (v2), so they are talking the same regional 'language' when providing fare data feeds that are available to consume. Fares (v2) is a more detailed version and improves on describing fare policy rules. Agencies may publish Legacy Fares (v1) and Fares(v2) independently of one another, however transition to Fares(v2) is recommended. Fares (v2) accounts for fare variations by modeling fare structures to account for the many factors that will determine a rider's fare. Mobility Data lists a spreadsheet resource [23] to help agencies organize the required data necessary for Fares (v2) GTFS files. Agencies have the opportunity to further align the GTFS feed with specifics that:

- Define a transit fare (one day pass, weekly/monthly pass, etc.) (fare_products.txt)
- List rules for single leg journeys (fare_leg_rules.txt)
- List rules for transfers (fare_transfer_rules.txt) (use the same unit of measurement, seconds)
- Describe service locations in the same fare zone (areas.txt, stops_area.txt, and fare_leg_rules.txt)
- Describe what fare media is accepted (fare_products.txt and fare_media.txt)
- List price differences based on fare media type (fare_media.txt, fare_products.txt,)
- Describe a contactless fare media option "tap to ride" (fare_products.txt) e.g., – tap to ride cEMV (contactless Europay, Mastercard, and Visa).
- Define price differences based on time and day of trip (calendar.txt) (use same units)
- Define time-variable fares along with zone-based fares (peak, non-peak)

The greater the ability to organize the data points in the categories above, the more fare costs are discoverable. As mentioned earlier, a regional fare table is less complex (fewer data points) when agencies align respective fare structures and the region has mostly aligned fares, for those who collect them. Trip planners can consume most of the Fares(v2) feeds so that riders can factor in

[23] https://share.mobilitydata.org/faresv2-template

costs when choosing between transit options. Further discussion of the GTFS feeds are presented in the next chapter.

Recommendation #6: Align user experiences for transfers, fare capping, and payment

Paying for transit should be straightforward. Riders should clearly understand their trip details and fare costs. From a policy standpoint it is recommended to simplify and align fare rules to the fullest extent possible. Complicated fare payment structures for the rider can act as a barrier to entry for new riders. The region is expanding to improve route frequency levels and attract riders. Complicated fare rules should not be the barrier to attract new riders.

- Riders need confirmation that their payment was accepted.
- Riders should be informed of any time limits on transfers.
- Riders should understand fare capping at time of validation. Validation messages should reflect when fare capping will be reached.
- Riders deserve clear feedback when they tap in, know how much they have been charged, and see transfer options.
- Riders have better access when websites and payment apps are multilingual and user friendly.

Recommendation # 7 Automate Fares for On-demand Service Modes

Services offered by the smaller, cutaway' buses providing on-demand transit include:

- Paratransit on-demand services (reservations required)
- Senior on-demand services
- Micromobility on-demand services areas with low transit propensity or density.

The on-demand and paratransit fare collection process has remained outside the main discussion of the fare collection practices typical of fixed routes (i.e., fare boxes or mobile ticketing). Fare data can be used to analyze fare for demographic insights. Fare data analysis gives insights into high ridership areas and could provide additional services to improve rider experience.

Depending on the agency and service provided, on-demand and paratransit service types are free or fared. Those agencies that collect fares may benefit from a more automated approach to fare collections. For example, agencies may consider an account-based collection method and adding smaller, tap-style validators for contactless smartcards or open payment options for on-board payment. Alternatively, it is possible to consider business rules and fare policies that permit taking payment information over the phone upon reservation. The region's ACCESS programs for paratransit and mobility programs show a potential opportunity for improvement since fares are paid in cash or by pre-paid punch cards or discount ticket booklet. There is steady phone support from customer service call centers for reservations supported by individual agencies to help reserve rides.

Certain MaaS software solutions specialize in using technology to enhance customer experience in both paratransit and mobility on demand. Mobility-on-demand solutions are now more dependable and flexible for the rider and more trackable by the agency. Routes are planned or cross-verified with AI insights to capture more value in each route driven. Pick-up reminder texts that incorporate Audio Video Interleave (AVI) (speech to text) and robo-texts are two popular functionalities offered to support reliable communication for paratransit and other on-demand type services.

Rider-facing apps can help book trips or pay for trips. With a MaaS solution in place, agencies and riders could forego the inconveniences of, processing tickets and cash handling. PalmTran, Palm Beach County, Florida saw a reduced call volume after the introduction of advanced software capabilities such as apps and rider dashboards for reserving and paying for on-demand service.

4.6 Roadmap Strategies for Regional Fare Collection

The following roadmap in Figure 4-9 takes into consideration the existing fare collection system and ongoing efforts for agencies in their continuing development of regionally integrated payments. While the steps are planned over three years, the timeline may shift based on advancements, priorities and the marketplace's technological improvements and offerings.

Figure 4-9. Roadmap of Recommendation Strategies for Regional Fare Collection

Step 1: Inventory Existing Systems Coordinate with agencies to determine existing hardware/software components of fare collection system. Rank needs and capabilities. Inventory existing equipment useful life; weigh cost of integrating with existing or new equipment. Address potential for alignment of contract terms from current vendors. Consider further automation of paratransit fare collections.		**Step 2: Analyze Fare Payment Practices** Coordinate with agencies to provide updated payment integration matrix that outlines, fares, rider classes, fare products and pricing, transfers, and fare media for fixed route, BRT, on-demand and paratransit modes. Review the current Title VI study for updates that may be required because of regional payment integration changes under consideration.		**Step 3: Identify Payment Approach as a Region** Develop operational solutions to align fare collections (i.e., policy, processes, business rules). Use matrix to identify/resolve variances across the region as much as practical. Consider a vendor Request for Information (RFI) process to learn about developments in rapidly changing industry. Confirm software/hardware /coms upgrades needed to integrate payment systems.
Years 0-1		**Year 1**		**Year 1**
Step 4: Procurement and Implementation of Payment System to Allow Open Payment and Platform Payments on BRT Use system inventory, regional fare rules, and RFI insights to develop procurement documents. Select a vendor to provide a system that allows cash and can allow for open payment from passengers and provide platform payments at BRT stations. Consider phased approach with a pilot just prior to full system implementation.				
Years 2-4				

4.6.1 Regional Fare Collections Budget Recommendations (Wake, Durham, and Orange County)

The region's agencies have different fare collection equipment systems on board their buses. The following provides a rough order-of-magnitude (ROM) estimate for three options to achieve regionally integrated payments. See Appendix B for a more detailed estimate.

Three agencies in the region use Umo 2.0 validators for electronic fare collection and two currently collect cash using Genfare fareboxes to collect fixed route fares in the region. As shown earlier in Figure 4-3, three agencies representing the highest ridership in the region collect fares while ten do not collect fares at this time. The blended approach of fare-free transit and fared transit creates additional complexity when regionalizing a payment system. Agencies working towards integrating a regional payment system typically align fare policies, business rules, hardware, and software solutions. The fewer variations and exceptions to rules typically translate into a simpler development and deployment of integrated payments in the region. It also translates into simpler fare rules that riders can understand and generalize for travel in the region.

In addition to the capital costs below, when agencies seek common fare collection systems agencies must consider funding internal work by planning and operations staff in the region for agency collaboration before, during, and after procurements. Regional alignment requires coordination and mutual understanding of current systems and criteria of future fare collection system throughout design and implementation.

Assumptions: While initial integration effort is considered, none of the on-going operational costs (SaaS, transaction fees, cell service, etc.) are included. Estimates are limited to equipment, hardware, and related software implementation including initial integration development and back-office development. Fleet size is based on 2023 NTD data. Table 4-1 presents a recommended split of the cost estimate among Wake, Durham, and Orange Counties based on a percentage of 2024 NTD hours within the region. The average amount of the range of figures provided for Options A, B, and C below are multiplied by the percent of all NTD hours for each agency to arrive at the totals presented in Table 4-1. Note that these are planning-level cost estimates to guide Counties in planning for the three approaches described within this chapter.

	OPTION A. Replace/upgrade current fareboxes with single validating farebox for all payments and open loop functions. Remove validators in use. Single back office.		OPTION B. Replace validators to accept open payment. Replace fareboxes with mechanical farebox. Single back office.		OPTION C. Integrate existing systems with open payment overlay. Keep newer existing fareboxes. Likely validator replacement. Preserve back-office status-quo.	
	Low	High	Low	High	Low	High
System Costs	$4,112,500	$6,557,800	$1,582,500	$3,278,800	$3,007,500	$4,524,800
Variable System Costs	$2,454,990	$5,177,870	$2,454,990	$5,177,870	$2,454,990	$5,177,870
Warranty	$104,400	$182,700	$104,400	$182,700	$104,400	$182,700
Option Estimate TOTAL	**$6,671,890**	**$11,918,370**	**$4,141,890**	**$8,639,370**	**$5,566,890**	**$9,885,370**

NOTE: Staffing and internal operations costs are not included.

Table 4-1. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Fare Collection Technology Options

Option A	**2024 NTD Hours ****	**Percent of All NTD Hours**
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		

Option A	**Total Cost for Years 1-5**
Wake County Total	**$5,570,661**
GoRaleigh Estimate	$4,464,200
GoCary Estimate	$526,964
GoTriangle Estimate	$579,497
Durham County Total	**$2,354,672**
GoDurham Estimate	$2,038,583
GoTriangle Estimate	$316,089
Orange County Total	**$1,482,583**
Chapel Hill Transit Estimate	$1,211,752
OCPT Estimate	$113,056
GoTriangle Estimate	$158,045

Option B	**2024 NTD Hours ****	**Percent of All NTD Hours**
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		

Option B	**Total Cost for Years 1-5**
Wake County Total	**$3,829,966**
GoRaleigh Estimate	$3,069,247
GoCary Estimate	$362,300
GoTriangle Estimate	$398,419
Durham County Total	**$1,618,895**
GoDurham Estimate	$1,401,576
GoTriangle Estimate	$217,319
Orange County Total	**$1,019,498**
Chapel Hill Transit Estimate	$833,109
OCPT Estimate	$77,729
GoTriangle Estimate	$108,660

Option C	**2024 NTD Hours ****	**Percent of All NTD Hours**
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		

Note: Cost estimate splits are based upon percent of all NTD hours within region. GoTriangle hours are split 55/30/15 among counties.

Option C	**Total Cost for Years 1-5**
Wake County Total	**$4,630,344**
GoRaleigh Estimate	$3,710,652
GoCary Estimate	$438,013
GoTriangle Estimate	$481,679
Durham County Total	**$1,957,208**
GoDurham Estimate	$1,694,474
GoTriangle Estimate	$262,734
Orange County Total	**$1.232,551**
Chapel Hill Transit Estimate	$1,007,211
OCPT Estimate	$93,973
GoTriangle Estimate	$131,367

Chapter 5. Regional GTFS Publishing Standards

Vision: General Transit Feed Specification (GTFS) and GTFS-Real-Time (GTFS-RT) feeds are coordinated across the region, regardless of differences in Computer Aided Dispatch (CAD)/Automated Vehicle Locator (AVL) systems. Tools ingesting a GTFS feed are easily able to pull and display data from across the region. Stop names and IDs are consistent across all feeds.

Objective: Identify recommended steps that transit agencies can take to enable coordination among GTFS and GTFS-RT feeds to provide passengers with a consistent display of real-time information through various transit trip planning interfaces.

5.1 Initial Findings and Opportunities

5.1.1 Summary of Current Conditions

Agencies use a range of tools to generate GTFS files as shown in Table 5-1. Many agencies rely on scheduling and planning software to produce the initial GTFS feed, which gets fed into their CAD/AVL system to generate a GTFS-RT feed. Table 5-1 presents a summary of how GTFS files are generated by the transit agencies operating fixed routes within the region.

Table 5-1. Summary of Technology Used in GTFS Publication by Transit Agency with Fixed Routes

Transit Agency	Scheduling System	CAD/AVL Systems	GTFS Feeds Link[24]
GoCary	TripSpark	TripSpark	GoCary GTFS-RT
GoRaleigh	Optibus	Clever Devices	GTFS and GTFS-RT Feeds
GoDurham	Optibus	Avail with Swiftly	Real-Time API
GoTriangle	TripSpark – FX/Blockbuster	TripSpark	GTFS-RT Feed Trip Spark
Chapel Hill Transit	Optibus	GMV/Syncromatics	GTFS-RT Feed
Town of Apex	Done by GoCary as operator of service.	Done by GoCary as operator of service.	
NCSU Wolfline	Hastus	Passio	GTFS Feed GTFS-RT Feed
Orange County	Does not have	Does not have	GTFS Feed

[24] All feeds available on GoTriangle Developer Resources page at: https://gotriangle.org/developer-resources.

Table 5-2. Summary of GTFS File Generation by Regional Transit Agencies with Fixed Route

Transit Agency	GTFS	GTFS-RT	GTFS Generation Process
GoCary	X	X	TripSpark schedule platform is used to generate the GTFS and exported through scheduling software, with minor refinement to the TripSpark CAD/AVL which produces the GTFS. The contracted operator then uses the GTFS to develop a run-cut in their software (Optibus) and then transfer it back to TripSpark.
GoRaleigh	X	X	GTFS feeds are generated in Remix; then sent to the contracted operator to update Optibus scheduling software; then sent to Clever Devices (the CAD/AVL provider) who translates them for use in their software and performs a QA/QC. Clever then sends the usable database files (including the GTFS) back to GoRaleigh who uploads the GTFS to a permalink on their website. Clever Devices generates the GTFS-RT feeds, which are hosted on the same website.
GoDurham	X	X	The GTFS static is generated in the scheduling software Optibus by the contracted operator, which is then sent to Trillium, who publishes the final static files. The static GTFS are imported into the CAD/AVL system Avail, but Avail is unable to produce a GTFS-RT, so GoDurham has brought in Swiftly to generate and manage a GTFS-RT feed.
GoTriangle	X	X	Schedule changes are made in Trapeze FX/Blockbuster that get translated into a GTFS, using a product by Trillium called GTFS Manager, that feeds directly into the TripSpark CAD/AVL system, which produces the GTFS- RT.
Chapel Hill Transit	X	X	The GTFS is generated in Optibus and then fed into the CAD/AVL system (GMV) that generates the GTFS-RT files. This is used in GMV (AVL system) to add GTFS-RT, updates, alerts feeds.
Town of Apex	X	X	Done by GoCary as the contracted operator of the service.
NCSU Wolfline	X	X	Passio is used to generate and update the static GTFS. Passio has built in configurations that allow NCSU to update the GTFS at any time. The GTFS is then given to the operating contractor who uses it for the runcut. All GTFS and GTFS-RT feeds are maintained in Passio and accessible via an API.
Orange County	X		The GTFS is generated in Remix, using the planning platform and then uploaded and hosted by National Rural Transit Assistance Program (RTAP). Orange County does not have fixed route scheduling or CAD/AVL software.

5.1.2 Cycle or Frequency of GTFS Updates

GTFS updates generally coincide with service changes. Most agencies update files 2–3 times per year, typically aligning with operator bid selections or semester schedules as presented in Table 5-3 below. GoRaleigh performs updates in January, May, and September, while GoTriangle historically does this in January/February and August but is considering a third update. NCSU Wolfline, having a simpler system, updates their GTFS feeds manually before each semester.

Table 5-3. Summary of Agency Bid Processes that Align with GTFS Updates

Transit Agency	Number of Bids Annually	Bid Cycle
GoCary	2+	Based on bid selections
GoRaleigh	3	January, May, and September
GoDurham	2+	Dependent on service changes
GoTriangle	2	August and Jan./Feb.
Chapel Hill Transit	3	Typically, January, May, and August
Town of Apex	2+	Done by operator GoCary
NCSU Wolfline	3	Spring, summer, and fall semesters
Orange County	Unknown	Unknown

Changes to Static GTFS Files for New Stops or Routes

Agencies vary in how they manage updates for new stops or routes. Passio allows for real-time updates by NCSU Wolfline, while GoCary handles updates on an as-needed basis but links them to service activation. GoRaleigh incorporates new routes and stops in its planning software and reflects them in GTFS during the next database update and will also add or move stops outside of the database update where needed, though this may result in delays. GoTriangle uses Trapeze FX to translate schedule or route changes into GTFS.

In general, the process for adding a new route and including it in the GTFS data is coordinated with the operator bid selection cycle. This allows transit operators to bid on a route and have it assigned to specific operators before it is introduced to the general public through a GTFS feed.

Maintenance of GTFS Feeds

GTFS maintenance processes vary widely:

- **NCSU Wolfline**: Maintains GTFS in Passio, accessible via an Application Programming Interface (API).
- **GoRaleigh**: Receives GTFS files from Clever Devices, uploads them to a public permalink, and distributes them to other stakeholders.
- **GoDurham**: Changes occur in Optibus during the service change process and the updated GTFS files are exported.
- **GoCary**: Generates a new feed when a conducted service change impacts the feed
- **Chapel Hill Transit**: Uses Optibus and GMV for feed updates.
- **GoTriangle**: Works on standardizing GTFS maintenance processes as part of CAD/AVL implementation.
- **Orange County**: Seeks external support to enhance GTFS updating efficiency.

5.2 Noted Challenges

The overall vision with respect to GTFS publishing standards is the coordination of GTFS and GTFS-RT feeds across the region, regardless of differences in CAD/AVL systems. Coordination will allow tools that ingest GTFS feeds to easily pull and display data from across the region, where stop names and IDs are consistent across all feeds. Through conversations and feedback provided by the agencies, several challenges were identified in being able to meet this vision. These challenges, which must be overcome, are as follows:

- **CAD/AVL Vendor Issues:** The agencies noted that while most of their concerns with CAD/AVL systems generally have been resolved through working with the vendor technical contacts, there can sometimes be long periods of wait times to resolve known issues with the systems.
- **Lack of CAD/AVL or Scheduling Technology:** Some agencies lack the software to easily generate a GTFS and are unable to generate a GTFS-RT
- **GTFS Updates:** Agencies update their GTFS in conjunction with service changes all at different times. Often agencies are not aware that others have made changes in their GTFS to shared stops or coordinated routes, and this is a key challenge.
- **Inconsistent Stop Identification:** There is a lack of consistency in naming bus stops and using the same Stop IDs for shared stops in the region. A naming convention framework was developed however employee turnover has resulted in a lack of implementation.
- **Documentation:** Agencies lack a (standard operating procedure) SOP for the process and timeline of updating GTFS feeds.
- **Integration:** Systems with separate technologies for generating GTFS and GTFS-RT must export data between the two systems, as they are not seamlessly integrated. Changes made in one system need to be manually carried through to the next.
- **GTFS Production Guidelines:** The Transit App and Google Transit have different guidelines for producing static GTFS data in regard to transfers. Google does not support transfer types (a mandatory field) 4 and 5. Transfer types 4 and 5 are used to link consecutive trips performed by a vehicle together. Google recommends instead using block transfers. Transit App allows for a type 4 and 5 transfer and discourages use of block transfers.

5.3 Opportunities for Innovation and Collaboration

During the fixed-route agency interview, it was noted that a prior bus stop naming convention file was developed in the region when GTFS was first being deployed by transit agencies. This file is dated 2010 and was reviewed as recently as 2021 in the region. This file may be able to serve as a starting point for creating a SOP around how shared stops are addressed in the naming convention file and what updates may be needed to enhance coordination between the agencies. Updates can be made in this file to note that GTFS-RT is a regional standard for transit information so that all agency feeds can be consumed by third-party information service providers (such as Google Maps, Transit App, etc.) and also be posted on respective agency websites for review.

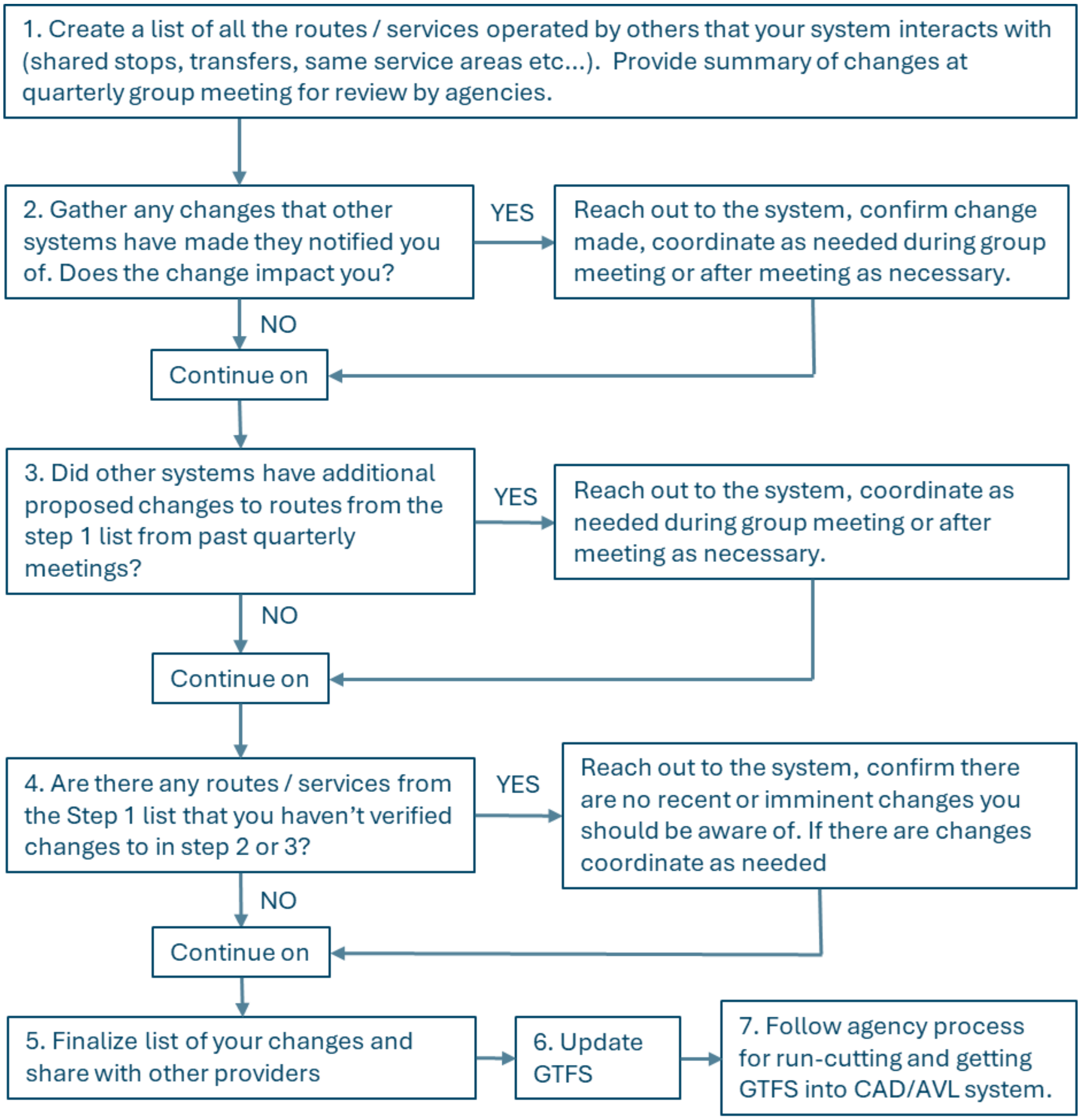
The updates to the file could also identify the anticipated cycles that each fixed-route agency follows when making updates to bus stops and routes in the region. Information on the cycles was previously gathered from surveys distributed to the agencies and it could be included in the updated file.

Other information could be included in an updated version of the naming convention with respect to GTFS/GTFS-RT feeds that are generated. This may include how each agency creates its GTFS feed, whether it be through use of a specific software or if it is created by a contracted service operator. This may provide guidance for other transit agencies that have questions about feed generation and updates.

Further discussion with the project management team about the naming convention will be needed to determine if any changes to the naming of directional headings are needed to improve coordination at shared stop locations.

Another opportunity for regional collaboration exists with respect to the planning for the updates made by transit agencies to their GTFS feeds. Figure 5-1 below presents a potential workflow for how transit agencies can identify impacts to transit service in areas of shared stops where changes to transit service will impact other agencies. The process is recommended to happen on a quarterly basis throughout the year at points where the transit agencies can meet to discuss service changes that may impact other transit agencies, and thus, update their GTFS feeds in the most efficient manner.

Figure 5-1. Potential Workflow for Regional Coordination to Support GTFS Updates by Agencies



5.3.1 Case Study: Vermont Agency of Transportation (VTrans)

Vermont Agency of Transportation (VTrans) has been contracting with Trillium since 2014, to produce and maintain GTFS datasets for all nine public transit providers across the state of Vermont. In 2016, VTrans received a Federal Transit Administration (FTA) Mobility on Demand (MOD) Sandbox grant to develop the VTrans Flexible Trip Planner—an innovative multimodal trip planning application that integrates both fixed-route and demand-responsive transit services.

The core objective of the MOD project was to enable flexible, multimodal trip planning capabilities. To achieve this, the project required the development and implementation of GTFS-Flex, an extension of GTFS designed to model demand-responsive transportation services. Several key innovations contributed to the project's success:

- GTFS-Flex feeds were developed for all public transit providers in Vermont.

- Enhancements to GTFS standards were proposed by the project team and subsequently adopted by MobilityData IO, the global steward of GTFS.
- The OpenTripPlanner (OTP) open-source platform was used as the foundation for the trip planner. Custom code was developed to enable OTP to ingest and utilize both GTFS and GTFS-Flex datasets. The code is publicly available on GitHub.

Trillium was responsible for coordinating with each transit agency to gather the necessary GTFS-Flex data needed, documenting how the GTFS-Flex was created. Vermont's GTFS static and GTFS-Flex feeds are published and publicly accessible at https://vermont-gtfs.org/. Trillium manages these feeds using its proprietary GTFS Manager platform. These datasets power the Go! Vermont Flexible Trip Planner, providing comprehensive statewide transit coverage.

All demand-response/on-demand transit providers in Vermont use the RouteMatch cloud-based ITS platform for CAD/AVL (Computer-Aided Dispatch/Automatic Vehicle Location), a system jointly procured by VTrans and the Vermont Public Transit Association (VPTA) in 2015. Fixed-route scheduling and CAD/AVL platforms vary by agency, depending on individual operational requirements.

Lessons learned from the project are as follows:

- Building a partnership with technology vendors who have a vested (financial) interest in the project is crucial.
- Handling large data sets requires strong data management practices, transit agencies can often lack the capability/knowledge or financial resources to properly invest in data management.
- Flexible services need to have clear definitions of service rules in order to generate a GTFS-Flex.
- High-quality service data is needed, often posted information is not clear on where buses stop, routing and schedules. This info is needed in order to generate a GTFS.

5.3.2 Case Study: Oregon Department of Transportation (ODOT)

Trillium, in partnership with the Oregon Department of Transportation (ODOT), developed the first web-based GTFS editor. At the time, ODOT was working on a statewide trip planner just as Google released the beta version of Google Transit. They quickly recognized that it was more advantageous to focus on creating data that Google's Trip planner could use than to invest in creating a proprietary tool. So, to support this effort, ODOT collaborated with Trillium to develop and refine a web-based GTFS Manager tool, making it easier for systems to turn schedule data into a GTFS. This tool is now offered by Trillium; it is not an open-source tool.

In 2020, ODOT expanded this collaboration by having Trillium generate GTFS-Flex data for demand-responsive transit systems. Since then, Trillium has been responsible for publishing both GTFS and GTFS-Flex data for 47 of Oregon's 58 transit providers. The remaining 11 agencies manage and publish their own GTFS data. Trillium works closely with each participating agency to collect, organize, and publish accurate GTFS data. This GTFS data supports a range of planning and analysis efforts by ODOT, including TNExT—an open-source, web-based platform developed by ODOT to analyze transit networks statewide. ODOT continues to innovate by developing new tools for creating, utilizing, publicizing, and improving GTFS data. Many of these tools are available on their GitHub repository: https://github.com/ODOT-PTS.

Lessons learned from this project are as follows:

- Trip_ID's and stops in APIs that publish GTFS-RT need to align with those in Static-GTFS or else there will be issues with integrating trip planning and real-time in third party apps.
- Interoperable open-source tools will provide more value over proprietary ones in the long run as they provide standardization.
- Open-source tools that are created should be published to allow for use (and improvement) by others.
- GTFS feeds need to be updated and maintained. If agencies (particularly those without CAD systems) change their schedules or service rules but don't update Trillium, the changes do not flow through to the GTFS, and inaccurate data is published to third-party trip planners.
- Conduct a small pilot when implementing new technology in order to test it out before rolling out systemwide.
- Standards and best practices need to be followed when generating GTFS.

5.4 Recommendations for Regional GTFS Publishing Standards

The following are recommendations for the region with respect to Regional GTFS Publishing Standards.

Recommendation #1: Develop Standard Operating Procedure (SOP) to define how regional partners name shared stops in GTFS

The region created a file in 2010 to coordinate bus stop naming. This file may be able to serve as a starting point for creating a standard operating procedure (SOP) around how shared stops are addressed in the naming convention file and what updates may be needed to enhance coordination between the agencies. This document can outline consistency not only in the naming of stops, but the directional headings provided to each route. The region should use cardinal directions (north, south, east, and west bound) and not in-bound or out-bound terminology from a central location. Cardinal directions are universal and would clear up any confusion, particularly among routes whose termini are both central locations.

Recommendation #2: Develop workflows to understand how GTFS edits can be made in a more timely manner than current timeframes allow

Workflows should be developed by each agency that outline the process for updating a GTFS. It should include timeframes, deadlines, roles and responsibilities, standards used, process for notifying other systems of changes, and the flow of information. **Error! Reference source not found.** Figure 5-2 outlines an example process diagram based on GoRaleigh's description of their GTFS update process that could be included in workflow documentation for editing a GTFS.

Other information could be included in an updated version of the naming convention with respect to GTFS/GTFS-RT feeds that are generated. This may include how each agency creates its GTFS feed, whether it be through use of a specific software or if it is created by a contracted service operator. This may provide guidance for other transit agencies that have questions about feed generation and updates.

Figure 5-2. GoRaleigh GTFS Update Process Diagram

Step 1: GTFS Feed Pull & Initial Edits GoRaleigh Staff uses "Remix" to pull data	Duration: 2 - 4 weeks		
Step 2: GTFS Transfer to RATP-Dev for Run-Cutting Edits are sent to RATP-Dev, which generates updated run-cuts using Optibus		Duration: 4 - 6 weeks	
Step 3: Run-Cut Implementation in CAD-AVL System Clever Devices performs QA on edits and run-cuts, then implements updated in CAD-AVL			Duration: 4 - 6 weeks
Overall Timeline	Duration: Approximately 3 months		

Recommendation #3: Schedule Quarterly Regional Coordination Meetings to Review Transit Service Changes Impacting Other Agencies

Regional coordination among transit agencies in the region at quarterly working group meetings can help to identify where future transit service changes by each agency may have an impact on other transit agencies, especially at shared stop locations and areas of overlapping transit service.

A potential workflow for regional coordination to support GTFS updates by agencies is presented in Figure 5-2 as an opportunity for regional collaboration on this effort. The processes for how agencies perform run-cutting and work with their CAD/AVL vendors may differ, but the intent of the process is to improve coordination and understanding of what may need to updated with an agency's GTFS feed.

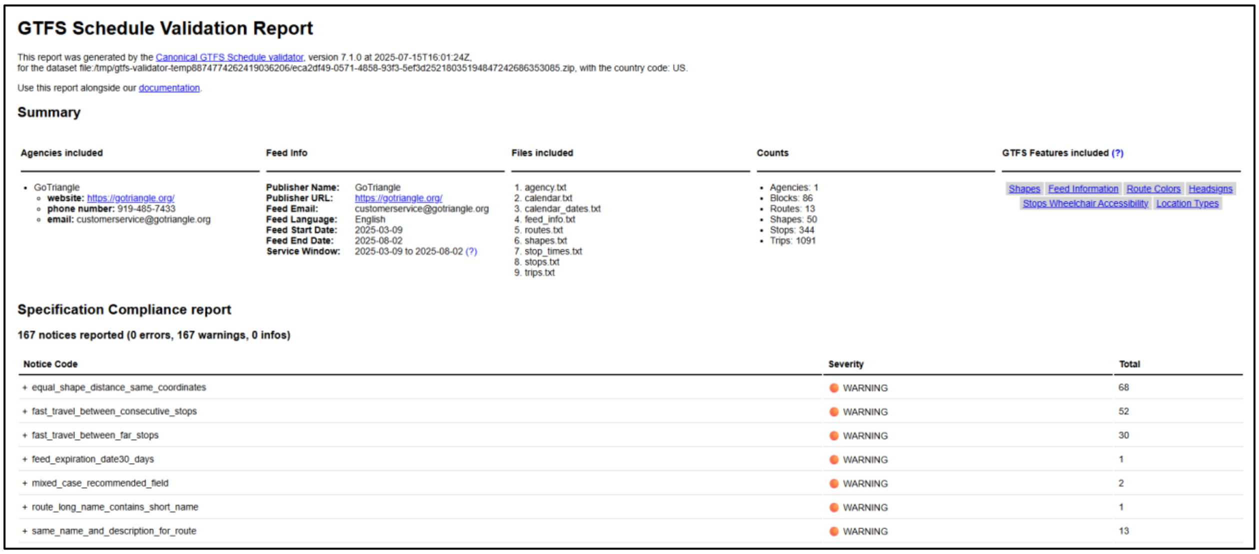
Scheduling the quarterly meetings to review transit service changes will need to be led by a regional agency that can champion the effort and host a location for the agencies to meet and review future transit service changes and the updates that will need to be made to GTFS feeds.

Recommendation #4: Implement Best Practices for Creating a GTFS Feed

GTFS.org is a centralized platform where GTFS rules, requirements, and best practices for generating and publishing are documented. A use case, best-practice is a specific type of service or use that has best practices across multiple files and fields. Agencies should implement the best practices outlined on GTFS.org: https://gtfs.org/documentation/schedule/schedule-best-practices/. Best practices are organized into four categories: general practices, publishing, file and field, and use case. Best practices pertain to the overall structure of the GTFS, and several data examples are provided by GTFS.org. Publishing best practices is the manner in which the GTFS is hosted and made available to the public. Best practice by file is recommendations by GTFS file, outlining it by each field within a file.

Once best practices are implemented, the GTFS should be run through a validator that checks the dataset against GTFS requirements and best practices. MobilityData offers a free web-based validator (https://gtfs-validator.mobilitydata.org/) where either a ZIP file of GTFS data can be uploaded or a URL provided. The validator will process the data and issue a report outlining issues found based on the severity level. Errors are critical and must be resolved in order to publish a usable GTFS. Warnings are notices that best practices are not being followed. Lastly, the info section highlights items that would affect the quality of the feed. Once run, agencies should go back and fix the errors and re-run the validator to ensure issues are fixed prior to posting the GTFS or pulling it into other software for use. Figure 5-3 is an example of a GTFS validation report from MobilityData for GoTriangle.

Figure 5-3. GTFS Validation report from MobilityData for GoTriangle



GTFS Schedule Validation Report

This report was generated by the Canonical GTFS Schedule validator, version 7.1.0 at 2025-07-15T16:01:24Z, for the dataset file:/tmp/gtfs-validator-temp8874774262419036206/eca2df49-0571-4858-93f3-5ef3d25218035194847242686353085.zip, with the country code: US.

Use this report alongside our documentation.

Summary

Agencies included

- GoTriangle
  - **website:** https://gotriangle.org/
  - **phone number:** 919-485-7433
  - **email:** customerservice@gotriangle.org

Feed Info

Publisher Name: GoTriangle
Publisher URL: https://gotriangle.org/
Feed Email: customerservice@gotriangle.org
Feed Language: English
Feed Start Date: 2025-03-09
Feed End Date: 2025-08-02
Service Window: 2025-03-09 to 2025-08-02 (?)

Files included

1. agency.txt
2. calendar.txt
3. calendar_dates.txt
4. feed_info.txt
5. routes.txt
6. shapes.txt
7. stop_times.txt
8. stops.txt
9. trips.txt

Counts

- Agencies: 1
- Blocks: 86
- Routes: 13
- Shapes: 50
- Stops: 344
- Trips: 1091

GTFS Features included (?)

Shapes Feed Information Route Colors Headsigns Stops Wheelchair Accessibility Location Types

Specification Compliance report

167 notices reported (0 errors, 167 warnings, 0 infos)

Notice Code	Severity	Total
+ equal_shape_distance_same_coordinates	WARNING	68
+ fast_travel_between_consecutive_stops	WARNING	52
+ fast_travel_between_far_stops	WARNING	30
+ feed_expiration_date30_days	WARNING	1
+ mixed_case_recommended_field	WARNING	2
+ route_long_name_contains_short_name	WARNING	1
+ same_name_and_description_for_route	WARNING	13

Transit agencies in the region may want to consider procuring an annual membership for MobilityData.[25] The benefits to the agencies would include access to events where updates on GTFS and its use can be communicated to a larger group of transit agencies around the country. Transit agencies in the region would each pay $2,500 on an annual basis to join the group and benefit from lessons learned by other agencies in GTFS implementation.

An alternative option for troubleshooting issues with GTFS feeds and publishing those feeds for the public exists with the Google Transit Data Sharing Portal. This portal was previously known as the Google Partner Transit Dashboard and provides transit agencies with a resource to work collaboratively with other transit agencies on issues with their GTFS feeds. More information on the Google Transit Partner Dashboard is available in the recommendations section of Chapter One.

Recommendation #5: Obtain technology to generate a GTFS that saves past versions and allows the agency to streamline their process when service changes are made.

GTFS feeds are a series of .txt files contained within a .ZIP file. At its most basic, it is comprised of seven files with information about stops, routes, trips, the agency, and when things operate. An

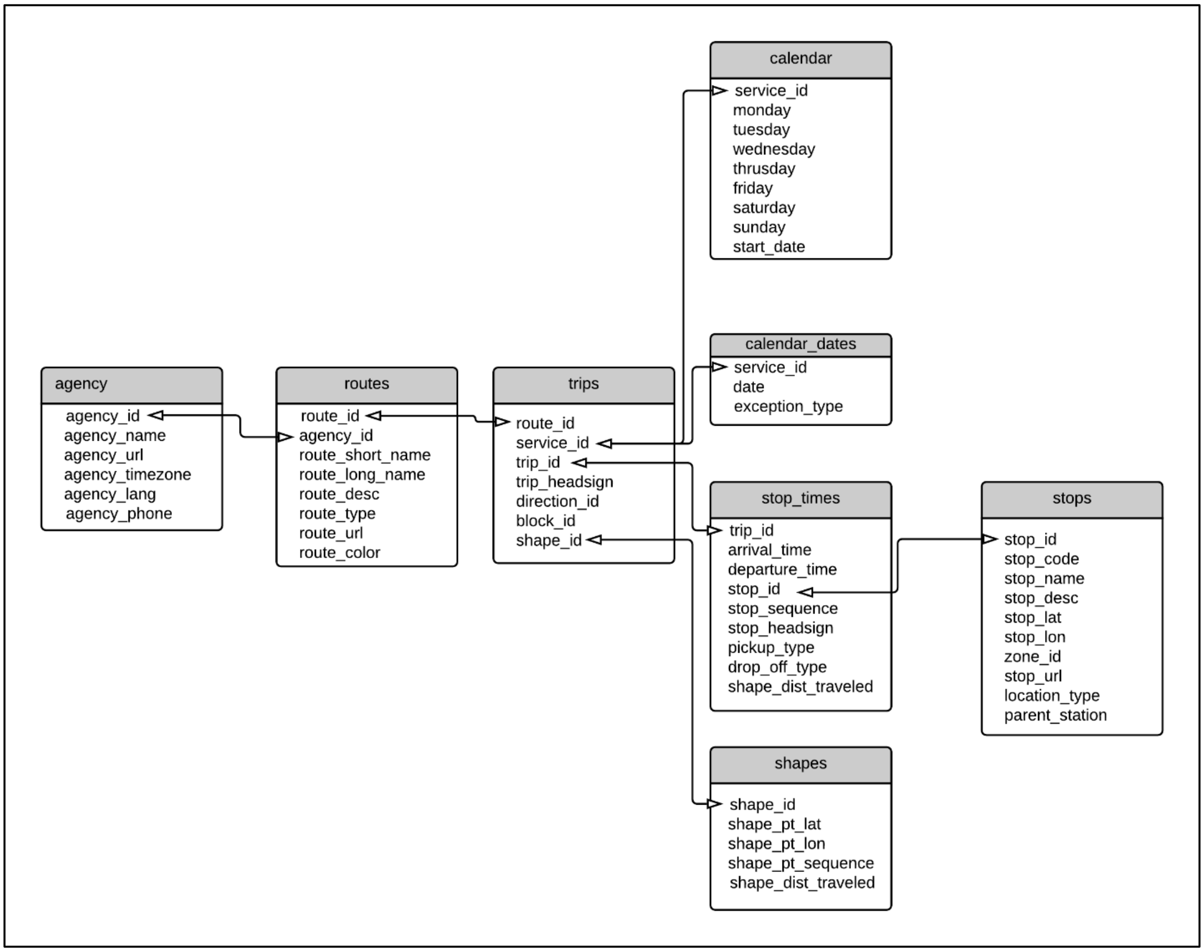
[25] Membership page available at: https://mobilitydata.org/members/.

eighth file, a shape.txt file, is not required but recommended because it shows the path the vehicle takes, often snapped to an underlying road network. Fields within the files link them together as shown in Figure 5-4.

While a GTFS can be created in Excel, a tool with drag and drop, an easy-to-use interface, and archive versioning can help streamline the process, quickly identify and remedy errors, and quicken the overall process. There are several web-based GTFS builders and software packages that can generate them, additionally almost all scheduling platforms can generate a GTFS. Commonly used Software-as-a-Service (SaaS) platforms for GTFS creation are:

- **Remix Planning:** Through the planning modules systems can build timetables, edit route patterns, trips, and timing, define stops, and create calendars. Each time a new GTFS is needed an old project can easily be copied and edited. Once complete a GTFS can be generated. The tool was designed for transit planning but later improved to generate GTFS.
- **Trillium GTFS Managed Services:** This is a managed service provided by Trillium where Trillium updates and maintains the GTFS feed on behalf of the agency. It is the service provided in the VTrans Case Study. The GTFS Manager product offered by Trillium that allows agencies to manage and edit their own GTFS will be discontinued after December 31, 2025. For agencies, such as GoTriangle, that want to continue with a Trillium product, they will need to transition towards the GTFS Managed Services where Trillium staff can create the GTFS feed as requested or procure the Optibus Planning software as described below.
- **Optibus Planning:** Optibus is owned by Trillium, and the planning package allows systems to build schedules, determine route alignments, define stops, and set service dates so that a GTFS can be developed. This software is a more robust version of the Trillium GTFS Manager software currently used by GoTriangle and schedule to be discontinued by Trillium at the end of the year.
- **AddTransit:** A purpose-built tool specifically for creating and editing a GTFS. The platform allows agencies to build a GTFS dataset from scratch, edit an existing GTFS, validate and test a GTFS for publishing to Google Maps, and host GTFS feeds for use by third-party applications such as trip planning apps.
- **Arcadis TRANSIT-data-tools:** The GTFS Data Manager by Arcadis allows systems to build, maintain, and validate a GTFS in one platform. It uses a map-based interface to manage routes and stops, has built in validation, and has a tool that allows for the upload of multiple systems GTFS and group validation to create a single regional GTFS.
- **Moovit Transit Data Manager:** A tool to create, build, edit, and share a GTFS by Moovit. Through the maps-based platform, systems can maintain their GTFS, visualize service, validate and correct errors in the GTFS, manage a log of GTFS edits, and collaborate amongst multiple users through permission-based roles.

Figure 5-4. GTFS File and Field Format and Connections.



Source: Pereira, Andrade, and Vieira[26]

Recommendation #6: Obtain planning/scheduling technology separate from the CAD/AVL system.

Systems should be creating a single GTFS for each bid that feeds into the CAD/AVL system, real-time passenger information, and other software used by agencies for service monitoring. The planning software should be map-based, allowing users to visualize routing and stops. The timetable developed in the planning component should automatically be brought into scheduling software to create a runcut. If the agency desires the GTFS to include the block ID field, then it must be generated from the scheduling software. A robust scheduling software is needed in order to handle complex union contract rules and optimize the process. The private contractor supplies the scheduling software for transit agencies that contract out operations. It is recommended the agency purchase its own software. When the contractor supplies the software, the agency takes on a considerable amount of risk. If the contractor exits the contract or is not chosen in the procurement process the agency risks losing access to current and historical data.

[26] Pereira, Rafael H. M., Pedro R. Andrade, and João Pedro Bazzo Vieira. 2022. "Exploring the Time Geography of Public Transport Networks with the Gtfs2gps Package." *Journal of Geographical Systems*, December. https://doi.org/10.1007/s10109-022-00400-x.

With the standardization of GTFS, transferring information from a planning/scheduling software to a CAD/AVL is much smoother process. Separate systems are recommended for resiliency. It is not uncommon for technology systems to be bought out or to go under and so having separate systems lessens the impact if this happens. When investing in enterprise software that includes all functions, the agencies become dependent on the vendor and locked into a contract. If issues occur it becomes very difficult to exit the contract as the agency has become fully dependent on the vendor. Lastly agencies should procure the right software for the right job. While CAD/AVL systems depend on data from planning/scheduling technologies, each serves a very different purpose.

5.5 Roadmap and Resiliency Plan for Future Years

A roadmap with phased steps is presented in Figure 5-5 below. Budgetary considerations are provided in Figure 5-6.

Figure 5-7 presents a recommended split of the cost estimate among Wake, Durham, and Orange Counties based on a percentage of 2024 NTD vehicles available for maximum service. The average amount of the estimate range provided in Figure 5-6 is multiplied by the available vehicles for each agency to arrive at the totals presented in Figure 5-7. Note that these are planning-level cost estimates to guide Counties in planning for the recommendations described within this chapter.

Figure 5-5. Roadmap of Implementation Steps for GTFS in the Region

Step 1. Quarterly Regional Coordination Meetings on Transit Service Changes Agencies can meet quarterly to review how future transit service at shared stop locations and other locations may impact updates that will need to be made to GTFS feeds.		**Step 2. Develop workflows to understand how GTFS edits can be made in a more timely manner than current timeframes allow** Create graphics and outline processes for the entire process from concept to implementation of a change in the GTFS.		**Step 3. Develop Standard Operating Procedure (SOP) to define how regional partners code shared stops in GTFS** Reinvigorate the document created for coordinating in naming jointly used bus stops within the GTFS data.
0-1 years		**1-2 years**		**Years 1-2**
Step 4. Implement Best Practices for Creating a GTFS feed Utilize the GTFS.org best practices and run GTFS in the Mobility Data Validator to confirm best practices are implemented.		**Step 5. Obtain technology to generate a GTFS** Systems which currently use Excel procure a SaaS technology to build and manage static GTFS.		**Step 6. Obtain planning/scheduling technology separate from CAD/AVL** Systems that provide transit agencies with the tools to perform scheduling and planning; provides for resiliency in the event that contracted service operator changes over time.
Years 1-2		**Years 1-2**		**Years 1-2**

Figure 5-6. Budgetary Planning-Level Recommendations for Transit Agency Consideration[27]

	Per Vehicle Estimate for Transit Agencies	Notes on Cost Estimates for Agency Considerations
Software for creating GTFS-Static	**$180-$700 annually per vehicle**	Costs are based on existing contracts held by Rio Metro Regional Transit District, Northwest Arkansas Regional Planning Commission and posted prices by AddTransit
Average Cost	**$440 per vehicle**	

Figure 5-7. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Regional GTFS Updates

Agency	**Buses in Fleet ****		**Total Cost per Year**	**Total Cost for all Years 1-5**
GoTriangle	82	**Wake County Total**	**$88,044**	**$440,220**
GoCary	20	GoRaleigh Estimate	$59,400	$297,000
GoDurham	63	GoCary Estimate	$8,800	$44,000
GoRaleigh	135	GoTriangle Estimate	$19,844	$99,220
Chapel Hill Transit	99	**Durham County Total**	**$40,348**	**$201,740**
		GoDurham Estimate	$27,720	$138,600
** Based on 2024 NTD Data		GoTriangle Estimate	$12,628	$63,140
Note: Cost estimate split is based upon the planning-level cost estimate by vehicles. GoTriangle hours are split 55/30/15 among counties.		**Orange County Total**	**$53,036**	**$265,181**
		Chapel Hill Transit Estimate	$43,560	$217,800
		OCPT Estimate	$4,064	$20,321
		GoTriangle Estimate	$5,412	$27,060

[27] Costs for GTFS-RT are outlined in Chapter 1, Real-time and Trip Planning.

Chapter 6. Open Transit Data Portal

Vision: A publicly available data source where local government staff, research partners, and engaged community members can easily find transit data.

Objective: Identify recommended steps that enable Triangle Region transit agencies and partner jurisdictions to collaboratively develop and sustain an open transit data portal that provides public access to standardized, high-value transit data, supporting transparency, innovation, and regional coordination.

6.1 Intended Audiences and Benefits

- **Government Entities:** Benefit from improved inter-agency coordination, data-driven planning and policy development, optimization and reduced redundancy in data requests. Open transit data can help improve multimodal transportation systems. Access to regional transit metrics supports transportation planning, smart mobility solutions, emergency management, grant applications, and equity assessments.
- **Universities and Nonprofits:** Gain reliable access to transit data for research, academic instruction, and program evaluation. Supports partnerships and innovation across the research ecosystem.
- **General Public:** Enhances trip planning experience, reduces frictional points for seamless transfers, and can help reduce wait times. Improved access to transit information fosters civic engagement and trust. Open dashboards and data tools support transparency and empower riders with better service awareness.

6.2 Priority Data Types and Reporting Standards

A standardized specification is essential for ensuring consistency, interoperability, and ease of integration across systems, making it the foundation of a reliable open transit data portal. An example seen throughout this report is the General Transit Feed Specification (GTFS), which along with its extensions like GTFS-RT, and GTFS-Ride, provides a common data format for publishing static and real-time transit information. These standards enable agencies, developers, researchers, and the public to access, share, and analyze consistent transit data across platforms, supporting a wide range of applications from trip planning to performance evaluation.

To maximize utility across audiences, the following transit data types in Table 6-1 are recommended for inclusion within an open transit data portal, each playing a critical role in supporting transparency, accessibility, and system planning:

Each dataset needs to follow open data best practices such as machine-readable formats (Comma-Separated Value (CSV), Javascript Object Notation (JSON)), metadata descriptions, update frequency tags, and version control where possible.

Table 6-1. Recommended Transit Data Types and Formats for Open Transit Data Portal

Data Type	Standard/Format to Use	Primary Applications
Schedules, Routes, Stops	GTFS-Static	Trip planning, integration with apps (e.g., Google Maps, Transit App), schedule analysis
Real-Time Vehicle Locations	GTFS-Realtime (GTFS-RT)	Real-time vehicle tracking
Ridership Statistics	GTFS-Ride, National Transit Database (NTD)-compatible CSV file	Equity analysis, demand modeling, service adjustments, funding justification
Stop and Route Amenities	GIS shapefiles, GeoJSON	Infrastructure planning, ADA compliance, rider information systems
Microtransit zones	GIS shapefiles	Provide a regional trip planning tool that includes microtransit. Review of where current and proposed microtransit zones are in region

6.3 Initial Findings and Opportunities

6.3.1 Summary of Current Conditions

Across the Triangle Region, transit data is managed separately by local transit agencies including, but not limited to GoTriangle, GoRaleigh, GoDurham, GoCary, Chapel Hill Transit, and Duke[28]. Each agency collects and maintains its own data on schedules, routes, vehicle locations, and performance metrics, often through their individual Computer Aided Dispatch/Automated Vehicle Locator (CAD/AVL) systems and Geographic Information Systems (GIS) platforms. However, these datasets are not consistently published or centrally accessible in a standardized, open format.

Each of these agencies publish GTFS and GTFS-Realtime feeds as part of the developer resources pages on their respective websites. While this provides a foundation for open data access, the scope, quality, and update frequency of these datasets vary by agency. The fixed route schedules from GTFS-Static feeds from all regions are published on GoTriangle's Map Schedules website[29]. Beyond this, there is no unified, region-wide open transit data portal that integrates these feeds or standardizes access for broader public use.

Stakeholders across government, academia, and the private sector have expressed interest in a centralized, reliable source for transit data to support planning, innovation, and public transparency.

[28] https://godurhamtransit.org/developer-resources
[29] https://gotriangle.org/maps-schedules/

6.4 Noted Challenges

The development of a regional open transit data portal presents several implementation challenges that must be addressed to ensure long-term success, data integrity, and stakeholder alignment. These challenges stem from variations in technical capacity, coordination gaps, and concerns about data security and maintenance.

- **Asynchronous Progress:** Transit agencies in the region are at varying stages of readiness when it comes to open data publishing. While some have established GTFS and GIS-based datasets available through their websites or municipal platforms, others are still developing basic data infrastructure or relying on manual processes. This disparity creates barriers to uniform data sharing and slows regional alignment.
- **Unaligned Priorities for Data Types:** Agencies differ in their views on which data types should be prioritized for inclusion in a regional portal. For example, some agencies may focus on publishing novel datasets not already accessible through third-party apps like Google Maps or Transit (e.g., microtransit zones, stop amenities, or fare structures), while others may concentrate on improving real-time data feeds like GTFS-RT. These divergent priorities, driven by local needs, technical capacity, or audience focus make it difficult to establish a unified roadmap for a regional portal that balances both innovation and foundational data needs.
- **Lack of Standardized Data Collection Processes:** Agencies currently use a variety of tools and internal procedures to collect and manage transit data. This inconsistency makes it difficult to integrate datasets across jurisdictions, introduces quality control issues, and limits the potential for automation and regional performance benchmarking.
- **Cybersecurity Risks:** Transit agencies expressed concern about the potential vulnerabilities introduced by publishing operational data online, especially without appropriate access controls or safeguards. Risks include unauthorized data manipulation, exposure of sensitive infrastructure details, or misuse of system Application Programming Interfaces (APIs).
- **Data Maintenance:** Maintaining current and reliable datasets is a resource-intensive process. Agencies noted challenges in keeping data updated, particularly when services change frequently or staff capacity is limited. Without automated tools or shared update protocols, data in the portal risks becoming outdated, undermining trust and usability.

6.5 Opportunities for Innovation and Collaboration

- **Streamline Internal Processes:** Agencies like Durham County and Orange County identified the need to automate manual data processes and improve feed generation capabilities (e.g., GTFS and GTFS-RT). These technical upgrades reduce administrative burden, improve data quality, and support more frequent updates to a regional portal.
- **Collaborative Governance**: The Town of Apex highlighted the importance of working with partners like GoCary and Via to ensure data sharing across service models. A centralized or co-led governance structure, anchored by willing lead agencies, can streamline data aggregation, clarify responsibilities, and foster stronger coordination between public agencies and private providers.

- **Leverage Existing Infrastructure**: Raleigh[30], Durham[31], Cary[32], and Chapel Hill[33] already operate open government data portals with limited transit data. These can serve as initial models or components of a broader regional portal.
- **Standardize Metrics and Methods:** Capital Area Metropolitan Planning Organization (CAMPO) and Orange County called for shared data standards and performance metrics to support comparability and collaboration. Developing these regionally will help align reporting, evaluation, and service planning practices.
- **Empower Stakeholders Through Open Access:** A well-designed open transit data portal can engage universities, nonprofits, developers, and community members. Transparent and reliable data access fosters innovation, public trust, and stronger civic participation in transit planning.

6.5.1 Survey Responses and Interview Summary

Triangle Region transit agencies were surveyed in January 2025 on the types of transit information that are currently available to the general public through web-based interfaces. Table 6-2 lists the agencies surveyed and types of information provided.

Table 6-2. Summary of Information Available to Public by Regional Transit Agencies

Transit Agency	Routes	Ridership	OTP*	Stops/ Stations	GIS Data	Other Data Types
GoCary				X	X	
GoRaleigh	X	X		X	X	Mobility
GoDurham	X			X	X	
GoTriangle	X			X	X	
Chapel Hill	X			X	X	GTFS, GTFS-RT
Town of Apex	X			X		Future/Conceptual
NCSU Wolfline	X	X		X		Ridership per hour
UNC-Chapel Hill	X			X		
Wake Forest	X					
Wake County	X	X	X		X	Mobility Infrastructure, Ridership per Hour, Route Productivity
Town of Morrisville				X		
Durham County	X	X		X	X	Mobility
Orange County	X	X		X	X	Mobility

* OTP = On-Time Performance

[30] https://data.raleighnc.gov/
[31] https://live-durhamnc.opendata.arcgis.com/
[32] https://experience.arcgis.com/experience/3f2d586f8edc46b291a0aa50b0e01e6e/page/Page?q=gocarydashboard
[33] https://opendata-townofchapelhill.hub.arcgis.com/

Transit agencies expressed interest in expanding the types of data available through an open transit data portal. Comprehensive datasets, including ridership, on-time performance, bus stops, route productivity, GIS data, and future conceptual plans, are priorities for agencies like GoDurham, GoRaleigh, CAMPO, and Orange County. Others, such as NCSU Wolfline and Chapel Hill Transit, focus more specifically on on-time performance or basic ridership data. GoRaleigh also emphasized the need to highlight transit-accessible points of interest to improve regional network visibility.

6.5.2 Case Study: Sound Transit Open Transit Data (Seattle, Washington)

To improve transparency, customer information, and regional coordination, Sound Transit launched the Open Transit Data (OTD) program to serve as a centralized hub for transit data across the Puget Sound region. The goal of the program is to make transit data from multiple agencies available in standardized formats to support both public-facing apps and internal planning efforts. The OTD program supports developers, researchers, civic technology groups, and regional planners by offering downloadable datasets and API access in a "one-stop shop" format. A notable strength of the OTD program is its clear and permissive data licensing structure. Sound Transit adopts the Open Data Commons Public Domain Dedication and License (PDDL), ensuring that data can be freely used, shared, and built upon without restriction. API usage is governed by straightforward terms of service that encourage responsible use while protecting system integrity. This legal framework lowers barriers to entry for third-party developers and enhances trust and transparency with the public.

Sound Transit serves as the lead agency and data steward for this effort, aggregating and publishing data from over nine collaborating transit providers. These include King County Metro, Pierce Transit, Community Transit, Intercity Transit, Everett Transit, Seattle Streetcar, Seattle Center Monorail, and Washington State Ferries. The program integrates static GTFS data, real-time GTFS-RT feeds, and spatial GIS datasets, providing coverage of local bus, light rail, commuter rail, ferry, and streetcar services.

The initiative originated in response to a regional call for better coordination of transit data tools and builds on the foundation of existing academic and open-source partnerships, most notably the OneBusAway real-time platform developed by the University of Washington. Sound Transit continues to use this API to serve real-time data to developers and applications across the region.

The Sound Transit OTD effort was phased to allow incremental progress:

- **Phase 1:** prioritized aggregation of GTFS schedule data and basic real-time bus tracking.
- **Phase 2:** added rail services and regional schedule reconciliation (e.g., resolving duplicate stop IDs).
- **Phase 3:** expanded GIS datasets and began integrating newer data types like GTFS-Flex for on-demand service.

While the OTD site itself focuses on downloadable data and developer APIs, Sound Transit also launched a System Performance Tracker[34] to provide public-facing dashboards on ridership, on-

[34] https://www.soundtransit.org/ride-with-us/system-performance-tracker

time performance, and customer satisfaction. This dual strategy allows OTD to serve as an open infrastructure layer, while the performance site supports public accountability and strategic communication.

The following are lessons learned from the project:

- **A centralized data platform can streamline regional collaboration.** By assuming the role of lead data steward, Sound Transit removed the need for developers and planners to integrate multiple agency feeds individually and made them accessible at a single centralized platform. This significantly improved access and usability.
- **Open-source tools accelerated implementation and reduced costs.** The adoption of OneBusAway allowed the agency to build on an existing, well-supported real-time system, avoiding the need for costly proprietary solutions.
- **Standardization requires early investment.** Sound Transit invested in cleaning and reconciling GTFS data across agencies—such as using prefixed stop IDs to avoid duplication—which was essential to build a consolidated regional dataset.
- **Open data supports both external innovation and internal efficiency.** The same APIs and GTFS datasets powering third-party apps are also used for internal tools such as station signage and trip planning, providing operational benefits beyond transparency.
- **Ongoing maintenance and community engagement are critical.** Sound Transit established a developer feedback loop and update notifications to ensure data quality remains high and API users stay informed.

6.5.3 Case Study: CapMetro Performance Dashboards for Strategic Transparency (Austin, Texas)

To improve transparency, track strategic goals, and support internal decision-making, Capital Metropolitan Transportation Authority (CapMetro) in Austin, Texas, developed and launched a comprehensive Performance Dashboard system.[35] This initiative aligns with CapMetro's Strategic Plan and provides a public-facing platform to communicate progress in key operational and organizational areas.

The goal of the dashboard was to build a centralized, interactive reporting tool that reflects agency performance in real time and enables both staff and the public to evaluate how CapMetro is meeting its objectives. The dashboard framework is organized around six core strategic themes: Customer Experience, Ridership, Safety, Workforce Investment, Financial Health, and Sustainability and Innovation.

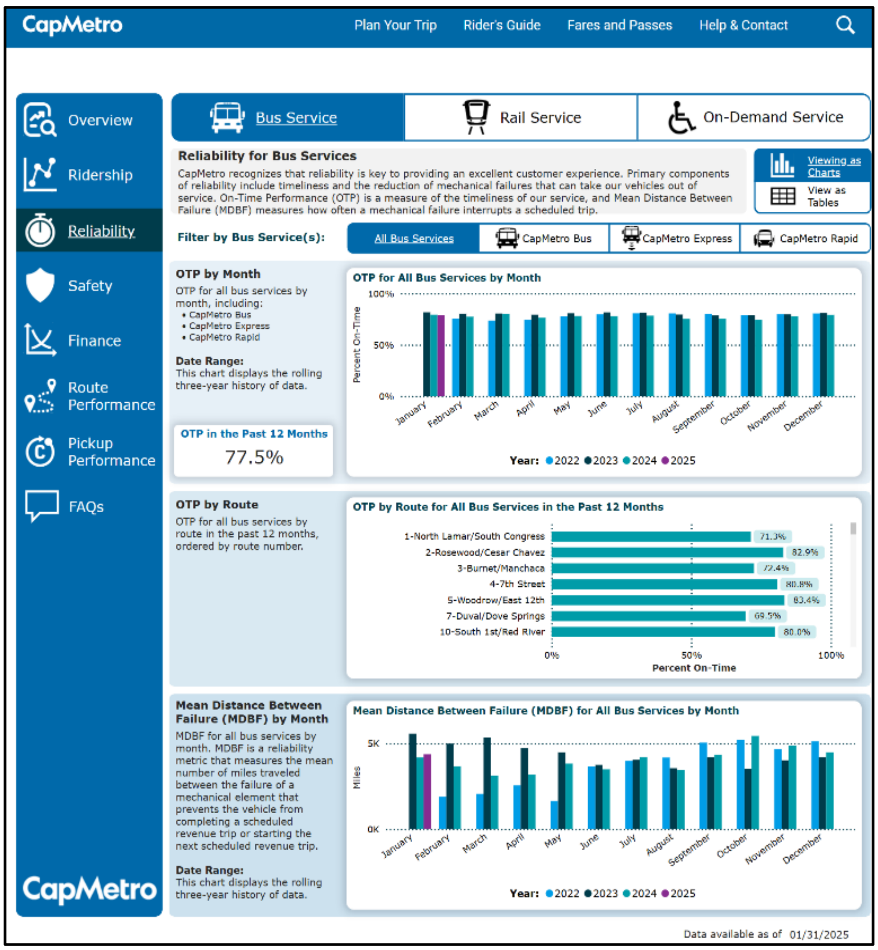
CapMetro collaborated with Foursquare ITP for strategic planning and dashboard design. Operational data quality and real-time integrity were supported through integration with the Swiftly platform, which aggregates Automatic Vehicle Location (AVL) and schedule adherence data. The public dashboard itself was built using Microsoft Power BI, providing an interactive interface for internal and public users alike.

[35] https://www.capmetro.org/about/performance-dashboard

The dashboard development process included:

- Identifying key performance indicators (KPIs) aligned with the agency's strategic goals
- Integrating real-time and historical data sources, including operational and customer feedback systems
- Developing internal dashboards for staff and executive oversight
- Publishing public-facing dashboards to enhance community transparency

Figure 6-1. CapMetro Dashboard



The following are lessons learned from the project:

- **Aligning dashboards with strategic goals ensures relevance.** CapMetro's dashboard content is directly tied to its Board-adopted Strategic Plan, ensuring consistency and focus across departments and leadership priorities.

- **Internal and external tools can be built from a common data foundation.** The use of Swiftly and Power BI allows CapMetro to generate dashboards for both internal planning and external transparency from the same underlying datasets.
- **Public dashboards increase accountability and community trust.** By presenting live metrics to the public, CapMetro strengthens its relationship with riders, advocates, and funding partners.
- **Cross-departmental collaboration is essential.** Dashboard success required coordination between planning, operations, Information Technology (IT), communications, and executive leadership to define KPIs, curate data, and establish update processes.
- **Ongoing maintenance and storytelling matter.** CapMetro pairs raw metrics with narrative context to help users interpret trends and understand agency decisions, improving the impact and usability of performance data.

6.6 Recommendations for Establishing an Open Transit Data Portal in the Triangle Region

Given the presence of multiple transit agencies across the Triangle Region—each with different levels of technical readiness and existing open data practices—it is recommended that regional partners pursue two complementary approaches to establish a comprehensive Open Transit Data Portal:

Approach #1: Leverage Existing Data Feeds to Build a Centralized Open Data Portal for all Regional Transit Feeds

Several agencies in the region already publish GTFS and real-time (GTFS-RT) feeds (e.g., GoDurham, GoTriangle, Chapel Hill Transit, GoRaleigh). This approach recommends building a centralized portal that integrates these feeds for unified access and visibility.

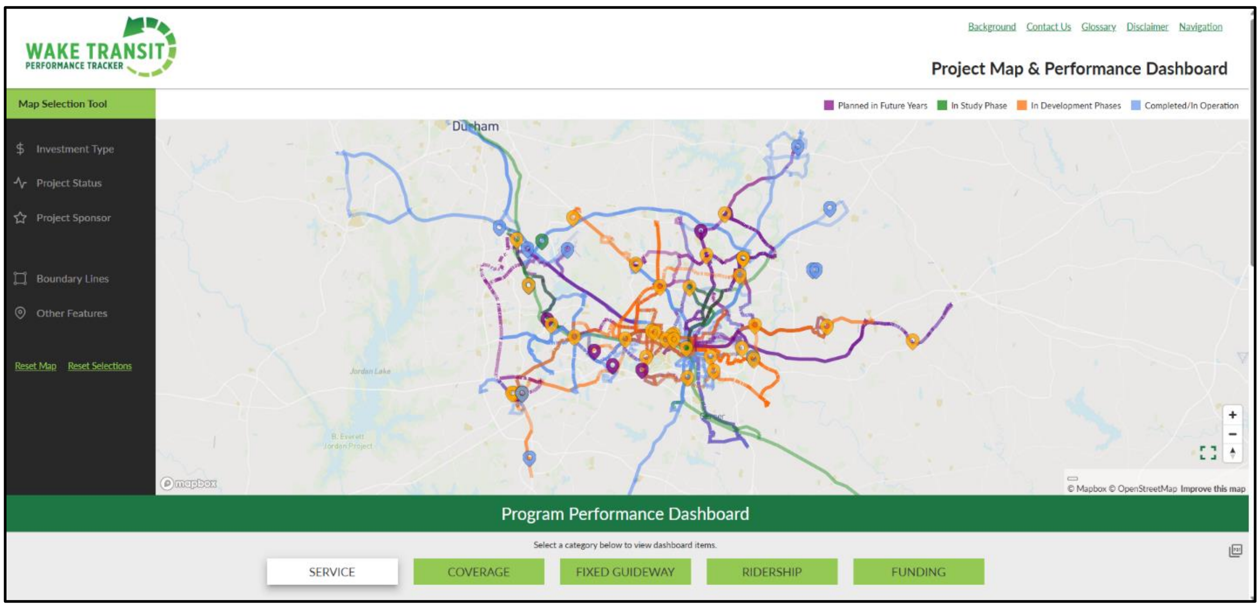
Key steps include:

1. Establish a lead agency or regional data steward (e.g., GoTriangle, CAMPO, Central Pines, Triangle West) to manage the data portal, coordinate updates, and support governance. This can include the use of existing staff at agencies, such as GoTriangle, who serve as data technicians to support transit operations.
2. Create a dedicated landing page or portal managed by the lead agency with links to individual agency feeds, APIs, and standardized metadata.
3. Publish a regional developer resource page that includes GTFS documentation, real-time API endpoints, and example use cases for developers and researchers.
4. Encourage all agencies to provide a public GTFS-RT feed, even if initially limited to core routes, using formats aligned with industry standards. A recommendation for the formal adoption of GTFS-RT by all agencies in the region is noted in the previous chapter.

This approach can be implemented quickly using existing infrastructure and requires minimal new investment. Note that this approach could include the modification of an existing dashboard known as the Wake Transit Performance Tracker shown in Figure 6-2. The dashboard can present regional data over time from a static database that allows a user to view specific projects throughout the region. One potential implementation strategy could include adapting the existing Wake Transit Performance Tracker, which currently visualizes county-level referendum-funded investments, as a base interface or model for the open transit data portal. However, any such adaptation should carefully respect the original intent and scope of the Performance Tracker platform, which is focused on communicating Wake County's transit investments to the public. Rather than merging purposes, agencies may consider developing a parallel interface or linked platform that complements the Tracker while serving a broader open data mission across the region.

Updates could be made to allow for other data to be updated on an automated basis from transit agencies that could report the data from their CAD/AVL systems. For example, real-time updates for CAD/AVL data would be ideal for ensuring accurate vehicle tracking and passenger information, whereas updates to static data such as routes and stops could follow a quarterly schedule to reflect planned service adjustments while minimizing administrative burden.

Figure 6-2. Wake Transit Performance Tracker



Approach #2: Develop a Regional Open Data Portal with Dashboards, Analytics, and Public Engagement Tools

Building upon Approach #1, regional partners may pursue the development of a more advanced open data portal that incorporates searchable datasets, interactive dashboards, GIS-based tools, and performance metrics, modeled from leading examples such as Sound Transit's Open Transit Data system and CapMetro's performance dashboard suite.

Key steps include:

1. Convene a regional working group of transit IT/data managers to define shared standards for open data publishing and priority datasets (e.g., ridership, headways, stop amenities, speed data, Automated Passenger Counter (APC) counts).

2. Develop a regional data schema or adopt an existing one (e.g., GTFS-Ride, GTFS-Flex, or NTD-compatible formats).
3. Use open data platforms such as ArcGIS Hub, Comprehensive Knowledge Archive Network (CKAN), or Socrata to host the portal, allowing for easy download, visualization, and API access.
4. Coordinate with regional universities and nonprofits to identify public research and planning needs that the portal should support.
5. Include guardrails for cybersecurity, data accuracy, and appropriate usage, modeled after Sound Transit's API and data terms of use.

6.7 Budgetary Planning Recommendations for Transit Agency Consideration

*Approach #1: Leverage Existing Data Feeds to Build a Centralized Open Data Portal for all Regional **Transit Feeds***

This approach builds on existing datasets and focuses on integration, hosting, and documentation, thereby minimizing new system development. Table 6-3 presents an estimated budget for implementing this approach. The total initial year investment is estimated to range from approximately $90,000 to $155,000, with annual ongoing costs projected between $50,000 and $75,000 [36] [37] [38]. The estimated budget is influenced by the current status of GTFS and GTFS-RT feeds among participating agencies and the level of harmonization required. If feeds are already published and well-maintained, initial setup costs can remain low, especially when leveraging open-source tools for integration and validation.

A key factor that can significantly reduce both startup and ongoing expenses is the assignment of an in-house staff member to serve as a regional data coordinator or steward. This internal coordination role can reduce the need for external consultants and streamline update processes. For most agencies, the bulk of ongoing costs, often 60% to 75%, are tied to staffing for data quality assurance, feed maintenance, and communication across jurisdictions. Portal hosting and maintenance costs are comparatively modest. Future discussion with regional entities is needed to identify the most appropriate agency to serve as a transit data steward for the region. This could include Central Pines, which serves as the regional Council of Governments (COG), Triangle West, which serves as the Metropolitan Planning Organization (MPO) for Durham and Orange Counties, CAMPO, which serves as the MPO for Wake County, or GoTriangle as the regional transit agency providing transit service throughout the region.

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[36] City of Fort Collins. (n.d.). *Open data portal software as a service: RFP documents.* Retrieved from https://records.fcgov.com/WebLink/DocView.aspx?dbid=0&id=8604650&repo=FortCollins

[37] City of Chicago. (2023). *Application infrastructure hosting and cloud computing services: Tyler Technologies Inc. (AIS)* [Procurement document]. Retrieved from https://www.chicago.gov/content/dam/city/depts/dps/SoleSource/NCRB2023/Tyler%20Technologies%20Inc%20%28AIS%29%20-%20Application%20Infrastructure%20Hosting%20and%20Cloud%20Computing%20Services.pdf

[38] Bloomberg Cities Network. (n.d.). *Open data: How much does it cost?* Retrieved from https://bloombergcities.jhu.edu/sites/default/files/bch-media/files/resources/civic_impact_open-data-how-much-does-it-cost.pdf

Table 6-3. Estimated budget for Approach#1 Implementation

Budget Item	Estimated Cost	Notes
Project coordination & regional data steward (0.5 Full-Time Equivalent (FTE))	$20,000–$40,000/year	Can be hosted by a regional entity, such as Central Pines, Triangle West, GoTriangle or CAMPO; covers coordination & governance. Future discussion with regional entities is needed to identify the most appropriate transit data steward for the region.
Integration software/scripts	$10,000–$15,000 (Year 1)	Open-source tools exist; customization and integration may be needed.
Metadata development and feed documentation	$5,000–$10,000 (Year 1)	One-time cost for feed standards, dataset description, and metadata.
Portal landing page (basic website or Content Management Systems (CMS)	$5,000–$15,000 (Year 1)	Lightweight approach using WordPress, CKAN, or similar tools.
GTFS and GTFS-RT feed validation tools	$5,000–$15,000 (Year 1)	Tools like Transitland Feed Registry or Google Transit Validator.
Staffing: Part-time data coordinator (0.5 FTE)	$40,000–$60,000/year	For data Quality Assurance (QA), updates, support, and communication with agencies. Can include staff time for data automation work on dashboard for region.
Ongoing hosting & maintenance	$10,000–$15,000/year	For server space, cloud backups, and domain registration.

Approach #2: Develop a Regional Open Data Portal with Dashboards, Analytics, and Public Engagement Tools

Approach 2 introduces more sophisticated user interfaces, real-time visualizations, and data tools, and as such, has higher upfront and recurring costs. Table 6-4 presents an estimated budget for implementing this approach. The total initial year investment is estimated to range from approximately $130,000 to $205,000, with annual ongoing costs projected between $90,000 and

$130,000[39] [40] [41] [42]. Major cost drivers for implementation include platform licensing (e.g., Socrata, ArcGIS Hub), dashboard development, and integration of diverse data sources like performance metrics or GIS overlays. The complexity of desired features, such as API endpoints, interactive charts, or accessibility filters, has a direct impact on costs. However, agencies can manage these expenses by leveraging existing enterprise licenses or dedicating internal staff with GIS or data science expertise to manage dashboard content and system upkeep. Over time, as with Approach 1, staffing becomes the largest share of recurring costs, covering data curation, stakeholder support, and continuous improvements to meet public and partner expectations. External development and maintenance contracts add flexibility but also increase costs.

Table 6-4. Estimated budget for Approach#2 Implementation

Budget Item	Estimated Cost	Notes
Regional data portal platform (ArcGIS Hub/Socrata)	$30,000–$60,000/year	Pricing varies; consider platform already in use by city/county agencies.
Dashboard & analytics development (e.g., Power BI)	$20,000–$40,000 (Year 2+)	Interactive visualizations for ridership, performance, and equity.
Custom APIs and developer documentation	$10,000–$25,000 (Year 2+)	To allow real-time data access and app development.
GIS data integration and mapping tools	$15,000–$30,000 (Year 2+)	Includes stop locations, routes, amenities, and overlays.
Schema and standardization efforts (GTFS-ride, etc.)	$10,000–$20,000 (Year 1)	Needed for ridership, APC, and performance datasets.
Staffing: Full-time open data coordinator (1 FTE)	$75,000–$100,000/year	Leads data governance, QA, publishing, and stakeholder engagement. Can include staff time for data automation work on dashboard for region.
Regional stakeholder engagement & training	$10,000–$15,000/year	Workshops, technical assistance, and agency coordination.
Cybersecurity & licensing audit	$5,000–$10,000 (Year 1)	Terms of use, access levels, and compliance.

[39] City of Fort Collins. (n.d.). *Open data portal software as a service: RFP documents.* Retrieved from https://records.fcgov.com/WebLink/DocView.aspx?dbid=0&id=8604650&repo=FortCollins

[40] City of Sacramento. (2023). *Enterprise agreement with Esri for ArcGIS software* [Council report]. Retrieved from https://sacramento.granicus.com/MetaViewer.php?clip_id=5619&meta_id=738436&view_id=22

[41] City of Chicago. (2023). *Application infrastructure hosting and cloud computing services: Tyler Technologies Inc. (AIS)* [Procurement document]. Retrieved from https://www.chicago.gov/content/dam/city/depts/dps/SoleSource/NCRB2023/Tyler%20Technologies%20Inc%20%28AIS%29%20-%20Application%20Infrastructure%20Hosting%20and%20Cloud%20Computing%20Services.pdf

[42] National League of Cities. (2016). *Open data policies report.* Retrieved from https://www.nlc.org/wp-content/uploads/2016/12/CSAR-Open-Data-Report-FINAL.pdf

Tables 6-5 and 6-6 on the following page present a recommended split of the cost estimate among Wake, Durham, and Orange Counties based on a percentage of 2024 NTD hours within the region. The average amount of the range of figures provided in Tables 6-3 and 6-4 is multiplied by the percent of all NTD hours for each agency to arrive at the totals presented in Table 6-5 and 6-6. Note that these are planning-level cost estimates to guide Counties in planning for the two approaches described within this chapter.

Table 6-5. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Approach 1 - Leveraging Existing Data Feeds

	2024 NTD Hours **	Percent of All NTD Hours
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		
Note: Cost estimate split is based upon the planning-level cost estimate by vehicles. GoTriangle hours are split 55/30/15 among counties.		

	Year 1 Total	Annual Total (Years 2-5)	Totals
Wake County Total	**$23,972**	**$55,436**	**$245,717**
GoRaleigh Estimate	$19,211	$44,425	$196,912
GoCary Estimate	$2,268	$5,244	$23,244
GoTriangle Estimate	$2,494	$5,767	$25,561
Durham County Total	**$10,133**	**$23,432**	**$103,863**
GoDurham Estimate	$8,773	$20,287	$89,920
GoTriangle Estimate	$1,360	$3,146	$13,942
Orange County Total	**$6,381**	**$14,757**	**$65,407**
Chapel Hill Transit Estimate	$5,215	$12,059	$53,449
OCPT Estimate	$487	$1,125	$4,987
GoTriangle Estimate	$680	$1,573	$6,971

Table 6-6. Wake/Durham/Orange County Split of Planning-Level Cost Estimate for Approach 2 - Developing Regional Open Data Portal

	2024 NTD Hours **	Percent of All NTD Hours
GoTriangle	146,063	**11%**
GoCary	73,052	**6%**
GoDurham	282,605	**22%**
GoRaleigh	618,864	**48%**
Chapel Hill Transit	167,983	**13%**
Total	1,288,567	**100%**
** Annual Vehicle Revenue Hours		
Note: Cost estimate split is based upon the planning-level cost estimate by vehicles. GoTriangle hours are split 55/30/15 among counties.		

	Year 1 Total	Annual Total (Years 2-5)	Totals
Wake County Total	**$13,484**	**$128,852**	**$528,891**
GoRaleigh Estimate	$10,806	$103,259	$423,841
GoCary Estimate	$1,276	$12,189	$50,031
GoTriangle Estimate	$1,403	$13,404	$55,019
Durham County Total	**$5,700**	**$54,464**	**$223,558**
GoDurham Estimate	$4,935	$47,153	$193,547
GoTriangle Estimate	$765	$7,311	$30,010
Orange County Total	**$3,589**	**$34,299**	**$140,785**
Chapel Hill Transit Estimate	$2,933	$28,028	$115,046
OCPT Estimate	$274	$2,615	$10,734
GoTriangle Estimate	$383	$3,656	$15,005

While Approach 1 offers a low-cost and practical starting point by centralizing access to existing transit feeds, Approach 2 provides a more future-ready solution that aligns with long-term regional goals. By incorporating interactive dashboards, performance metrics, and advanced data visualization tools, Approach 2 enables deeper insights for planners, researchers, and the public. It supports more sophisticated use cases such as equity analysis, service optimization, and cross-agency performance comparisons—capabilities that are increasingly essential for modern transit planning and public accountability. Additionally, by investing in a robust platform now, regional agencies can reduce technical debt over time and avoid duplicative efforts across agencies, ultimately fostering stronger collaboration and public trust.

Table 6-7 presents a summary of the pros and cons of these two approaches for review and consideration.

Table 6-7 Comparison of Pros and Cons of Approaches for Regional Open Data Portal

Approach 1: Leverage Existing Data Feeds to Build Open Data Portal		**Approach 2:** Develop New Regional Open Data Portal	
Pros	**Cons**	**Pros**	**Cons**
Lower cost overall due to use of existing agency resources	Limited in different types of analyses that could be performed	**More sophisticated user interfaces**	Higher cost due to licensing with vendors
Minimizes new system development	Require lead agency to manage ongoing coordination in region	**Aligned with longer term regional goals**	Additional cost with maintenance of servers over time
Use of existing staff as regional steward(s) for data analysis		**Can allow for deeper analysis of equity and service optimization**	
Use of existing data feeds in region		**Can help to reduce duplicative efforts**	

6.8 Roadmap and Resiliency Plan for OTD in Future Years

The following roadmap outlines phased steps that regional transit partners can take to establish and sustain an Open Transit Data (OTD) Portal, regardless of whether they pursue a foundational data aggregation model (Approach 1) or a more advanced portal with analytics and dashboards (Approach 2). Phases 1 through 4 represent common actions applicable to both approaches, including data standardization, governance, and centralized public access. Phases 5 and 6 apply when the region elects to pursue the expanded functionality described in Approach 2, such as visualization tools, performance dashboards, and engagement features. This roadmap is supported by resiliency strategies to ensure the portal remains accurate, secure, and adaptable over time.

Figure 6-3. Roadmap of Implementation Steps for Transit Agencies for Operations

<u>Step 1</u>: Inventory Existing Data Feeds and Systems Conduct a baseline review of existing open data feeds (GTFS, GTFS-RT, GIS) across GoTriangle, GoDurham, GoRaleigh, Chapel Hill Transit, and others. Determine frequency of updates, data quality, and hosting status.	**<u>Step 2</u>: Designate Regional Data Steward and Develop Governance Framework** Establish a lead agency responsible for maintaining the regional data portal, with documented roles for contributing agencies and a maintenance/ update protocol.	**<u>Step 3</u>: Publish Phase 1 Open Data Portal** Launch a central landing page with: • Links to agency GTFS/GTFS-RT feeds • Metadata documentation • API references • Regional contact information Use a lightweight platform (e.g., existing transit website or open-source CMS) for quick deployment.
Years 0-1	**Years 0-1**	**Year 1**
<u>Step 4</u>: Build Consolidated Regional Feed and Developer Tools Aggregate individual agency feeds into a regional GTFS bundle. Provide a validation process for data accuracy and duplicate resolution. Launch developer guides and sandbox environment.	**<u>Step 5</u>: Incorporate GIS and Performance Datasets** Expand portal to include route maps, service frequency layers, stop-level ridership, and fare data. Allow basic charting or export functions.	**<u>Step 6</u>: Launch Interactive Dashboards and API Hub** Create public dashboards using Power BI, Tableau, or open-source tools. Include KPIs such as on-time performance, trip counts, safety stats, and customer feedback. Implement a lightweight API gateway.
Years 1-2	**Years 3-4**	**Years 4-5**
Step 7: Resiliency and Long-Term Governance Plan Develop strategies to ensure the sustainability of the portal, including**:** • Redundancy in hosting and data storage • Role-based data publishing permissions • Periodic data audits • Institutionalization within regional planning or MPO workflows		
Years 5-6		

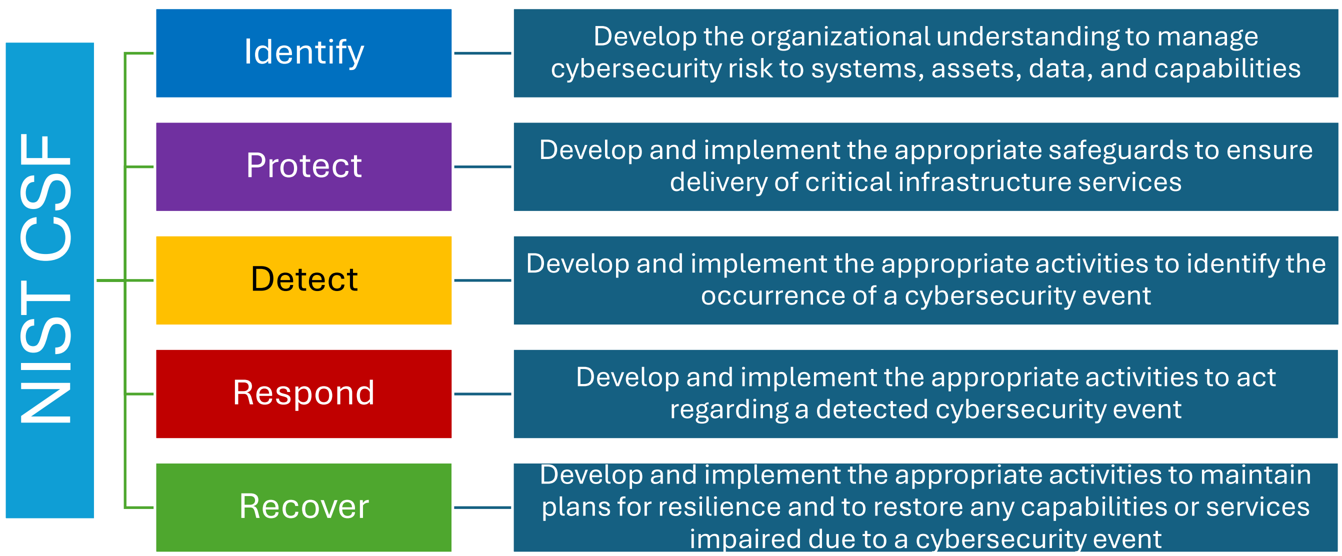
6.9 Implementation Considerations and Cybersecurity Recommendations

To ensure the success, sustainability, and integrity of a regional open transit data portal it is common for agencies to consider incorporating the following implementation safeguards and considerations from the outset:

- **Data Accuracy**: The credibility of the portal depends on the reliability of its data. Automated QA checks, detailed update logs, and structured stakeholder review periods prior to publishing will help build public trust and ensure that decisions based on this data are well-informed and defensible.
- **Open Licensing**: Adopting a permissive license such as Creative Commons BY 4.0 promotes transparency and innovation. It allows developers, researchers, and the public to build tools, conduct analysis, and create value-added services—while still maintaining appropriate attribution to the source agencies and avoiding legal ambiguity.
- **Redundancy and Continuity**: A resilient system requires built-in redundancy. At least two agency staff members should be trained in system administration to avoid single points of failure. Additionally, using cloud backups and dataset versioning ensures operational continuity in the event of outages, personnel changes, or data corruption.
- **Regional Alignment**: To avoid fragmentation and duplication of effort, formal agreements across participating agencies should clearly define responsibilities, update frequencies, data stewardship roles, and priority datasets. This alignment is essential for ensuring long-term collaboration, data interoperability, and consistent public service across jurisdictional boundaries. A Working Group can be developed to meet on a regular basis before and during open data portal development so that the best/preferred practices can be implemented for data management and so that processes can be streamlined. Many of these are formalized as workflows in agency business rules and policies.
- **Cybersecurity Recommendations**: A secure portal must balance openness with protection. Implementing tiered user access for administrative tools, API key controls for developers, and publishing anonymized datasets for public consumption will mitigate risks of data misuse, system breaches, and privacy violations, especially when dealing with sensitive or operational data.
    - Perform risk assessment of the data to be published on the portal.
      (e.g., Identify sensitive data, anonymize or remove personally identifiable information, assess potential risks.
    - Develop a data management plan that provides framework for data collection, organization, processing and getting the data ready for open data portal and/or for decision-making purposes.
    - Considering various transit agencies supporting the management of open data portal, develop a data access management framework to establish role-based access control, logging and monitoring of activities.

- Assess current practices using cybersecurity evaluation tools such as FTA's Cybersecurity Assessment Tool for Transit (CATT)
- Develop cybersecurity framework in alignment with industry standards. Key resources include:
  - FTA's Cybersecurity Guidelines (Link)
  - National Institute of Standards and Technology (NIST) Cybersecurity Framework (CSF). (Link) The five functions of the NIST CSF are as shown in Figure 6-4.
- Ensure that systems are up to date and in compliance with the latest cybersecurity standards including but not limited to NIST SP 800-53: Security and Privacy Controls for Information Systems and Organizations (Link)
- Ensure that the data is encrypted and, open data portal and supporting infrastructure is hosted in a secure environment that meets the latest cybersecurity standards. Any third-party service integration must also comply with the established IT protocols and standards.
- Perform periodic security audits and assessments such as penetration testing.

Figure 6-4. The five functions of National Institute of Standards and Technology Cybersecurity Framework



Chapter 7. Conclusion

This Regional Technology Plan guides cohesive planning decisions for transit agencies and stakeholders in Durham, Orange, and Wake Counties. A key theme is increased mobility through interoperability of current and future transit technologies. The vision for increased mobility across the three counties resonates with the recommendations listed in the Regional Technology Plan. It presents the core technologies that work together to improve mobility, the processes needed to establish the technologies, and recommendations on policy guidance for regional decisions related to transit technologies.

The Technology Plan references the technology stack needed to plan, monitor, route, pay for, and secure transit. It stresses the interoperability required in order to integrate transit technologies across the region with efficiencies for riders and transit staff. It addresses the opportunities for collaborative governance to foster stronger coordination between public agencies and private providers.

7.1 Regional Technology Plan Summary Schedule

A good customer experience is the foundation from which the Regional Technology Plan is based. From a rider-centric perspective, technology facilitates processes that surround a rider journey like an ecosystem. The quality of each process that touches a rider journey is therefore a critical component to achieving good customer experience.

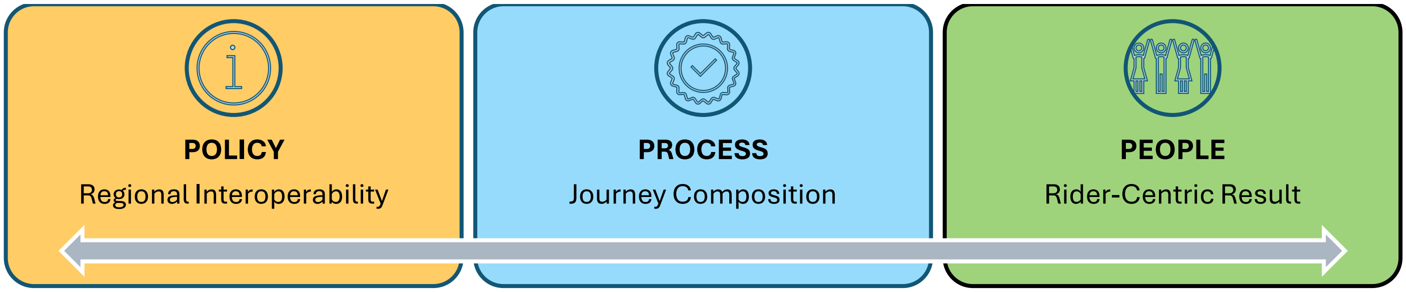
As agencies move towards a regional approach to technology, policy decisions are required since technology operates locally and regionally. The Regional Technology Plan strives to maintain a local transit agency goals while still viewing technology recommendations from a rider's ability to use transit regionally**.** Recommendations for trip planning, Transit Signal Prioritization, service planning, integrated payments, GTFS, and open data, were developed into an action roadmap for regional progress toward greater interoperability of transit, specifically transit data, in the region.

These collective actions are presented in a summary roadmap in Figure 7-2.

Roadmap actions and recommendations fall into three main categories: people, process, and policy. The categories serve as reminder that sound policy and processes are foundational to giving technology-based solutions the fullest opportunity to serve local and region needs.

- PEOPLE: Rider-centric result.
- PROCESS: Local and regional approach to the rider journey.
- POLICY: Governance strategies align for regional interoperability.

Figure 7-1. Customer Experince Foundation for Regional Technology



The roadmap summary on the following page gives context to other steps needed along the way to prepare for the technology locally and regionally. The steps are categorized as 'policy' apply to mostly internal decisions related to governance, which then provides the guidance which is translated into processes for a regional approach to technology. The category process shows where to garner efficiencies or tackle barriers to roadmap steps. The category 'people' describes roadmap recommendations that have rider-facing results. When agencies put policies and processes in place for rider-centric results, investing in transit technologies makes sense.

Agencies can begin working on those recommendations that are identified as occurring within Year 0 and Year 1 within each of the chapters. These recommendations can be considered as low-hanging fruit items that support other recommendations within each of the chapters of the Regional Technology Plan.

Figure 7-2. Technology Planning Roadmap

Chapter	Roadmap Classification	Roadmap Summary	Year	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Chapter 1: Passenger and Real-Time Trip Planning	Process	TP 1. Establish GTFS-RT as the standard for real time transit data.	0-1							
	People	TP 2. Monitor data quality in real time feeds using tools (Google Transit Planner Dashboard).	1-2							
	Process	TP 3. Contact CAD/AVL vendors to determine system upgrades and configurations.	1-2							
	People	TP 4. Provide passengers with multiple options for accessing real-time transit information.	1-2							
	People	TP 5. Monitor potential for integration of applications that can improve the ease of use for transit operations for passengers.	2-3							
	People	TP 6. Enhance trip planning with detour notifications and service updates.	3-5							
	Process	TP 7. Establish standards and Minimum Requirements for Location Sensing Components	3-5							
Chapter 2: Transit Service Planning	Process	SP 1. Commit to interoperability. Inventory systems, coordinate with MPOs and agencies.	0-1							
	Process	SP 2. Determine connectivity goals, maintain regional data map for current system inventory.	1-2							
	Policy	SP 2a. Use a process to consider new transit technology solutions (five principles of interoperable transit technology).	0-6							
	Process	SP 3. Identify staff for regional service planning coordination. Develop workflows.	2							
	Policy	SP 4. Identify regional solutions, level of effort, advertise Industry RFI for service planning solutions, and coordinate regional interfaces.	2-3							
	People	SP 4a. Leverage university resources, Triangle Regional Model feedback loop.	2-3							
	Policy	SP 5. Identify service planning approach as a region.	4							
	Policy	SP 6. Consider economies of scale; leverage statewide contracts.	4-5							
	Process	SP 6a. Use origin-destination study to validate complexity and scale of solution.	4-5							
Chapter 3: Transit Signal Priority	Policy	TSP 1. Include NTCIP 1211 in Plans for TSP Operations/Expansion	1-2							
	Policy	TSP 2. Establish Stakeholder Contact Listing for Future TSP Working Group	0-1							
	Process	TSP 3. Review CV approach for TSP with NCSU MMCVP pilot project.	1-2							
	Process	TSP 4. Determine if existing cloud-based TSP can use NTCIP 1211/ SAE J2735 standards.	2-3							
	Process	TSP 5. Review transit routes and identify candidate TSP corridors.	1-2							
	Process	TSP 6. Identify TSP approach along North-South BRT corridor.	2-3							
	Policy	TSP 7. Identify TSP approach along Raleigh BRT corridors.	3-4							
	Policy	TSP 8. Identify corridor for TSP System Interoperability Testing.	4-5							
	Policy	TSP 9. Coordinate with Signal System Expansion for Emergency Vehicle Preemption	4-5							
Chapter 4: Regionally Integrated Payments	Policy	IP 1. Inventory existing payment systems.	0-1							
	Policy	IP 2. Analyze fare hardware, software, and practices. Develop regional payment matrix, maintain cash payments, confirm Title VI requirements.	1							
	Process	IP 2a. Explore integration of microtransit and TNC payments into regional payment systems.	1							
	Process	IP 3. Identify regional payment approach (policy, processes, and business rules)	1							
	People	IP 4. Adopt open payment solutions for fixed route. Determine BRT on/off board validation.	2-4							
Chapter 5: GTFS Publishing Standards	Policy	GTFS 1. Quarterly meetings on transit service changes.	0-1							
	Policy	GTFS 2. Develop workflows for timely GTFS edits.	0-1							
	Process	GTFS 3. Create SOPs for coding shared stops in GTFS.	1-2							
	People	GTFS 4. Use tools like a Mobility Data Validator to ensure GTFS best practices.	1-2							
	Process	GTFS 5. Procure planning software to streamline GTFS generation.	1-2							
	People	GTFS 6. Separate planning and scheduling tools from CAD/AVL systems for resiliency.	1-2							
	Policy	OTD 1. Inventory existing open data feeds; establish governance framework	0-1							

Chapter 6: Open Transit Data Portal	Policy	OTD 2. Establish a regional steward to manage the portal.	0-1	
	People	OTD 3. Publish Phase 1 open data portal	1	
	Policy	OTD 4. Build consolidated regional feed and developer tools for regional GTFS bundle	1-2	
	Process	OTD 5. Incorporate GIS and performance data sets	3-4	
	People	OTD 6. Launch interactive Dashboards and API hub	4-5	
	Policy	OTD 7. Develop resiliency and long-term governance plan.	5-6	
	Policy	OTD 8. Implement cyber security measures to protect data integrity.	0-6	

7.2 Key Regional Technology Plan Recommendations

As transit agencies in the region expand the use of hardware and software applications to support transit operations, funding from Durham, and Orange, and Wake Transit Plans can support the procurement of the applications. The process for how agencies can request funding/reimbursement from these three County plans is discussed within this section.

7.2.1 Funding Request Form

The Regional Technology Plan is intended to provide guidance to the agencies on how technologies and applications across six different priority areas can be procured that are scalable and interoperable for the region. As transit agencies look to procure these technologies and applications, the recommendations of the Regional Technology Plan can guide their decision on which technologies and applications would be approved as scalable and interoperable with other agencies throughout the region.

Transit agencies that desire to seek reimbursement from the County Transit Plans for any type of transit agency procurement are required to fill out an existing funding application request form in which information is provided about their specific funding request. This form can be applied to any type of transit agency procurement for transit operations, ranging from new buses and bus shelters for passengers to other items that support transit operations.

The existing County Transit Plan funding application forms were discussed with the project group in May 2025, and it was noted that the existing forms can be utilized in their existing state. References to specific portions of the Regional Technology Plan can be referenced within the request form to be filled out by transit agencies to note how their proposed technology procurement is in line with the plan's recommendations for the region.

In general, the funding request form will include the following areas that require additional information to support the request:

- Description of proposed transit technology procurement that requires funding including the total estimated amount of the procurement
- Reference to section(s) of the Regional Technology Plan that contains information and other recommendations related to the proposed transit technology.
- Estimated improvement to transit operations from use of transit technology. This can be an improvement that either passengers would primarily see and feel (i.e. reductions in transit travel times) and/or an improvement primarily by transit operations staff (i.e., new software).
- Whether the agency has reviewed other potential available sources of funding. This may include local/state/federal sources of funding and the rationale for why County Transit Plan funding is the best source for the funding.

7.2.2 Key Regional Technology Plan Funding Recommendation

The following is proposed as an idea for how transit technologies can be funded based on an approval of the funding request form:

A proposed local match of what the transit agency is willing to make for the transit technology procurement. Local matches can be set on the following scale:

- A local match of 10% from the local agency is recommended for procurements that are less than $50,000 in estimated costs.
- A local match of 15% from the local agency is recommended for procurements that are between $50,000 and $250,000.
- A local match of 20% from the local agency is recommended for procurements greater than $250,000.

For transit technology procurements that only impact transit services in a single County, the remainder of the funding request will be covered by that respective County Transit Plan.

For transit technology procurements that have a regional benefit across Wake, Durham, and Orange Counties, the remainder of the funding request could be split as 70% from Wake, 20% from Durham, and 10% from Orange Counties based on current population split.

7.3 NCDOT Funding and Grant Alignments

7.3.1 NCDOT Moves 2050

As early as 2019, the *NC Moves 2050 Drivers and Opportunities – Technology Plan*[43] points to the need of increased mobility and considers it a State strategic objective for transportation in North Carolina. A multimodal travel into a single platform to meet future transportation needs. It states, "Transportation is moving on from **single operators or modes** and into a **user-focused service** where there is a need for simple, integrated and highly customized end-to-end solutions…" where riders expect transit to offer real-time travel options that TNCs have made commonplace. The long-term planning document also suggests leveraging technology for MaaS with the adoption of "a unified digital platform where users could plan, book, and pay for any transportation mode. The 2021 companion document, MC Moves 2050 Implementation Plan[44] incorporates a Transportation Performance Management process to bring long range planning strategies to action. It gives steps that foster coordination and relationships with MPOs and others to inform future alignment with state strategies in RPO-led plans, CTPs, STC studies and other regional transportation and economic studies.

The Region Technology Plan promotes many of these same concepts as the basis for successful changes to technology and workflows. Agencies in the region can therefore align recommendations in the Regional Technology Plan to the *NC Moves 2050* objectives when requesting funding from the state.

7.3.2 NCDOT Public Transportation Strategic Plan

The Regional Technology Plan recommendations also align with the *NCDOT Public Transportation Strategic Plan*. This 2018 document promotes strategies for regional collaboration, cross-regional

[43] https://connect.ncdot.gov/projects/planning/nc-moves-2050-plan/Documents/NC%20Moves%202050_Drivers%20and%20Opportunities_Technology.pdf
[44] . https://www.ncdot.gov/initiatives-policies/Transportation/nc-2050-plan/Documents/nc-moves-implementation-plan.pdf

travel, regional commuter services, and building a connected state-wide transit network that "will build upon existing services and embrace evolving technologies to connect North Carolina's communities to tomorrow."[45]

7.3.3 NCDOT Locally Coordinated Plan

It would stand to reason that funding grants would be provided to agencies and stakeholders who seek similar strategies outlined 2025-2029 Statewide Locally Coordinated Plan (LCP)[46]. The LCP is a framework for mobility options to seniors and individuals with disabilities by coordinating federal and state transportation grant programs, including "Section 5310" – Enhanced Mobility of Seniors and Individuals with Disabilities Program and the Rural Operating Assistance Program (ROAP). The Regional Technology Plan outlines several recommendations that align with LCP strategic priorities. As shown in Figure 7-3, expanding transit service in the area specifically lists "Increase connections to other transit agencies to promote regional connectivity" as a recommended strategy. New/extending services include the strategy to "provide connections from demand-response service (on-demand) to fixed route services".

Figure 7-3. NCDOT Locally Coordinated Plan Strategic Priorities

LCP District 5

Strategy	Public support	Quality of Life Improvement	Activity Hub/ Connectivity	Financial Feasibility	Ease of Implementation	Safety	Priority
Provide operational expenses	◆	◆	◆	⬖	⬖	⬖	Very High
Capital purchase of service	◆	◆	◆	⬖	⬖	⬖	Very High
Microtransit pilot program	◆	◆	◆	⬖	⬖	◆	Very High
Use mobility management strategies	◆	◆	◆	⬖	⬖	⬖	Very High
Expand transit service area	◆	◆	◆	◇	⬖	⬖	Very High
Improve agency efficiency through technology	◆	⬖	⬖	⬖	⬖	◆	Very High
Improve service efficiency and coordination	⬖	⬖	⬖	⬖	◆	◆	High
New or extended services	◆	◆	◆	◇	◇	⬖	High
Increased support for accessible infrastructure	◆	◆	⬖	⬖	◇	◆	High
Increase financial accessibility to service	◆	◆	⬖	◇	◇	⬖	High
Provide a range of service types	⬖	◆	◆	◇	◇	⬖	High
Increased funding for reliable and accessible fleets within FTA useful life	◇	◆	⬖	◇	◇	◆	Medium
Increased funding for administrative and operating support	◇	◇	◇	◇	◆	◇	Medium

The current Infrastructure Investment and Jobs Act (IIJA) funding will end in September of 2026. Congress is currently working on a bill to secure the multi-year funding. The current federal budget environment has agencies in the US preparing for fewer federal grants and funding streams. Still, Chairman of the Transportation and Infrastructure (T&I) Committee, Sam Groves said in May, "While

[45] https://www.ncdot.gov/divisions/integrated-mobility/public-transit-services/statewide-strategic-plan/Documents/december-2018-strategic-plan.pdf
[46] https://www.ncdot.gov/divisions/integrated-mobility/public-transit-services/statewide-locally-plan/Documents/statewide-coordinated-plan-final-report.pdf

the model for legacy transit systems may suit large cities, one size does not fit all. In many communities, options such as buses and microtransit are better options than subways or light rail. This bill will seek to ensure that transit works for communities of all sizes across the country."[47]

7.4 Regional Priorities

The overarching conclusions apply to each of the priority areas addressed in the Plan. The conclusions have been guided by and maintain current practices observed in the region.

1. **Need for Regional Coordination:** Effective transit planning and operations in the Triangle Region require collaboration among transit agencies, particularly in areas like GTFS publishing, fare collection, real-time information, and transit signal priority.
2. **Standardization and Best Practices**: Adopting standardized processes, such as GTFS best practices, NTCIP 1211 for transit signal priority, and open data standards, is essential for improving interoperability, data quality, and regional alignment.
3. **Technology Upgrades:** Develop processes for regional benefit when investing in modern tools and systems. Systems recommendations include planning/scheduling software separate from CAD/AVL systems, open payment solutions, and advanced GTFS generation tools. Consider the ability to streamline operations and improve local and regional service of multiple modes of transit. The core set of transit technologies required is a direct function of an agency's size and the different modes offered. There are differences in the technology solutions requirements for small, medium, and large agencies.
4. **Regional Open Data Portal:** Two approaches are recommended: leveraging existing data feeds for a basic portal or developing a more advanced portal with dashboards and analytics, which may be phased. Establishing a centralized open transit data portal is critical for improving transparency, supporting innovation, and enabling data-driven decision-making.
5. **Equity and Accessibility:** Maintaining equitable options for unbanked riders, such as cash payments, and integrating modern payment methods like open payments and contactless smartcards are common in modern fare collection systems with regional interoperability.
6. **Resiliency and Sustainability:** Regional transit requires robust governance frameworks, cybersecurity measures, redundancy in hosting and staffing, and alignment of regional priorities. Interoperability between agencies in the region is an operational hallmark.
7. **Phased Implementation:** The roadmap for each priority area highlights steps, allowing agencies to incrementally build on existing systems while preparing for future needs.

[47] https://aptapassengertransport.com/making-transit-work-for-all-americans/

8. **Collaboration and Innovation**: Opportunities for regional collaboration, such as shared standards, quarterly coordination meetings, and partnerships with universities and nonprofits, can drive innovation and improve regional transit systems.

9. **Cost Considerations:** Budget estimates for various initiatives highlight the importance of balancing needs of agencies upfront with technology deployment and the ongoing operational costs to ensure scalability and resiliency.

10. **Focus on Rider Experience:** Enhancing trip planning tools and improving real-time information are key to delivering a seamless and high-quality rider experience. Meet riders where they are by integrating first-mile/last-mile solutions is one example of providing options to riders to demonstrate the ease and reliability of regional transit.

7.5 Interoperability Challenges:

The document identifies several challenges in achieving interoperability across transit systems in the Triangle Region.

1. **Differences in Technology and Systems:**
    a. Transit agencies use various CAD/AVL systems, scheduling software, and GTFS generation tools. This creates difficulties in sharing and coordinating data across agencies since systems are not seamlessly integrated.
    b. Some agencies lack the necessary technology to generate GTFS-RT feeds or have systems that require manual updates due to age or lack of data integration. Other agencies have to wait weeks for vendor support for GTFS changes to appear.

2. **Inconsistent Data Standards:**
    a. Core data principles illustrated in Figure 7-4 demonstrate the value of data standards: Data is valuable, available, reliable, authorized, clear, efficient, and accountable. Data to be shared among transit agencies and mobility providers requires a standardized process. AASHTO's Transportation Asset Management (TAM) is a tool for agencies to align decision making that is based upon quality information and well-defined objectives.[48] The Guide advises that data, itself should be treated as an agency asset to manage.
    b. Stop names, IDs, and directional headings are inconsistent across agencies, leading to confusion at shared stops and overlapping routes.
    c. Agencies that use different guidelines for GTFS production, such as transfer data that is listed in a different GTFS field than other agencies, can cause compatibility issues with third-party trip planning apps like Google Maps and Transit App that seek transfer parameters in specific fields.

[48] https://www.tamguide.com/guide/

Figure 7-4. Core Data Principles

Principle 1: **VALUABLE**	**Data is an asset—** Data is a core business asset hat has value and is managed accordingly.
Principle 2: **AVAILABLE**	**Data is open, accessible, transparent, and shared—** Access to data is critical to performing duties and functions, data must be open and usable for diverse applications and open to all.
Principle 3: **RELIABLE**	**Data quality and extent is fit for a variety of applications—**- Data quality is acceptable and meets the needs for which it is intended.
Principle 4: **AUTHORIZED**	**Data is secure and compliant with regulations —** Data is trustworthy and safeguarded from unauthorized access, whether malicious, fraudulent or erroneous.
Principle 5: **CLEAR**	**There is a common vocabulary and data definition—** Data dictionaries are developed and metadata established to maximize consistency and transparency of data across systems.
Principle 6: **EFFCIENT**	**Data is not duplicated —** Data is collected once and used many times for many purposes.
Principle 7: **ACCOUNTABLE**	**Decisions maximize the benefit of data—** Timely, relevant, high-quality data are essential to maximize the utility of data for decision making.

3. **Unaligned Priorities:**
    a. Agencies have different needs and views on which data types and systems should be prioritized for integration, such as GTFS-RT, OTP thresholds, or fare collection systems.
    b. The county-based approach to transit planning has been historically decentralized. A more centralized approach to transit planning features the regional coordination of different systems toward interoperability.
4. **Lack of GTFS Coordination:**
    a. Agencies update GTFS feeds at different times, often without notifying others about changes to shared stops or coordinated routes.
    b. A formalized process for regional collaboration on transit service changes or GTFS updates would enhance GTFS alignments.

5. **Vendor Limitations:**
    a. CAD/AVL vendors may have long wait times to resolve technical issues, or process changes.
    b. Proprietary solutions can limit interoperability with other systems and depending on architecture limit the data compliance and banking regulations required for open payments.
    c. Some vendors may not support standards like NTCIP 1211 for transit signal priority, making it potentially difficult to achieve cross-jurisdictional TSP operations.
6. **Resource Constraints:**
    a. Maintaining accurate and updated data is resource-intensive, and some agencies lack the staff or technical capacity to manage frequent updates or quality assurance.
    b. Most agencies have private operators that provide services on fixed and on-demand transit modes.
    c. Smaller agencies may struggle to invest in advanced tools or systems needed for interoperability.
7. **Cybersecurity Concerns:**
    a. Publishing operational data online introduces risks such as unauthorized data manipulation, exposure of sensitive infrastructure details, or misuse of APIs.
8. **Fare Collection Disparities:**
    a. Agencies have different fare policies, payment systems, and levels of readiness for adopting open payment solutions, complicating efforts to unify fare collection across the region.
9. **Fragmented Governance:**
    a. There is no centralized entity or framework to oversee regional interoperability efforts, making it challenging to align priorities, standards, and processes across agencies.
    b. Develop a process with vendors and third parties that establishes data ownership. Data is valuable. There are three main areas where data ownership is important when formalizing a processes to consume and publish data: between mobility providers and integrators, between service providers (agencies, private operators, and TNCs), and between service providers and banks that process payments in the event that service providers settle payments internally.
10. **Data Quality Issues:**

a. Inconsistent or incomplete data, such as mismatched trip IDs between static GTFS and GTFS-RT feeds, can reduce the reliability of trip planning and real-time information systems.

b. Websites that are not regularly updated can confuse the riding public.

The challenges discussed in the Regional Technology Plan highlight the need for standardized processes, collaborative governance, and investments in modern technology to achieve interoperability across the region. AASHTO Transportation Asset Management Guide, Chapter 7[49] specifically addresses the challenges addressed here. Chapter 7 details the strategies, processes, and policy decisions needed to shift to an integrated operation. Consider the tailored guidelines developed by AASHTO (American Association of State Highway and Transportation Officials) when aligning ITS, highway infrastructure and road-based transit systems with transit in Durham, Orange, and Wake Counties. While the examples of data are dominated by highway assets like bridges, the process and policies surrounding the data practices are transferable to challenges with transit data.

7.6 Keys for Interoperability

Technology integration can improve interoperability across transit systems in the Triangle Region by overcoming challenges that typically hinder a seamless transit journey. The ten outcomes of integrating transit technologies in the Region punctuate the need for common processes and policies around technology deployment.

1. **Standardized Data Formats:**

   a. GTFS and GTFS-RT: Using standardized formats for static and real-time transit data ensures consistency across agencies, making it easier for third-party apps and systems to ingest and display data. GTFS and GTRT feed alignment is critical when integrating different technology stacks from different agencies to achieve seamless regional transit.

   b. GTFS-Flex: Incorporating GTFS-Flex for demand-responsive services can improve integration of microtransit and paratransit modes into regional trip planning tools.

2. **Unified Fare Collection Systems:**

   a. Open Payments: Implementing open payment solutions (e.g., contactless smartcards, mobile wallets) allows riders to use a single payment method across agencies, reducing friction and improving the rider experience.

   b. Account-Based Fare Systems: Integrating fare collection systems with account-based solutions enables fare capping, seamless transfers, and consistent fare policies across the region. The region has already deployed account-based fare collection for full-fare, reduced-fare, and no-fare riders.

[49] [7. Information and Systems – AASHTO TAM Guide]

3. **Integrated Planning and Scheduling Tools:**
    a. Separate Planning Software: Using robust planning and scheduling software separate from CAD/AVL systems ensures resiliency and allows agencies to optimize routes, schedules, and runcuts while maintaining interoperability.
    b. Automated GTFS Generation: Software tools can streamline GTFS creation and updates, ensuring timely and accurate data sharing.
4. **Regional Transit Signal Priority (TSP) Systems:**
    a. NTCIP 1211 Standard: Adopting this standard for TSP operations ensures compatibility between signal controllers and transit vehicles across jurisdictions.
    b. Cloud-Based TSP Systems: Integrating cloud-based TSP systems with CAD/AVL platforms allows for real-time schedule adherence-based priority requests.
5. **Open Transit Data Portals:**
    a. Centralized Data Access: A regional open data portal can aggregate GTFS, GTFS-RT, GIS, and ridership data, providing a single source of truth for developers, planners, and the public.
    b. Interactive Dashboards: Tools like Power BI, Tableau, or native service planning tool dashboards that use aligned data can help agencies to visualize performance metrics. Regional visualization presents the opportunity for agencies to monitor and improve service quality collaboratively.
6. **Real-Time Information Systems:**
    a. High-Frequency GPS Polling: GPS polling rates and latency in CAD/AVL systems can be upgraded to ensure accurate real-time vehicle tracking and improve trip planning reliability.
    b. Integration with Trip Planning Apps: APIs connected to real-time data apps like Google Maps and Transit App provide riders with consistent and accurate information.
7. **Collaborative Platforms:**
    a. Shared APIs: Reduced data duplication and improved coordination are a result of shred APIs.
    b. Regional Coordination Tools: Platforms for quarterly meetings and shared workflows can help agencies align service changes and GTFS updates.

8. **Cybersecurity and Resiliency:**
    a. Secure Hosting: Using cloud-based systems with encryption and compliance with cybersecurity standards ensures data integrity and protects sensitive information.
    b. Privacy Policy: Data sharing and customized "mobility experiences" requires development of data ownership and privacy policies. It is imperative to protect and keep secure the identity of riders that are making payments in an integrated system throughout the payment and settlement process.
    c. Redundancy: Implementing backup systems and role-based access controls ensures continuity and reduces risks of loss or misuse of data.
9. **Integration with Microtransit and TNCs:**
    a. Deep Links: Integrating microtransit and Transportation Network Companies (TNCs) into trip planning and payment systems allows riders to seamlessly combine modes for first-mile/last-mile solutions.
    b. Zone-Based Fare Integration: Aligning microtransit zones and fare policies with fixed-route services amplifies regional transit destinations.
10. **Automated Data Validation:**
    a. GTFS Validators: Tools like MobilityData's GTFS Validator can ensure data quality and compliance with best practices, reducing errors and improving interoperability.

7.7 Efficiencies with Interoperability

Interoperability significantly impacts system efficiency by enabling seamless coordination, reducing redundancies, and improving the overall functionality of transit systems. The Plan addresses several ways in which interoperability enhances system efficiency:

1. **Regional Collaboration:**
    a. Shared Goals: Interoperability fosters collaboration among agencies, aligning priorities and improving regional transit planning.
    b. Performance Benchmarking: Standardized data enables agencies to compare performance metrics and identify areas for improvement.
2. **Streamlined Data Sharing:**
    a. Consistent Data Formats: Standardized formats like GTFS and GTFS-RT ensure that transit data is easily shared and integrated across agencies, reducing manual updates and errors.

b. Real-Time Updates: Interoperable systems allow for real-time data sharing, improving the accuracy of trip planning and vehicle tracking, which reduces delays and enhances rider satisfaction.

3. **Optimized Resource Allocation:**

   a. Data-Driven Decisions: Interoperable systems provide access to on-time performance, and route productivity data, enabling agencies to optimize schedules, routes, and fleet utilization.

   b. Reduced Redundancies: Shared data and systems eliminate duplication of efforts, such as maintaining separate GTFS feeds or fare collection systems.

   c. Options for Riders: Transit system integration can include trip planning for first and last miles

4. **Faster Service Adjustments:**

   a. Automated Updates: Integrated planning and scheduling tools allow agencies to quickly implement service changes and update GTFS feeds, reducing downtime and improving responsiveness.

   b. Transit Signal Priority (TSP): Interoperable TSP systems improve bus travel times by prioritizing vehicles at intersections, reducing delays and improving schedule adherence.

5. **Improved Coordination Across Agencies:**

   a. Shared Stops and Routes: Consistent naming conventions and stop IDs at shared locations reduce confusion and ensure smooth transfers between agencies.

   b. Regional Service Planning: Interoperability enables agencies to align schedules, routes, and service changes, minimizing gaps and overlaps in service coverage.

6. **Enhanced Rider Experience:**

   a. Seamless Transfers: Unified fare systems and real-time trip planning tools make it easier for riders to navigate multiple transit providers without friction. The region has many such instances of this option for riders today since fares are not collected from riders all but three agencies in the region.

   b. Integrated Payment Systems: Open payment solutions and fare capping simplify fare collection, reducing boarding times and hence improving operational efficiency.

7. **Cost Savings:**

   a. Shared Infrastructure: Interoperability reduces the need for separate systems and platforms, lowering implementation and maintenance costs.

b. Efficient Operations: Unified systems streamline workflows, reduce administrative burdens and free up resources for other priorities.

8. **Improved System Reliability:**

    a. Redundancy and Resiliency: Interoperable systems with standardized protocols ensure continuity during outages or disruptions, maintaining service reliability.

    b. Error Reduction: Automated data validation and consistent standards reduce errors in scheduling, fare collection, and real-time information.

9. **Enhanced Multimodal Integration:**

    a. Microtransit and TNCs: Interoperability allows for better integration of microtransit and Transportation Network Companies (TNCs), improving first-mile/last-mile connectivity and expanding service options.

    b. Unified Trip Planning: Riders can plan multimodal journeys across agencies using a single platform, reducing travel time and complexity.

10. **Scalability:**

    a. Future-Ready Systems: Interoperable systems are easier to scale as transit networks expand, accommodating new routes, modes, and technologies without major disruptions.

Interoperability enhances system efficiency by improving coordination, reducing redundancies, optimizing resources, and delivering efficiencies for both riders and transit agencies. It creates a more cohesive and reliable transit network that is better equipped to meet regional mobility needs. At its core interoperable systems require agency policy alignments and standardized processes that bolster operational guidance as a region.

The region has made extensive strides in delivering more frequent and reliable routes. Agencies use responsive on-demand routes that connect transfer routes and strategic express buses and future BRT stations. help move communities from one area in the region to another. BRT infrastructure coincides with stations that are in planning and under construction to help drivers get out of their cars.

The Triangle Region is budgeting significant sums to improve transit infrastructure. Capital programs and operational reliability to regain ridership since COVID. Rider real-time trip planning communication, account-based fares, flexibility of service types, and advanced timing with priority signalization are all significant strides towards a cohesive transit infrastructure.

Capital improvements like stations and specialized BRT lanes signal a clear push towards a more interconnected transit system in the region. Interoperability of technology and integration of transit systems in a phased approach with pilots is also a significant commitment toward transit growth in the region.

Appendices

Appendix A: Test Case of the Umo Trip Planning Feature

Test Case: Trip planning with UMO using origin and destinations from agencies that do not use the Umo trip planning module.

The UMO trip planner module is part of the smartcard and validator solution offered by Cubic. Agencies who elect to contract for these services include GoTriangle, GoRaleigh, GoDurham, GoCary, OCPT, and NC State. Those that do not have UMO trip planning include Chapel Hill Transit and UNC Chapel Hill.

For reference, Chapel Hill Transit is fare-free and does not participate in UMO fare collection. GoCary publishes the Apex1 Route that appears in UMO.

As shown in Figure 2, UMO has difficulty connecting routes efficiently. Confusing or unrealistic routes are more pronounced between agency cities that do not participate in the Umo fare collection.

Interestingly when isolating the Apex1 route for Apex travel, the Umo trip planner works as anticipated and shows the Apex1 route shown in Figure 1.

Figure 1. Umo trip planning within Apex, NC

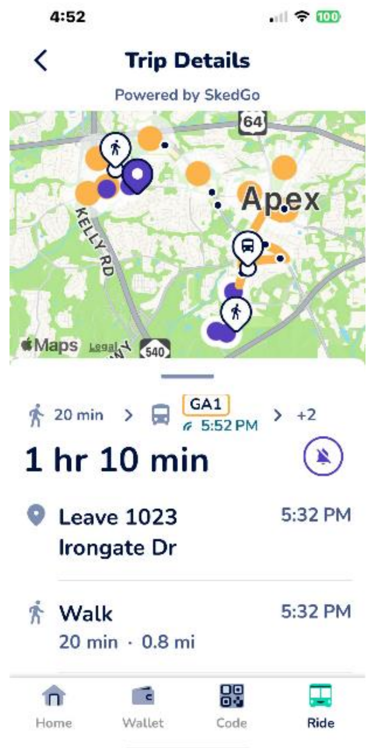
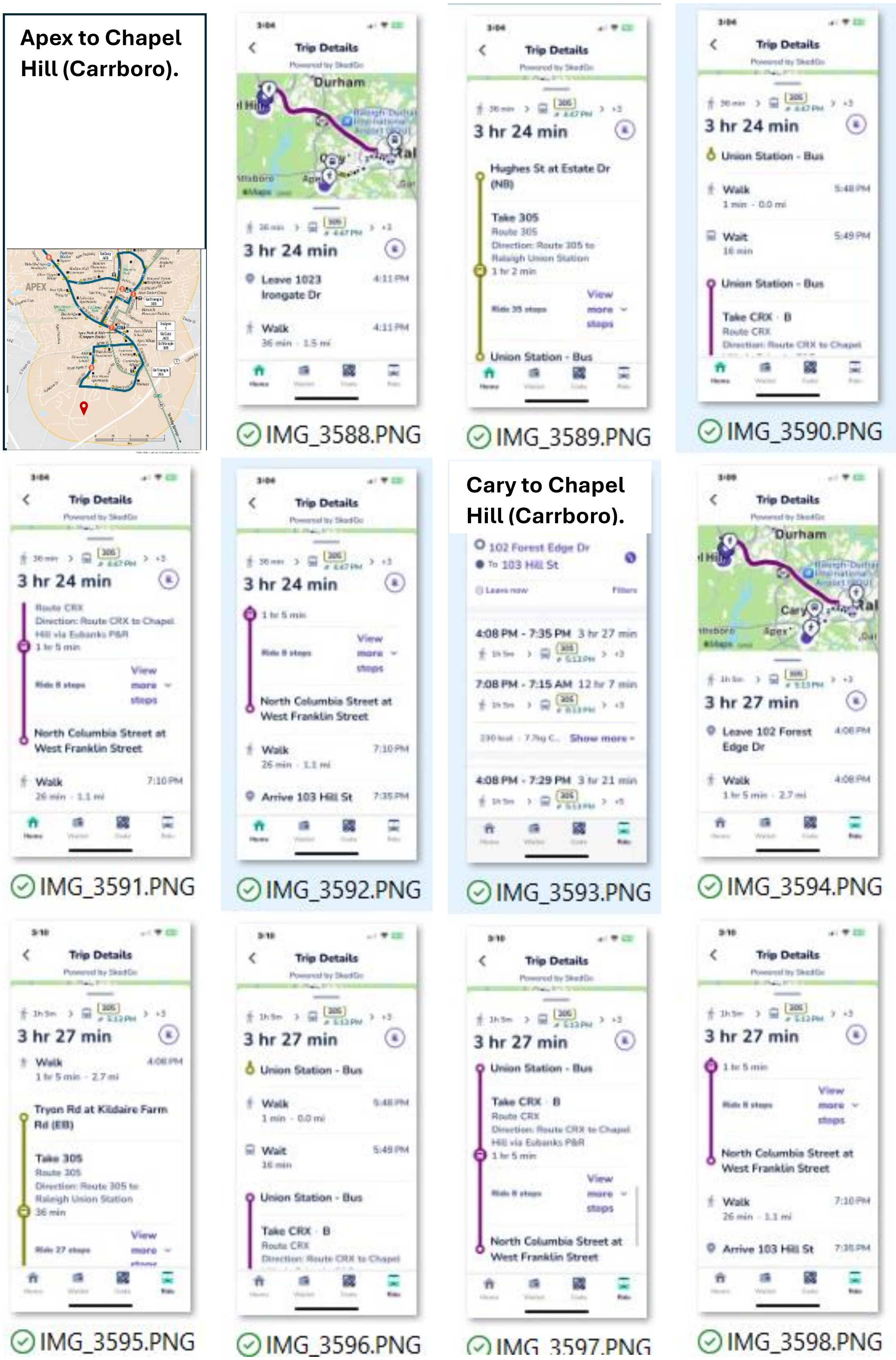


Figure 2. Umo trip planning from Apex 0-3to Chapel Hill, NC and Cary to Chapel Hill



Appendix B: Planning Estimate for Payment Integration Technology.

General Assumptions:

Number of units based on fixed route fleet size from 2023 NTD, VOMS data. Operations costs for agencies are not considered in this estimate; no on-going operational costs (i.e., tap transaction fees, cell service) are included in this planning phase of a dynamic industry. Costs for technical specification, RFP development or studies are not included in this technology estimate. Back-office implementation at a regional level assumes testing existing integrations and development of new integrations that are needed for reconciliation, accounts, robust reporting, fare processing, and revenue management. Specific assumptions follow at the end and are noted per line item in parentheses.

Cost Element Worksheet		Unit Cost Low	Unit Cost High	Number of units	Total Cost Low	Total Cost High	*Low - High Average*
One-Time System Costs							
OPTION A Replace/Upgrade fareboxes to accept open payment. Replace current validators. One back-office	Electronic registering farebox (with smart card reader) (1)	9000	13000	261	$2,349,000	$3,393,000	$2,871,000
	Stand-Alone Platform validator (3)	5000	8000	23	$115,000	$184,000	$149,500
	Stand-Alone, On-board validator (optional) (3)	2000	4000	261	$522,000	$1,044,000	$783,000
	Onboard probe equipment (1)	7000	11000	8	$56,000	$88,000	$72,000
	Garage hardware/software/probes (1)	15000	45000	8	$120,000	$360,000	$240,000
	Revenue equipment (vaults, bins, etc.) (1)	40000	60000	8	$320,000	$480,000	$400,000
	Dedicated On-board Cellular (as may be required) (10)	500	800	261	$130,500	$208,800	$169,650
	Application software (new open payments module) (2)	300000	500000	1	$300,000	$500,000	$400,000
	Back Office Implementation (2)	200000	300000	1	$200,000	$300,000	$250,000
	Total One Time Costs: Electronic Registering Fare Box for open payments				**$4,112,500**	**$6,557,800**	*$5,335,150*
OPTION B. Upgrade validators that accept open payment. Replace fareboxes with	Portable (hand-held) smart card validator (3)	2000	3000	32	$64,000	$96,000	*$80,000*
	Stand-Alone Platform validator (3)	5000	8000	23	$115,000	$184,000	*$149,500*
	Stand-Alone On-board validator (3)	2000	4000	261	$522,000	$1,044,000	*$783,000*
	Mechanical farebox (if removing current farebox) (4)	2000	5000	261	$522,000	$1,305,000	*$913,500*

Cost Element Worksheet		Unit Cost Low	Unit Cost High	Number of units	Total Cost Low	Total Cost High	*Low - High Average*
mechanical farebox. One back office.	Revenue equipment (vaults, bins, etc.) (if removing farebox) (4)	18000	22000	8	$144,000	$176,000	*$160,000*
	Dedicated On-board Cellular (as may be required) (10)	500	800	261	$130,500	$208,800	*$169,650*
	Application software (new open payments module) (2)	10000	65000	1	$10,000	$65,000	*$37,500*
	Back Office Implementation (2)	75000	200000	1	$75,000	$200,000	*$137,500*
	Total One Time Costs: Validator upgrade for open payments				**$1,582,500**	**$3,278,800**	*$2,430,650*
OPTION C. Integrate existing systems with open payment overlay. Keep existing fareboxes. Likely validator replacement. Preserve back-office status-quo.	Stand-Alone Platform validator (3)	5000	8000	23	$115,000	$184,000	*$149,500*
	Stand-Alone On-board validator (3)	2000	4000	261	$522,000	$1,044,000	*$783,000*
	Mechanical farebox (5)	2000	5000	99	$198,000	$495,000	*$346,500*
	Revenue equipment (vaults, bins, etc.) (5)	18000	22000	99	$1,782,000	$2,178,000	*$1,980,000*
	Dedicated On-board Cellular (as may be required) (10)	500	800	261	$130,500	$208,800	*$169,650*
	Application software (new open payments module) (2)	10000	65000	1	$10,000	$65,000	*$37,500*
	Back Office Implementation (2)	250000	350000	1	$250,000	$350,000	*$300,000*
	Total One Time Costs: Overlay install for open payments on existing system				**$3,007,500**	**$4,524,800**	*$3,466,150*
Optional One Time System Costs							
	Ticket vending machines (TVM) (6)	30000	50000	19	$570,000	$950,000	*$760,000*
	Station Installations (civil, infrastructure, PMgt.) (7)	10000	20000	15	$150,000	$300,000	*$225,000*
	Enforcement Devices (handheld) (8)	1000	4000	261	$261,000	$1,044,000	*$652,500*
	Fare media costs (contactless smartcards Go Passes) (9)	3	5	30,000	$90,000	$150,000	*$120,000*
	Total Optional One-Time Costs				***$1,071,000***	***$2,444,000***	*$1,757,500*

Cost Element Worksheet		Unit Cost Low	Unit Cost High	Number of units	Total Cost Low	Total Cost High	*Low - High Average*
Variable System Costs *Blended estimate does not include Optional System One Time Costs: $4,293,800.00*							
	Spare parts (10% - 15% of equipment cost)	429,380	644,070	1	$429,380	$644,070	*$536,725*
	Support services include training, documentation, and revenue testing (10% - 15% of equipment cost)	429,380	644,070	1	$429,380	$644,070	*$536,725*
	Integration Design Hours at $230. /hr.	140	600	230	$32,200	$138,000	*$85,100*
	Installation (10% - 30% of equipment cost)	429,380	1,288,140	1	$429,380	$1,288,140	*$858,760*
	Nonrecurring engineering & software costs (5% - 25% of equipment cost)	214,690	1,073,450	1	$214,690	$1,073,450	*$644,070*
	Equipment maintenance costs (5% - 10% of equipment cost)	214,690	429,380	1	$214,690	$429,380	*$322,035*
	Software licenses/system support (15% - 20% of equipment cost)	644,070	858,760	1	$644,070	$858,760	*$751,415*
	Clearinghouse costs (e.g., card distribution, transaction settlement, revenue allocation) (3% - 5% of annual volume)	61,200	102,000	1	$61,200	$102,000	*$81,600*
	Contingency (10% -15% of variable system cost)	-	-	1	$0	$0	*$0*
	Total Variable Costs				***$2,454,990***	***$5,177,870***	*$3,816,430*
Warranty							
	4- Year Warranty (years 2-5) per device	400	700	261	**$104,400**	**$182,700**	*$143,550*

Summary of Planning Estimate for regional integrated payments

	OPTION A. Replace/upgrade current fareboxes with single farebox or validator for all open loop functions. Remove validators in use. One back office.		OPTION B. Upgrade validators that accept open payment. Replace fareboxes with mechanical farebox. One back office.		OPTION C. Integrate existing systems with open payment overlay. Keep newer existing fareboxes. Likely validator replacement. Preserve back-office status-quo	
	Low	High	Low	High	Low	High
System Costs	$4,112,500	$6,557,800	$1,582,500	$3,278,800	$3,007,500	$4,524,800
Variable System Costs	$2,454,990	$5,177,870	$2,454,990	$5,177,870	$2,454,990	$5,177,870
Warranty	$104,400	$182,700	$104,400	$182,700	$104,400	$182,700
Option Estimate TOTAL	$6,671,890	$11,918,370	$4,141,890	$8,639,370	$5,566,890	$9,885,370

NOTES:

(1) Upgrades cash fareboxes that accept open loop payments, quantity may be less depending on vendor. Quantity includes seven for agency test labs.

(2) Presumes one license and one back office for region with back-office access for agencies collecting fares.

(3) Upgrades validators that accept open loop payments, quantity may be less depending on vendor. Quantity includes seven for agency test labs.

(4) Quantity presumes farebox replacement.

(5) Quantity presumes integrating 162 existing FastFare fareboxes until end of service life.

(6) TVMs include: 2-Durham Station, 3-Regional Transit Center, 3-Raleigh Union Station, 1-UNC Hospitals, 1-Raleigh Mobility Hub, 2-Chapel Hill BRT, 6- other enhanced transit stops. (planned station equipment presumed to be included in station costs estimate)

(7) TVMs assume installation at stations under cover. Consider including as part of the civil contract for future capital projects.

(8) Fare policy will dictate actual number of devices. Quantity includes seven for agency test labs.

(9) Assumes reissuance of all media. Quantity may be adjusted depending on vendor selected.

(10) Operational and monthly costs for cellular are not included.

Appendix C: Summary of Public Comments on Regional Technology Plan Chapters

The main chapters of the Regional Technology Plan were made available by GoTriangle for review by the general public as passengers of public transit in the region between the dates of September 22nd and October 6th, 2025. The comments were reviewed by project staff and are summarized in the summary matrix on the following pages. Some of the longer comments from individuals were split into parts A, B, C, etc… to relate the comments to the various chapters of the plan. Responses to the comments and a general disposition of comments are provided in the far right columns of the summary matrix on the following pages.

Appendix C -- Summary of Public Comments on Chapters of Regional Technology Plan

Comment Disposition Legend

A - Comment accepted. Change made to document; B - Comment accepted, future change will be made to document; C - Comment not accepted, and no changes made to document.

#	Chapter #	Comment	Disposition	Responses to Comments
1	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	All of these are absolutely EXCEPTIONAL and 100% great things for Triangle transit. The data access will be phenomenally helpful for riders and those interested in learning more about Triangle transit. The TSP will be transformative for the performance of service across the region and is a truly exceptional idea. PLEASE!!!	C	Thanks for the comments. Changes to all chapters of the plan are being made with final input from transit agency staff in October and November 2025.
2	Ch. 1: Real Time Information; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology	TSP is a phenomenal idea and should be implemented wherever possible. I think that real-time location data (i.e., next stop) should be utilized on the screens on the buses that have them. I have seen this only once before on a GoRaleigh bus, but never since. Currently, they just display ads. I also think that a tap-to-pay system on the fare collectors that allows for use with credit cards is a must-have, especially for casual/new riders.	C	Thanks for the comments. Chapter 3 on TSP will contain guidance to allow for agencies to plan for TSP in future years. Making information available on vehicle was not discussed with project group for Chapter 1, but can be brought to agency attention, as it will involve integration with on-board CAD / AVL systems. Tap-to-pay system with credit cards (i.e. Open Payment) is recommended within Chapter 4 of the plan.

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3	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	Faster, standardized, and better-coordinated sharing of route and service information is a MUST for our region! It's not the early 2000s anymore; since people don't always make a distinction between GoTriangle and local bus operators (e.g. "this bus is red! and that one is green! so what?"), riders may not even realize this is a challenge that exists (or one that matters!). Through this lens, the fact that we haven't already done this seems like a shortcoming - so this is a sorely needed upgrade for the Triangle.; For the recommendation to "Obtain technology to generate a GTFS that saves past versions and allows the agency to streamline their process when service changes are made": there's a free, mature technology that already exists, though!	C	Thanks for the comments. Recommendations within Chapter 5 are for the agencies to follow in the coming years. Specific vendor names are not pointed out as recommendations, as agencies can determine which solution is best for them and for the region.

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#	Chapter #	Comment	Disposition	Responses to Comments
3A	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	In the software development and data science worlds, "version control" is an established technique to track updates to files (including when and how files are added, modified, or deleted). Established open-source tools to do this like Git (which anyone in software or data science should know how to use in 2025) or Data Version Control are even capable of doing this in decentralized environments where:1) multiple "master copies" of files exist (e.g. each transit agency has their own notion of the "latest GTFS feeds"); 2) updates can be pushed or accepted dynamically (e.g. each agency "pulls" updates from another feed, or one agency makes a "pull request" to ask another agency to accept its updates), and; 3) when changes to GTFS files are made, they can trigger "hooks", or scripts that are automatically run to perform certain tasks (e.g. validating files to catch obvious formatting errors, generating request emails or data transfers to third-party vendors)	C	Thanks for the comments. Transit agency staff are familiar with the processes followed for updating GTFS data and feeds. Updates are made in coordination with CAD / AVL systems that provide real-time information on bus locations.

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3B	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	It sounds like GTFS files are just text files, and our goals are to track different versions of changes (which, by definition, includes the ability to examine previous versions and "roll back" updates to previous states) while making it easier for local agencies to share information with each other. By using some formal version control mechanism, transit data could be updated more quickly without inherently relying on a commercial solution. If individual agencies choose to do so, their repos themselves could also be available for the public to view (or even participate in editing, if agencies choose to allow that) - and that would greatly improve operational transparency.	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.
3C	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	A possible workflow would look like: 1. GoTriangle, CAMPO, or TWTPO initializes repos for GTFS-Schedule and GTFS-RT files (one organization can maintain multiple repos, and each repo should be the home of one conceptual category of files). Repos may be private so that they cannot be viewed unless a user is authenticated - or they could even be made available so that the general public can see it. For the latter, popular tools like GitHub are free to use. 2. Repo administrators configure their repos so that pull requests and reviews are required for merges. Note that this defines who is allowed to suggest or directly make changes to a repo; it's separate from a setting for visibility.	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.

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3D	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	3. Have others "fork" from the regional repo so that they have their own versions. For example, a fork could be created by individual staff at the regional agency on their own computers (e.g. if they want to export changes from Remix). However, this is a flexible process. Assuming that they have access to the regional agency's repo, a GitHub account run by another agency could do this (e.g. Chapel Hill Transit could make its own branch which they'll consider to be their own "master repo"), as well as individuals from partnering agencies (e.g. an individual GoDurham planner).	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.
3E	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	4. Individual repos make their own changes to GTFS files etc. as appropriate. Notice that, if you have your own local repo that is forked off of (i.e. is a branch that's an offshoot from) the regional repo, then your repo is, itself, a Git repo. Thus, you can make our own changes to schedules, track changes (or roll back to older versions) as appropriate, and keep track of when you (don't) get updates from the regional repo. Individual instances of recorded changes in a repo are called "commits" (since you're making a record to say that you've committed yourself to a change in that repo).	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.

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3F	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	5. Individual repos could choose to "pull" updates from the regional repo (or any other repo that is "remote" to it). This makes it so that a "local" repo can stay up to date with changes made elsewhere. How often this happens, as well as what is considered to be remote repos of interest, depends on the individual or agency. (For example, a senior GoCary planner may want to regularly pull from a senior planner in GoRaleigh so that they can regularly trade notes on schedule changes. However, the planner in Cary probably does not care about what a new employee-in-training in Chapel Hill Transit is doing; they do not need to set up that person's repo as another remote branch.)	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.
3G	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	6. As the reverse of Step 5: if someone makes changes and wants the regional repo to adopt them, the owner of that repo would go to the regional repo and make a "pull request", thereby requesting the other repo to pull their changes. For example if GoWake Access makes changes to their GTFS feed and wants the regional repo to incorporate it, a GoWake Access planner with view access to the regional repo would make that request. Cloud-based Git platforms have web browser-based interfaces to manage this process, so in that example, the GoWake Access staffer would fill out a form that explains the changes they've made, and submit the request.	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.

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3H	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	7. An administrator of the regional repo would review the pull request from the previous step. The regional repo's admin can choose to accept as-is so that the proposed changes are immediately a part of the regional repo, ask for additional changes (which the submitter of the pull request can do by making additional commits), or flatly reject the request.8. If the regional repo is configured with certain hooks, they could be run immediately after a pull request is received, when merges are made, or at any some other point in time as appropriate. This will likely be done through the web platform that is hosting the regional repo.	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.
3I	Ch. 2: Service Planning Tools; Ch. 5: Regional GTFS; Ch. 6: Open Data Portal	9. If the data files in the regional repo are mature and stable to some extent such that it's time to make a formal release of GTFS files (e.g. to generate a static copy to upload to a data portal webpage), the repo could be "packaged" into a more versioned release that is more polished. Cloud-based Git platforms usually offer tools to do this - but the host of the regional repo may choose to do this in conjunction with formal in-person meetings with other planners, or through more involved processes.	C	Thanks for the comments. Transit agencies in the region will need to review workflows for how best to update GTFS feeds within each work environment that includes CAD / AVL systems and contracted service operators.

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4	Ch. 1: Real Time Information; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology	Passenger real time info must be present on the buses. GoRaleigh and GoTriangle have screens in most of their new buses, it's about time they start displaying next stop info and route information instead of ads. It's 2025 after all. TSP sounds like something that needs to be implemented through the whole system and keep buses running on time. Get rid of UMO and contract with somebody else. That app is a hot mess. Also, paying with a credit card or Apple/Google Pay needs to be a thing.	C	Thanks for the comments. Making information available on vehicle was not discussed with project group for Chapter 1, but can be brought to agency attention, as it will involve integration with on-board CAD / AVL systems. Chapter 3 on TSP will contain guidance to allow for agencies to plan for TSP in future years. Tap-to-pay system with credit cards (i.e. Open Payment) is recommended within Chapter 4 of the plan for fixed route buses. No changes to existing vendors are recommended within the plan though.
5	Ch. 1: Real Time Information; Ch. 4: Regional Fare Technology	Tap and pay using credit cards or UMO cards. Should apply to paratransit. ; Look at the 2040 Cary Community Plan and see if your plans for transit aligns with theirs.		Thanks for the comments. Tap-to-pay system with credit cards (i.e. Open Payment) is recommended within Chapter 4 of the plan for fixed route buses.
6	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology; Ch. 6: Open Data Portal	Congratulations on the excellent transit technology documents and priorities. (Trivia: before his retirement, my brother was a Cubic transit technology executive with thirty years at the company.) Please remember that not everyone can afford a smart phone, so an mobile app is not a universal solution. As a senior with aging eyesight, an amputated thumb, arthritis, and budget constraints, I still depend on a desktop computer -- not a hand-held device. Displaying the bus status (number of minutes until arrival) with a monitor at the bus stop would be ideal. Otherwise, there needs to be a "phone live operator" option when worried that the bus will never arrive.	C	Thanks for the comments. Chapter 1 provides information on existing CAD / AVL systems that can provide transit information on desktop computers.

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6A	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology; Ch. 6: Open Data Portal	Obviously, the frequency with which "canceled trips" occur must be addressed beyond technical alerts. Frustrated by the recent unreliability of the 305 bus from Apex to Raleigh. GoTriangle needs a back-up system with stand-by driver so that stops are not skipped completely on the one-hour routes.	C	Thanks for the comments. Specific comments on routes and canceled trips can best be addressed by agency staff.
6B	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology; Ch. 6: Open Data Portal	I am a bus-dependent resident of Apex, read the town's transit publications, and attend transit board meetings. There is significant backlash here by people who think the GoApex Route One is "always empty" and a "waste of money." The released statistics get criticized for only showing combined trips rather than a unique rider count. Personally, I think the entire regional bus system should use the same bus pass card for electronic scanning when boarding. Apex could still make the rides free for anyone with a registered card or honor the GoTriangle free/discount program. Presumably scanning of the cards could be tracked. Then Apex could ideally see passenger behavior. For me, I ride all three busses that pass through Apex: GoApex 1, the ACX Apex-Cary Express, and the GoTriangle 305 -- plus I will be a regular user of the new GoCary 9 when it launches. Data showing ridership patterns when correlated with user demographics would be invaluable. The surveys in Apex get overwhelmed by the 99% of responses from nonriders, so the actual preferences and requirements of bus regulars get buried.	C	Thanks for the comments. Transit agencies in the region can work together in the coming years on the recommendations within the Regional Technology Plan to improve ease of transit travel throughout the region.

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6C	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools;	"Route visualization" is crucial to measure and improve: "The shared stop feature is also important to analyze in the event of a missed connections for a GoTriangle bus that was late in connecting with another operating partner's route." In my experience, the GoCary Route 5 and the GoTriangle 305 are rarely synched up near WakeMed Cary, which results in a long wait -- without any sense that the bus operators care.	C	Thanks for the comments. Specific comments on routes and canceled trips can best be addressed by agency staff.
6D	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools;	The "service planning" figure 10 chart about model improvements is great, especially "how people travel." As a low-tech option, I would gladly track my activities for a week (even every quarter), showing how far I walked, what bus I rode, the destination and purpose, and the reliability. Rider-specific logs could supplement what the data might show, such as the walking time required to and from stops. Equally important is when bus-dependent riders decide that the excessive time for a three-transfer-trip is too much hassle in exchange for attending a desired activity. I often want to attend a weekend regional festival, plot out the travel route, and then give up.	C	Thanks for the comments. Specific comments on routes and canceled trips can best be addressed by agency staff.
6E	Ch. 3: Transit Signal Priority;	Regarding transit signal prioritization, I use GoCary Route 5 to transfer to the GoTriangle 305 that connects with Apex. I'm not sure that tiny improvements in running time during the pilot period will justify the cost. In my experience, the Route 5 has serious problems when the bus breaks down and never completes the loop. That means a thirty-minute delay for riders. I was recently trying to take the Route 5 when the front bus door refused to close and thus the loop never even left the bus depot. For riders, buses never showing up is a much bigger problem, although I understand the importance of tightly-scheduled transfer connections.	C	Thanks for the comments. Chapter 3 on TSP will contain guidance to allow for agencies to plan for TSP in future years.

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6F	Ch. 3: Transit Signal Priority;	I think intersection "walk signal" timing is probably more important for a rider perspective. To reach both the ACX Express and the 305 in downtown Apex, I need to get across the Hunter-Salem intersection. That signal is absurd -- giving extravagant priority to vehicles and a brief infrequent too-fast crossing option for the many waiting pedestrians. The railroad crossing can also interrupt momentum. I need to leave home early because of the likely pedestrian challenges at the intersection, which adds to my total walk-plus-bus travel time. Make sure that any signal changes ensure that pedestrians are most important!	C	Thanks for the comments. Chapter 3 on TSP will contain guidance to allow for agencies to plan for TSP in future years.
6G	Ch. 4: Regional Fare Technology;	Wow that Chapel Hill Transit has not accepted fares in over twenty years.Even for bus routes that are free, I think scanning a regionwide smart card GoPass is a useful way to track ridership throughout the system. Riders could reasonably be asked to confirm demographic information and destination preferences every six months or every year through an online interface for pass renewal. I think infrequent riders without a pass (thus not bus-dependent) should be charged a fare. For the past year while shifting into retirement, I have qualified for a Transit Assistance Pass. I believe the income cap of $35,000 is fair. This service should be implemented and honored by all the local bus agencies. Note that I use a physical pass, because I am not a smart phone person.	C	Thanks for the comments. Transit agencies in the region can work together in the coming years on the recommendations within the Regional Technology Plan to improve ease of transit travel throughout the region.

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6H	Ch. 6: Open Transit Data Portal	Data collection is needed on the number of potential users who are unable to get a seat on a door-to-door ride through Wake County Access. I am eligible and have tried calling in early enough by phone to be one of the lucky people. But I have NEVER been connected for a reservation in time. In my experience, there is no tracking on these declines. A system is needed to know what percentage of callers (potential passengers) never get a seat because the hold system is overloaded, they reach an operator after capacity is exceeded, or they give up on even trying. In my experience, "demand for assistance" is not tracked. Ideally, there should be a ticketing system that shows demographics, starting address, desired destination, purpose of trip, and whether a ride was secured. This door-to-door service is a failure, except for a lucky few each day.	C	Thanks for the comments. Specific comments on routes and canceled trips can best be addressed by agency staff.
6I	Ch. 6: Open Transit Data Portal	Love that the public is included in this vision: "A publicly available data source where local government staff, research partners, and engaged community members can easily find transit data." Ridership-per-hour and number-of-trips-by-month-per-rider would be useful. Cancelled trips and bus maintenance disruptions should be disclosed. I am registered for the email notifications about route changes, but these reports under-report how often the bus just never shows up. Storytelling is important: "pair raw metrics with narrative context to help users interpret trends and understand agency decisions." Judging by the hostile and untrue social media posts from anti-transit people in Apex, an advocacy element is needed to put ridership counts and cost-per-trip in a favorable light.	C	Thanks for the comments. Transit agencies in the region can work together in the coming years on the recommendations within the Regional Technology Plan to improve ease of transit travel throughout the region.

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6J	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology; Ch. 6: Open Data Portal	I appreciated the reference links in these documents, because I want to be a more-informed bus advocate. Suggestion: every bus should consistently display the time and next stop location on the in-bus monitor. Every bus should consistently have the audio announcement about the next stop. On unfamiliar routes, I sometimes have trouble spotting exactly where I need to disembark. Please do not overlook the value of bus stop based communication, signage, and displayed updates. Similar to how subways usually show how many minutes until the next train arrives.	C	Thanks for the comments. Transit agencies in the region can work together in the coming years on the recommendations within the Regional Technology Plan to improve ease of transit travel throughout the region.
6K	Ch. 1: Real Time Information; Ch. 2: Service Planning Tools; Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology; Ch. 6: Open Data Portal	The high costs concern me. From a rider perspective, this behind-the-scenes technology is important, especially if bus reliability can be improved. But exponentially more valuable would be adding covered benches throughout the system and improving reliability so that a replacement back-up bus or even small branded vehicles complete the route when riders are stuck waiting at stops.	C	Thanks for the comments. Transit agencies in the region can work together in the coming years on the recommendations within the Regional Technology Plan to improve ease of transit travel throughout the region.
7	Ch. 3: Transit Signal Priority; Ch. 4: Regional Fare Technology;	Service needs to be so good that enough people want to pay a fare to take transit in lieu of a car. This is the most fundamental truth that must underlie all our plans. The only item on here that does this is transit signal priority, so please do this at every intersection throughout the region. Service must be fast, frequent, and easy. When buses come at intervals less than 15 minutes, trip planning and real time status aren't as critical.	C	Thanks for the comments. Chapter 3 on TSP will contain guidance to allow for agencies to plan for TSP in future years.