Transit Signal Priority Summary

April 21, 2022

City of Durham | Exult Engineering | GO Durham

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SYSTEM INVENTORY AND ONGOING EFFORTS

The City of Durham Transportation Department and GoTriangle transit agency work in partnership to maintain and operate a robust transit service network. Their system features a fixed-route transit service, called GoDurham, and an on-demand transit service, called GoDurham ACCESS. Through this study, the City of Durham Transportation Department is seeking to be proactive with the deployment and use of innovative technology. The City has recently put innovative vehicles and technologies into service that enhance ridership experience and improve reliability over the past several years. The City is also currently managing several ongoing efforts and studies for continued improvement.

This section summarizes the City's existing assets and also highlights some of those ongoing efforts to document how they relate to this Durham Fleet Expansion and Revitalization Plan (hereafter referred to as the "Durham Transit Technology Plan".

1. Existing Transit Assets

Existing Bus Fleet and Facilities

The City and GoDurham maintain a rolling stock of vehicles. The fleet is comprised primarily of diesel fueled vehicles. Most vehicles average 60,000 – 70,000 miles per year. The goal is to retire vehicles after about 10 years of service. The existing active fleet of GoDurham buses are shown in Table 1 below.

Table 1. Existing Bus Fleet

Vehicle Year & Model	Quantity
2008 Gillig 40ft Low-Floor Bus	6
2010 Gillig 40ft Low-Floor Hybrid Electric Low-Floor	18
2012 Gillig 40ft Low-Floor Hybrid Electric Low-Floor	5
2017 Gillig 40ft Low-Floor Bus	12
2018 Gillig 40ft Low-Floor Bus	3
2019 Gillig 40ft Low-Floor Bus	4
2021 Gillig 40ft Low-Floor Electric Bus	2
2021 Gillig 40ft Low-Floor Bus	8
Total Existing	58

Table 1 highlights that the City of Durham does own a number of hybrid electric buses and two fully electric buses. Additionally, the City has placed an order for an additional six Gillig 40-foot low-floor electric buses. These buses were planned to be received in 2022, but now have an anticipated delivery date of Q1 of 2023. When those buses are received, the six 2008 Gillig 40-foot low-floor buses will be retired to maintain a total fleet size of 58 buses. The City and GoDurham are also currently working on a procurement agreement with local partners to provide a more efficient and cost-effective way of procuring vehicles.

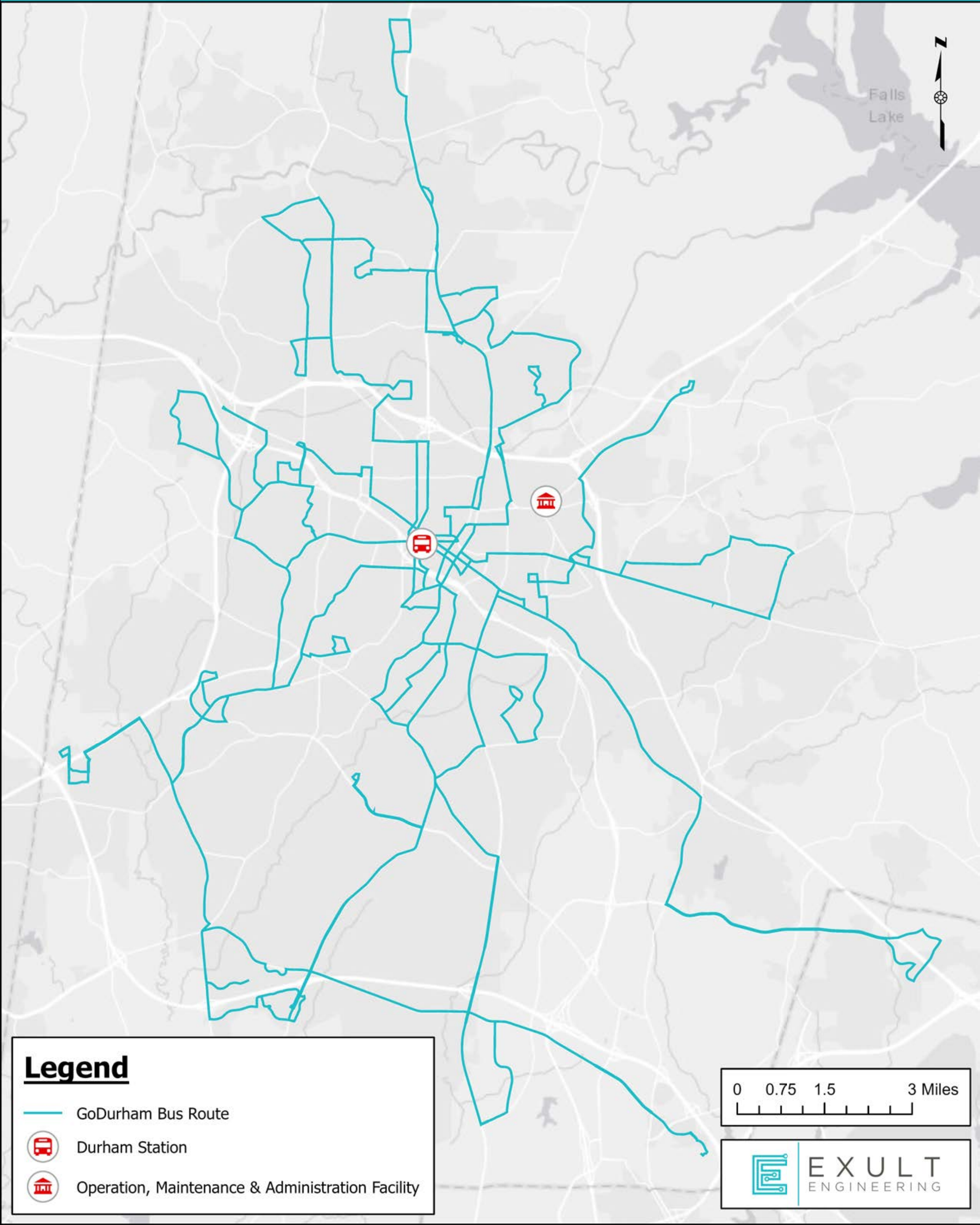
In 2021, the City of Durham adopted a *Carbon Neutrality & Renewable Energy Action Plan*. That plan documents the City's goal of reaching carbon neutrality for City operations by 2040 and the City and

GoDurham efforts to add electric vehicles to the transit service fleet are actions towards achieve the goals set forth in that plan.

2. Existing Services

GoDurham currently operates 24 bus routes, offering fixed-route and ADA paratransit on-demand services. The map in Figure 1 on the following page provides a high-level overview of the City's fixed routes. GoDurham ACCESS provides service within the city limits and to any location within three-quarters of a mile of a fixed-route bus route. The maps also display two notable transit facilities: the Durham Station and the GoDurham Operation, Maintenance, and Administration Facility.

Figure 1: Existing Routes and Transit Facilities



3. Relevant Projects Underway

CAD/AVL Procurement

An RFP was advertised in November 2021 for a new computer-aided dispatch/automatic vehicle location (CAD/AVL) system which includes onboard systems, central systems, depot systems, and wayside systems. GoDurham selected Avail Technologies and issued their notice to proceed on March 8, 2022. In addition to the base CAD/AVL solution, the vendor will also exercise the following optional items included in the RFP:

- Automated Vehicle Monitoring (AVM)
- Radio integration for "closed mic" communications
- Transit Signal Priority (TSP) integration
- Creating a second WLAN bulk data transfer location at Durham Station
- New scheduling/run-cutting/daily workforce management solution (Optibus)

Innovative Traffic Signal Technologies

In addition to owning and operating approximately 60 city signals, the City of Durham Engineering Department maintains nearly 400 signals citywide. The City has made recent efforts to enhance their traffic signal system and provide innovative technologies related to transit. Listed below are some of those efforts:

Durham Signal System Project – The City is currently halfway through construction of a Signal System Upgrade Project (anticipated construction completion 2024). The project consists of upgrading every traffic signal in the system. Special features such as emergency vehicle preemption and flashing yellow arrows are being added. Most notably, the project is expanding the City's fiber optic communication network and upgrading all intersections 2070LX controllers with ASC/3 software. These upgrades modernize the traffic signal system and pave the way for enhanced signal technologies, including transit technologies.

AI Equipment Installation – The Durham Signal System is investing approximately $1M in implementing Applied Information's (AI) Connected and Automated Vehicle (CAV) technology. This includes installing AI-500-085 Glance Preempt & Priority Video Capable field monitoring units (FMU) controllers at 267 signalized intersections. These devices allow adding priority & preemption, streaming video, and monitoring intersection status and health. The goal is to utilize compatible communications for emergency, rail, and TSP. A budget request was recently submitted to install Applied Information's Connected Vehicle System (CVS) onboard units in emergency vehicles; there is not currently a budget request to do so for transit vehicles, but existing contract mechanisms are in place to enable this procurement.

Queue Jump Pilot – The City recently installed and implemented a queue jump pilot for the intersection of NC 55 at Odyssey Drive. The intersection features an exclusive bus lane pocket and transit-faced signal heads that allow the bus to be served independently of the vehicular phase.

GoDurham Better Bus Project

GoDurham currently has the *Better Bus Project (BBP)* underway, which is a series of five individual projects that look to improve bus access and reliability. As a part of the BBP, GoDurham procured Kittelson and Associates to conduct a *Bus Speed and Reliability System Analysis*. The goal of the analysis was to identify locations where bus speed and/or reliability needs improvement. The study found 13 "hot spots" where passenger delay was relatively high and bus speeds were relatively low. Recommendations for improvements were provided for these hot spots such as signal timing adjustments, bus stop relocation, transit signal priority implementation and/or geometric/striping improvements in order to improve bus speed and reliability.

The project is also preparing TSP System guidance, including a TSP recommendation memorandum and a TSP System Architecture Framework to provide technical guidance requirements on this technology. Because the Fayetteville Street and Holloway Street Corridors are of primary focus in the BBP, this Durham Transit Technology Plan will provide practical implementation recommendations for TSP pilots along these corridors to align with the BBP goals.

TRANSIT SIGNAL PRIORITY PLAN

1. TSP Overview

Traffic signal priority (TSP) is an operational strategy that gives special treatment to transit vehicles at signalized intersections, at times prioritizing their progression through the intersection. The goal of TSP is to improve schedule adherence and transit travel time efficiency while minimizing impacts to traffic operations. Improved bus service can encourage mode shift away from personal vehicles to transit. Existing TSP implementations have shown a travel time savings of approximately 15% with very minor impacts to the overall intersection operations. TSP integration is an option that was included in the new CAD/AVL RFP scope that was recently awarded to Avail Technologies by the City of Durham.

TSP systems involve the transit vehicle, transit fleet management, traffic control, and traffic control management. These four systems are then enhanced with the following four functional applications:

VEHICLE DETECTION	A system to deliver vehicle data (location, number of passengers, schedule adherence, etc.) to a device that is routed to a Priority Request Generator (PRG).
PRIORITY REQUEST GENERATOR/SERVER	A system to request priority from the traffic control system and handle multiple requests if necessary.
PRIORITY CONTROL STRATEGIES	A traffic control system software enhancement that provides TSP control strategies (green extension, early green, etc.) that address the functional traffic requirements.
TSP SYSTEM MANAGEMENT	Incorporates transit and traffic TSP functions in transit management and traffic control management that can configure settings, log events, and provide reporting.

2. Priority Control System Architecture

An important consideration for implementing TSP is the priority control system architecture. It is recommended that the City of Durham implement active priority conditional TSP, which provides priority treatment to a transit vehicle following detection and subsequent priority request activation. The possible approaches to the priority control system architecture are *distributed*, *centralized*, and a *hybrid* of the two as summarized below.

Distributed

Distributed architecture is designed to have the vehicle communicate directly with the intersection. Priority control equipment is needed both on the vehicle and at the intersection; no existing communication infrastructure is required. It is possible to manage and monitor the system from a central location if intersections have fiber/Wi-Fi/cellular communications.

Figure 2. Distributed TSP

Centralized

Figure 3. Centralized TSP Architecture

Centralized architecture is designed to have the vehicle communicate through its Automatic Vehicle Location (AVL) system to the traffic signal through an integration between the AVL system and the traffic signal system. With this type of system, the PRG is often within the AVL software, and the PRS is either in the central traffic signal software or the signal controller firmware. The PRS processes the request, decides what signal timing modifications to make, and sends them to the signal controller generally via the traffic signal communications. Centralized architecture approaches are in modern times are often cloud-based systems.

Hybrid

A hybrid architecture provides the benefits of the distributed and centralized systems as users migrate from one architecture to another. This system utilizes the existing technologies already in place and pairs it with new technology. The system used can be tailored for each intersection or vehicle based on what serves its needs best. The entire system or certain parts of it can be managed and monitored from a central location. A hybrid architecture would enable the City of Durham to benefit from the historic reliability of a distributed system while providing flexibility and a built-in transition path to the more cutting-edge, yet less proven centralized TSP capabilities.

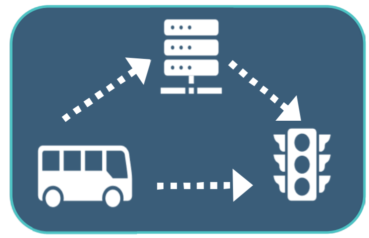


Figure 4. Hybrid TSP Architecture

3. Partner Agency TSP Systems

Several Triangle regional partners have made steps towards implementing TSP. Below is a summary of these systems and their current implementation status.

City of Raleigh and GoRaleigh

The City of Raleigh and GoRaleigh recently selected ACT EMTRAC for implementing TSP. ACT EMTRAC uses Global Navigation Satellite System (GNSS) technology and secure wireless communication to provide signal priority and can be implemented using both distributed and centralized architecture.

GoRaleigh's TSP system will be a centralized (cloud-based) system that integrates with the GoRaleigh CAD/AVL system. Vehicle detection will occur via virtual detection zones that are defined by GPS coordinates. Each GoRaleigh bus has a windows-based computer on board that will have software installed to allow it to communicate via cellular network to the cloud. From the cloud, NTCIP messages will be sent to the traffic signal controllers. Raleigh's system will require no new equipment on the bus or at the intersection. The City of Raleigh viewed this as a priority for them due to limited space in their cabinets and additional equipment needed was a significant factor in their selection process. This system is standalone, can be used with various signal software, and can be implemented across municipalities.

ACT EMTRAC's solution for Raleigh uses a centralized architecture, but they also offer a distributed architecture solution. The basic EMTRAC components for a distributed architecture include a Vehicle Computer Unit (VCU), cabinet-mounted Priority Detector, and cabinet- or pole-mounted antenna. The VCU utilizes GPS and internal navigation to determine precise location and transmits a priority request when passing through detection zones. The Priority Detector then relays the priority request call to the traffic controller. These components communicate wirelessly using secure frequency-hopping spread spectrum radio. EMTRAC reports that the VCU excels in tracking vehicle locations in urban environments with tall buildings.

Town of Cary

The Town of Cary is implementing TSP using AI's Connected Vehicle System (CVS). Their TSP system is a distributed architecture solution with onboard vehicle units that communicate to roadside units. The system is integrating with Cary's standard ASC/3 software. The AI onboard units have been installed on their transit vehicles and they are in the process of being integrated on-board with the TripSpark AVL units.

AI's CVS includes the Glance software system that communicates with the AI-500-085, and AI-500-095 hardware units. The AI-500-085 unit is mounted in the traffic signal cabinet and enables 4G LTE cellular communication to the signal and connects the system with Glance. The AI-500-095 unit is a roadside unit that supports dual-mode, dual-active DSRC and C-V2X radio communication and communicates wirelessly with the AI-00-085 to pass data to Glance. The DSRC/C-V2X antenna is a high-gain and omni-directional antenna that is mounted to the top of the signal pole.

TSP Implementation with ASC/3 Case Study: Montgomery County, Maryland

Another example of TSP implementation with ASC/3 firmware is in Montgomery County, Maryland. Their system contains approximately 900 signals and they have implemented traditional architecture TSP provided by GTT Opticom on their Bus Rapid Transit (BRT) routes, which involves 45 signals and 30 buses. Montgomery County has not currently implemented TSP on their fixed scheduled routes. When TSP was initially implemented, they were using version 2.45 of ASC/3, which required a data key to be TSP-ready. Currently, they are running version 2.65.30 on most signals. Any version of ASC/3 later than 2.52 does not need a data key to run TSP. Montgomery County reported no significant challenges with TSP on ASC/3 and reported getting very helpful instructions from Econolite when integrating. They did note that their software and technology limits them to the early green and extended green priority strategies and that occasionally hardware breaks and needs to be replaced, which is to be expected.

4. TSP Components in Durham

When considering TSP components, the three projects listed below directly relate to Durham's TSP integration. These projects involve an existing investment in hardware, software, and/or physical improvements related to TSP implementation.

1) AI Equipment Installation – The AI equipment installation involves an existing capital investment in installing Connected and Autonomous Vehicle (CAV) field monitoring units (FMUs) with TSP functionality provided by Applied Information (AI) in 267 signal cabinets.
2) CAD/AVL Procurement – The CAD/AVL procurement includes a TSP integration software option that will be exercised.
3) Better Bus Project – The BBP includes physical improvements to two corridors in order to improve access and bus travel time.

The four functional components of a TSP system and their current applications in Durham are expanded upon below:

Vehicle Detection

Vehicle detection can occur via an onboard unit or the AVL system depending on the system architecture format. The AI equipment that the City of Durham is installing at 267 of their intersections provides TSP functionality. With this solution, onboard units would then communicate to the signal cabinets via a 900-MHz radio-based signal or a cellular connection, ensuring a backup to communication. The radio-based signal requires the vehicle to be relatively close to the signal, which limits its ability to give much advance notice to the signal controller to consider implementing transit signal priority. The cellular communication does not utilize the City's network but rather goes from onboard the vehicle to the cloud, to the signal controller. The cellular communication allows the buses to notify the signal controller well in advance of its impending arrival, giving the controller more time to adjust signal timings accordingly. Additionally, it can communicate to multiple controllers at the same time.

Priority Request Generator/Server

The CAD/AVL contract will include TSP integration and there are many advantages to this. It provides for lateness conditionality and opens an expanded set of technological possibilities for the PRG/PRS system and data collection. It is recommended that the City of Durham integrate the on-board systems, to enable the AVI units to send data regarding schedule, door open/closed, and automated passenger counters to the PRG. This will enable effective PRG management and conditional TSP. The traffic signal controllers will function as the PRS.

Priority Control Strategies

There are two priority strategies for implementing TSP – passive and active. Passive priority strategy simply involves favoring roads with significant transit use in the signal timings and/or using the average bus speed in coordinate signal timings rather than average vehicle speed. Active priority strategy involves detecting a transit vehicle and then considering whether it should be given priority. Within active priority, there can be TSP and conditional TSP (which considers variables such as number of passengers onboard, schedule adherence, etc.). Conditional TSP offers many benefits but is not always available depending on the traffic signal software capabilities and TSP hardware functionalities.

TSP System Management

The City of Durham currently uses Econolite Centracs for their central software and ASC/3-LX (version 32.64.30, configuration L3200) for controller firmware. The controllers are 2070LX and the cabinets are 332's. A hybrid solution would integrate a cabinet-based priority/preemption hardware unit with the 2070LX controllers to enable pulsed output from the TSP hardware to the traffic signal controllers for priority calls. This would enable provision of PRS in the traffic signal cabinet.

5. TSP Procurement & Implementation

Careful planning and procurement are key to a successful implementation of TSP. Listed below are factors to consider when looking at a TSP Procurement Implementation.

Signal Retiming/Analysis – The Durham Signal System intersections operate 2070LX controllers with ASC/3 software, which feature a TSP module that allows for early green and green extension TSP functionality. The TSP parameters can be coded directly into the controller via the module, but will require field technician time. Coordination and training with the vendor (Econolite) on proper use of the module will be essential. Because the City of Durham has recently contracted a team to perform corridor retiming following the Signal System Upgrade, the City and GoDurham should ensure that any signal timing upgrades for a potential TSP corridor occur well before or after the TSP pilot implementation. This will guarantee that any results produced from the TSP are directly attributable to the TSP functionality and not by outside influences.

Vendor Demonstrations – While not necessary, a vendor demo can help expand on the initial findings of this plan. Vendors are willing to offer demonstrations to prospective clients to provide real-world demonstrations of the technology. Demonstrations differ from pilots in that they are presentations in a controlled environment. They may take place at a test signal facility or at an isolated intersection during an off-peak time. Demonstrations are also good opportunities for the City and GoDurham staff to obtain a practical experience of the vendor's integration with the City's systems and assets. When narrowing a focus on vendors, the focus should be primarily on systems that are compatible with Durham's existing systems; while secondarily considering future integration with other Triangle systems.

TSP System Procurement – The City and GoDurham should decide on a single vendor for implementing TSP. This plan offers some insight into the available technologies offered on the market, but the City and GoDurham will need to jointly decide on the type of technology and vendor, while keeping in mind the systems and vendors that partner agencies in the Triangle are using.

The City and GoDurham should decide how they would like to proceed with implementing TSP from a contractual standpoint. They should weigh the costs of extending existing contracts in place (for example, with Applied Information or through Go-Triangle with ACT EMTRACS) versus the effort involved in releasing a TSP equipment RFP. Partner agency procurements should also be considered here as the Town of Cary and City of Raleigh have recently acquired TSP technology. Existing contracts with vendors may be leveraged to reduce the time required for procurement.

Pilot Implementation – It is recommended that the City and GoDurham start with a TSP pilot to test the functionality of the selected technology. The pilot should be implemented in such a way that allows for a proper evaluation. Traditionally, a pilot corridor would be carefully selected via analysis. Intersections that currently operate over capacity and have little to no slack time to allocate to a TSP movement will not benefit from TSP and therefore are not good candidates for a TSP pilot. The City and GoDurham have expressed interest in focusing the pilot to the Fayetteville Road and Holloway Street corridors from the *Better Bus Project,* therefore this Durham Transit Technology Plan assumes that the pilots will be implemented on those two key corridors. Section 6 provides more details for implementing a TSP pilot on these corridors.

Pilot Evaluation – The effectiveness of the TSP pilot should be evaluated following successful installation and implementation. It is important to note that any improvements in travel time, reductions in delay, queuing, etc., should be isolated to only the TSP integration. To obtain the most accurate results, no signal timing adjustment or geometric improvements that might influence congestion should be performed to the subject corridors during the TSP pilot evaluation period. If performed as expected, this data will be helpful to present to stakeholders to garner support for further expansion of the system.

6. TSP Pilot

As Durham considers implementation of TSP, a pilot program is recommended as an initial implementation. A TSP pilot would involve a full TSP implementation for a portion of Durham's signalized intersections and transit fleet. Implementing a pilot would allow Durham to evaluate the effectiveness of TSP in achieving established goals and integration of selected technologies while requiring a smaller initial capital investment.

As a result of the *Better Bus Study*, improvements are being made to the Fayetteville Street (GoDurham Route 5 from Lakewood Avenue to Riddle Road) and Holloway Street (GoDurham Route 3 from Roxboro to Highway 70) corridors to improve bus speeds and reliability. Given the existing attention on and improvement to these corridors, they were identified as good candidates for a TSP pilot program.

Some agencies have indicated that it can be difficult to guarantee that particular buses will be designated to particular routes. This leads to having to install onboard units on the entire fleet, even for a pilot program. GoDurham indicated that the ability to dedicate particular buses to particular routes could be more attainable during the current low service time due to COVID-19 impacts. As directed by the City, half of the transit fleet (approximately 29 buses) was assumed to be outfitted with onboard units for the pilot program for the Durham Transit Technology Plan analysis.

Each corridor was reviewed to determine which intersections within those study corridors will or will not have FMUs installed as part of the current AI hardware installation. Based on a high-level analysis of the Fayetteville Street corridor, it is anticipated that 13/13 intersections will already be outfitted with the AI FMUs. Therefore, no additional FMUs would be required for the Fayetteville Street corridor. For the Holloway corridor, 10/11 intersections are planned to have AI FMUs installed. Therefore, one additional FMU would be required and installed to have TSP functionality at the intersections along the Holloway Street corridor. Maps depicting the Fayetteville Street and Holloway Street study corridors and intersections with or without the AI FMUs are shown in Figure 5 and Figure 6, respectively.

It is important to note that while TSP can still provide travel time savings and improve efficiency even when not installed at all intersections along a corridor. If cost is a constraint, or if a particular intersection within a corridor is already operating over capacity, it may be more cost-effective to omit TSP implementation at that single intersection.

Figure 5: Fayetteville Road Corridor Pilot

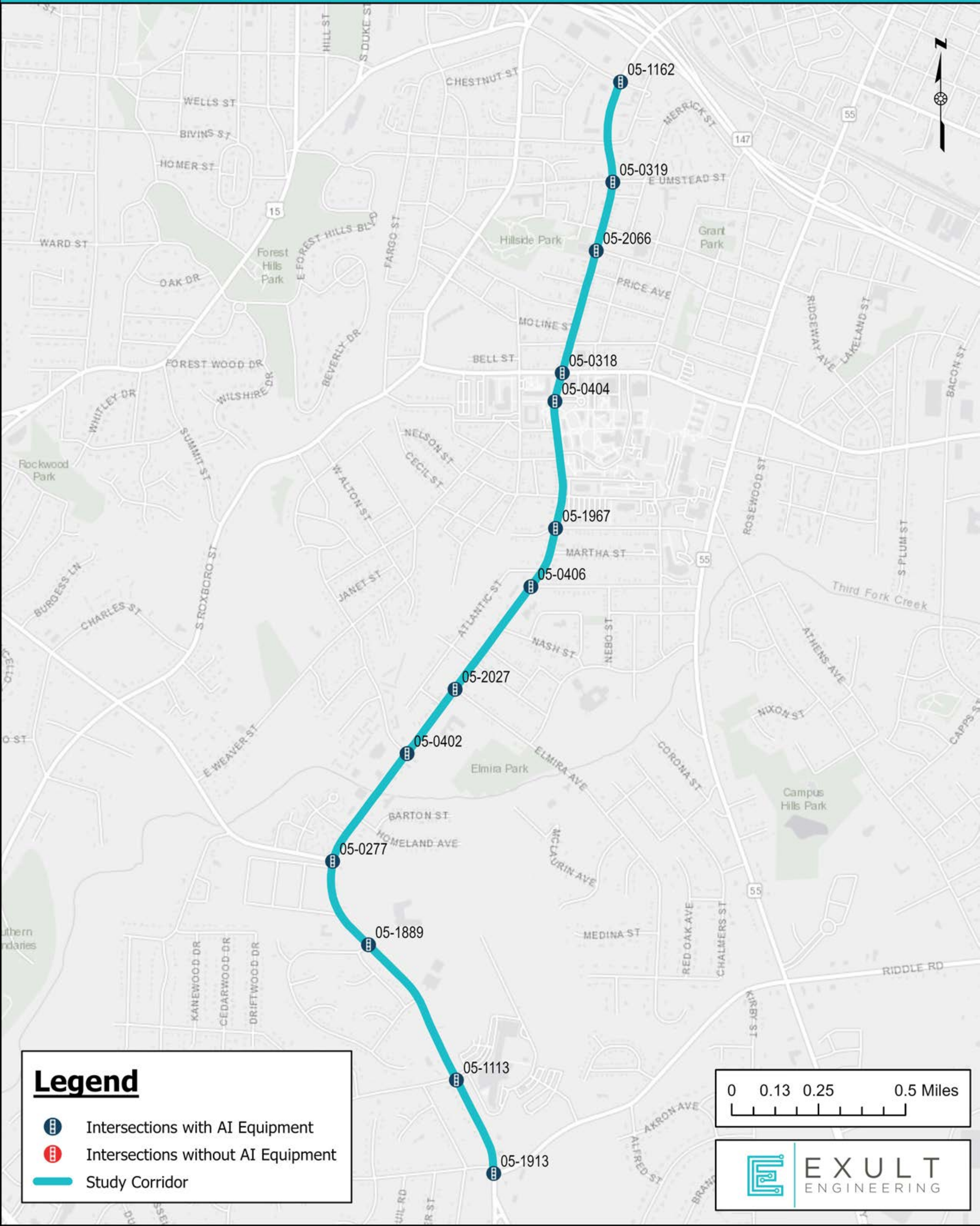
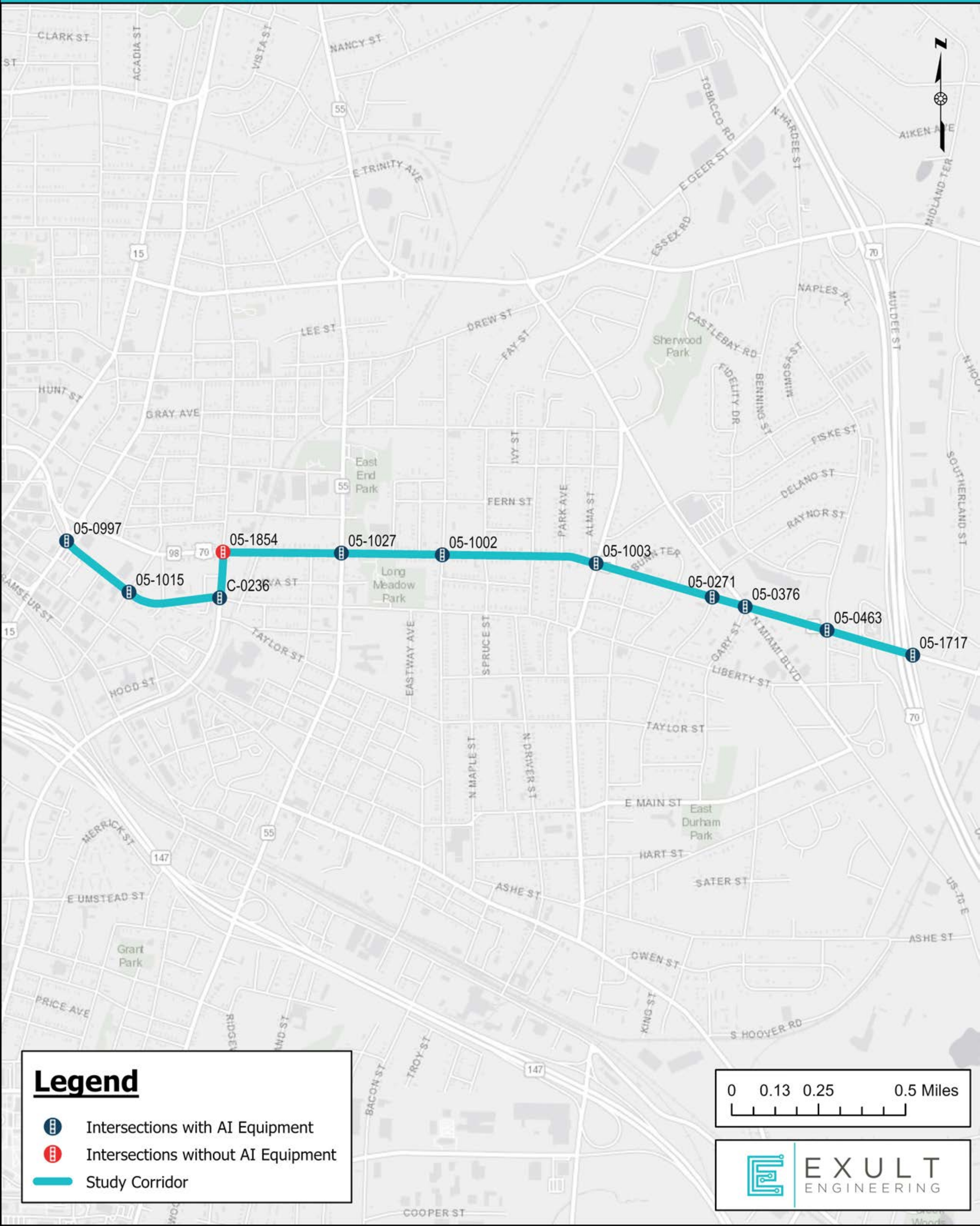


Figure 6: Holloway Street Corridor Pilot



7. TSP Pilot High-Level Cost Summary

A high-level cost summary for the Fayetteville Road and Holloway Street Corridor pilot was prepared for three different potential TSP solutions and is presented on the following pages in Table 2, Table 3, and Table 4. The cost summary includes hardware costs, software/operating costs, and design and integration costs.

Hardware costs include any hardware necessary for functionality. In the hybrid and distributed solutions, this includes hardware installed on the buses and at the intersection. For the centralized (cloud-based) system, no hardware is required.

Software/operating costs include any costs associated with software required or ongoing operating costs. For the AI solution, the software license is included in the first 5 years of operation. In a centralized system, software integration costs are substantial as they take the place of any hardware costs and they are harder to estimate accurately.

Design and integration costs were also captured. Successful TSP involves committed time and coordination between transit staff, the engineering staff, and the vendor personnel. Design and integration costs may also include modifying signal plans, updating the signal timing schedules for TSP, signal controller programming, vendor coordination, integrating with the CAD/AVL vendor, and signal technician training.

Following successful implementation, it is highly recommended that an evaluation study be performed. The study should analyze the effectiveness of TSP, which will require modeling and data gathering effort performed by staff. Public outreach should also be considered. Although TSP can be viewed as a benefit to buses and riders, some citizens may see it negatively once they understand that their green time is being allocated to a transit movement and communicating the results to the public may provide an understanding of the benefits of TSP.

Table 2. TSP Pilot Cost Estimate: AI Connected Vehicle System Hybrid Solution

HARDWARE COSTS			
Description	Units	Cost/Unit	Total Cost
Onboard Unit	29	$5,000	$145,000
Wayside Intersection Unit	1	$5,000	$5,000
HARDWARE COSTS SUBTOTAL			$150,000
SOFTWARE/OPERATING COSTS			
Description	Units	Cost/Unit	Total Cost
License/Cellular Fees (included first 5 years)	1	$0	$0
SOFTWARE/OPERATING COSTS SUBTOTAL			$0
DESIGN & INTEGRATION COSTS			
Description	Units	Cost/Unit	Total Cost
Planning	1	$25,000	$25,000
Signal Design Updates	24	$3,000	$72,000
Signal Timing Implementation	24	$4,000	$96,000
Signal Controller Programming	1	$31,500	$31,500
Vendor Project Management	1	$175,000	$175,000
1-Year Monitoring, Evaluation, & Analysis	1	$50,000	$50,000
DESIGN & INTEGRATION SUBTOTAL			$449,500
SUBTOTAL			$599,500
CONTINGENCY (25%)			$150,000
ESTIMATED TOTAL FOR PILOT			$749,500

Table 3. TSP Pilot Cost Estimate: ACT EMTRAC Distributed Solution

HARDWARE COSTS			
Description	Units	Cost/Unit	Total Cost
Vehicle Computer Unit Kit (Onboard)	29	$5,000	$145,000
Priority Detector Kit (Intersection)	24	$5,200	$124,800
Yard Interrogator (garage mounted, optional)	1	$14,500	$14,500
HARDWARE COSTS SUBTOTAL			$284,300
SOFTWARE/OPERATING COSTS			
Description	Units	Cost/Unit	Total Cost
Central Monitor/Systems Manager Software	1	$50,000	$50,000
SOFTWARE/OPERATING COSTS SUBTOTAL			$50,000
DESIGN & INTEGRATION COSTS			
Description	Units	Cost/Unit	Total Cost
Planning	1	$25,000	$25,000
Signal Design Updates	24	$3,000	$72,000
Signal Timing Implementation	24	$4,000	$96,000
Signal Controller Programming	1	$31,500	$31,500
CAD/AVL Integration/Vendor Project Mgmt	1	$175,000	$175,000
1-Year Monitoring, Evaluation, & Analysis	1	$50,000	$50,000
DESIGN & INTEGRATION SUBTOTAL			$449,500
SUBTOTAL			$783,800
CONTINGENCY (25%)			$196,000
ESTIMATED TOTAL FOR PILOT			$979,800

Table 4. TSP Pilot Cost Estimate: ACT EMTRAC Centralized (Cloud-Based) Solution

HARDWARE COSTS			
Description	Units	Cost/Unit	Total Cost
Onboard Unit	- -		-
Wayside Intersection Unit	-	-	-
HARDWARE COSTS SUBTOTAL			$0
SOFTWARE/OPERATING COSTS			
Description	Units	Cost/Unit	Total Cost
1-Year Cloud-Based Service Annual Fee	1	$75,000	$75,000
ATMS Interface Integration	1	$250,000	$250,000
C2C Cloud-Based Services (design, installation, configuration, testing, & deployment)	1	$450,000	$450,000
SOFTWARE/OPERATING COSTS SUBTOTAL			$775,000
DESIGN & INTEGRATION COSTS			
Description	Units	Cost/Unit	Total Cost
Planning	1	$25,000	$25,000
Signal Design Updates	24	$3,000	$72,000
Signal Timing Implementation	24	$4,000	$96,000
Signal Controller Programming	1	$31,500	$31,500
CAD/AVL Integration	1	$250,000	$250,000
1-Year Monitoring, Evaluation, & Analysis	1	$50,000	$50,000
DESIGN & INTEGRATION SUBTOTAL			$524,500
SUBTOTAL			$1,299,500
CONTINGENCY (25%)			$325,000
ESTIMATED TOTAL FOR PILOT			$1,624,500

The City of Durham should take into consideration the following factors when comparing the various TSP approaches outlined in the cost summary above:

Compatibility

- GoCary is in the process of installing the AI TSP. Cary traffic signals feature the same software as Durham (ASC/3).
- GoRaleigh is currently implementing a pilot of the ACT EMTRAC system for use with Bus Rapid Transit along New Bern Avenue.
- The City of Durham has already invested in AI hardware for other signalization uses within the City. The purchase of additional units for intersections may provide for more efficient utilization of those units for purposes outside of TSP.
- There are additional software integration challenges present with a cloud-based system versus a hardware-based.
- The Avail Technologies CAD/AVL integration with the various systems should be further explored.

Expandability

- For a transit system the size of GoDurham's, either TSP approach (distributed or centralized) is expected to work well.
- A hybrid or centralized system requires a larger upfront capital cost but is more cost effective to scale up for future expansion than the hardware-based distributed systems.
- The City and GoDurham's existing partnership with AI might allow for a more seamless acquisition of additional hardware.

Features/Capability

- All options have the potential for conditional active TSP, but this should be confirmed with the City of Durham's specific signal system software and firmware, as limitations may exist.
- Distributed and hybrid systems offer more reliability due to having years of proven implementations. Hardware-based systems in the past have been seen as more reliable but will require hardware-based maintenance and replacements over time.
- Cloud-based systems are adaptable and future upgrades can be pushed easier.

8. High-Level Schedule of Implementation

The table below provides a general schedule for implementing a TSP pilot. The schedule assumes a 1-year active evaluation period after successful install.

Table 5. TSP Pilot Schedule

Task	Timeline
Planning	3 months
Design & Implementation	6 - 9 months
Evaluation, Verification, and Validation	12 months

9. TSP Expansion

Following TSP Pilot implementation and evaluation, the City and GoDurham can look to expand the TSP functionality across the City. It is recommended that other key transit corridors be considered for TSP expansion. The City should use a methodological approach to determining which intersections and corridors are ideal for the next TSP integration. Shown below are some considerations for identifying ideal candidates for TSP implementation.

CHARACTERISTICS OF IDEAL TSP CANDIDATES

- ⇨ Existing signal operations suggest ample "slack" or leftover cycle time. This cycle time will need to be allocated to the bus and should be done without jeopardizing other vehicular traffic.
- ⇨ The transit route has frequent bus volumes (short headways) so that the TSP functionality provides a good cost-benefit ratio.
- ⇨ Low pedestrian volumes and good spacing between intersections so that TSP functionality is not impacted on a regular basis by other demands.
- ⇨ Poor level of services so that the TSP benefit is significant.
- ⇨ Technical capabilities for (or already having some TSP equipment installed) to provide cost savings to the City and GoDurham.

10. TSP Summary

TSP is an operational strategy that is continually improving with today's technologies. TSP systems can either be centralized, distributed, or hybrid and the type of system will determine the hardware or software requirements. This chapter highlighted some of the aspects and frameworks of TSP, where the City of Durham's signal and transit system stands for readiness of TSP, what partner agencies are doing in the realm of TSP, practical approaches for implementing TSP, and a high-level cost summary for implementing a TSP pilot. The estimated cost for deploying a pilot on both the Fayetteville Road and Holloway Street corridors would be expected to be approximately $750,000 – $1,625,000, depending on the type of system chosen.

11. TSP Recommendations

It is recommended that the City of Durham proceed with implementing TSP pilots along either the Fayetteville Street Corridor, Holloway Street corridor, or both. The pilot will provide the City and GoDurham insight into the practicality and usefulness of TSP.

It is recommended that the City of Durham integrate the on-board systems, to enable the AVI units to send data regarding schedule, door open/closed, and automated passenger counters to the PRG. This will enable effective PRG management. The traffic signal controllers will function as the PRS.