

CENTRAL CONNECTICUT RAIL STUDY



TASK #9: BUS RAPID TRANSIT ALTERNATIVE



CONNECTICUT DEPARTMENT OF TRANSPORTATION
STATE PROJECT NUMBER: 171-366

JULY 2015

Table of Contents

Introduction.....	2
BRT Elements.....	7
Running Ways.....	8
Stations.....	10
Vehicles.....	12
Fare Collection.....	12
Intelligent Transportation Systems	13
Service and Operating Plans	14
Branding.....	14
BRT Options for the Central Connecticut Rail Corridor.....	15
Option 1.....	16
Option 1A.....	21
Option 1B.....	22
Option 1C	24
Option 2.....	27
Alternatives Evaluation.....	28
CTfastrak	29
Planned CTfastrak Improvements	29
Conclusion	32

Introduction

This report presents a review of the elements of Bus Rapid Transit (BRT) that could be applied to existing and future transit service in the Central Connecticut rail corridor, a distance of approximately 24 miles between Berlin and Waterbury, Connecticut. The term Bus Rapid Transit can be interpreted in many ways depending on the source. As a starting point, a basic definition of Bus Rapid Transit (BRT) established by the U.S. DOT Federal Transit Administration is provided herein to clarify how it is being applied in the context of this report. Following this, the report presents several alternatives that would establish Bus Rapid Transit service within the corridor. The primary assumption is that any BRT alternative would be an extension of CTDOT's new BRT line, CTfastrak, which currently operates between New Britain and Hartford. The alternatives consider extension of CTfastrak from New Britain to Waterbury by various alignments. This analysis is one component of a more comprehensive alternatives analysis that is presented in the Central Connecticut Rail Study (CCRS) - a feasibility study of public transportation alternatives in the rail corridor between Waterbury and Berlin, Connecticut. The full study considers multiple modes of transportation – including light rail, commuter rail, bus rapid transit and freight rail improvements.

Definition of Bus Rapid Transit (BRT)

Bus Rapid Transit (BRT) has been defined by the Federal Transit Administration (FTA) per Section 5302 Chapter 53 of title 49, United States Code, as amended by MAP-21 as:

“a bus system in which the majority of each line operates in a separated, dedicated, right-of-way for transit during peak periods and includes features that emulate the services provided by rail transit including – defined stations, traffic signal priority; short headways for a substantial part of weekdays and weekend days; and any other features [...] necessary to produce high-quality transit services that emulate the services provided by rail transit”

This definition means that a BRT system may include a mixture of both exclusive guideway and non-dedicated guideway with traffic signal priority, so long as the exclusive guideway (during peak periods) constitutes a “majority of the line” and so long as the other features emulating rail transit are present. All BRT systems meeting this definition are classified as fixed-guideway.

In a report titled “Characteristics of Bus Rapid Transit for Decision-Making” by the FTA in 2009, a BRT system is defined as having the following seven major elements: running ways, stations, vehicles, fare collection, intelligent transportation services (ITS), service and operating plans, and branding elements. For the purpose of this report, when a system that is being evaluated has at least one but not all of the seven major elements of BRT that improve bus service, it is considered BRT Light. BRT Light is also called BRT “Lite”, Better Bus, or Enhanced Bus service and is often the baseline alternative required in BRT alternative assessments for FTA funding.

BRT Alternatives in the Central CT Rail Corridor

Three BRT alternatives have been identified for evaluation as part of this study. They were developed based on the following assumptions:

1. One BRT option would be to establish a running way as an exclusive bi-directional busway within the existing Pan Am Southern rail right-of-way.
2. All other BRT options considered would operate outside of the Pan Am Southern rail right-of-way and would need to operate within the existing roadway network; no new roadway or lane construction outside of the rail right-of-way would occur.

Exclusive BRT Running Way along Pam Am Southern Railroad Right-of-way

The first BRT alternative was evaluated early in the study and included a review of constructing exclusive bus lanes from Berlin to Waterbury within the Pan Am Southern right-of-way, a distance of approximately 24.3 miles. This alternative assumed two exclusive lanes would be constructed the entire length of the corridor. BRT stations would be located at Waterbury, Plymouth, Bristol, Plainville, New Britain and Berlin, with connections to CTfastrak at New Britain station (Figure 1), and commuter rail connections at Waterbury and Berlin.

Figure 1: CTfastrak New Britain Station



The initial cost estimates were based on the actual cost per mile of the Hartford-New Britain segment of CTfastrak. Total estimated costs exceeded \$1.5 billion due to the following:

- 1) Much of the rail right-of-way structures could not accommodate new BRT lanes, thereby requiring construction of more than 20 miles of new structures to provide for bi-directional bus service.
- 2) A new BRT running way in both directions would require property acquisition and new roadway construction over a 24 mile distance.
- 3) New stations would need to be built at three locations and expansion of existing BRT/rail stations would need to occur at the remaining three locations, including pedestrian walkways and bridges.
- 4) The cost to provide railroad protection to Pan Am Southern would be considerable given the close proximity of this BRT alternative alignment to an operating railroad.

Discussion with Pan Am Railroad determined that a BRT option within the rail right-of-way would require considerable negotiation. A Pan Am representative indicated they did not support construction of a Bus Rapid Transit line within their railroad right-of-way. As a result of this

and the other factors listed above, this alternative was determined to be the most challenging of the BRT options considered.

BRT Alternatives Outside of the Rail Right-of-way

Two (2) alternatives were identified that do not use the freight rail right-of-way, but instead follow one of two routes, described below and depicted on included maps. These options do not involve any construction, expansion, or reconfiguration of the existing roadway system. For both alternatives, it is assumed that buses would operate along existing general purpose lanes with no modifications to the roadway infrastructure. It may be possible though to reconfigure the existing general purpose lanes to add additional lanes or queue by-pass lanes (also known as queue jump lanes) using the existing right-of-way. Each alternative was reviewed for its BRT potential, its interactions and connectivity with the new CTfastrak routes, and its market viability. In addition, transit service improvements already implemented by CTDOT as part of the CTfastrak program for this corridor were reviewed to avoid redundancies.

The BRT Alternative routes outside of the Pan Am Southern rail right-of-way that were considered are as follows:

- Option 1: Route 72/372, Route 6, and Route 8 to Waterbury
 - Option 1A: Extend CTfastrak to Bristol.
 - Option 1B: Extend service along the CTfastrak route 923 and/or 102 to Plymouth.
 - Option 1C: Extend service along the CTfastrak route 923 and/or 102 to Thomaston with connections to CTTRANSIT Waterbury.
- Option 2: Interstate 84 (I-84) from New Britain to Waterbury with potential feeder service from adjoining towns to I-84

Figure 2 illustrates the various alignments considered in this report.

[illegible]

¹ Levinson, H., Zimmerman, S., Clinger, J., Gast, J., Rutherford, S., Bruhn, E. *TCRP report 90: Bus rapid transit, Volume 2: Implementation Guideline*. Transportation Research Board of the National Academies, Washington DC (2003).

³ Ridership data collected from May 2015 was compiled based on existing routes 923, 102, 542, 541, 543 and 502 for Option 1, and routes 925 and 928 for Option 2.

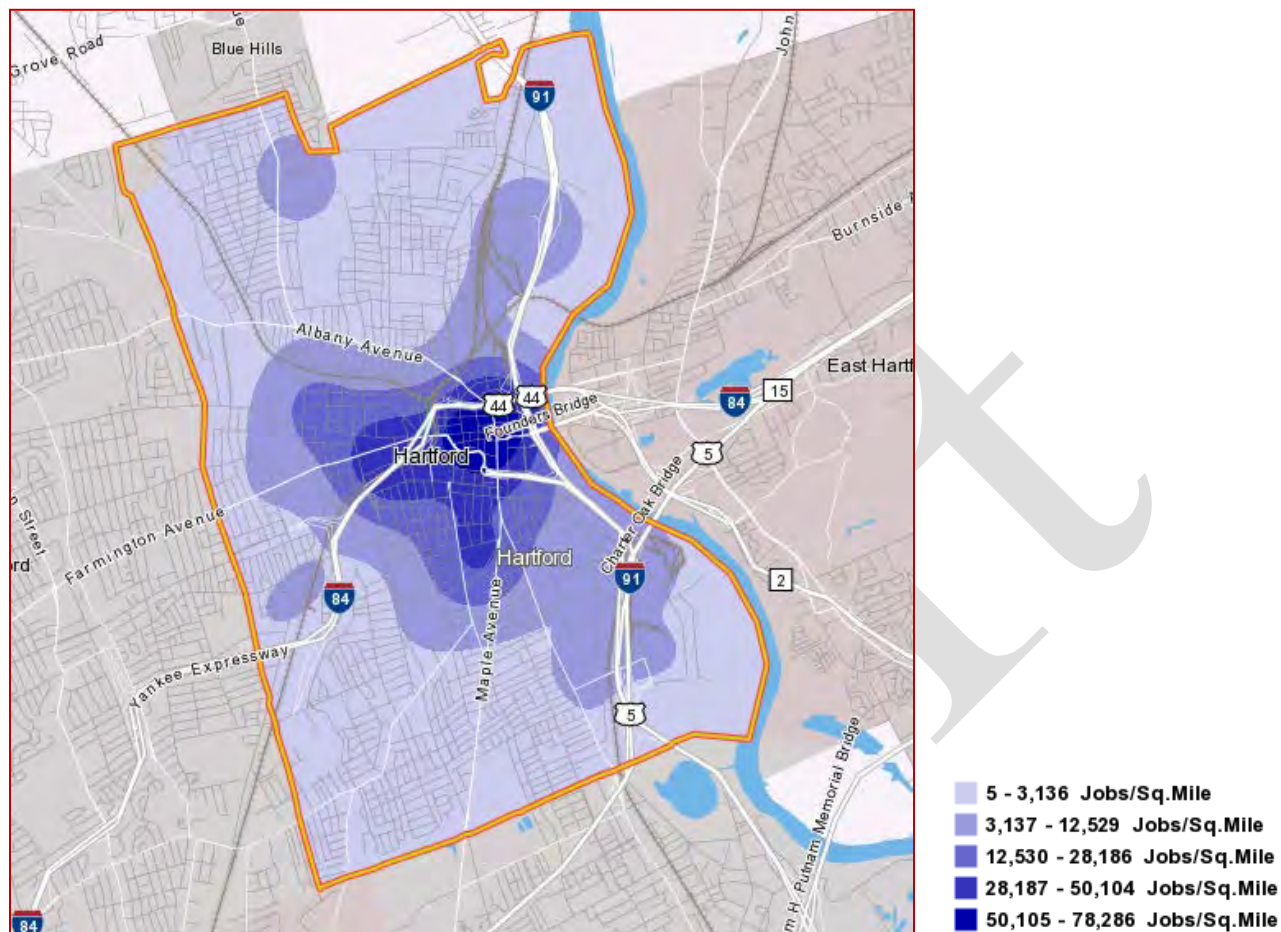


Figure 3: Hartford Employment Density

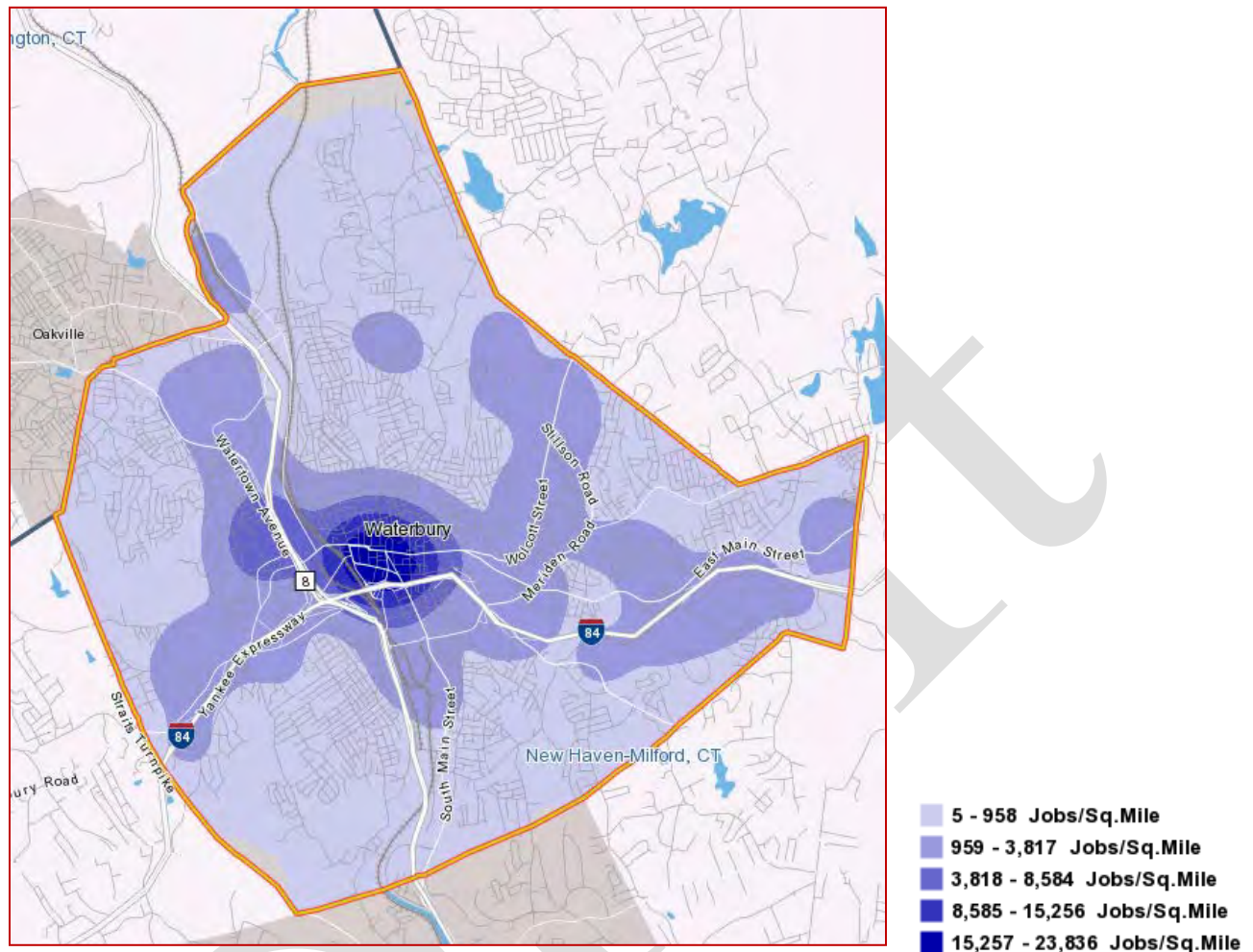


Figure 4: Waterbury Employment Density

BRT Elements

Bus Rapid Transit characteristics, practices and standards have been studied extensively in the U.S. and internationally. Examples include the U.S. DOT Federal Transit Administration (FTA), which established BRT guidelines in its document, *Characteristics of Bus Rapid Transit for Decision Makers*. In addition, the American Public Transportation Association (APTA), through its APTA Standards Development Program, provided guidance on the design of running ways, service, stations, ITS, and branding for BRT services. At the international level, the Institute for Transportation and Development Policy (ITDP) published the first Bus Rapid Transit Standards document. For this analysis, FTA guidelines are used as a tool to help evaluate the BRT options available for the Central Connecticut corridor, recognizing that every system and geographic area within the country is unique and that what matters ultimately is what service is provided and how successful it will be in attracting ridership.

Based on the FTA guidelines, and as previously mentioned, there are seven major elements that are necessary for service to be characterized as BRT, and 11 other non-physical attributes highly important in the development of a successful BRT system. The seven major elements are:

1. Running Ways
2. Stations
3. Vehicles
4. Fare collection
5. Intelligent Transportation Systems (ITS)
6. Service and Operations Plan
7. Branding Elements

In addition to these core elements, other common and highly important attributes of BRT include:

System Performance

1. Travel time savings
2. Reliability
3. Identity and image
4. Safety and security
5. Capacity
6. Accessibility

System Benefits

1. Ridership
2. Capital Cost Effectiveness
3. Operating Efficiency
4. Transit Supportive Land Development
5. Environmental Quality

A system that contains some BRT elements but not all seven major elements defined by the FTA is often called BRT Light (or BRT “Lite”, Better Bus Service, or Enhanced Bus).

A brief description of each of the major BRT elements is described below:

Running Ways

Running ways are where the BRT vehicle travels and, according to the FTA, are the most critical element in determining speed and reliability of a system. Running ways have three primary characteristics: type, marking and guidance.

Running way types can be on-street in mixed traffic or off-street using a dedicated right-of-way. The alignment of the running way is best located to minimize conflicts with other traffic, in order to minimize the risk of delay with turning conflicts, parking, taxis, and delivery vehicles. Many of the running ways require extensive roadway widths when the BRT treatment is not on an exclusive right-of-way. Dedicated lanes allow buses to move more quickly. On arterial roads, dedicated lanes can save 1-2 minutes of travel time per mile compared to pre-BRT. On dedicated roadways, such as that of CTfastrak it can save 2-3 minutes per mile. Typical BRT

operating speeds on an arterial road are 14 MPH⁴ and along dedicated lanes can be upwards of 50 MPH⁵.

Running way markings are treatments that indicate a BRT lane on the right-of-way just as tracks indicate where a train travels. Markings act as enforcement and can be in the form of signs, raised delineators, pavement markings, or pavement coloring/materials. Enforcement and/or segregation of the right-of-way are critical in order to differentiate BRT from other vehicle travel lanes. Examples of running way marking treatments are shown in Figure 5. Running way markings also include intersection treatments. Several intersection treatments can be used to advance BRT through an intersection and prevent conflicts from turning traffic. The most basic method is to forbid turning movements across the bus lane. This approach is the most effective at increasing vehicle speed through the intersection (Figure 6). Queue jump lanes can also be used. These lanes give the bus lane priority over other traffic at the intersection with a signal phase for the BRT vehicle preceding the general traffic lanes (Figure 7).



Figure 5: Examples of Running Way Marking Treatments

⁴ Darido, G., Cain, A. *Report on South American Bus Rapid Transit Field Visits: Tracking the Evolution of the TransMilenio Model*. National Bus Rapid Transit Institute, (2007).

⁵ APTA BRT Operations Working Group. *Operating a Bus Rapid Transit System*. American Public Transportation Association, Washington DC (2010).



Figure 6: Prohibited Left Turns

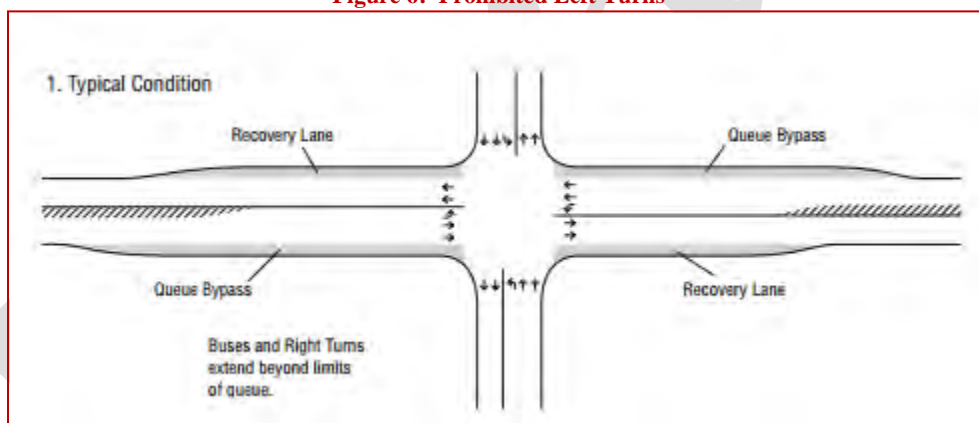


Figure 7: Queue Jump Lanes

Running way guidance can help control a vehicle's side to side movement along the running way. Vehicles must be equipped with automatic lateral guidance.

Stations

BRT stations help develop the brand (Figure 8) and are typically attractive and provide a safe and comfortable place to wait. They should have a sheltered waiting area, be well lit, clearly delineate which routes utilize which bays if multiple routes service it, be fully accessible, have passenger amenities, multimodal access, passing capabilities for routes which do not service the station, and have security through the use of cameras, guards, or other safety enhancing technologies. The station, along with the vehicle, should also allow for platform-level boarding (Figure 9). Platform-level boarding is where the station platform and bus floors are level. This reduces the time needed to board and disembark the vehicles and improve accessibility. By

reducing the platform gap, typically to less than two inches, safety is also increased. Multiple techniques such as alignment markers, guided docking, and Kassel curbs (a beveled curb) can be used to reduce the gap. It is important, however, to ensure that it is possible to board the vehicle without the presence of a platform. Routes often leave the BRT corridor and must be able to service stops without a platform. Stations along arterial roads should be placed far side from intersections to minimize delay and conflicts.



Figure 8: HealthLine BRT Station (Cleveland, OH)



Figure 9: Level Platform Boarding

Vehicles

Vehicles servicing the stations should be modern, attractive, and branded. At a minimum, 40' vehicles should be used, but often the demand warrants 60' articulated buses, which offer increased passenger capacity. High quality BRT vehicles often have wider doors which improve boarding and alighting speeds and passenger circulation. Some BRT vehicles offer boardings from both sides of the bus, such as vehicles used on the Cleveland HealthLine. BRT vehicles also have aesthetic enhancements such as larger windows, enhanced lighting and seating which are inviting and improve the passenger experience. The recent trend is to operate environmentally-friendly vehicles such as hybrids, electric, ultra-low sulfur, CNG, and others as part of an overall marketing and branding effort. Locally, the design for CTfastrak meets many of the marks of high quality vehicle design. The articulated low floor buses are the flagship vehicle of the CTfastrak fleet and have three doors to speed up boarding and alighting. These hybrid diesel-electric vehicles have super low emissions and use less fuel than a traditional diesel city bus.



Figure 10: CTfastrak Vehicle

Fare Collection

Fare collection includes the collection process, payment options, media types and fare structure. Off-board fare collection is the preferred methodology as it reduces the dwell time of vehicles at a station so passengers are able to load faster and use all vehicle doors. This increases the speed along the corridor and improves the passenger experience. There are two ways to conduct off-board fare collection: turnstiles and proof-of-payment (Figure 11). With turnstiles, passengers pass through a gate where their fare is verified upon entering the system. With proof-of-payment systems, passengers pay at a kiosk prior to boarding and carry the ticket on-board where they may be asked by an inspector to show proof of payment. Turnstiles minimize fare evasion, reduce personnel needs for inspectors, provide a better method for collecting passenger data, and can be easier to implement at stations with multiple routes; however, this system can be more expensive to implement initially and requires routine maintenance.



Figure 11: Off-Board Fare Collection Systems

Electronic fare collection (EFC) is the preferred method for BRT fare collection. EFC includes Magnetic Stripe Cards and Smart Cards and the benefits include faster boarding, ease of zonal based fares, multiple applications, minimal cash transfers, exact fare collection, and ease of use by passengers. However, EFC systems can be expensive and timely to implement correctly.

Intelligent Transportation Systems

Intelligent transportation systems (ITS) elements can improve the transit system's performance through using advanced communication technologies. ITS can include Transit Signal Priority (TSP), automatic vehicle location (AVL) for dispatch and operational controls, computer aided dispatch, automated scheduling, automatic passenger counters (APC) if proof-of-payment fare collection is used, collision warning, precision docking, vehicle monitoring systems, real time information at the stations to inform passengers of vehicle arrival times, and in-vehicle automatic announcement of stops.

Signal control for transit vehicles is a highly effective treatment to speed up buses. There are two types of TSP, signal preemption and signal priority. Signal preemption (ending a red light early to switch to green) is not an option in Connecticut for transit vehicles. Numerous local approvals would be needed for preemption, which involves a complex process that has traditionally been reserved for emergency vehicle operations only. However, signal priority would be feasible for the corridors under consideration. Signal priority would extend a green light to allow a vehicle to pass through and may use actuation to switch the red light to green only if it is within a defined set of signal-cycle design parameters. Figure 12 provides an example of a typical TSP set up at intersections.

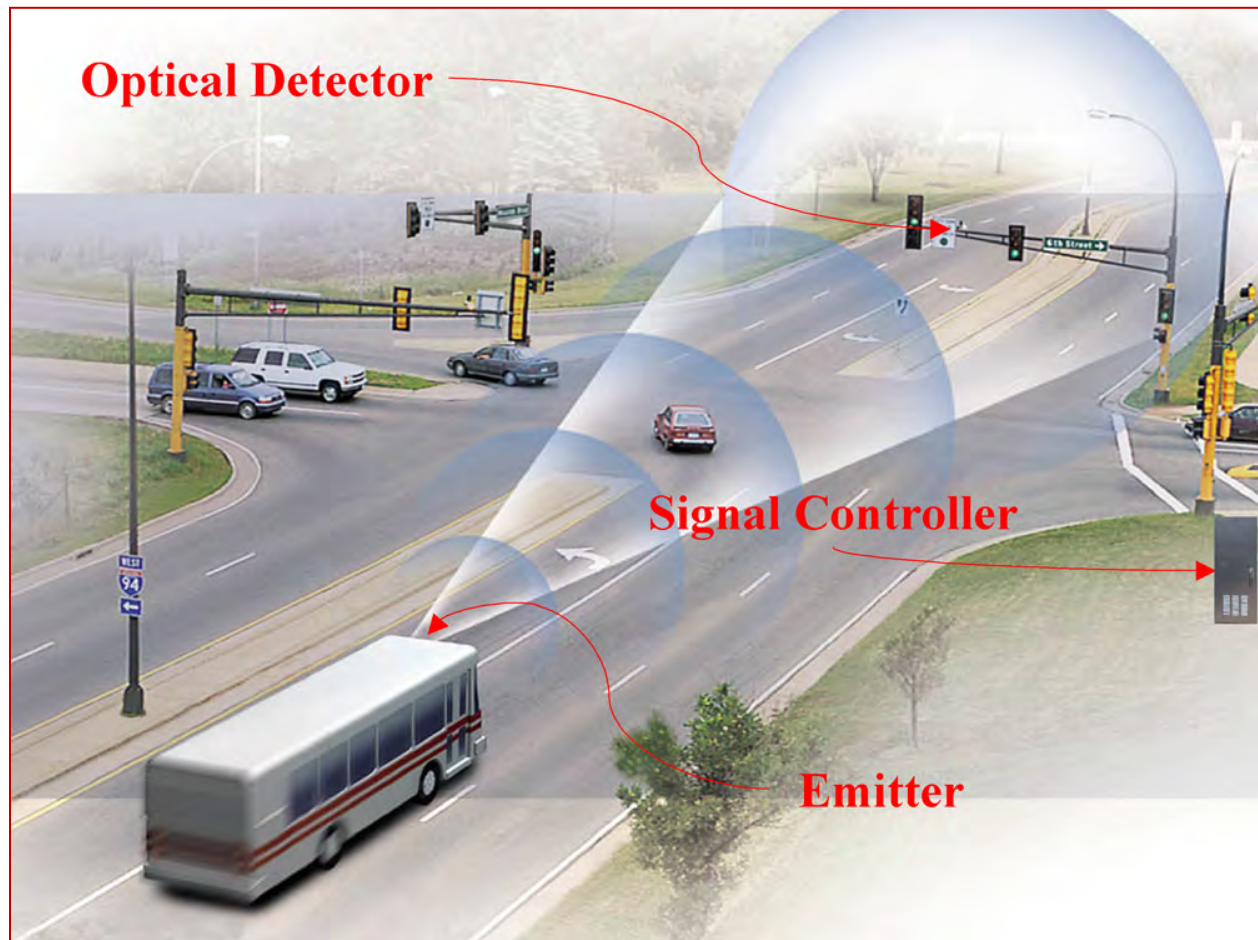


Figure 12: Transit Signal Priority

Service and Operating Plans

BRT systems are typically characterized as having a high level-of-service due to the high volume passenger loads. Service should operate seven days a week for at least 18 hours a day. Headways during the peak hours are typically 8-10 minutes and 12-15 minutes during the off-peak. The corridor also often has multiple routes servicing it, with a variety of route types such as express, feeders, connecting routes, and all-stop routes.

As outlined earlier, optimizing stationing, introducing new vehicle design, intelligent transportation systems (ITS), and a high frequency and reliable service, paired with distinct marketing can be applied to the Options under consideration and would advance the service overall.

Branding

Marketing often involves branding the corridor to clearly differentiate the service as BRT. BRT is often delineated from the rest of services and uses a unique naming/numbering system, separate colors or logos and its own fleet of vehicles. A good branding program will have promotional materials, such as brochures, provide concise information and can easily be

transported to events and displayed at information tables. To meet the needs of residents in the service area, materials should be printed in additional languages as needed.



Figure 13: Marketing the CTfastrak bus

BRT Options for the Central Connecticut Rail Corridor

Three alignment options to connect New Britain to Waterbury via a BRT system were discussed for the corridor. One option was presented in which BRT would be used within the rail right-of-way. After discussion with stakeholders, it was determined this option was not the right-sized solution for the corridor and would not be further evaluated in the analysis.

The two remaining options for the corridor both could have elements of BRT, but do not allow for a dedicated right-of-way, one of the seven BRT elements defined by the FTA. A system that does not meet all seven elements is categorized as BRT Light or Better Bus. Without a dedicated right-of-way, the proposed options for the corridor fall into this category. BRT Light/Better Bus services are enhanced bus services with some elements of BRT which will improve the travel speed along the corridor and passenger experience. Table 1 provides information on the differences between full BRT service and BRT Light service.

For both alignment options it may be possible to institute off-board fare collection and level platform boarding at all stations, two of the seven major BRT elements. Additionally, these routes could be branded as a unique service or incorporated into part of the CTfastrak branding. Attractive, safe stations could be developed with real-time information as well as the use of attractive vehicles with automatic announcements, AVL, and APCs.

Table 1 Differences between High-End BRT and BRT Lite⁶

	High-End BRT/Full Service	BRT “Lite”/Moderate-Service
Running Ways	Exclusive Transit-ways; Dedicated Bus Lanes; Some grade separation	Mixed Traffic
Stations/Stops	Enhance Shelters to large temperature---controlled transit centers	Stops, sometimes with shelter, seating, lighting, and passenger information
Service Design	Frequent services; integrated local and express services; timed transfers	More traditional service designs
Fare Collection	Off-vehicle collection; smart cards; multi-door loading	More traditional fare media
Technology	Automated Vehicle Location (AVL); passenger information systems; traffic signal preferences; vehicle docking/guidance systems	More limited technological applications

Option 1

Option 1 would depart the CTfastrak New Britain Station and head west on Route (RT) 72 West and merge with I-84. The service would then depart I-84/RT 72 at exit 33 in Plainville to continue on RT 72 to Bristol, then west on RT 6 and finally south on RT 8 to Waterbury where the service would serve both the train station and Waterbury Green. Please note the following:

- **Dedicated Right-of-way:** BRT roadway elements are limited on this corridor beyond the CTfastrak New Britain Station. Given the current lane configuration and merging of RT 72 and I-84, a bus-only or high-occupancy vehicle (HOV) lane on RT 72/I-84 is not desirable as it would place the lane in the center of traffic.
- **Other BRT elements:** There is the possibility for Transit Signal Priority (TSP) along RT 6 and portions of RT 72. Many of the signals currently in Bristol and Plymouth have the emitters and necessary equipment for this technology. However, synchronizing equipment would need to be installed onboard the vehicles. It is unknown whether the equipment and emitters in the various towns are cross compatible, so it is unknown if more than one set of equipment would need to be installed per vehicle. Queue jumps may be possible at up to 12 locations (Figure 14 and Table 2). These locations were selected based on the ability to reconfiguration lanes within in the existing right-of-way. Figure 15 shows examples of intersections and where a queue jump might go. A full

⁶ Cervero, R. (2013). Bus Rapid Transit (BRT): *An Efficient and Competitive Mode of Public Transport*. Retrieved from University of California, Institute of Urban and Regional Development Web site: <http://iurd.berkeley.edu/wp/2013-01.pdf>

traffic analysis would need to be conducted to determine the impact on traffic and if the queue jump should be installed at each signal.

Draft

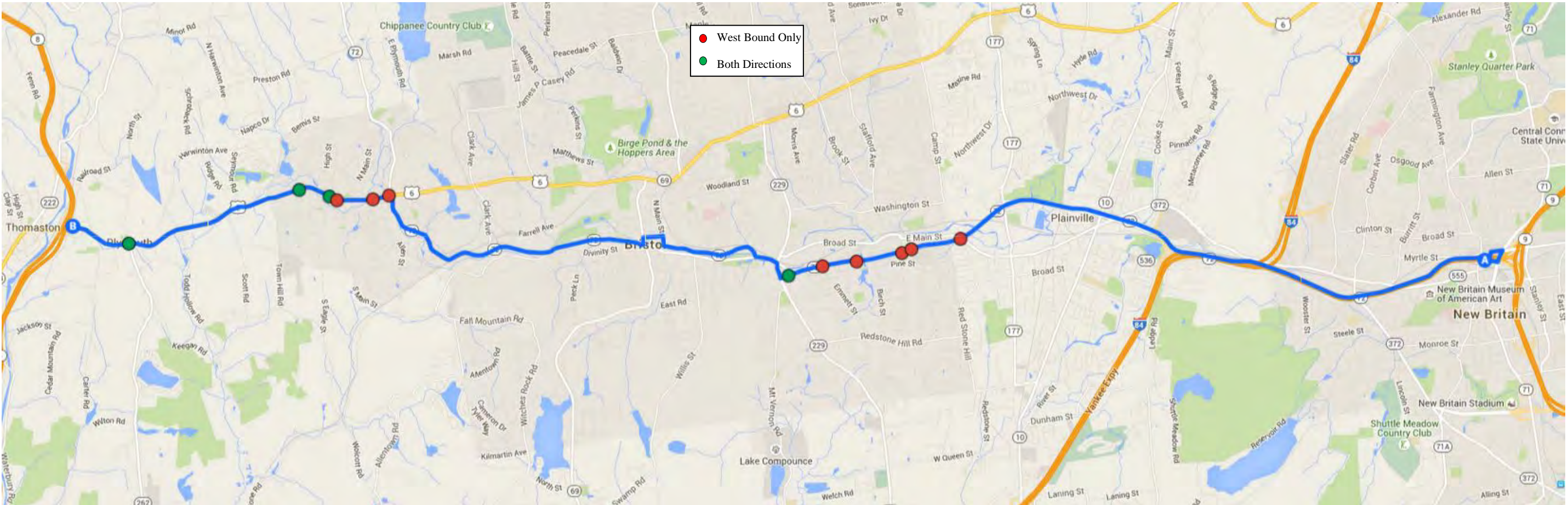


Figure 14: Map of Possible Queue Jump Locations

Table 2: Possible Queue Jump Locations

Intersection	Direction	Roadway Modification
372/72	WB and EB	Eliminate LT or shared LT and Through or shared with RT
Lincoln Ave/72	WB and EB	Eliminate LT or shared LT and Through or shared with RT
Central St/72	WB and EB	Eliminate LT or shared LT and Through or shared with RT
Pine St/72	WB and EB	Eliminate LT or shared LT and Through or shared with RT
Emmett St/72	WB and EB	Eliminate LT or shared LT and Through or shared with RT
Mitchell St/72	WB	Replace/use bus stop area
Main St/72	WB and EB	Eliminate LT or shared LT and Through; EB shared with RT
Allen St/6	WB and EB	Eliminate LT or shared LT and Through; EB shared with RT
Wood CT/S. Main St/6	WB and EB	Eliminate LT or shared LT and Through; EB shared with RT
Prospect St/6	WB	Eliminate EB parking
Elm St/6	WB	Eliminate LT or shared LT and Through
262/6	WB	Replace parking lane/use bus stop area

Key: LT (Left Turn Lane); RT (Right Turn Lane); WB (Westbound); EB (Eastbound)

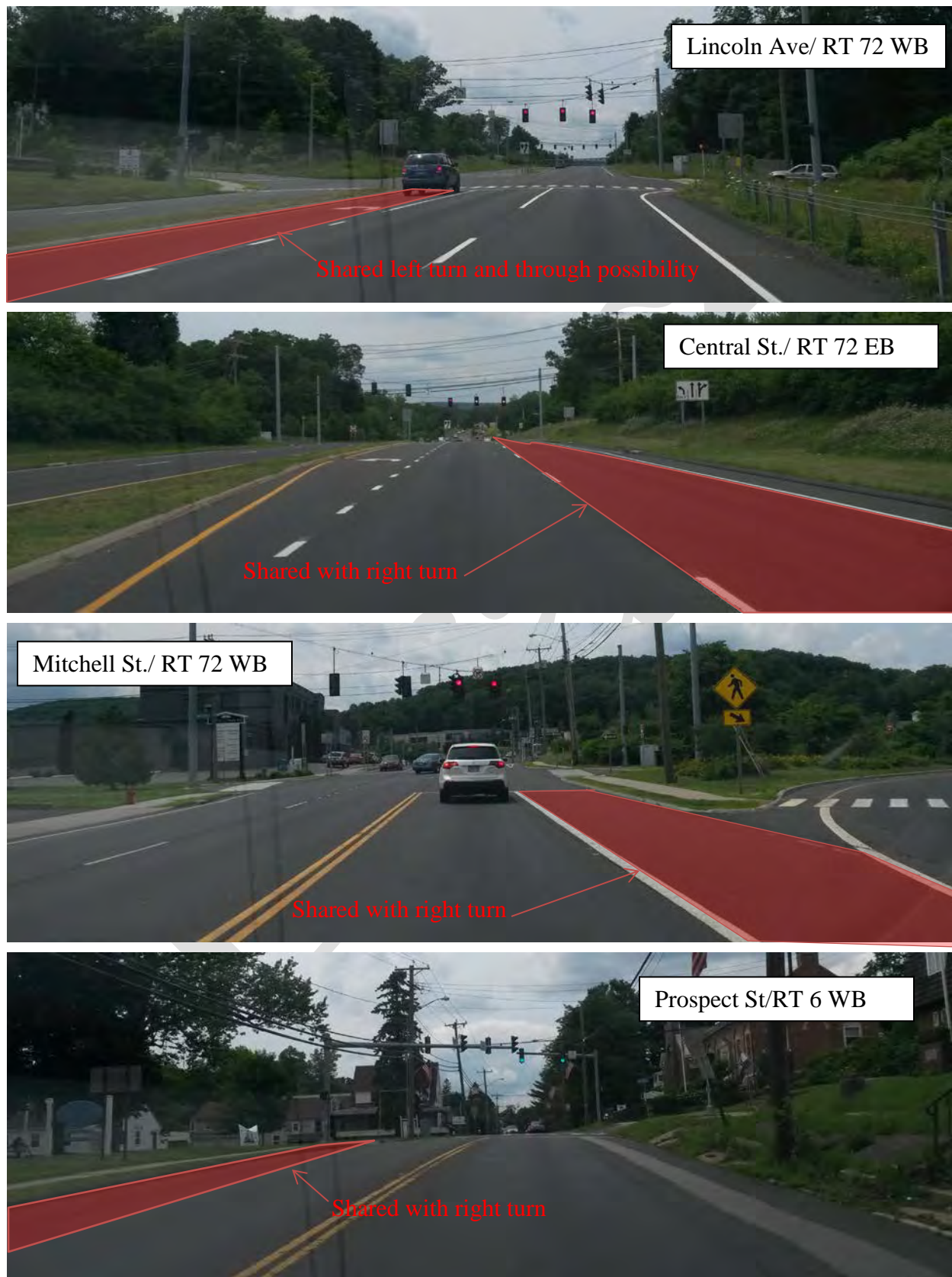


Figure 15: Example Possible Queue Jump Locations

The last segment of the service is RT 8, and it was determined that it would be feasible but inefficient to repurpose lanes for HOV or bus-only uses due to the limited number of existing lanes (two in each direction). Additional infrastructure would be needed to add a new lane, but this is outside of the constraints of the CCRS. Anecdotal evidence based on observations and average daily traffic (ADT) count data from the Connecticut Department of Transportation (CTDOT) leads the Study Team to believe that this road is not heavily used or at capacity, and therefore the bus would be able to operate in mixed traffic with minimal delays.

Possible Alternatives to Option 1 could be to:

- 1A. Extend the CTfastrak fixed guideway to Bristol;
- 1B. Extend either route 502, 923, or 102 to Terryville; or
- 1C. Implement express service between Waterbury and Thomaston with a connecting express bus between Thomaston and New Britain by extending either route 502, 923, or 102.

Option 1A

Option 1A would require that existing infrastructure be altered to create a dedicated right-of-way between Bristol and New Britain, to be considered BRT. One possible alignment would be that of Route 502 (Figure 16), which follows Black Rock Ave to RT 372 to East Main Street to RT 72. A full BRT alignment would require reconfiguring existing roadways and infrastructure that would connect Bristol to CTfastrak. These roads are narrow and appear to be near capacity, so general purpose travel lanes could not be repurposed without substantial impacts on traffic. Rebuilding the roadways to accommodate BRT would be costly, require property acquisition, have potential environmental impacts and be time consuming. BRT Light could be implemented as an alternative between Bristol and New Britain with Transit Signal Priority. Transit signal priority would extend a green light allowing the vehicle to pass through but would not truncate a red light early to green.

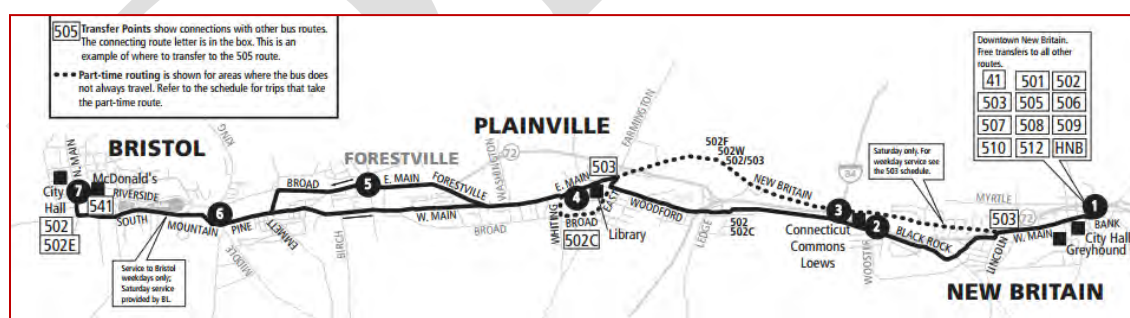


Figure 16: Route 502

In downtown Bristol there is potential for a station in the vicinity of the Renaissance Downtowns revitalization project (Figure 17). This site would require the creation of a parking lot for a park-and-ride. There may be potential resistance against using the Renaissance Downtowns site; they may not be amenable to allowing the buses to access their property; it is not uncommon to hear concerns regarding vehicles potentially damaging pavement. CTTransit is currently working to secure a park-and-ride lot in downtown Bristol for existing routes.



Figure 17: Renaissance Downtowns Development Site

Option 1B

Option 1B would extend the CTfastrak route that connects Bristol to New Britain to Terryville. This would include the development of stations in Bristol and Plymouth. A logical service expansion could be to extend bus Route 102 or possibly the 923 express to Plymouth. This change would add service to Plymouth and may improve travel time along the corridor if TSP was applied. Implementing this option would increase the cycle time for whichever bus routes are chosen. To maintain the current headways, one additional vehicle may be needed.

There are two potential sites in Plymouth for a station. The first (Site 1, Figure 18) is in downtown Terryville, a business and residential district. There is very limited space and right-of-way would need to be obtained to install a bus pull out. There appears to be potential for

developing a park-and-ride lot in small, underutilized commercial lots or in the Immaculate Conception Church parking lot (approximately 20 spaces). The church lot would be the preferred park-and-ride location over multiple small underutilized lots.



Figure 18: Station Site 1, Plymouth

Site 2 (Figure 19) is in the vicinity of the Adams IGA shopping plaza. Servicing the plaza may pose difficulties because there is only one access and egress point when traveling east. Parking spaces would have to be removed to allow for the buses to maneuver, and the shopping center may not want vehicles parking at their facility all day, taking up valuable space allotted for customers. Additionally, the shopping center may not be amenable to allowing the buses to access their property; it is not uncommon to hear concerns regarding vehicles potentially damaging pavement. The right-of-way should be examined to determine if the roadway could accommodate bus pull outs on either side of RT 6 without infringing on private property.

Site 1 is the preferred station location, as there is a higher population density; the station could be serviced from the street as opposed to Site 2, which may require deviating into the shopping center or expanding the right-of-way; and there is potential for less conflicts from commercial developments who may see transit as a hindrance to their operations.

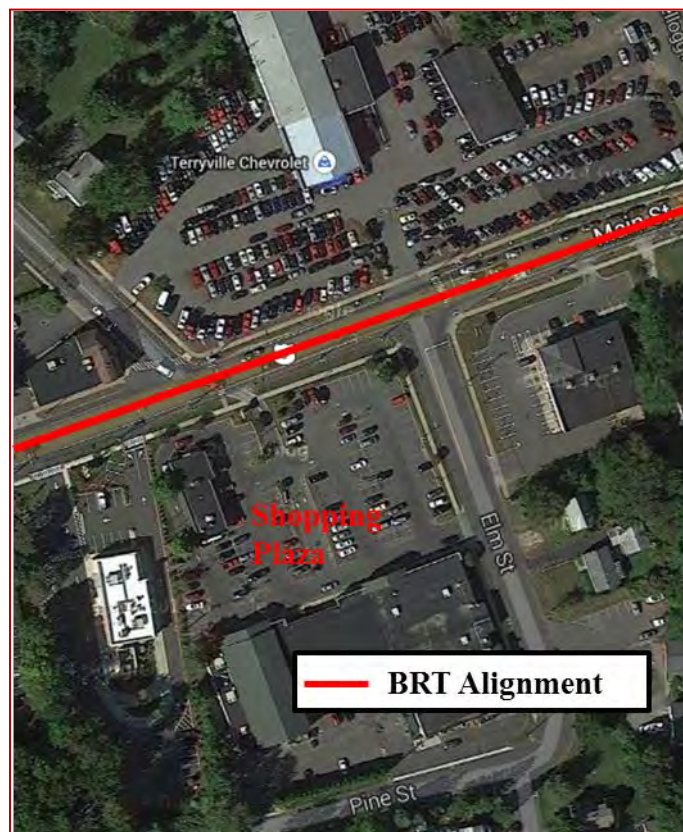


Figure 19: Station Site 2, Plymouth

Option 1C

Option 1C would require further surveying in order to determine the demand in Plymouth. If demand to Waterbury exists, it could be feasible to operate an express route to the Thomaston Park-and-ride with possible connections at the Park-and-ride if bus routes 502, 923 or 102 are extended to the parking facility. Option 1C would be dependent on findings from an origin/destination survey of Plymouth residents.

Option 1C would add service to Plymouth and Thomaston and provide connections from Bristol and westward to Waterbury and could improve the travel time along the corridor if TSP was applied. Implementing this option would greatly increase the cycle time for bus routes 502, 923 or 102, which could have ramifications on operations. To maintain the current headways, additional vehicles may be needed to extend an existing route and add a new route to the CTTransit Waterbury division. This option is only feasible if the Waterbury Division of CTTRANSIT implements service between Thomaston and Waterbury. An ongoing Comprehensive Operations Analysis (COA) is currently being conducted by a consultant to determine whether there is demand for service to Waterbury from Plymouth and Bristol. If demand exists, then travel times via transit would need to be modeled from Bristol and Plymouth to Waterbury via transferring in Thomaston at the park-and-ride or transferring at the New Britain CTfastrak station to express routes 925 or 928.

The first step would be analyzing origin/destination data for Plymouth/Bristol to determine if there is demand for service to Waterbury. This could be conducted through a survey of residents or by analyzing origin-destination information via GPS data. Upon analyzing the results and possibly conducting preference surveys, and if it is determined that there is demand to Waterbury from Plymouth, a set of routes will be developed with a connecting transfer at the Thomaston park-and-ride lot. The first route would be an extension of select trips from either bus routes 502, 923, or 102 to the park-and-ride lot. The second route would be an express bus from Waterbury via RT 8 to Thomaston where it would connect with the previously mentioned route. The second route should be coordinated with the results of the ongoing CTTRANSIT Waterbury COA effort.

The Thomaston park-and-ride lot is located adjacent to RT 8 at exit 39. It is a single bay with 40-50 parking spaces and only one access point. It is not possible to expand this lot due to steep grades and existing infrastructure. To service the lot with a bus, an additional access point along Pleasant Street must be created so that the bus could loop in and out. A few parking spaces would need to be removed to create an additional access point. At a site visit, the lot was at approximately 90% capacity and may not be able to support additional vehicles due to bus service. An exploration of alternative sites for a park-and-ride without requiring property acquisition shows that there is a lot of sufficient size at the intersection of Scott Road and Main Street that is owned by the state (Figure 21). This lot is approximately 1.8 miles east of the Thomaston lot and could contain up to 40 parking spaces. A property map for this lot can be seen in Figure 22.



Figure 20: Thomaston Station Site

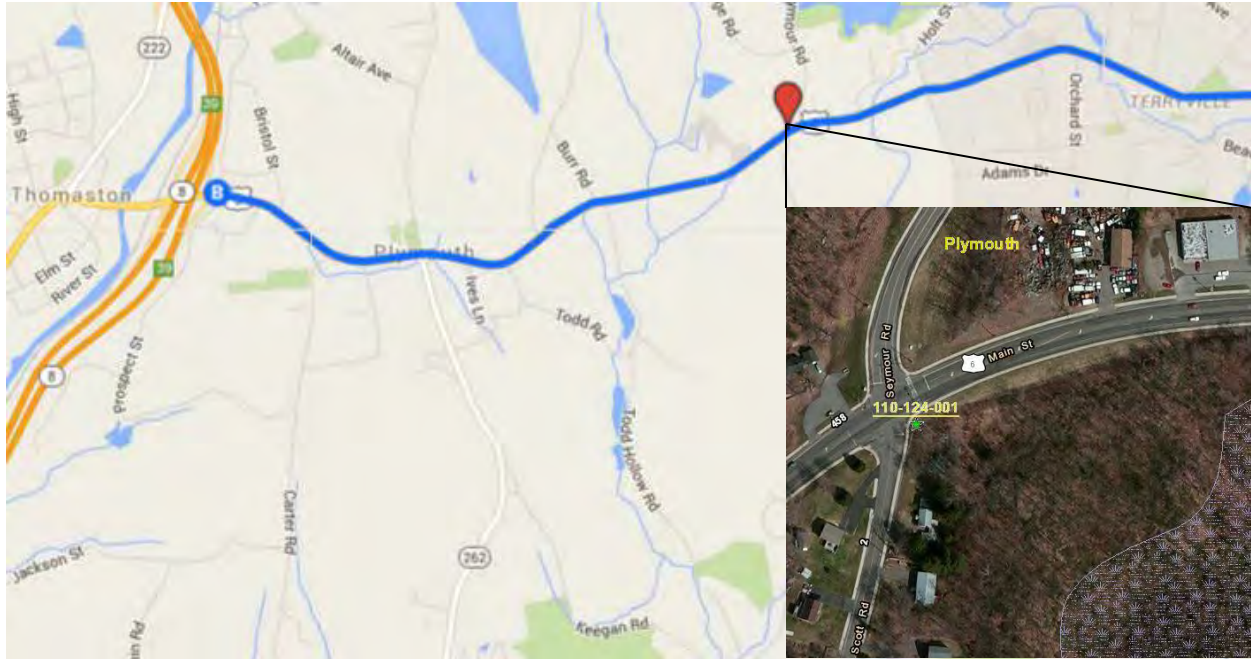


Figure 21: Potential Station Location

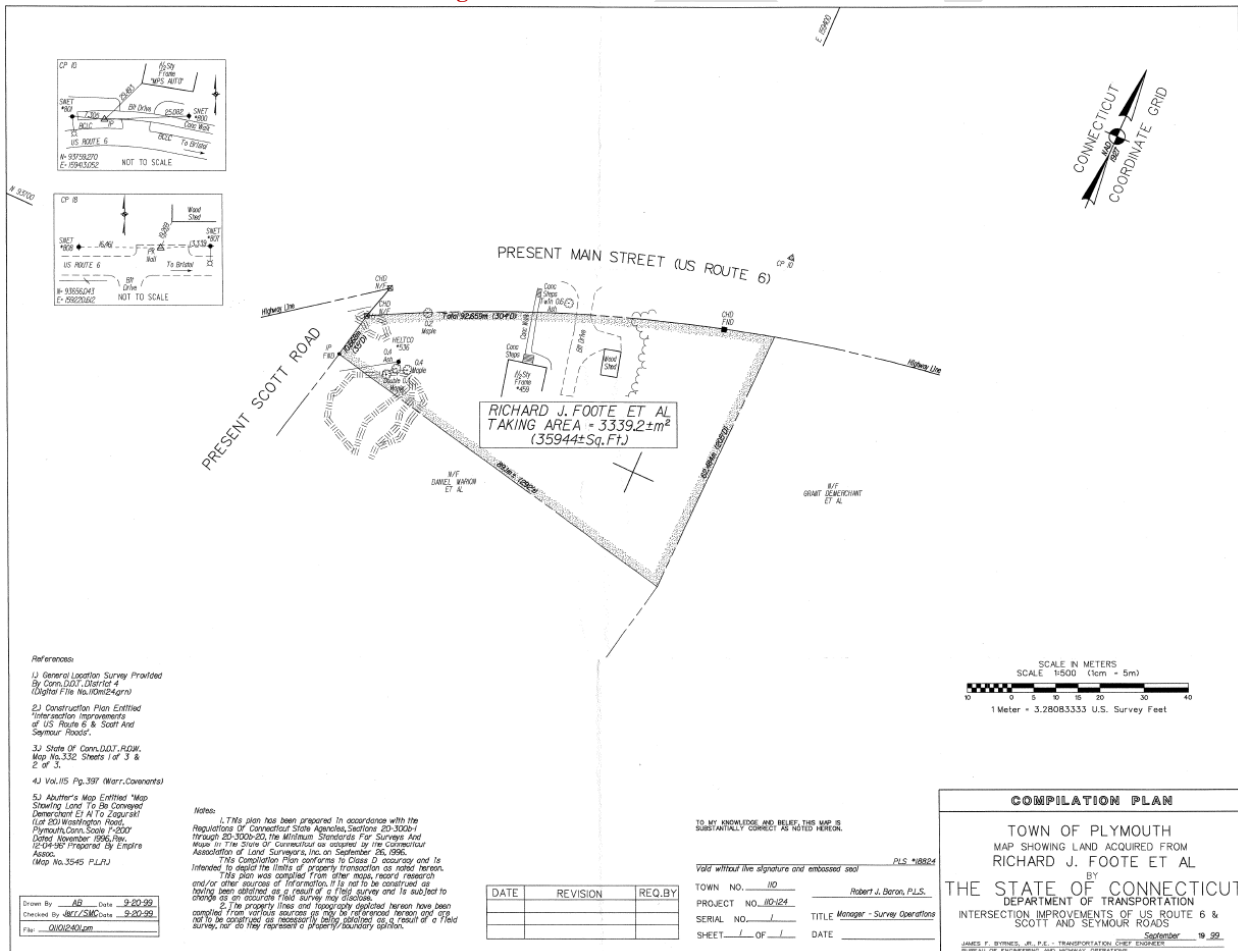


Figure 22: Property Map of Site 110-124-001

Option 1C is contingent upon many factors. The result of the CTTRANSIT Waterbury Comprehensive Operation Analysis (COA) must show that there is demand along the RT 8 corridor from Thomaston to Waterbury to justify establishing an express route between the two. A study must be done to determine if there is demand to Waterbury from Plymouth and/or Bristol. If demand exists, travel times would need to be calculated, and transferring in Thomaston instead of New Britain would have to provide a shorter trip. Lastly, the park-and-ride in Thomaston would either need to be reconfigured to provide easy access and egress, or a new facility would need to be constructed.

Option 2

Option 2 would follow RT 72 and I-84 from New Britain to Waterbury with no intermediate stops in between. Due to heavy traffic volumes along I-84 and limited space, it would not be prudent to designate an existing general purpose lane as HOV or bus-only. This would most likely cause the level of service on I-84 to drop substantially. In Waterbury, the route would serve both the Green and the train station.

As part of the CTfastrak service plan, a new route was implemented during peak hours: Route 925 (see Figure 14) connecting Hartford to Waterbury along CTfastrak and I-84. Bus Route 925 is almost identical to the CCRS BRT Light Option 2 between New Britain and Waterbury. In addition to bus Route 925, Route 928 provides service during non-peak hours connecting CTfastrak to Waterbury along I-84 with stops in Southington and Cheshire. Bus Route 925 operates on 30-minute headways during the peak weekday hours only⁷, and it takes 64 minutes to travel between Main Street in Hartford and the Waterbury Green via CTfastrak and I-84 (Table 3). Bus Route 928 operates during off peak times and in the off peak direction during peak periods on a 60 minute headway. It operates weekdays from 4:15 AM to 2 AM, Saturdays 5 AM to 1 AM and Sundays 6:45 AM to 9:30 PM. It takes 70 minutes to travel between Main Street in Hartford and the Waterbury Green via CTfastrak and I-84; this is 6 minutes more than bus Route 925 as it services more locations. Based on the analysis of the proposed new routes with the implementation of CTfastrak, Option 2 would be redundant service and provide no additional benefit to the corridor without altering the roadway configuration along I-84 to accommodate dedicated or high-occupancy vehicle lanes.

Table 3: 925 Waterbury Express Schedule

925 WATERBURY EXPRESS													
WEEKDAY SERVICE (No Service Saturday or Sunday)													
Waterbury > Cheshire > New Britain > via CTfastrak > Hartford							Hartford > via CTfastrak > New Britain > Cheshire > Waterbury						
Timepoints	1	2	3	4	5	6	Timepoints	11	12	13	14	15	16
Route	Metro-North Waterbury Station on Meadow St	Waterbury Green on West Main St	St. Mary's Hospital on South Elm St	Waterbury Park & Ride on I-84 exit 26	New Britain Station on I-84 exit 26	CTfastrak Platform D	Hartford Capitol & Park Terrace	Hartford Capitol & Park Terrace	The Bulfinch	Downtown Hartford	Main & Albemarle Sq	St. Mary's Hospital on South Elm St	Metro-North Waterbury Station on Meadow St
925	5:52	5:58	6:01	6:06	6:16	6:28	7:46	7:49	7:52	7:55	7:59	8:09	8:12
925	6:12	6:18	6:21	6:26	6:36	6:48	7:06	7:09	7:12	7:15	7:19	7:29	7:32
925	6:33	6:39	6:42	6:47	6:57	7:09	7:27	7:30	7:33	7:37	7:40	7:50	7:53
925	6:55	7:01	7:04	7:09	7:19	7:31	7:49	7:52	7:55	7:59	8:03	8:13	8:16
925	7:25	7:31	7:34	7:39	7:49	7:61	7:79	7:82	7:85	7:89	7:93	8:03	8:06

⁷ This route will operate in the AM peak inbound to Hartford and PM peak heading outbound from Hartford. All other service between Waterbury and Hartford will be covered via the 928.

Alternatives Evaluation

Option 1, including three additional sub-options, and Option 2 were evaluated based on the seven major elements of BRT, suggested alignments, and the feasibility of obtaining the BRT elements aforementioned. The Running Ways, at the minimum, must have delineators or colorized pavement on the corridor to be scored “yes”. Stations must be set back from intersections, have passing lanes, level platform boarding, be spaced at least 0.5 miles apart, be lit, and have shelters. Vehicles must be environmentally friendly with the highest standards for low emissions, 2 wide doors or 3+ doors for boarding, and provide universal access. For fare collection, it must be possible for at least one non CTfastrak station to have off-board fare collection on the proposed corridor where the individual pays at a kiosk before entering the vehicle. For ITS elements, there would need to be real-time information available, vehicles would have automatic annunciation of stops, and dispatch and operational controls would have AVL. To have a high level of service, multiple routes must service part of the corridor with varying service types (local, express, limited, etc.), and have either late-night or weekend service. For branding, some of the buses, routes and stations in the corridor must follow a single unified brand regardless of the rest of the system.

Table 4: Alternative Matrix Scoring

BRT Element	Option 1	Option 1A	Option 1B	Option 1C	Option 2
Running ways	No – New infrastructure not feasible within existing lane configuration	Yes	No – extends existing routes on current ROW	No - extends existing routes on current ROW	No - new dedicated ROW would impede existing traffic flow
Stations	Yes	Yes	Yes	Yes	Yes
Vehicles	Yes	Yes	Yes	Yes	Yes
Fare Collection	Yes	Yes	Yes	Yes	Yes
Intelligent Transportation Systems (ITS)	Yes	Yes	Yes	Yes	Yes
Service and Operating Plan	No - express only, no variety of route types	Yes	No -express only, no variety of route types	No -express only, no variety of route types	No-express only, no variety of route types
Marketing	Yes	Yes	Yes	Yes	Yes

Summarizing above qualitative assessment, the preferred alternative for BRT Light to evaluate further as part of the CCRS alternative assessment is Option 1B. Option 1B would serve the areas with the largest demand, provide Plymouth with service, follow the rail corridor, and require less infrastructure and capital equipment investments than the other options. Option 1 would provide overlapping service with existing routes between New Britain and Bristol. Option 1A would be costly to implement and require extensive roadway modification. Option 1C would provide connecting service in Thomaston but the market analysis shows there is very little

demand beyond Terryville. Option 2 would mimic existing CTfastrak routes and provide no new benefit.

CTfastrak

CTfastrak is a 9.5 mile dedicated transit guideway between Hartford and New Britain, CT that meets all of the criteria described above for Bus Rapid Transit (BRT). It is the first BRT system in Connecticut. CTfastrak opened for service on Saturday, March 28, 2015. As part of the evaluation of BRT routing options for the Central Connecticut Rail Study, this report reviewed planned routes to effectively extend CTfastrak and as many of its BRT elements as possible into the existing conventional transit service between New Britain, Bristol and Waterbury. The following is an overview of CTfastrak service plans.

Planned CTfastrak Improvements

As part of the CTfastrak service plan, three routes (502, 923, and 102) now connect Bristol to Hartford. Route 502 - Black Rock Ave provides local service between the New Britain Station and Bristol City Hall and is an existing route as part of the CTTRANSIT New Britain Division. Between the intersection of RT 72 and RT 372 and downtown Bristol, this route and Option 1 would follow the same path (Figure 23), a corridor approximately 3.5 miles in length. Bus Route 502 currently operates on a 60-minute headway during the peak and 90-minute headway in the off-peak. Service runs from 5 AM until 1 AM on weekdays. On the weekends, service is every 90 minutes between 6 AM and 1 AM on Saturdays and between 7 AM and 8:30 PM on Sundays. The one-way running time between Bristol and the New Britain Station is 38 minutes.

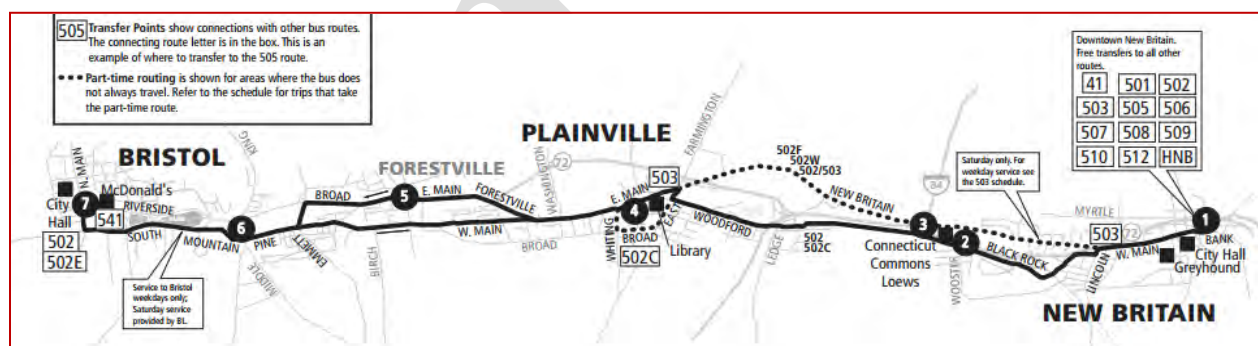


Figure 23: Route 502 CTfastrak

Route 923 is an express route from Hartford to Bristol via CTfastrak. Between New Britain and Bristol City Hall, Option 1 would follow the same path as bus Route 923 (Figure 24). Bus Route 923 only operates during the peak hours (5:55 AM to 8:57 AM and 3:30 PM to 7:01 PM, with one midday round trip) on a 20-minute headway (Table 5). The total travel time between downtown Bristol and Main Street in Hartford is 48 minutes. The travel time between downtown Bristol and the downtown New Britain CTfastrak station is 22 minutes. CTfastrak schedules can be found at www.cttransit.com.

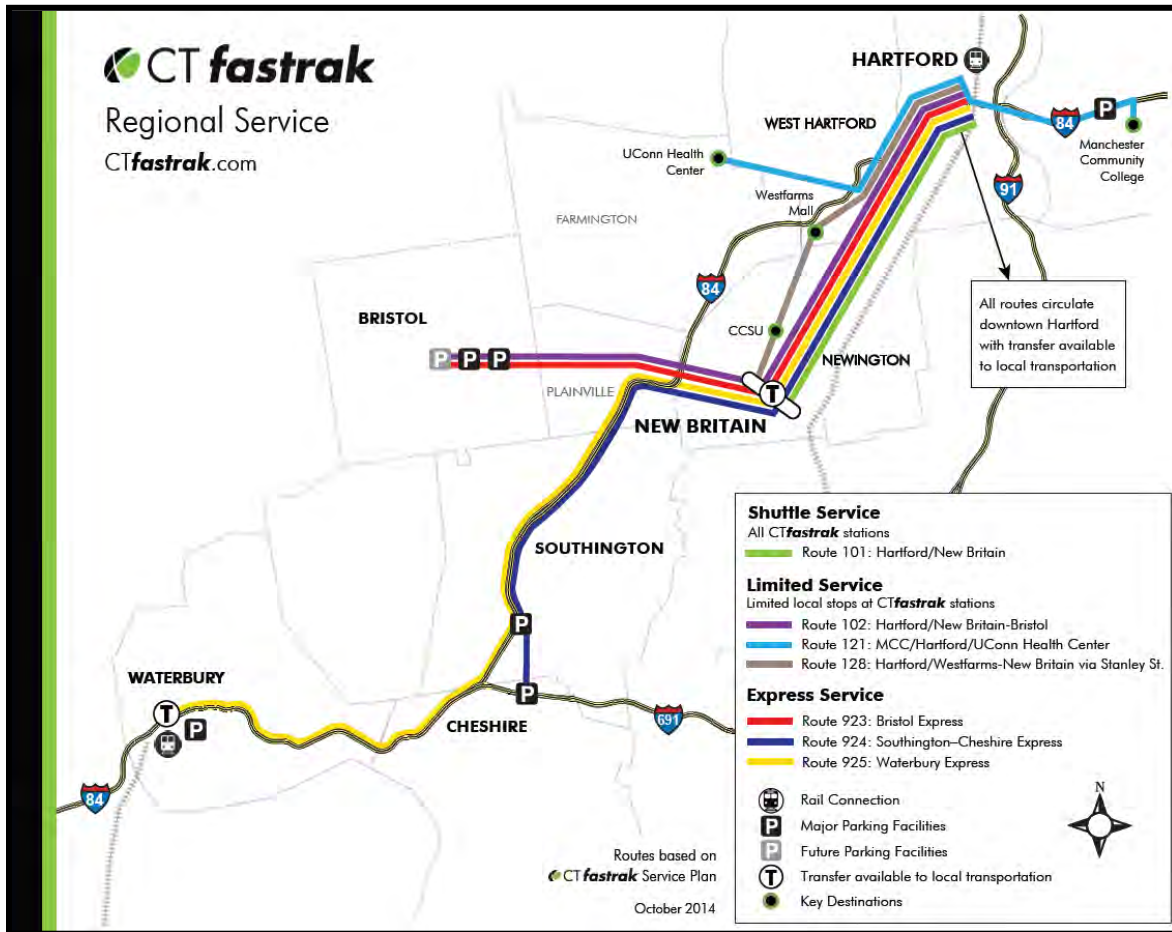


Figure 24: Proposed CTfastrak Regional Bus Routes

Table 5: 923 Bristol Express Schedule

923 BRISTOL EXPRESS												
Operates between downtown Bristol and Hartford, via CTfastrak												
WEEKDAY SERVICE (No Service Saturday or Sunday)												
Bristol > New Britain > Via CTfastrak > Hartford												
Timepoints	1	2	3	4	5	6	7	8	9	10	11	12
Route	Bristol City Hall N Main & Laurel	Bristol / Lake Ave Park & Ride- Rte. 229 & 72	Bristol / Todd St Park & Ride- Rte. 72	CTfastrak New Britain Station	CTfastrak Bay O or R	CTfastrak S1 Station	Farmington & Flower	Union Station	Aylam & Union	Thompson's Pearle Ave	Downtown Hartford Rising Ground	Hartford Capitol & Park Terrace
923	5:57	6:04	6:09	6:19	*6:33	*6:36	*6:39	*6:42	*6:45	*6:49	6:52	
923	8:37	8:34	8:38	8:39	*8:53	*8:56	*8:59	*9:02	*9:05	*9:09	9:12	
923	6:52	6:59	6:44	6:54	*7:08	*7:11	*7:14	*7:17	*7:20	*7:24	7:27	
923	6:52	6:59	7:04	7:14	*7:28	*7:31	*7:34	*7:37	*7:40	*7:44	7:47	
923	7:12	7:19	7:24	7:34	*7:48	*7:51	*7:54	*7:57	*8:00	*8:04	8:07	
923	7:32	7:39	7:44	7:54	*8:08	*8:11	*8:14	*8:17	*8:20	*8:24	8:27	
923	8:02	8:09	8:14	8:24	*8:38	*8:41	*8:44	*8:47	*8:50	*8:54	8:57	
Hartford > Via CTfastrak > New Britain > Bristol												
Timepoints	12	11	10	9	8	7	6	5	4	3	2	1
Route	Hartford Capitol & Park Terrace	The Bankwell Capitol & Washington	Downtown Hartford Rising Ground	XL Center Main & Abraham Sq	Union Station Aylam & High	Farmington & Johnson Ave	CTfastrak S1 Station	CTfastrak Bay O or R	New Britain Station	Bristol / Todd St Park & Ride- Rte. 72	Bristol / Lake Ave Park & Ride- Rte. 229 & 72	Bristol City Hall N Main & Laurel
923	12:12	12:15	12:20	12:22	12:24	12:26	12:31	12:45	12:54	12:58	1:04	
923	2:12	2:15	2:20	2:22	2:24	2:26	2:31	2:45	2:54	2:58	3:04	
923	2:37	2:40	2:45	2:47	2:49	2:51	2:56	3:10	3:19	3:23	3:29	
923	4:05	4:09	4:15	4:17	4:19	4:21	4:26	4:40	4:49	4:53	4:59	
923	4:25	4:29	4:35	4:37	4:39	4:41	4:46	5:00	5:09	5:13	5:19	
923	4:45	4:49	4:55	4:57	4:59	5:01	5:06	5:20	5:29	5:33	5:39	
923	5:07	5:10	5:15	5:17	5:19	5:21	5:26	5:40	5:49	5:53	5:59	
923	5:37	5:40	5:45	5:47	5:49	5:51	5:56	6:10	6:19	6:23	6:29	
923	6:07	6:10	6:15	6:17	6:19	6:21	6:26	6:40	6:49	6:53	6:59	

Route 102 operates from Hartford to Bristol, but unlike bus Route 923 it stops at all stations along CTfastrak (Figure 25). Outside of the peak periods, this bus Route 102 is coordinated with bus Route 502. It runs seven days a week from 4:55 AM to 1:15 AM Monday thru Friday; 5:15 AM to 1:15AM on Saturday; and 7:15 AM to 9:15 PM on Sunday (Table 6). The one-way running time between Bristol and Hartford is 63 minutes. This is 15 minutes longer than the 923

express bus. Service is every 30 minutes during weekday peak hours and every 60 minutes during the weekday off-peak period and on weekends.

With CTfastrak operational as of March 2015, there are several routes connecting New Britain to Bristol. Preliminary results from the CCRS market analysis show that Terryville, the portion of Plymouth on the border of Bristol, is the extent of the demand for service (Figure 26). Given the current demand and the changes made in connection with CTfastrak, Option 1 as it currently stands would replicate service between New Britain and Bristol and provide very few additional benefits to the region without changing infrastructure.

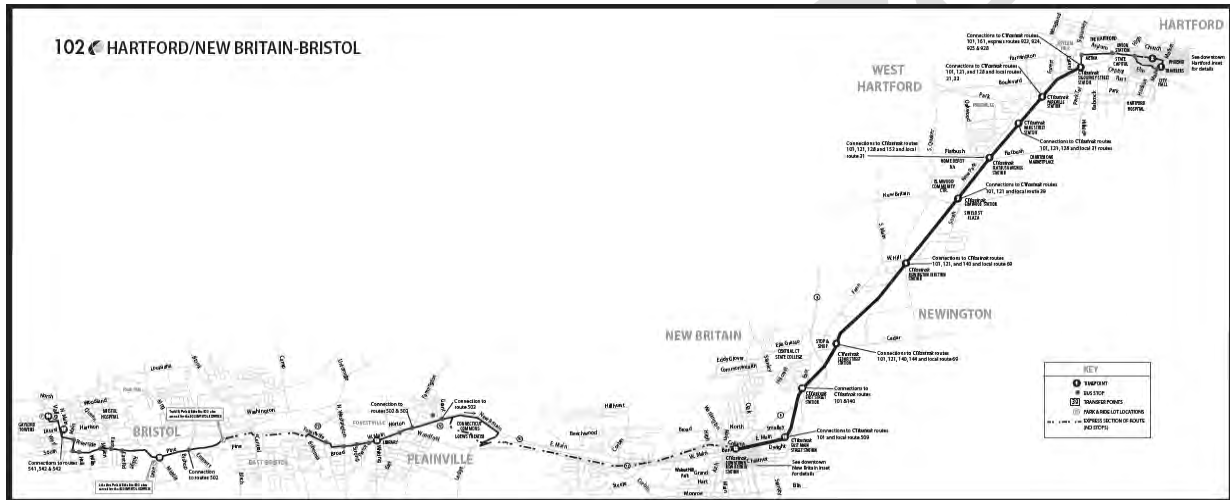


Figure 25: Route 102 Map

Table 6: 102 Hartford/New Britain-Bristol Schedule Example

102 CTfastrak HARTFORD/NEW BRITAIN/BRISTOL

Operates between downtown Hartford and Bristol, stopping at all CTfastrak stations

Bus Service Updated April 4, 2015

WEEKDAY SERVICE

Hartford ▶ via CTfastrak ▶ New Britain ▶ Bristol

Timepoints	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Route	Travelers Main & Atheneum Sq	Union Station Asylum St & High	Farmington & Asylum Pl	CTfastrak Sigourney Street Station Platform B	CTfastrak Parkville Station Platform B	CTfastrak Kane Street Station Platform B	CTfastrak Flatbush Avenue Station Platform B	CTfastrak Elmwood Station Platform B	CTfastrak Newington Junction Station Platform B	CTfastrak Cedar Street Station Platform B	CTfastrak East Street Station Platform B	CTfastrak East Main Street Station Platform B	CTfastrak Downtown New Britain New Britain Bay H	Plainville Library East Main St	Bristol Todd Street Park & Ride (Drop off only upon request)	Bristol Pine & Middle	Bristol Lake Avenue Park & Ride (Drop off only upon request)	Bristol City Hall North Main & Laurel	Continues to route
102	4:55	4:59	5:01	5:05	5:07	5:09	5:11	5:13	5:16	5:19	5:21	5:23	5:26	5:36		5:46		5:52	..
102	5:40	5:45	5:47	5:51	5:53	5:55	5:57	5:59	6:02	6:05	6:07	6:10	6:13	6:23		6:33		6:39	102
102	6:25	6:30	6:32	6:37	6:39	6:41	6:43	6:45	6:48	6:51	6:53	6:56	6:59	7:10		7:22		7:28	102
102	7:00	7:05	7:07	7:12	7:14	7:16	7:18	7:20	7:23	7:26	7:28	7:31	7:34	7:45		7:57		8:03	102
102	7:30	7:35	7:37	7:42	7:44	7:46	7:48	7:50	7:53	7:56	7:58	8:01	8:04	8:15		8:27		8:33	..
102	8:00	8:05	8:07	8:12	8:14	8:16	8:18	8:20	8:23	8:26	8:28	8:31	8:34	8:45		8:57		9:03	102
102	8:30	8:35	8:37	8:42	8:44	8:46	8:48	8:50	8:53	8:56	8:58	9:01	9:04	9:15		9:27		9:33	542
102	9:15	9:20	9:22	9:27	9:29	9:31	9:33	9:35	9:38	9:41	9:43	9:46	9:49	10:00		10:12		10:18	542
102	10:15	10:20	10:22	10:27	10:29	10:31	10:33	10:35	10:38	10:41	10:43	10:46	10:49	11:00		11:12		11:18	542
102	11:15	11:20	11:22	11:27	11:29	11:31	11:33	11:35	11:38	11:41	11:43	11:46	11:49	12:00		12:12		12:18	542
PM																			
102	12:15	12:20	12:22	12:27	12:29	12:31	12:33	12:35	12:38	12:41	12:43	12:46	12:49	1:00		1:12		1:18	542
102	1:15	1:20	1:22	1:27	1:29	1:31	1:33	1:35	1:38	1:41	1:43	1:46	1:49	2:00	R2:08	2:13	R2:15	2:21	542
102	2:15	2:20	2:22	2:27	2:29	2:31	2:33	2:35	2:38	2:41	2:43	2:46	2:49	3:00	R3:08	3:13	R3:15	3:21	102
102	2:55	3:00	3:02	3:07	3:09	3:11	3:13	3:15	3:18	3:21	3:23	3:26	3:29	3:40	R3:48	3:53	R3:55	4:01	102
102	3:25	3:30	3:32	3:37	3:39	3:41	3:43	3:45	3:48	3:51	3:53	3:56	3:59	4:10	R4:18	4:23	R4:25	4:31	102
102	4:05	4:10	4:12	4:17	4:19	4:21	4:23	4:25	4:28	4:31	4:33	4:36	4:39	4:50	R4:58	5:03	R5:05	5:11	102
102	4:35	4:41	4:43	4:48	4:50	4:52	4:54	4:56	4:59	5:02	5:04	5:07	5:10	5:21	R5:29	5:34	R5:36	5:42	102
102	5:05	5:11	5:13	5:18	5:20	5:22	5:24	5:26	5:29	5:32	5:34	5:37	5:40	5:51	R5:59	6:04	R6:06	6:12	102

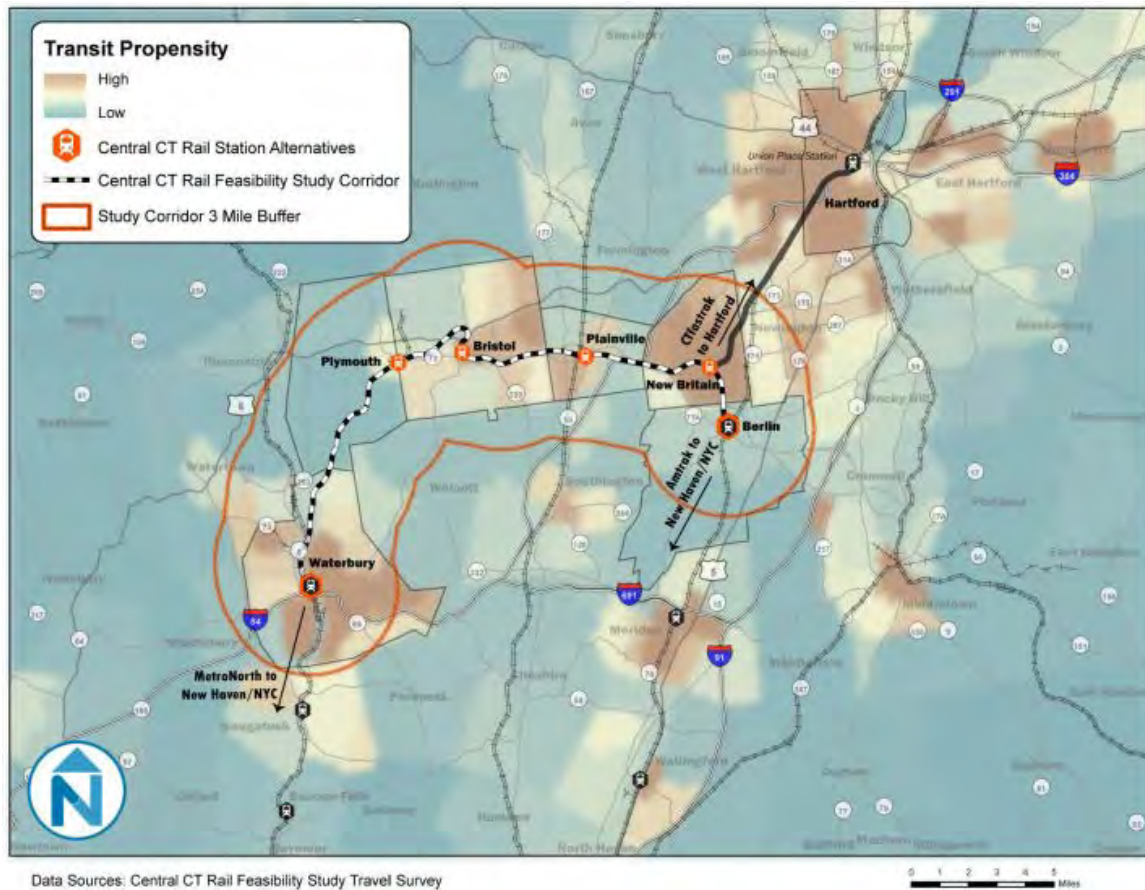


Figure 26: Transit Propensity and Demand Map

Conclusion

As a first step to improving public transportation in the Central Connecticut rail corridor, Bus Rapid Transit (BRT) presents itself as a viable alternative. Operating within the existing freight rail right-of-way, while technically feasible is not a preferred option due to the private ownership of the freight line and the high cost of constructing a dedicated bus right-of-way adjacent to or incorporated within an operating freight line. Given that a fully dedicated BRT running way along the railroad is not a practical transportation solution in this corridor, BRT options that utilize the existing roadway network were considered. It does not necessarily require construction, expansion or reconfiguration of the existing roadway network such as I-84 or RT 72 within the corridor. It can build upon already established BRT elements developed for CTfastrak, such as branding, ITS, stationing elements and service enhancements. This could be accomplished by extending CTfastrak services between Hartford, Waterbury and New Britain and Plainville, Bristol and Plymouth. The work performed for this report confirms and reinforces this as a positive step in the improvement of public transportation in the corridor between New Britain and Terryville where demand exists.

However, specific infrastructure improvements to introduce major infrastructure elements of BRT do not offer benefits that would justify the expense.

Option 1 as it currently stands would replicate CTfastrak service and provide very few additional benefits to the CCRS corridor without changing infrastructure. A bus-only or high-occupancy vehicle (HOV) lane on RT 72/I-84 is not desirable within the current lane configuration and merging of RT 72 and I-84, which would place the lane in the center of traffic. Signal priority would be effective and preferred over signal preemption.

Option 1A would require major infrastructure improvements to implement full BRT. These roads are narrow and appear to be near capacity and lanes could not be reassigned to bus transit without substantial impacts on traffic. Rebuilding the roadways to accommodate full BRT would require property acquisition, have potential environmental impacts and be time consuming. However, BRT Light with Transit Signal Priority would improve the travel time without major infrastructure cost. Use of the existing active rail right-of-way is not viable.

Option 1B would not improve travel time along the corridor but would add service to the eastern side of Plymouth where demand is moderate. Implementing this option would increase the cycle time for the 923 or 102, which could have ramifications on the greater CTfastrak operations. To maintain the current headways, one additional vehicle may be needed. TSP may help increase bus travel speeds, but not enough to operate without an additional vehicle.

Option 1C is only possible if the result of the CTTRANSIT Waterbury COA justifies establishing an express route between Waterbury and Thomaston: if there is demand to Waterbury from Plymouth and/or Bristol; if travel times are shorter than transferring in New Britain; and if a new park-and-ride in Thomaston is constructed. Implementing this option would increase the cycle time for bus routes 502, 923 and/or 102, which could have ramifications on the greater CTfastrak operations. To maintain the current headways, an additional one or two vehicles may be needed.

Option 2 would duplicate CTfastrak service along RT 72 and I-84 from New Britain to Waterbury. No new service other than that already included in the CTfastrak service plan is being proposed. Due to heavy traffic volumes along I-84 and limited space, it would not be prudent to designate an existing general-purpose lane as HOV or bus-only. Adding additional lanes would be costly.

The preferred alternative for BRT Light to evaluate further as part of the CCRS alternative assessment is Option 1B. Option 1B would serve the areas with the largest demand, provide Plymouth with service, follow the rail corridor, and require less infrastructure and capital equipment investments than the other options. The most logical way to introduce BRT is through a phased-in approach following the guidance from CTDOT on planned BRT service improvements. Introduction of the CTfastrak program, including the addition of CTfastrak elements (bus station elements, vehicles, fare collection and ITS) could be a positive step to improving transit connectivity, usage and overall ridership. This would build upon work already completed by CTDOT as part of the new CTfastrak system and would be a lower cost option compared to infrastructure investments required for other transit and rail alternatives considered for the corridor.