



Wake County Transit Plan Update

Schedule and Cost Feasibility of Major Capital Projects

February 7, 2020 – FINAL

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*****IMPORTANT NOTE*****

Appendix A is intended to document an essential step taken early in the process to update the Wake County Transit Plan that was used to inform later plan update development steps. The cost and schedule feasibility information for major capital projects represented in Appendix A was prepared during the fall and winter of 2019/2020 and reflects a snapshot at that time of the projects' assumed characteristics, implementation timelines, and corresponding costs. Subsequent to the fall and winter of 2019/2020, feasibility study for these major capital projects continued, and further changes to these details were made based on new information. The most updated assumptions (and those carried forward as the official assumptions supporting the Wake County Transit Plan Update) for project characteristics, implementation timelines, and corresponding costs are reflected in the main Wake County Transit Plan Update document and in Appendices C and E.

1 Overview

INTRODUCTION

The Wake Transit Vision Plan Update intends to: 1) reevaluate expenditure and schedule assumptions for major capital projects assumed in the originally adopted Wake Transit Plan and determine the financial impact of these underlying assumptions; and 2) build on these findings to determine remaining financial capacity and expand the Wake Transit Plan implementation horizon from 2027 to 2030. This technical memo, the first in a series, is focused on updating the schedule and cost feasibility assumptions of the Wake Transit Plan's major capital projects.

The Wake Transit Plan included five major capital investments: development of a commuter rail line and four bus rapid transit (BRT) corridors. Combined, the five projects account for over 75% of the capital investments in the Wake Transit Plan. As of December 2019, each project is within a different stage of the project development phase.

The project team, including Capital Area Metropolitan Planning Organization (CAMPO), the Wake Transit Plan Update Core Technical Team (CTT), and the consultant team, collaborated to compare planned capital projects against updated implementation timeline and cost assumptions. The process was developed using three main steps:

1. Review original and updated cost and timeline estimates for commuter rail and BRT projects.
2. Inventory project development teams' updated cost and implementation timeline estimates for individual projects.
3. Survey similar projects implemented in the United States to understand implementation experience, especially with regard to cost estimation and implementation timeframe.

KEY FINDINGS

The adopted Wake County Transit Plan acknowledged in its Plan Implementation and Finance section that the first few years of implementation will involve further study and significant design for projects that require significant investment to balance the careful use of taxpayer dollars with thoughtful investment in transit. The Plan acknowledged that the costs of and timing for those projects will evolve as further study and design reveals new information.

Assumed cost and schedule estimates for the Wake Transit Plan's major capital projects – one commuter rail line and four BRT corridors – have changed as project planning has advanced. Based on the results of further study for commuter rail and the BRT corridors through a Wake Transit Fixed Guideway Corridors Major Investment Study (MIS), alternatives analysis for commuter rail, and preliminary design for the New Bern Avenue BRT corridor, the Wake Transit Plan major capital projects are assumed to exceed both originally estimated costs and implementation timeframes based on a variety of factors. These factors include the impact of inflation from elongating implementation timeframes and higher construction costs associated with more aggressive assumptions for infrastructure improvements (e.g. percentage of BRT corridor alignments with dedicated runningway). These factors will continue to be tweaked as project planning and design continues, which may result in increases or decreases to updated assumptions. Additionally, further consideration should be given to lessons from peer reviews suggesting that costs and schedules can be vulnerable to the federal project development process and the duration and financial resources required from project sponsors to complete projects.

Figure 1 Change in Estimated Spending for Major Capital Projects

| <i>\$,000's</i> | Baseline: FY20 Work Plan | Updated Assumptions: Lower Bound | Updated Assumptions: Upper Bound | Estimated Change in Spending |
|-----------------|-----------------------------|-------------------------------------|-------------------------------------|---------------------------------|
| Total | \$1,231,644 | \$1,390,094 | \$1,791,966 | + \$158,450 to 560,322 |
| FY18 | \$0 | \$0 | \$0 | \$0 |
| FY19 | \$6,952 | \$8,572 | \$8,572 | +\$1,620 |
| FY20 | \$63,724 | \$27,000 | \$27,000 | -\$36,724 |
| FY21 | \$178,668 | \$108,360 | \$108,360 | -\$70,308 |
| FY22 | \$299,223 | \$75,943 | \$137,128 | -\$223,280 to -\$162,095 |
| FY23 | \$279,965 | \$131,071 | \$169,171 | -\$148,894 to -\$110,794 |
| FY24 | \$172,952 | \$218,900 | \$287,219 | +\$45,949 to +\$114,267 |
| FY25 | \$173,653 | \$265,259 | \$334,456 | +\$91,606 to +\$160,802 |
| FY26 | \$56,507 | \$262,659 | \$338,830 | +\$206,152 to +\$282,323 |
| FY27 | \$0 | \$180,288 | \$235,115 | +\$180,288 to +\$235,115 |
| FY28 | \$0 | \$89,572 | \$116,811 | +\$89,572 to +\$116,811 |
| FY29 | \$0 | \$22,471 | \$29,304 | +\$22,471 to +\$29,304 |

Note: in year-of-expenditure dollars

The overall combined spending curve for the Wake Transit Plan major capital investments has shifted by two to three years, with the bulk of the spending in FY23 to FY27 rather than in FY21 to FY25 as originally assumed (see Figure 1 and Figure 2). Total costs for both commuter rail and the four (4) BRT corridors combined are now assumed to be about \$158.45 to \$560.32 million greater than planned in the adopted FY20 Wake Transit Work Plan, depending on which alignments are chosen for the BRT corridors and where the commuter rail project lands within the assumed updated cost range. This updated estimate represents a 13% to 45% increase in cost compared to original estimates, and this change takes into account both of the following:

- Refinement in the scope and scale of projects, such as infrastructure requirements for commuter rail and dedicated lanes for BRT, have increased assumed project cost estimates by 5% to 35%.

- Since project timelines have been extended by two to three years, with a majority of spending in the latter half of the cost curve, inflation associated with construction costs have increased assumed cost estimates by 8% to 10%.

Due to these shifts in the schedule, the Wake Transit Plan partners will likely spend less than planned in FY19 to FY23 and more than planned in FY24 to FY29. The first project currently planned to start service is the New Bern BRT in 2023, and assumptions regarding the schedule for initiating commuter rail service have been adjusted by two years from FY27 to FY29.

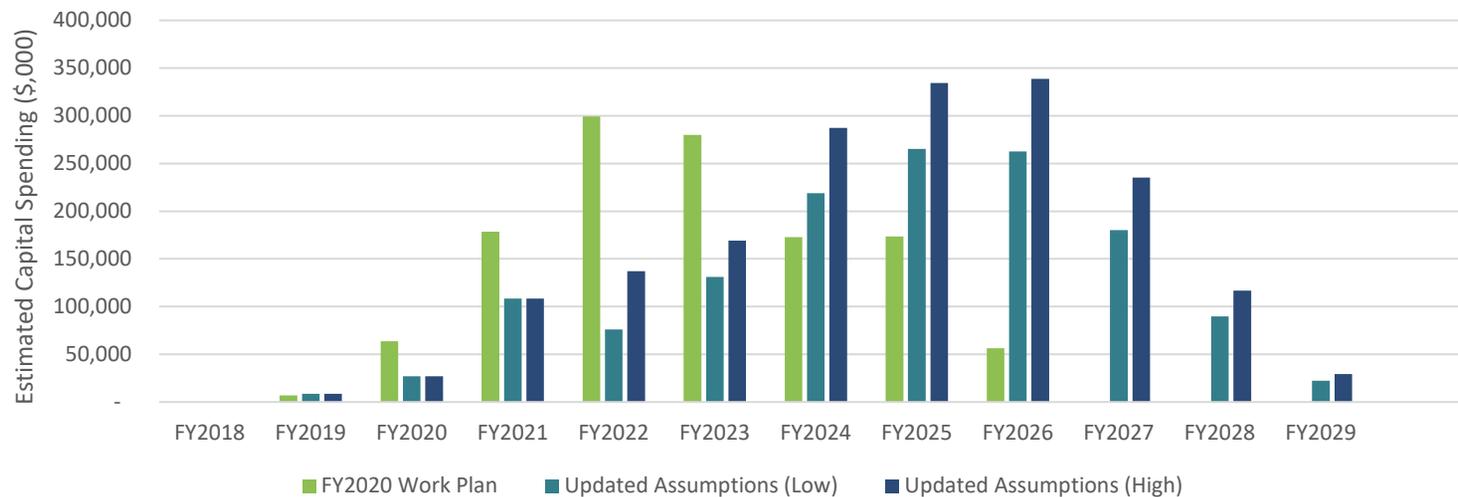
Through conversations with the project planning teams at GoTriangle and the City of Raleigh and a review of peer projects around the country, the Vision Plan Update team has identified the following factors that may further impact the cost and schedule assumptions beyond the updated estimates yielded from this task:

- While there is always risk associated with construction projects, the peer review findings suggest most projects that assume federal financial participation run into problems by underestimating the time and financial costs associated with moving a project through the federal process.
- The FTA Small Starts and New Starts processes are complicated. A common pitfall identified by the peers is that, during early stages of project development, agencies tend to underestimate the cost and time required to plan and design projects, which can cause FTA grant award and construction start dates to occur much later than originally envisioned. The rigor associated with the FTA project development process should not be underestimated.
- Part of the complication with the project development and design process is that the amount of coordination required,

which in this case will be with local partners such as the Transit Planning Advisory Committee (TPAC), local governments, North Carolina Department of Transportation (NCDOT), and North Carolina Railroad (NCRR), is also frequently underestimated. Staffing resources at partner agencies do not always adjust because of new local projects.

- Project sponsors and funders expect that cost and schedule assumptions will be updated and refined as projects proceed through project development and final design. For example, as the Southern, Western, and Northern BRT corridor alignments are determined and they proceed through project development and final design, assumed costs may increase or decrease and schedules may change as more characteristics of and conditions surrounding the projects become known.

Figure 2 Comparison of FY20 Work Plan Vs. Updated Assumptions for Total Major Capital Project Expenditures



Note: in year-of-expenditure dollars

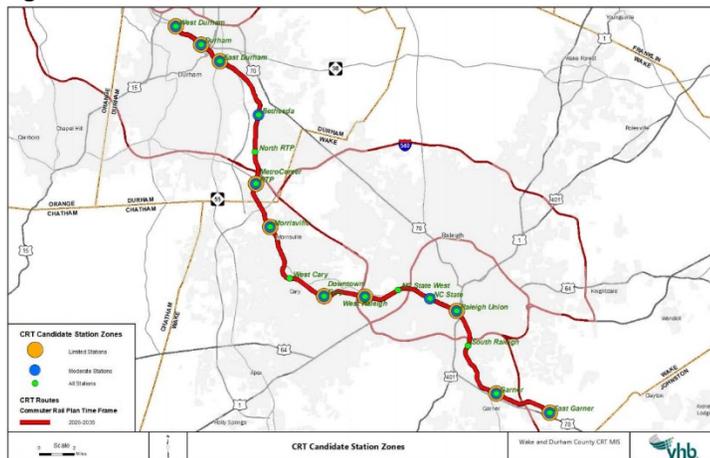
2 Commuter Rail

PROJECT DESCRIPTION

One of the signature projects in the Wake Transit Plan is commuter rail, which was originally planned to connect West Durham in Durham County with Garner in Wake County, traveling via downtown Raleigh, N.C. State University, Cary, Morrisville, and the Research Triangle Park. Commuter rail was designed to be a joint Durham County and Wake County effort, with operations on a 37-mile stretch of existing rail corridor owned by the North Carolina Railroad Company and shared with Amtrak and NCDOT Carolinian/Piedmont trains and freight lines.

Under the Wake Transit Plan, commuter rail services will provide up to eight trips in each direction during peak hours and one or two trips each way during midday and evening hours, recognizing that the rail line will continue to operate as a shared resource balanced against the needs of commuters and other travelers.

Figure 3 MIS Potential CRT Candidate Station Zones



Source: MIS

In terms of capital investments, the commuter rail project assumes rail track improvements, development of 14 stations (up to 20 stations total along potential extensions, see Figure 3), plus vehicles. GoTriangle is the primary agency responsible for the development and implementation of the commuter rail project.

ESTIMATED SCHEDULE AND COST

In 2016, the Wake Transit Plan estimated the cost of the Wake County portion of the commuter rail project at \$887.8 million. The original cost estimates included the following assumptions:

- A cost-sharing formula where Wake County would be responsible for two-thirds of the total cost, and Durham County would be responsible for the remaining one-third.
- Half (50%) of the estimated expenses would be covered by Federal Transit Administration (FTA) grants.

The Wake Transit Plan originally assumed work on commuter rail would begin in FY18 and will be ongoing until FY26, with the service opening in 2027 (see Figure 4). The original cost and spending curves assumed most spending would occur between FY22 and FY25 to move the project into final design and then construction (track updates, station development, and vehicle purchases).

To account for delays in implementation planning, Wake Transit Plan partners updated schedule assumptions from the original Wake County Transit Plan as part of the FY 2020 Wake Transit Work Plan. This process primarily held the assigned financial resources constant and reassigned them to the remaining Wake Transit Plan timeframe, so all funding would be used by 2027. Updated assumptions did not change the overall project cost or

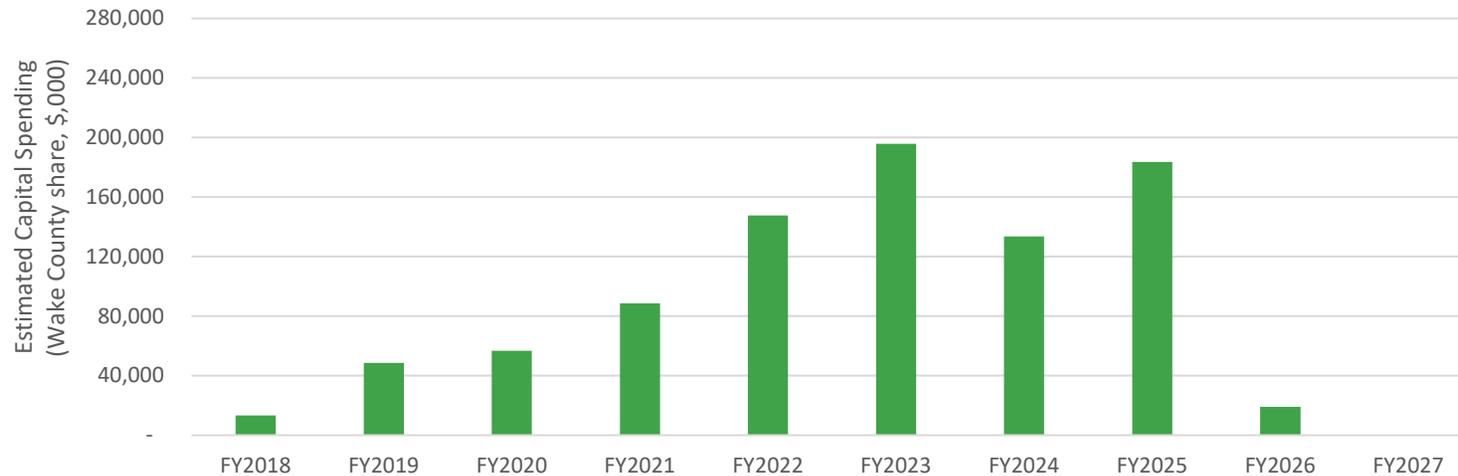
delay the project opening year (see Figure 5). As compared with the original Wake County Transit Plan estimate, the forecasts updated for the FY20 Wake Transit Work Plan show a later start year and associated spending occurring in the FY21 and FY26 timeframe.

UPDATED PROJECT ASSUMPTIONS

As discussed, development of the commuter rail project has been slower than originally assumed due to the need for an extended planning and feasibility study phase. Updated assumptions for the commuter rail project cost and schedule have been impacted by a variety of factors, including greater clarity on infrastructure improvements necessary to support reliability expectations for planned service, identification of details that will require

negotiations with the railroad owner and freight operators, requirements for carefully coordinating and negotiating involvement of funding partners and stakeholders along the corridor, challenges associated with sensitive high-risk environments along the corridor, and accounting for other rail projects, encroachments, and operating pressures. Project delays also are reflective of the dissolution of Durham County’s planned light rail project and the associated political impacts. Consequently, as of November 2019, Wake Transit’s commuter rail project remains in the early stages of development and pre-project development planning. Commuter rail is being managed by GoTriangle, with technical support provided by a consultant team. The team has recently released new cost estimates, including updated assumptions about the project delivery schedule, shown in Figure 6.

Figure 4 Original Wake Transit Plan Assumed Commuter Rail Expenditures by Year (2016 estimates)



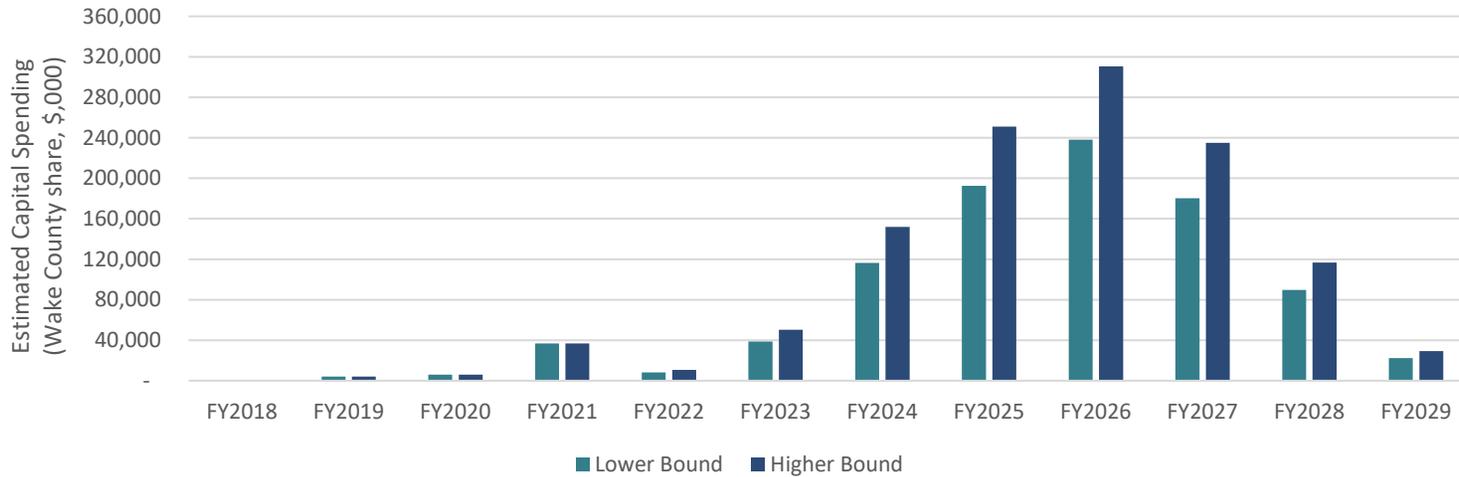
Source: Wake Transit Plan, 2016; in year-of-expenditure dollars

Figure 5 FY20 Work Plan Assumed Commuter Rail Expenditures by Year



Source: FY20 Work Plan; in year-of-expenditure dollars

Figure 6 Winter 2019/2020 Assumptions for Commuter Rail Development (Planned Expenditures by Year)



Source: GoTriangle Staff; in year-of-expenditure dollars

The updated assumed cost curve shifts the commuter rail opening year to 2029, instead of the 2027 opening estimated in the Wake Transit Plan and FY20 Work Plan. The majority of project development, as well as some right-of-way acquisitions, is assumed to happen between FY21 and FY23. The construction and bulk of spending is scheduled for FY24 to FY28. The total cost, partially as a result of inflationary influences from shifting the schedule, has also increased from prior estimates: the Wake share is now represented as range between \$933.33 million and \$1,202.88 million in year-of-expenditure dollars, since decisions have not been finalized regarding specific infrastructure requirements, level of service, and other factors. A handful of factors could change the updated assumptions for commuter rail spending:

- **Railroad coordination.** The current spending timeline assumes timely engagement with the operating railroads in the corridor beginning in 2020 and continuing throughout project development, design, construction, and start-up. Delay in initiating formal engagement or delay in progressing with network modeling and subsequent activities would result in further changes to the project timeline.
- **Change in partner participation.** The commuter rail project assumes participation from two major partners, Wake and Durham Counties. As of December 2019, the commitment levels of the individual partners are in negotiation, especially with regards to the pace of moving forward to project development, design and construction. Durham County is currently in the process of reweighing investment priorities through a wholesale update of its transit plan. There is also potential that the entire commuter rail project does not go forward, or for other partners to join the agreement.
- **Requirements or decisions to include additional contingency beyond what is currently assumed.** The current cost estimate and schedule are planning-level estimates, which include

reasonable contingencies based on what is known about the project at this time and assumptions about unknown items based on industry experience with similar projects. As the project is further defined, the FTA may require and/or the project team may recommend modifying the budget and/or schedule to carry a higher level of contingency. While this could be mitigated by controlling the scope of the project, this could ultimately increase the total budget and further modify the project timeline. FTA has changed how it assesses the risk of a project, including requiring agencies to demonstrate they are prepared to face risks that may disrupt cost and schedule. Agencies must also show that they have the project management expertise to back their implementation timelines.

PEER REVIEW

Since 2000, there have been a handful of commuter rail projects in the United States that developed from planning to operations. As part of updating the schedule and cost feasibility of the Wake Transit Plan major capital projects, the project team considered the experience of peer systems. This peer review was designed to identify unanticipated tracks and pitfalls encountered by the peers that may hold lessons for Wake Transit Plan major capital project implementation.

Two peers were selected for consideration. These peers were selected first by considering commuter rail systems evaluated as part of the MIS project (see Appendix A) and then looking at other commuter rail projects completed in the last five years. Other factors considered when identifying peers included projects with track sharing, comparable service miles, and project timing. With this perspective in mind, the project team recommends **SunRail (Orlando, FL)** and the **Hartford Line (CT & MA)** as peer projects:

- The **SunRail Commuter Rail** connecting downtown Orlando, Florida with Kissimmee and Poinciana Industrial Park opened in 2014 after many years of planning. At 32 miles, it is roughly the same length as the West Durham-Garner extents of the planned Wake Transit Commuter Rail Project. The service was also proposed on an active rail corridor, owned and operated by CSXT and with service shared by Amtrak. SunRail was also a peer in the MIS effort.
- The **Hartford Line** connecting New Haven, CT; Hartford, CT; and Springfield, MA opened in 2018. While a significantly longer project than the proposed Wake Transit commuter rail Project, like the Wake project, this project focused on updating a portion of an existing rail network. A notable difference between Hartford and the Wake Transit Commuter Rail is that, in Connecticut, track was owned by Amtrak rather

than a private railroad, although the rail corridor is shared with freight service. Further, the project was sufficiently complicated and involved collaboration with numerous stakeholders to consider it a relevant peer.

Detailed summaries of these two projects' development, cost, and schedules can be found in Appendix A. The following key findings and lessons learned may be useful for GoTriangle as the commuter rail project enters development:

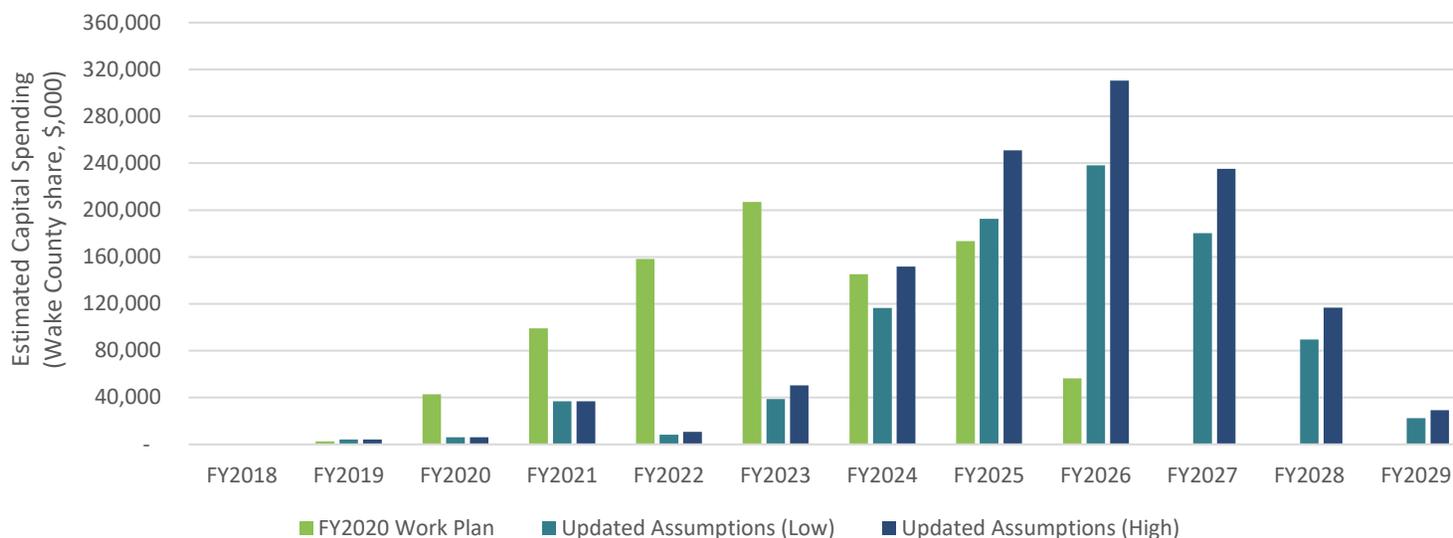
- Having state government in support of commuter rail can help move projects along more quickly; likewise without state support, projects can stall. The Hartford Line had three consecutive governors in full support of rail, and they helped advocate for the project at all levels of government. In Florida, the SunRail project stalled for about three years due to roadblocks from the Florida Legislature and/or Governor.

Figure 7 Change in Estimated Spending from Baseline to Updated Assumptions for Commuter Rail (in \$,000s)

| | FY20 Baseline Assumptions (FY20 Work Plan) | Updated Assumptions: Lower Bound | Updated Assumptions: Higher Bound | Estimated Change in Spending |
|--------------|---|-------------------------------------|--------------------------------------|---------------------------------|
| Total | \$885,275 | \$933,344 | \$1,202,881 | +\$48,059 to +\$317,606 |
| FY19 | \$2,636 | \$4,256 | \$4,256 | +\$1,620 |
| FY20 | \$42,724 | \$6,000 | \$6,000 | -\$36,724 |
| FY21 | \$99,033 | \$36,724 | \$36,724 | -\$62,309 |
| FY22 | \$158,438 | \$8,303 | \$10,828 | -\$150,125 to -\$147,610 |
| FY23 | \$207,075 | \$38,728 | \$50,506 | -\$168,347 to -\$156,569 |
| FY24 | \$145,209 | \$116,457 | \$151,833 | -\$28,782 to +\$6,624 |
| FY25 | \$173,653 | \$192,450 | \$250,975 | +\$18,796 to +\$77,322 |
| FY26 | \$56,507 | \$238,116 | \$310,529 | +\$181,609 to +\$254,022 |
| FY27 | 0 | \$180,288 | \$235,115 | +\$180,288 to +\$235,115 |
| FY28 | 0 | \$89,572 | \$116,811 | +\$89,572 to +\$116,811 |
| FY29 | 0 | \$22,471 | \$29,204 | +\$22,471 to +\$29,304 |

Source: FY20 Work Plan, GoTriangle Staff; in year-of-expenditure dollars

Figure 8 Comparison of FY20 Work Plan and Updated Assumptions for Commuter Rail Expenditures



Source: FY20 Work Plan, GoTriangle Staff; in year-of-expenditure dollars

- Working with Amtrak can be difficult to navigate and negotiate but can lead to mutually beneficial partnerships. Florida DOT had a contract with Amtrak to maintain SunRail vehicles at Amtrak facilities, which reduced project schedule risk. In Connecticut, Amtrak operates about half the trains on the Hartford Line, and there is full fare integration between the two entities.
- Project timelines for commuter rail tend to be much longer than expected. From the first alternatives analysis to the opening date, SunRail took 12 years to be fully realized. For the Hartford Line, it was 15 years between the start of the Implementation Plan for Commuter Rail and the opening date. Such long timelines lead to changes in costs as well, due to inflation and changes in the economy over time.

SUMMARY FINDINGS

The most up-to-date Wake-Durham commuter rail estimates from the GoTriangle project team represent an assumed shift in both schedule and cost when compared to the FY20 Work Plan baseline. Figure 7 shows the difference in the assumed amount of spending for each fiscal year until opening, and Figure 8 compares the cost over time for the two estimates. The changes in assumed spending include the following:

- Assumed cost curves will shift spending by roughly two years, delaying the opening year for the commuter rail project to 2029. Investment in commuter rail at a rate of \$100 million per year or more is assumed occur between FY24 and FY27. This reflects the two-year delay from the prior planned years of heavy investment (FY22 to FY25).

- The assumed total cost for Wake Transit for the project will increase by \$48.06 to \$317.61 million, or 5% to 36%, in year-of-expenditure dollars. Wake Transit will spend less than planned in FY20 to FY23, but dramatically more than planned in FY24 to FY29.
- This 5% to 36% increase in estimated costs is impacted by both a refinement in project characteristics demanding certain infrastructure requirements, resulting in a -4% to 24%

change in cost, and inflationary influences from the shift in timeline, resulting in a 9% to 12% increase in year-of-expenditure costs. Even though the costs attributed to assumed infrastructure requirements for the lower bound updated assumptions are slightly lower than the baseline, inflation due to increased spending on a later project timeline means that the total year-of-expenditure cost range is higher than the baseline FY20 Work Plan estimates.

3 Bus Rapid Transit

PROJECT DESCRIPTION

The Wake Transit Plan includes approximately 20 miles of bus rapid transit (BRT) service, split into four general corridors that all begin/end in downtown Raleigh. The four corridors are designed to create a high capacity transit network along an east-west and north-south spine (see Figure 9). These services are the core service of the Wake Transit Plan's frequent transit network. Service is designed to operate every 10-20 minutes, depending on time of day, from 4AM to midnight.

While there is a clear plan for BRT project development, as blueprinted by the Wake Transit Fixed Guideway Corridors Major Investment Study (MIS), several elements such as final corridor alignments and BRT technology investments have yet to be determined. However, in every case, BRT is assumed to operate on dedicated lanes for a minimum of 50 percent of each corridor. Other investments include transit signal priority (TSP) at every signalized intersection, specialized vehicles, and enhanced stations with BRT branding. The City of Raleigh was designated as the project sponsor for the development and implementation of all four corridors in the BRT network.

Wake BRT: New Bern Avenue

The Wake BRT: New Bern Avenue projects is furthest along in its development process. From downtown Raleigh, the BRT will travel east on New Bern Avenue (and west on Edenton Street), then continue on New Bern Avenue past the Wake Medical Campus. Figure 10 shows the corridor and proposed stations. Based on stakeholder and community input and ridership

projections, the project team extended the New Bern Avenue BRT beyond its original scope east from the Wake Medical Campus to New Hope Road. While the project partners agreed to extend BRT service, the extension will operate in mixed traffic rather than in dedicated lanes.

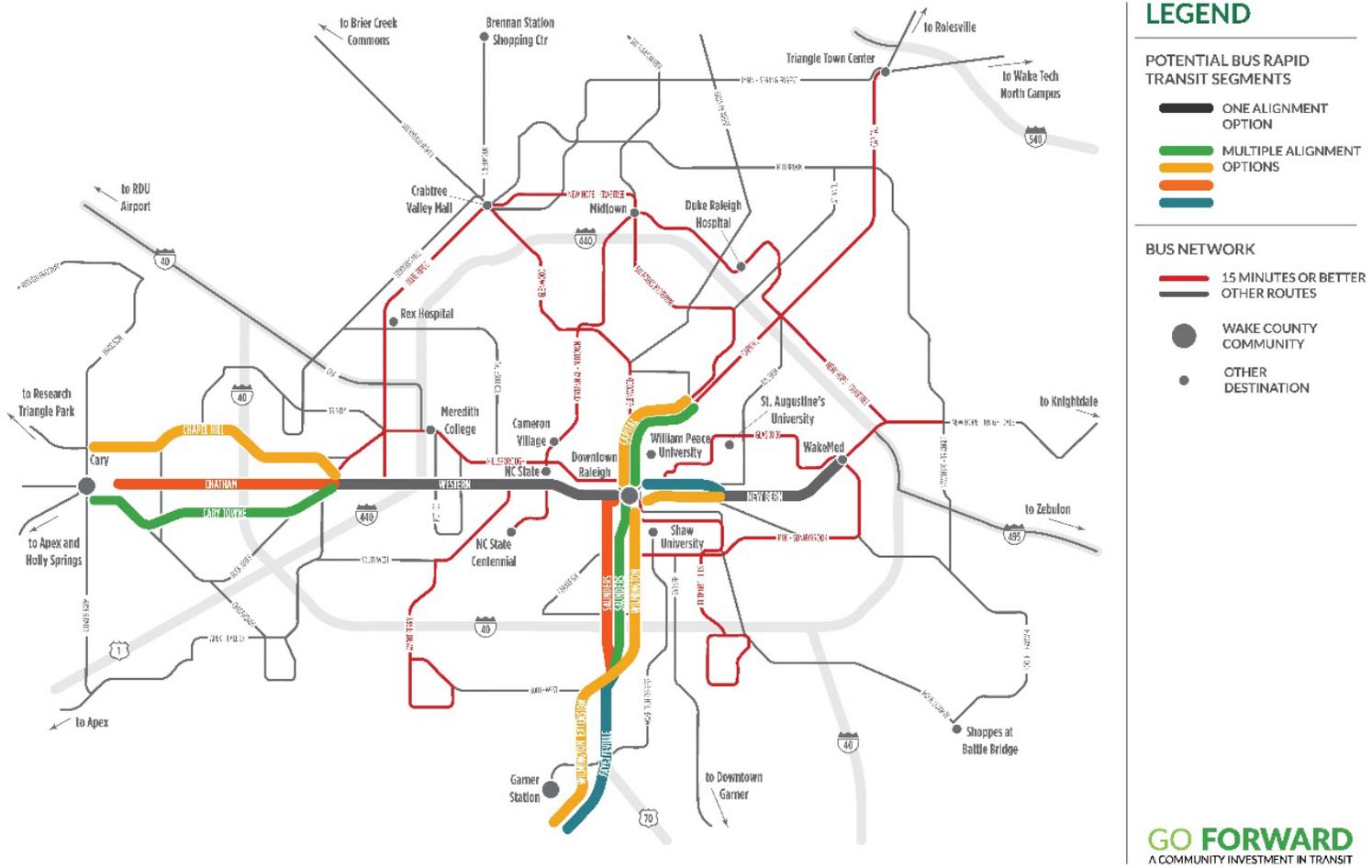
Wake BRT: Southern Corridor

The Wake BRT: Southern Corridor extends south of downtown Raleigh from South Street to Purser Drive. There are three options for the northern part of this corridor: South Street and S. Saunders Street (2.4 miles), McDowell Street and S. Saunders Street (2.4 miles), or Wilmington Street (2.4 miles). For the southern part of this corridor, there are two options: on a new roadway extension of Wilmington Street (1.8 miles), or Fayetteville Road (1.7 miles). Once the Locally Preferred Alternative is identified, the Southern Corridor will enter into the federal Small Starts Project Development phase in Spring 2020.

Wake BRT: Western Corridor

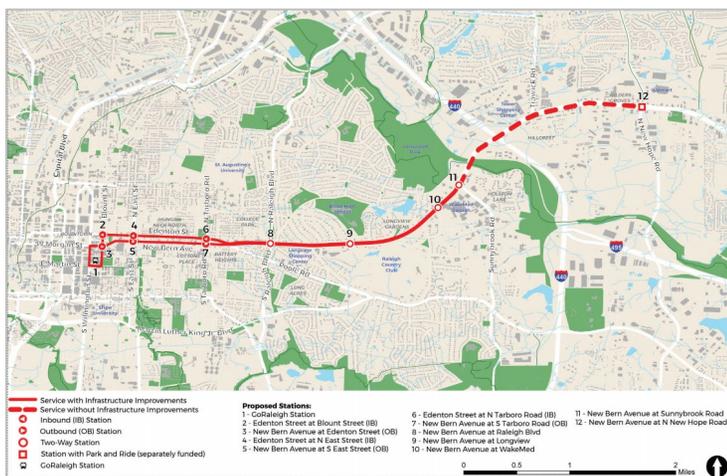
The Wake BRT: Western Corridor is the longest proposed corridor, extending west of downtown Raleigh to downtown Cary. The eastern segment of this route will operate on Western Boulevard between Wilmington Street and Hillsborough Street for 4.8 miles. There are three options for the western segment: Chapel Hill Road (4.1 miles), Chatham Street (3.1 miles), or Cary Towne Boulevard and Walnut Street (3.9 miles), all terminating in downtown Cary.

Figure 9 Raleigh 2027 Bus Network with BRT Alignments



Source: Wake Transit Plan

Figure 10 New Bern Corridor BRT



Source: City of Raleigh

The City of Raleigh is leading a Wake BRT: Western Boulevard Corridor Study to identify the preferred Western Corridor alignment. This study and input from the Cary Multimodal Transit Facility Feasibility Study suggest a potential new alignment through Cary (see Figure 11 for all four corridor alternatives). Once the Locally Preferred Alternative is identified through the Western Boulevard Corridor Study, the Western Corridor will enter into the project development phase in Spring 2020.

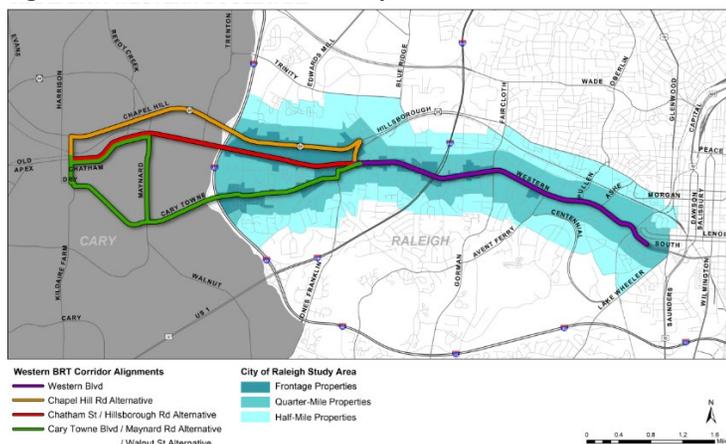
Wake BRT: Northern Corridor

The Wake BRT: Northern Corridor extends north from downtown Raleigh to a future transit center at Crabtree Boulevard. There are two potential configurations for this service: West Street and Capital Boulevard or remaining on Capital Boulevard for the entire alignment. Current plans suggest the Capital Corridor will enter project development last in 2021.

ESTIMATED SCHEDULE AND COST

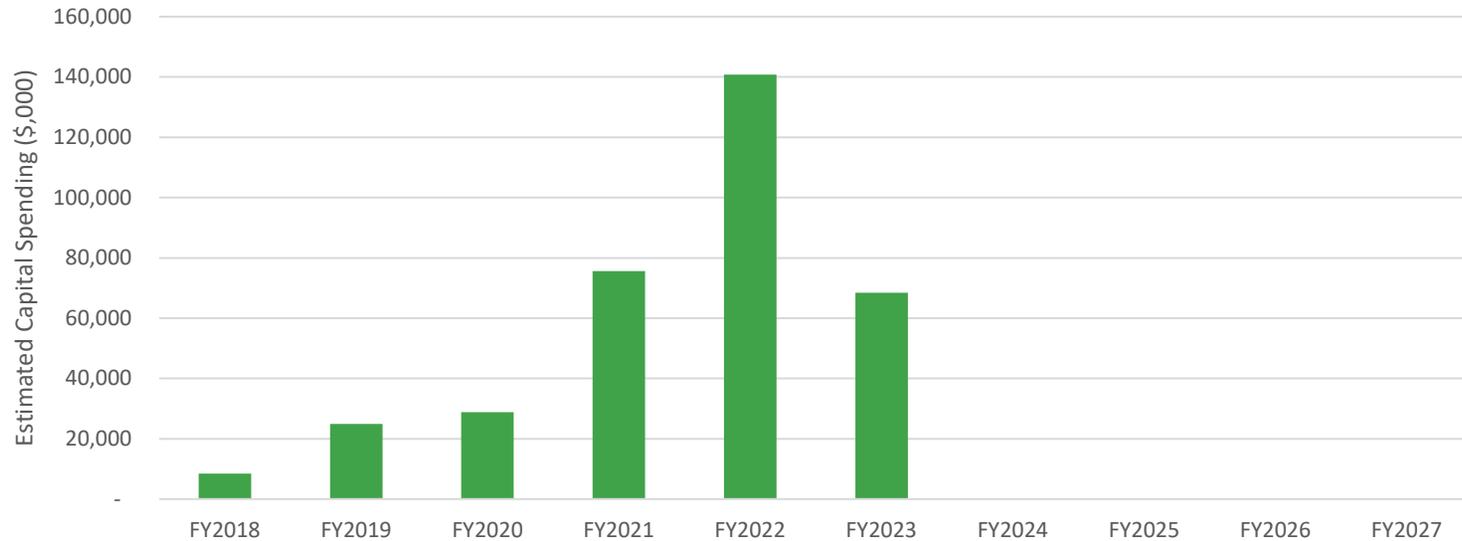
The original Wake Transit Plan estimated the cost of the four BRT corridors at \$347 million total in year of expenditure dollars for capital expenses (see Figure 12) and acknowledged that further implementation planning would occur to refine project characteristics, including cost and schedule feasibility. This estimated cost was based on an assumption that dedicated runningway would be constructed along a minimum of 50 percent of the corridors. The financial model for the Plan also assumed all four corridors would be implemented in parallel, such that the four projects would move into project development in 2018 with operations starting in 2024. Capital costs would be shared equally between the FTA and Wake Transit funds, or roughly \$174 million paid for by Wake Transit funds.

Figure 11 Western Corridor BRT Options



Source: City of Raleigh

Figure 12 Original Wake Transit Plan Assumed BRT Expenditures by Year



Source: Wake Transit Plan; in year-of-expenditure dollars

Since the original Wake Transit Plan, cost and schedule assumptions for the BRT corridors have been developed and updated several times between 2016 and 2019. The first adjustment was developed as part of the MIS conducted in 2018, which included more detailed corridor feasibility planning work and estimated the cost by corridor. With the exception of downtown Raleigh, the planning-level BRT costs generated by the MIS were based on an assumption that 100 percent of the BRT corridor alignments would involve construction of dedicated runningways that are separate from general-purpose lanes. The original Wake Transit Plan assumed that 50 percent of the corridors would involve construction of separate dedicated runningway. The MIS created a low and high estimate for each corridor, depending on route alignments, and estimated BRT

development costs at between \$375 million and \$484 million in 2018 dollars (see Figure 13). The Southern Corridor has the greatest range in cost between its alternatives, due to the infrastructure investments required for one of the corridor alignment alternatives.

The MIS also broke down the cost of each corridor into the ten FTA Standard Cost Categories (five construction categories, plus right-of-way, vehicles, professional services, unallocated contingency, and finance charges), but did not break down the cost by estimated year of expenditure, since a schedule for each corridor was not developed. Since the MIS estimates are in 2018 dollars, the totals for each alternative are not directly comparable to total costs estimated in the Wake Transit Plan and annual work plans, which are in year-of-expenditure dollars with inflation

considered. In general, however, MIS estimates represent a higher cost and level of investment for the four BRT corridors than in the Wake Transit Plan, primarily due to the greater amount of dedicated runningway assumed.

The FY20 Annual Work Plan, largely based off of the original Wake Transit Plan, was developed at the same time as the MIS, so findings from the MIS were not incorporated into this work plan. For the FY20 Work Plan, shown in Figure 14 and Figure 15, the City of Raleigh included separate, more detailed project development and construction cost estimates for the New Bern Corridor. For the remaining three corridors, the Wake Transit partners estimated the combined cost curve based only upon pre-project development planning to date. The total estimated cost remained the same as the original Wake Transit Plan estimates, as did the opening year for all the lines (by 2024).

Figure 13 MIS BRT Estimated Cost (in thousands)

| Corridor | Least Costly Alternative | Most Costly Alternative |
|-----------------------------|--------------------------|-------------------------|
| Wake BRT: New Bern Avenue | \$64,861 | \$64,861 |
| Wake BRT: Southern Corridor | \$84,092 | \$158,891 |
| Wake BRT: Western Corridor | \$148,217 | \$167,585 |
| Wake BRT: Northern Corridor | \$78,390 | \$92,968 |
| Total | \$375,661 | \$484,306 |

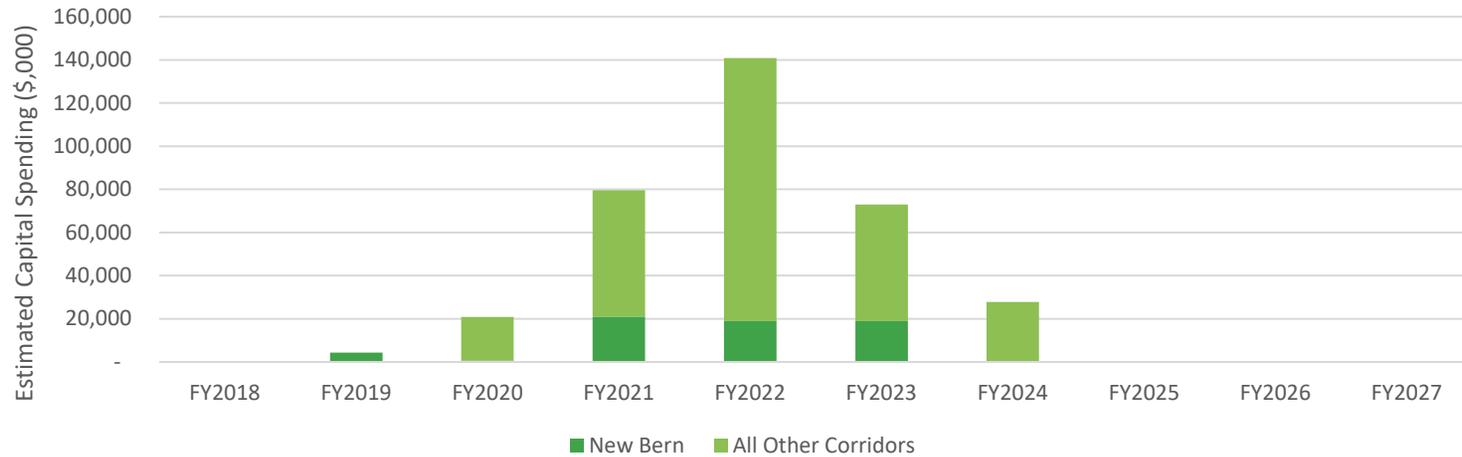
Source: MIS; in 2018 dollars. Note: New alternative for Western Corridor on Maynard Road was not included in MIS.

Figure 14 FY20 Work Plan Assumed BRT Expenditures by Phase and Year

| Corridor/ Phase | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | Total |
|------------------------------------|----------------|--------------------------|-----------------|------------------|-----------------|-----------------|------------------|
| New Bern Corridor | | | | | | | \$63,848 |
| Project Development & Final Design | \$4,316 | \$631 | \$1,000 | | | | \$5,947 |
| Right-of-Way | | | \$1,000 | | | | \$1,000 |
| Construction | | | \$18,967 | \$18,967 | \$18,967 | | \$56,901 |
| All Other Corridors | | | | | | | \$282,421 |
| Project Development & Final Design | | \$20,369 | \$3,000 | | | | \$23,269 |
| | | <i>Southern: \$6,540</i> | | | | | |
| | | <i>Western: \$8,290</i> | | | | | |
| | | <i>Northern: \$5,540</i> | | | | | |
| Right-of-Way & Construction | | | \$55,668 | \$121,818 | \$53,923 | \$27,743 | \$259,152 |
| Total BRT Cost | \$4,316 | \$21,000 | \$79,635 | \$140,785 | \$72,890 | \$27,743 | \$346,269 |

Source: FY20 Work Plan; in year-of-expenditure dollars

Figure 15 FY20 Work Plan Assumed BRT Expenditures by Year



Source: FY20 Work Plan; in year-of-expenditure dollars

UPDATED PROJECT ASSUMPTIONS

In mid-2019, the City of Raleigh submitted an FTA Small Starts Grant application for the New Bern Corridor with costs estimated at \$71.5 million in year of expenditure dollars. FTA Small Starts is a competitive grant program, with grant awards being subject to scoring and funding availability. The application assumes the total of City of Raleigh and Wake Transit revenues would be matched equally by the FTA. The City of Raleigh’s most recent estimate is substantially similar to the \$64 million estimated in the MIS, which is in 2018 dollars. Wake Transit partners are currently in the process of developing the FY21 Work Plan, and the City of Raleigh submitted the estimates shown in Figure 16 as the draft updated cost estimates for the corridor.

Though project construction is planned to go through 2023, the City of Raleigh is requesting all of the funds in FY21. This request reflects the City of Raleigh’s need to demonstrate to the FTA that

the local match is available and to potentially enter into a single-year FTA grant agreement. Further, by securing local and federal funds in FY21, the City of Raleigh will have more flexibility to purchase right-of-way and enter different phases of construction without having to wait to finalize funding.

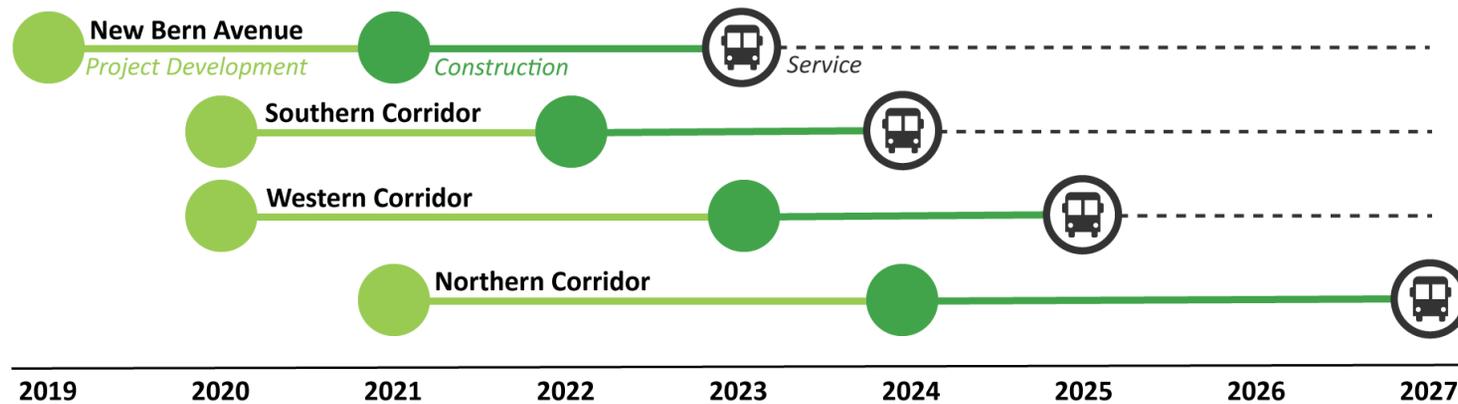
In the time since the MIS and FY20 Work Plan were published, the City of Raleigh refined the BRT implementation schedule (see Figure 17). As discussed, the New Bern corridor is well into the project development phase with construction planned for 2021 to 2023. The Southern and Western Corridors are entering project development concurrently, with construction planned for 2022 to 2023 and 2023 to 2024, respectively. The Northern Corridor is planned to enter project development in 2021 and will be the last to open for service in 2027.

Figure 16 Draft New Bern Costs for FY21 Work Plan

| Category | Funding Source | FY19 | FY20 | FY21 | Total |
|------------------------------------|------------------|----------------|--------------|-----------------|-----------------|
| Project Development & Final Design | Wake Transit Tax | \$4,316 | \$631 | \$1,953 | \$6,900 |
| Right-of-Way | Wake Transit Tax | | | \$44 | \$44 |
| Construction | Wake Transit Tax | | | \$19,204 | \$19,204 |
| | Federal | | | \$35,655 | \$35,655 |
| | Raleigh | | | \$3,261 | \$3,261 |
| Equipment (Vehicles) | Wake Transit Tax | | | \$4,024 | \$4,024 |
| Unallocated Contingency | Wake Transit Tax | | | \$2,995 | \$2,995 |
| Total | | \$4,316 | \$631 | \$67,136 | \$72,083 |

Source: City of Raleigh; in year-of-expenditure dollars

Figure 17 BRT Implementation Schedule (as of 2019)



Source: City of Raleigh; subject to change as each project enters into Project Development

Figure 18 Approximate Expenditure Schedule by FTA Standard Cost Category

| FTA Standard Cost Category | Project Development | | | | Construction | |
|---|--|--------|--------|----------|--------------|----------|
| | Year 1 | Year 2 | Year 3 | Year 3/4 | Year 4/5 | Year 5/6 |
| 10 Guideway & Track Elements | | | | 33% | 33% | 33% |
| 20 Stations, Stops, Terminals, Intermodal | | | | 33% | 33% | 33% |
| 30 Support Facilities | | | | 33% | 33% | 33% |
| 40 Sitework & Special Conditions | | | | 33% | 33% | 33% |
| 50 Systems | | | | 33% | 33% | 33% |
| 60 ROW, Land, Existing Improvements | | | | 100% | | |
| 70 Vehicles | | | | 100% | | |
| 80 Professional Services | As estimated in FY20 and FY21 Work Plans, and remaining amount divided evenly over remaining years of Project Development. | | | | | |
| 90 Unallocated Contingency | Divided evenly among all years after FY 21 | | | | | |

The City of Raleigh has not developed a more detailed implementation schedule beyond what is shown in Figure 17. As part of assessing cost and schedule feasibility, the Vision Plan Update team estimated costs by year for each corridor. For New Bern, the cost by year is represented in the draft FY21 Work Plan (Figure 16). For the other three corridors, the project team used the MIS estimates by FTA Standard Cost Category to allocate the portion of the project budget spent by year by category (see Figure 18 for the approximate rough schedules). Our baseline analysis reflects an assumption that project development and construction each require 2.5 to 3 years for each corridor. It's important to note that the Professional Services category is largely tied to Project Development, for which more exact estimates have already been made for FY20 in the FY20 Work Plan

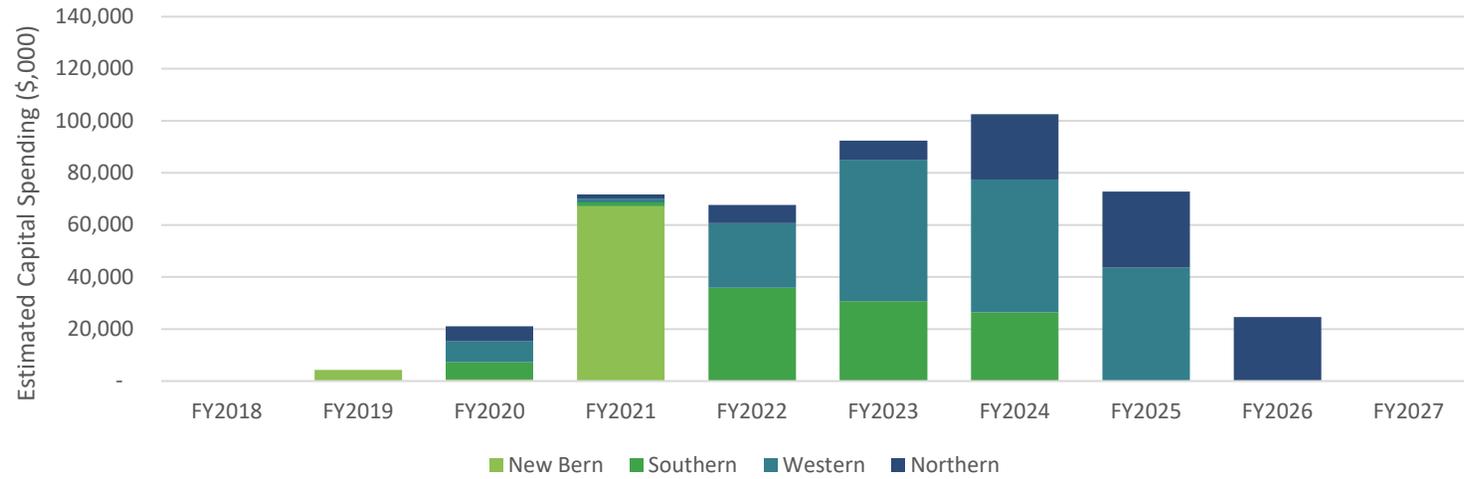
(Figure 14) and for FY21 in the draft FY21 Work Plan (which allocates \$1.5 million to each of the three corridors in FY21).

The Vision Plan Update team used the estimates by Standard Cost Category from the MIS for the Southern, Western, and Northern corridors and combined these with the rough schedule in Figure 18 to estimate cost curves for BRT capital development, inflated to year-of-expenditure dollars. Since the alignments have not been chosen for these corridors yet, the cost estimates vary. The low-end cost assumptions are shown in Figure 19 and the high-end assumptions in Figure 20. In both cases, the BRT network will complete construction in the same timeframe.

Based on this analysis, the cost to develop the BRT network is estimated between \$454.76 and \$589.09 million in year-of-

expenditure dollars. A handful of factors could change the updated assumptions for BRT spending:

Figure 19 Fall 2019 Assumptions for BRT Development (Lower Bound Planned Expenditures by Year)



Source: City of Raleigh, MIS, Nelson\Nygaard Estimates; in year-of-expenditure dollars

Figure 20 Fall 2019 Assumptions for BRT Development (Upper Bound Planned Expenditures by Year)



Source: City of Raleigh, MIS, Nelson\Nygaard Estimates; in year-of-expenditure dollars

- **The alignments of the Southern, Western, and Northern Corridors have not been chosen.** The scale of construction needed for the chosen alternatives may extend or shorten the construction timelines and increase or decrease total project costs.
- **Changes in construction cost may occur.** These costs vary with the economy, and prices increase during economic upturns and decrease during downturns.

FTA project development processes and definitions are in flux. As with the commuter rail project, the City of Raleigh and its partners will have to show that they can manage greater cost and schedule risk than required by BRT projects.

PEER REVIEW

The project team surveyed BRT projects implemented in similarly sized and positioned communities in the United States to understand their experiences, focusing on planned schedule and cost estimates. We considered the peer systems evaluated as part of the MIS and other projects with similar characteristics nationally (Appendix B). Some of the key factors for consideration when identifying peer BRT projects were the use of dedicated lanes, a relatively recent opening year, and route length. The Wake County BRT service consists of four corridors planned concurrently and crosses jurisdictional boundaries, which are also factors considered.

Based on this scan, the project team recommended using IndyGo Red Line (Indianapolis, IN), Swift BRT (Snohomish County, WA), and ART (Albuquerque, NM) as comparable projects.

- The **IndyGo Red Line** opened in August of 2019 as the first BRT line in Indianapolis's planned network. IndyGo also has two additional planned lines (Blue and Purple). Like Wake Transit's BRT, the Red Line operates in mostly dedicated lanes.
- **Swift BRT** is operated by Community Transit in Snohomish County, WA, and connects major population and employment centers north of Seattle. The first line opened in 2009, the second in 2019, and the third is planned to open in 2024. Swift mostly operates in side-running business-and-transit lanes.
- The **ART** is a BRT project in Albuquerque, NM that started operating in 2017. Though there is only one line, the capital cost per mile and level of infrastructure investment is similar to that of Wake Transit BRT. The opening of ART has been delayed due to numerous issues, so lessons learned from this project can help Wake County adjust its planning based on schedule and cost changes.

Detailed summaries of these three projects' development, cost, and schedules can be found in Appendix B. The following key findings and lessons learned may be useful for the City of Raleigh as the BRT projects enter development:

- Constructing stations with level boarding is more complicated than most agencies expect. Staff from both IndyGo and Community Transit emphasized that concrete pads are crucial for durable level boarding but adds more time and complexity to construction.
- IndyGo and Community Transit staff also suggested splitting construction bids into different packages to make the project easier to manage and to guarantee the

best expertise at the lowest cost for each component of the project.

- As ABQ Ride learned from its two-year delay in implementing ART, electric buses require time and extensive testing, and orders should not be rushed.
- The FTA is an essential partner to most infrastructure investment projects. However, the duration of the project may mean that the federal process could change. For example, for some peers, a change in the required contingency created funding challenges.

SUMMARY FINDINGS

The updated BRT cost curves represent a shift in schedule and cost when compared to the FY20 Work Plan baseline. Figure 21 shows change in the dollar value that the Wake Transit Plan may need to spend in each fiscal year through 2027. Figure 22 compares the cost over time between the FY20 Work Plan estimates, the current lower bound estimates, and the current upper bound estimates. The changes in spending and schedule include the following:

- Project development and construction are now staggered for the four corridors, with New Bern as the first to start service in 2023 and the Northern Corridor as the last to start in 2027.
- Significant spending on the BRT project development and construction is expected between FY21 and FY25. The FY20 Work Plan assumed heavy spending would occur between FY21 and FY23.
- Our analysis suggests the cost to build four BRT lines will be \$110.39 million to \$242.72 million, or 32% to 70%, more than estimated in the FY20 Work Plan. The Wake Transit Plan should expect to spend more than planned in the FY20 Work Plan in FY23 to FY26.

- The 32% to 70% increase in cost estimates is due to both changes to the project scope, resulting in 27% to 63% increase in costs, and inflation from a longer construction timeline, resulting in 5% to 7% increase in costs. The changes to the project scope are primarily for the level of infrastructure investment for these BRT corridors. For example, the MIS planned for a significantly larger amount of dedicated runningway than the baseline Wake Transit Plan, and the project team used the MIS, extrapolated to year-of-expenditure dollars, to update cost assumptions for the Southern, Northern, and Western Corridors.

These current assumptions may be vulnerable to the following changes, beyond the expected cost increase:

- A common mistake identified by the peers is that agencies tend to be optimistic about project development, especially project costs but also schedules. The experience of the peers suggest that resources are consumed quickly and the rigor of the FTA project development process should not be underestimated.

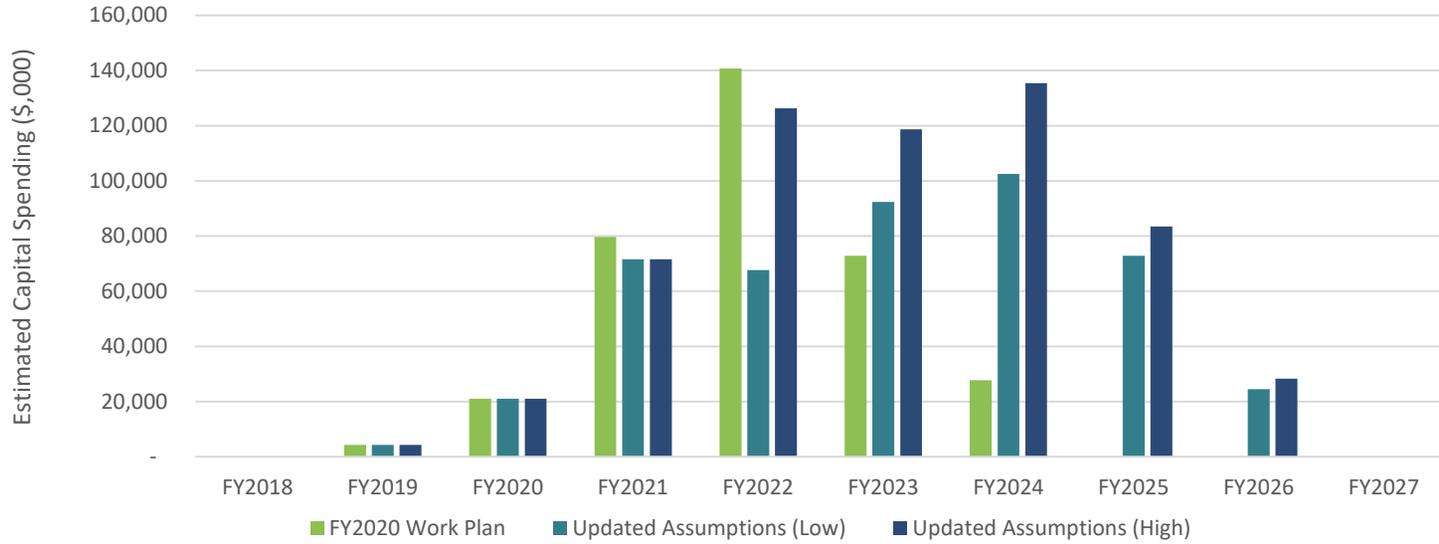
- The Wake Transit Plan BRT projects are sized under the FTA’s Small Starts project. While less complicated than New Starts projects, they still require extensive collaboration with local, regional and federal partners and should not be underestimated.
- The FTA is wary of risk in project plans, especially funding risks. Such risks increase when implementing a portfolio of projects as is outlined by the Wake Transit Plan’s BRT network. One of the strengths of the Wake Transit Plan is access to a dedicated funding stream.
- Once alignments of the Southern, Western, and Northern Corridors are chosen, cost and schedule will need to be further refined to the scale of construction needed for each project.
- Bids from construction firms may come in more or less than expected, and construction of stations may take more money and time than expected.

Figure 21 Change in Estimated Spending from Baseline to Updated Assumptions for BRT

| <i>,\$000's</i> | Baseline: FY20 Work Plan | Updated Assumptions: Lower Bound | Updated Assumptions: Upper Bound | Estimated Change in Spending |
|-----------------|--------------------------|----------------------------------|----------------------------------|---------------------------------|
| Total | \$346,369 | \$456,760 | \$584,926 | +\$110,392 to +\$242,717 |
| FY19 | \$4,316 | \$4,316 | \$4,316 | \$0 |
| FY20 | \$21,000 | \$21,000 | \$21,000 | \$0 |
| FY21 | \$79,635 | \$71,636 | \$71,636 | -\$7,999 |
| FY22 | \$140,785 | \$67,640 | \$126,300 | -\$73,145 to -\$14,485 |
| FY23 | \$72,890 | \$92,343 | \$118,665 | +\$19,453 to +\$45,775 |
| FY24 | \$27,743 | \$102,474 | \$135,386 | +\$74,731 to +\$107,643 |
| FY25 | 0 | \$72,809 | \$83,481 | +\$72,809 to +\$83,481 |
| FY26 | 0 | \$24,543 | \$28,301 | +\$24,543 to +\$28,301 |

Source: FY20 Work Plan, City of Raleigh, MIS, Nelson\Nygaard Estimates; in year-of-expenditure dollars

Figure 22 Comparison of FY20 Work Plan and Current Assumptions for BRT Expenditures



Source: FY20 Work Plan, City of Raleigh, MIS, Nelson\Nygaard Estimates; in year-of-expenditure dollars

Appendix A: Peer Commuter Rail Projects

TABLE OF POTENTIAL COMMUTER RAIL PEER PROJECTS

| Service | Operation Year | Capital Cost/Mile (millions) | Annual Operating Cost (millions) | Track Length (miles) | Track Sharing | Number of Stations |
|-----------------------------------|----------------|------------------------------|----------------------------------|----------------------|-----------------|--------------------|
| Wake Transit (Raleigh, NC) | 2029 | \$48.8 (YOE \$'s) | \$21.1 (2029 \$'s) | 37 | Freight, Amtrak | 14 |
| Peers Used in MIS | | | | | | |
| A-Train (Denton, TX) | 2011 | \$14.6 | \$12.8 | 21 | Freight | 5 |
| MetroRail (Austin, TX) | 2010 | \$5.5 | \$23.1 | 32 | Freight | 9 |
| SunRail (Orlando FL) | 2014 | \$12.6 | \$31.2 | 32 | Freight, Amtrak | 12 |
| Music City Star (Nashville, TN) | 2006 | \$1.8 | \$5.2 | 33 | Freight | 6 |
| Tri-Rail (Miami, FL) | 1989 | \$18 | \$90 | 71 | Freight, Amtrak | 18 |
| VRE (Washington, DC) | 1992 | Unk | \$69.9 | 35/54 | Freight, Amtrak | 10/13 |
| TRE (Dallas, TX) | 1996 | \$10.6 | \$28 | 36 | Freight | 10 |
| Northstar (Minneapolis, MN) | 2009 | \$10.3 | \$16.7 | 40 | Freight | 7 |
| COASTER (San Diego, CA) | 1995 | Unk | \$16.7 | 41 | Freight, Amtrak | 8 |
| Front Runner (Salt Lake City, UT) | 2008 | \$18.3 | \$45.2 | 89 | Partly, Freight | 16 |
| A-Line (Denver, CO) | 2016 | \$55.4 | \$46.7 | 23 | No | 8 |
| Other Potential Peers | | | | | | |
| Hartford Line (CT & MA) | 2018 | Unk | Unk | 62 | Amtrak | 9 |

SUNRAIL (FL)

Overview

SunRail is a commuter rail line in the Orlando, Florida, area serving the 2.7 million residents of Orange, Osceola, Seminole, and Volusia Counties (Figure 23). Phase 1 of SunRail opened in 2014 on tracks owned by the Florida Department of Transportation (DOT) and shared with freight and Amtrak. Florida DOT operates the line, which now includes Phase I and Phase II South. Operations are expected to transition to the Central Florida Commuter Rail Commission in 2021 through an interlocal agreement already in place. For the development and construction of the project, the capital funding breakdown was 50% from FTA New Starts, 25% from state funds, and 25% split among the four counties and the City of Orlando.

For Phase I, trains ran on weekdays between 12 stations, with 18 daily round trips. The capital cost of the project was approximately \$12.6 million per mile, or \$403 million total, and operating costs were \$31.2 million in FY16. In July of 2018, the southern part of Phase 2 opened, adding 17.2 miles and 4 stations to the route. The service level increased to 20 roundtrips each weekday, and operating costs were \$38.2 million in FY19.

Schedule

FDOT experienced major delays during project development, as shown in Figure 24. The agency conducted an alternatives analysis (AA) and settled on a locally preferred alternative (LPA) in 2002 to 2004. In 2007, the LPA entered the New Starts Preliminary Engineering (PE) phase, with an anticipated opening year of 2010. Once the project entered Final Design (FD), the anticipated opening year was pushed back to 2011.

Figure 23 SunRail Phase I Map



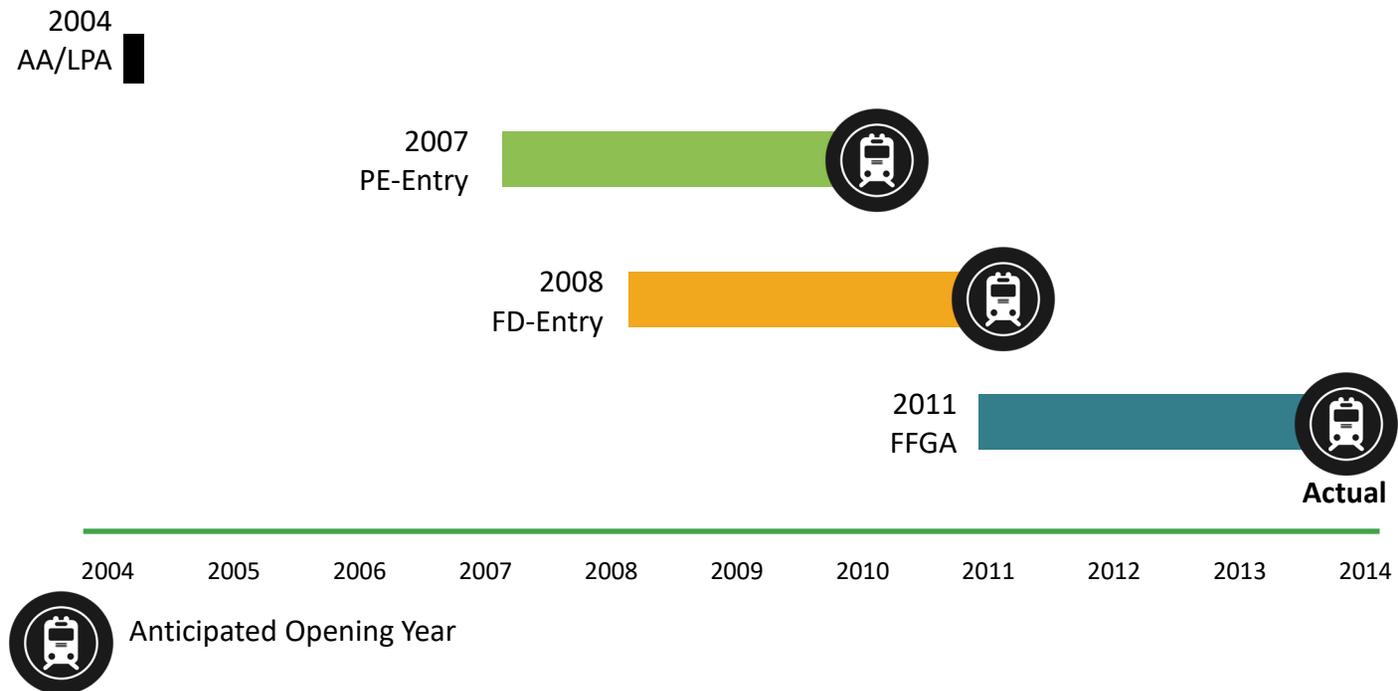
Source: SunRail

However, FDOT only received the Full Funding Grant Agreement (FFGA) in 2011, which shifted the actual opening date to May 2014. Many of these delays were due to legislative and political issues. In 2008, the Florida Legislature delayed the project due to liability and indemnification issues with the right-of-way, and in 2009, they initially voted against an insurance proposal brought forward by FDOT before eventually supporting it later that year. In 2011, the governor froze all construction contracts, delaying the progress of construction.

Costs

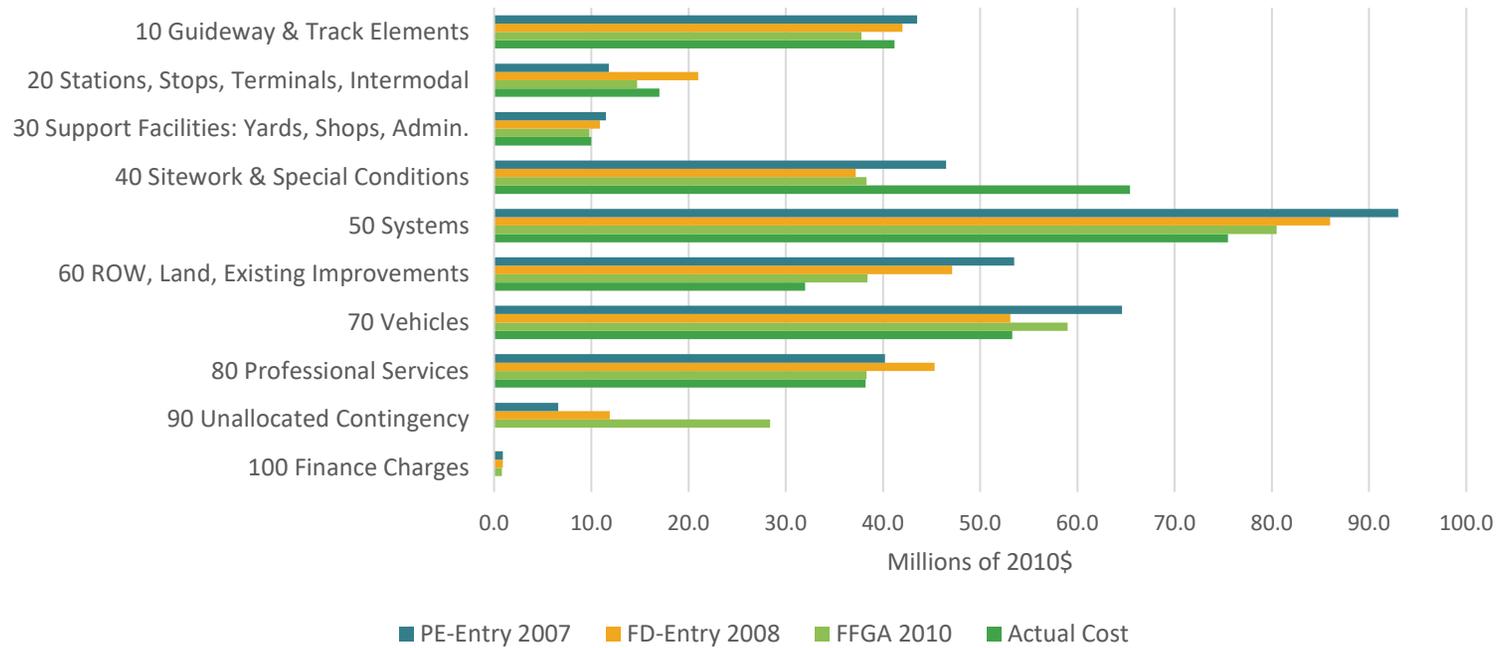
The estimated costs throughout the project remained relatively consistent, and the actual cost was on budget. However, estimates of individual cost categories differed throughout the process, as shown in Figure 25. FDOT underestimated sitework construction costs, as estimates were produced during the recession, but ultimately made the purchases during economic recovery, when costs were higher. Systems construction and vehicles were generally overestimated.

Figure 24 SunRail Phase I Schedule Changes



Source: SunRail Phase I Before & After Study

Figure 25 SunRail Estimated vs Actual Costs by Standard Cost Category and Phase



Source: SunRail Phase I Before & After Study

Lessons Learned

The SunRail project team shared several lessons they learned that may be useful as GoTriangle develops the Wake-Durham commuter rail:

- Early transit-oriented development (TOD) planning helps with local buy-in and seeding development.
- Visiting peers or inviting them to present for lessons learned workshops can help identify challenges in the process.
- SunRail’s cost risk was reduced by having more than 75% of the FFGA known or committed through contracts and advanced design for remaining bid items prior to the FFGA application.
- SunRail’s schedule risk was reduced through ownership of the corridor, a contract with Amtrak to maintain vehicles at the Amtrak facility near the SunRail facility, the inclusion of a new dispatch center, and the adoption of CSXT construction standards rather than creating new ones for FDOT.

HARTFORD LINE (CT & MA)

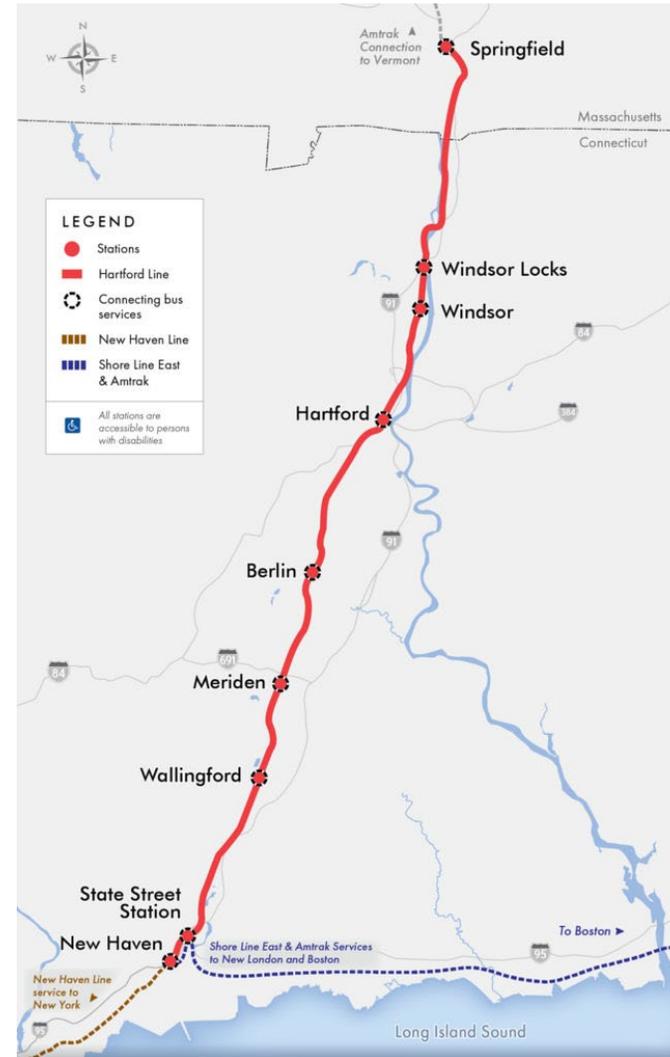
Overview

The Hartford Line is a regional rail service operating between New Haven, CT and Springfield, MA via Hartford, CT. Service commenced on the entire 63-mile corridor in June 2018, serving the 1.9 million residents of central Connecticut and southwest Massachusetts. For the development and construction of the project, the capital funding breakdown was about 17% Federal Railroad Administration (FRA) High Speed Intercity Passenger Rail (HSIPR) Program funds (as part of the American Recovery and Reinvestment Act) and 83% state funds.

Currently, there are nine stations along the line, and four infill stations are in development. On weekdays, 18 round trips operate between New Haven and Hartford. Of these 18 round trips, 12 also operate between Hartford and Springfield. On weekend days, 14 roundtrips operate between New Haven and Hartford, with 11 also operating to Springfield. Service is provided by a mix of Amtrak and CTrail trains operated by a single service provider (a joint venture of TransitAmerica Services and Alternate Concepts). On weekdays, eight of the 18 round trips are operated on Amtrak trains. On weekend days, six of the 14 round trips are operated on Amtrak trains.

The Hartford Line advertises a “one ticket, any train” policy for its customers, meaning any ticket may be used on any train between Springfield, MA and New Haven, CT, including intermediate stations. Amtrak tickets are accepted on CTrail Hartford Line trains, and CTrail Hartford Line tickets are accepted on Amtrak trains. Passengers must buy a separate ticket for connecting service bus, Metro North, Amtrak, and Shore Line East service in New Haven.

Figure 26 Hartford Line Map



Source: Connecticut Business and Industry Association

The original 63-mile rail corridor between New Haven and Springfield had previously been served only by six daily Amtrak round trips, but the majority of the corridor (about 39 miles) was single tracked. The majority of funding allocated to Hartford Line construction has been dedicated to double tracking and/or relaying track along the corridor. Combined, these projects (the last phases of which remain ongoing), are expected to cost \$1,202 million (2018 USD), making for an average cost of \$17 million/mile.

Once the portion of the corridor between Hartford and Springfield is double-tracked, Hartford Line administrators envision 25 round trips per weekday, resulting in 30-minute frequencies during peak travel times.

Schedule

The Connecticut Department of Transportation (CTDOT) experienced some delays during project development; however, these were largely the result of a new funding source—the Federal HSIPR Program—becoming available in 2008. In 2003, Connecticut initiated an Implementation Plan for Commuter Rail service in Connecticut, which was published in June 2005, and an Environmental Impact Analysis (EIA) of this new commuter rail service was initiated in 2008. Before this study was completed, however, President Obama and Congress created the HSIPR Program to support new intercity and high-speed passenger rail service. For the first time since Amtrak was created, the Federal government made funding available to support new intercity and high-speed rail investments.

The creation of this new funding source resulted in the FRA requiring the Hartford Line project to essentially restart from scratch. Connecticut, its partner states (Massachusetts and

Vermont), and Amtrak presented a new plan for a mix of intercity and regional trains along the corridor to the FRA in 2009. FRA and FTA supported the new plan, and the Hartford Line ended up receiving about \$190 million from the HSIPR Program. Since the conclusion of the HSIPR Program, the Hartford Line has received about \$14 million from the FTA for station renovations and a Rail Alternatives Analysis.

Once the development plan for the corridor was re-created to leverage HSIPR funding, CTDOT estimated that the line would begin operation in mid-2017. The actual opening date for the line was June 2018. This one-year delay was the result of more difficult than expected construction conditions in the railroad right-of-way: During the 1980s, Amtrak had stopped maintaining one track along much of the corridor in order to save money on maintenance costs, and as a result, some right-of-way required extra work during Phases 1 and 2 in order to be double tracked.

Costs

The first phase of Hartford Line construction was over-budget, but later phases of the project were on budget. Phase 1's capital costs were estimated by the FTA to be \$6 million/track mile, but the eventual cost of double tracking the Meriden-Newington corridor was about \$14 million/track mile. This large difference in cost was largely the result of the Amtrak union's mandated large crew size, which inflated costs. Later phases of the project took into account the higher costs associated with building on an Amtrak corridor, resulting in all subsequent phases remaining on-budget. The costs and sources of each phase of the Hartford Line project are presented below in Figure 27.

Figure 27 Hartford Line Funding Components

| Funding Component | Location | Cost | Federal Share | State Share |
|---|--|-----------------|-----------------|------------------------------|
| Phase I | Meriden-Newington | \$147.7 million | \$40.0 million | \$107.7 million |
| Phase 2 Implementing Grant | New Haven-Hartford | \$352.5 million | \$120.9 million | \$231.6 million |
| Phase 3A | Windsor | \$122.9 million | \$30.0 million | \$92.9 million |
| State Street Station | New Haven | \$18.8 million | \$10.0 million | \$8.8 million |
| Hartford Rail Alternatives Analysis | Hartford | \$4.9 million | \$3.9 million | \$1.0 million |
| Meriden TOD & Other Costs | Various | \$61.3 million | n/a | \$61.3 million |
| Phase 3B Design | Windsor – Springfield | \$27.5 million | n/a | \$27.5 million |
| Phase 3B Construction | Windsor – Springfield | \$186.6 million | n/a | \$186.6 million (not funded) |
| Phase 4 Design | (N. Haven, W. Hartford, Windsor, Windsor Locks, Enfield) | \$33.5 million | n/a | \$33.5 million |
| Phase 4 Construction | (N. Haven, W. Hartford, Windsor, Windsor Locks, Enfield) | \$246.0 million | n/a | \$246.0 million (not funded) |

Source: Connecticut Department of Transportation

Lessons Learned

The Hartford Line project team shared several lessons they learned that may be useful as GoTriangle develops the Wake-Durham commuter rail line:

- Today, the right-of-way where Wake-Durham commuter rail service is planned is served by several daily Amtrak services (Palmetto, Silver Star, Silver Meteor, Piedmont, and Carolinian). This presents the opportunity for the region to partner with Amtrak to provide commuter service between Durham and Raleigh in much the same way as CTDOT does on the Hartford Line. The project team cautioned that long-distance Amtrak trains are often very off-schedule due to delays caused by freight train interference, so this arrangement has resulted in some service reliability problems.
- Prior to the Hartford Line, Amtrak was “adamantly” unwilling to share intercity train travel operations with an additional service provider. The Hartford Line shows that interagency cooperation can successfully bring about a shared operating agreement with Amtrak.
- The Hartford Line project team emphasized the benefits of having a vocal supporter in the form of the state’s Governor. The project’s lifetime has spanned three different governors from both the Republican and Democratic parties. All three governors supported the project and made it a priority to pass bond measures in order to realize the project’s construction.
- The Hartford Line saved capital costs and were able to keep extra delays at bay by entering into a train leasing agreement with the MBTA. The majority of service along the line is operated by leased MBTA commuter rail trains; the rest of the service is provided by Amtrak trains.

Appendix B: Peer BRT Projects

TABLE OF POTENTIAL BRT PEER PROJECTS

| Service | Operation Year | Capital Cost/ Mile (millions) | Annual Operating Cost (millions) | Length (miles) | Bus Lane? | # of Lines (+ Planned) | Cross City Lines? |
|-------------------------------|----------------|-------------------------------|----------------------------------|----------------|-----------|------------------------|-------------------|
| Wake Transit (Raleigh, NC) | 2023-27 | \$23-29 (YOE \$'s) | \$14 (2024 \$'s) | ~20 | Mostly | 4 | Yes |
| Peers Used in MIS | | | | | | | |
| HealthLine (Cleveland, OH) | 2008 | \$28.1 | \$8.2 | 7.1 | Yes | 1 | No |
| Orange Line (Los Angeles, CA) | 2005 | \$26.9 | Unk | 18 | Yes | 1 | No |
| EmX (Eugene, OR) | 2007-17 | \$7.1 | Unk | 28 | Mostly | 2 | Yes |
| Swift Green (Snohomish, WA) | 2009-24 | \$6.0 | \$6.2 | 12.5 | Some | 2 (+1) | Yes |
| ART (Albuquerque, NM) | 2017-19 | \$15.2 | \$6.2 | 14 | Yes | 1 | No |
| Other Potential Peers | | | | | | | |
| Red Line (Indianapolis, IN) | 2019-23 | \$7 | \$8 | 13.5 | Mostly | 1 (+2) | No |
| GRTC Pulse (Richmond, VA) | 2018 | \$8.5 | Unk | 7.6 | Some | 1 | No |
| sbX (San Bernardino, CA) | 2014 | \$12.2 | Unk | 15.7 | Some | 1 (+9) | Yes |
| UVX (Central Utah) | 2018 | \$14.5 | Unk | 11 | Mostly | 2 (+2) | Yes |

INDYGO RED LINE (INDIANAPOLIS, IN)

Overview

Opened in 2019, the Red Line is Indianapolis's first BRT project. IndyGo operates the service on a 13.5-mile corridor with 28 stations, serving 60,000 people and 136,000 jobs. The bus runs on dedicated lanes for most of the route, and about a third of stations are on the side of the street and two-thirds are in the center of the street. The Red Line is the first of three corridors planned for Indianapolis; the Purple Line will open in 2022 and the Blue Line in 2024.

The total capital cost for the red line was \$96.3 million, or \$7 million per mile, funded 80% from an FTA Small Starts Grant and 20% from local revenues. The annual operating cost is predicted to be \$7 or 8 million. The service currently runs every 10 minutes all day on weekdays and every 15 minutes all day on weekends. The average weekday boarding in September 2019 was 7,700 riders per day.

Schedule

The development and construction of the Red Line took 4.5 years, which is about three quarters of a year later than initially estimated. After decades of trying to build light rail in Indianapolis, the City shifted its focus to BRT in the early 2010's. Project development for the Red Line started in 2015, with an opening date in Autumn of 2018. By August 2017, the opening date was pushed back to mid-2019, which was in line with the actual opening date in September of 2019. Figure 29 shows the schedule at different points of the project.

Delays were largely due to local and federal politics. In 2017, the project stalled for six months since the City did not want to

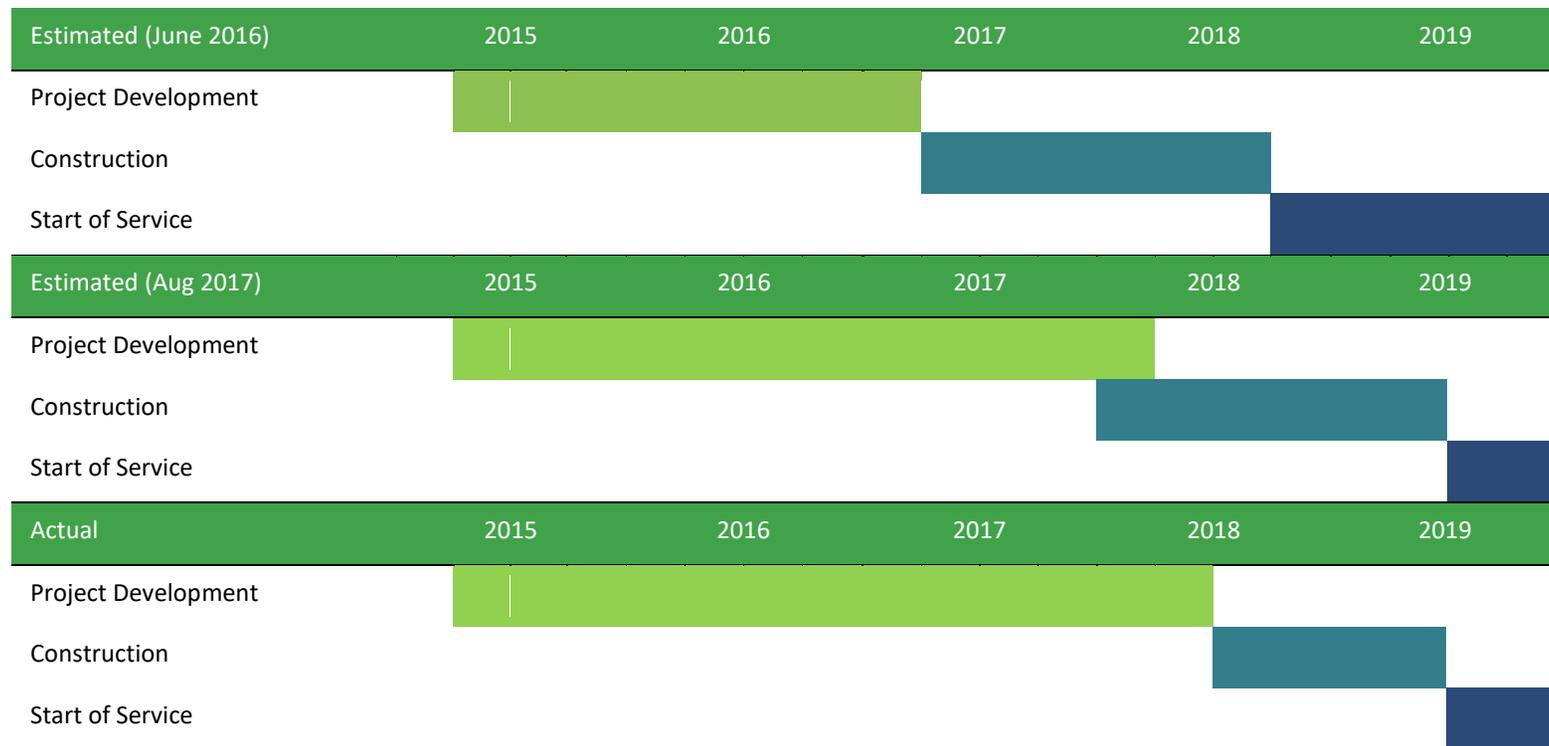
proceed further with the project until receiving funding recommendations from the FTA. Once the bids were selected, IndyGo experienced a four-month delay in receiving the grant due to the change in the federal administration. Construction time, on the other hand, was shortened to prevent the open date from further delays. Construction bids came in lower than expected, so IndyGo was able to spend their extra and contingency funds on overtime labor to speed up construction.

Figure 28 IndyGo BRT Map



Source: IndyStar

Figure 29 IndyGo Red Line Schedule Changes



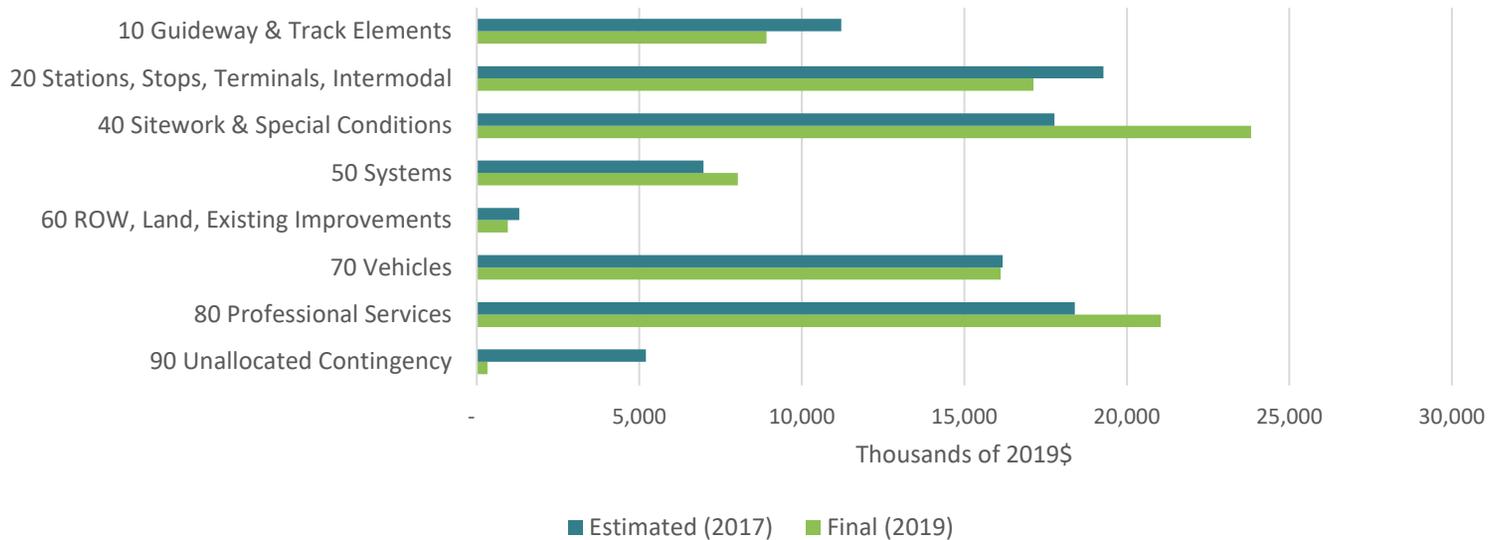
Source: IndyGo Staff

Costs

IndyGo maintained a budget of \$96.3 million while building the Red Line and finished on budget. As shown in Figure 30, guideways and stations were less costly than estimated, while more of the budget was spent on sitework and professional services than expected. All the unallocated contingency was spent as well. A significant portion of the savings in construction and the unallocated contingency was used on overtime labor to speed up construction, which mostly went into the labor-intensive sitework.

In talks with the FTA, the agency wanted IndyGo to increase its initial 12-15% contingency to 15-30% (depending on phase). Since IndyGo wanted to stick to the budget, it instead reduced the project scope by making some low priority components, such as snow melt coils in the station platforms, into bid alternatives rather than mandatory. Since IndyGo ended up not using the entire contingency budget, most of these low priority components were added back into the scope.

Figure 30 IndyGo Red Line Estimated vs Actual Costs by Standard Cost Category



Source: IndyGo Staff

Lessons Learned

The Red Line project team shared the following lessons learned from their BRT development process:

- Agencies should always plan for more time, especially with FTA funding and local politics.
- Splitting contractors into two contract packages can lead to better expertise and potentially lower costs. One engineering firm can rarely do both roadwork and station-work at a better quality and price than two separate firms.
- While planning for multiple BRT routes, gaining FTA trust will make the project go smoother. The FTA wants to see multiple agency staff dedicated to the project, not just consultants.
- Level boarding requires tight tolerances, and the same contractor should first build the stations, then install bus pads on the road.
- Center stations are better than side stations, since building one two-sided station is cheaper than building two stations. They are also a more efficient use of space and better received by the public.

SWIFT BRT (SNOHOMISH COUNTY, WA)

Overview

Swift is a BRT network in Snohomish County, WA, just north of Seattle. Community Transit opened the Swift Blue Line in 2009, and the Green Line recently opened in early 2019. Swift buses run every 10 minutes during most of the day on weekdays, and every 15-20 minutes early morning and late nights, as well as weekends. A third line, the Orange Line, is in its project development phase and is set to open in 2024.

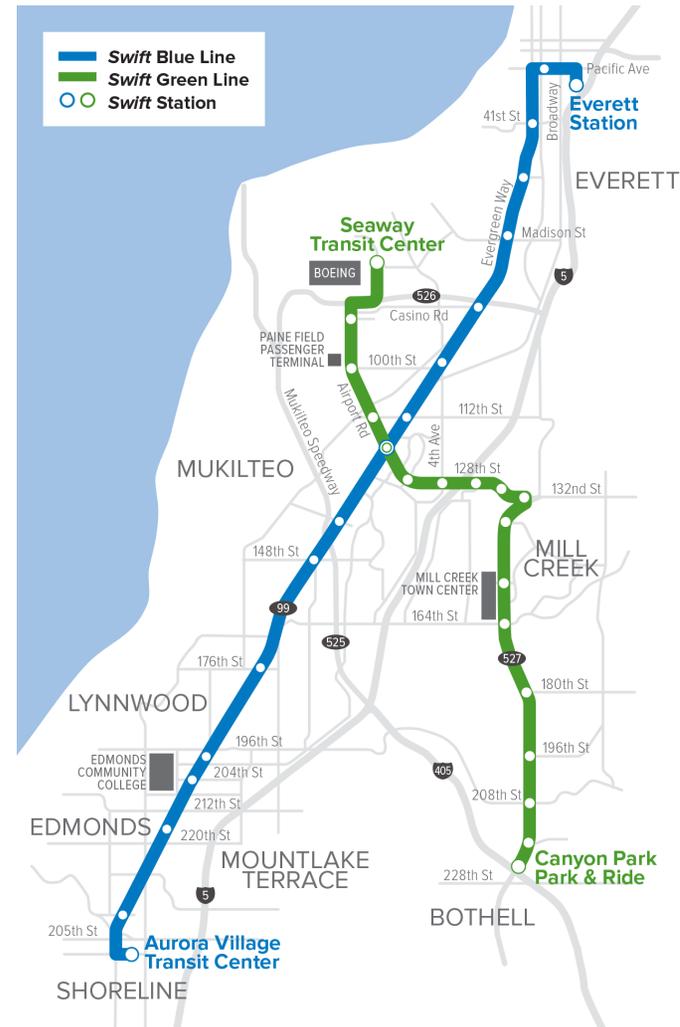
The Blue Line corridor is 16.7 miles and 17 stations, and the service currently has 6,000 daily weekday boardings. This route was entirely locally funded, at \$34 million total, or \$2 million per mile in 2009 dollars. The bus runs on existing Business Access and Transit (BAT) lanes, so Community Transit did not have to put funds into building new lanes. Operating costs for the Blue Line are about \$8 million per year.

The Swift Green Line is Community Transit's first FTA Small Starts project, so it serves as a peer to Wake County's BRT corridors. The corridor is 12.5 miles of queue jump and general traffic lanes, and there are 18 stations. Capital costs were \$73 million total, or \$5.8 million per mile, 65% of which was paid for by the FTA, 17.5% paid for locally, and 17.5% through a state matching fund. The Green Line currently has an average of 2,100 weekday boardings, and the number is growing. Operating costs are estimated to be about \$7 million per year.

Schedule

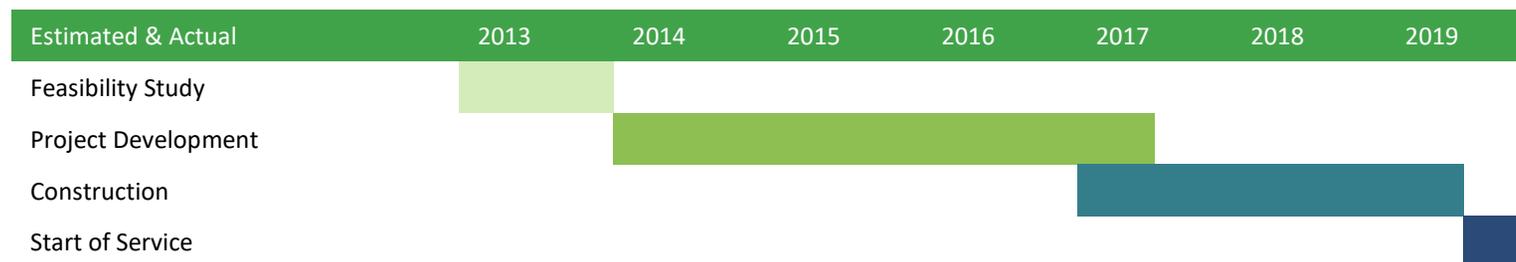
The Swift Green Line project mostly kept to Community Transit's estimated schedule (Figure 32), but the project required much effort to stay on schedule.

Figure 31 Swift BRT Map



Source: Community Transit

Figure 32 Swift Green Line Schedule



Source: Community Transit Staff

Community Transit submitted the FTA Small Starts Grant application mid-2014 and was approved at the end of the same year. However, once the Small Starts Grant was appropriated in Congress, they heard that grant execution would be delayed due to the change in federal administration. Community Transit applied for a Letter of No Prejudice from the FTA, which confirms the grant but does not guarantee the grant is coming, and then brought the letter to their Board to get permission to proceed without the federal funding available yet. As delays persisted, they applied for a second letter, which allowed them to continue until April 2018, when FTA finally gave them the funds.

Costs

In addition to sticking to the schedule, Swift Green Line also stayed within budget. Community Transit predicts that the project ended up \$2 million under budget, but they are in the process of closing out the project, so exact final cost is still to be determined. Figure 33 shows the expenditures by Standard Cost Category estimated during project development. Based on conversations with agency staff, construction generally went over budget, especially stations and the new transit center, while vehicles were

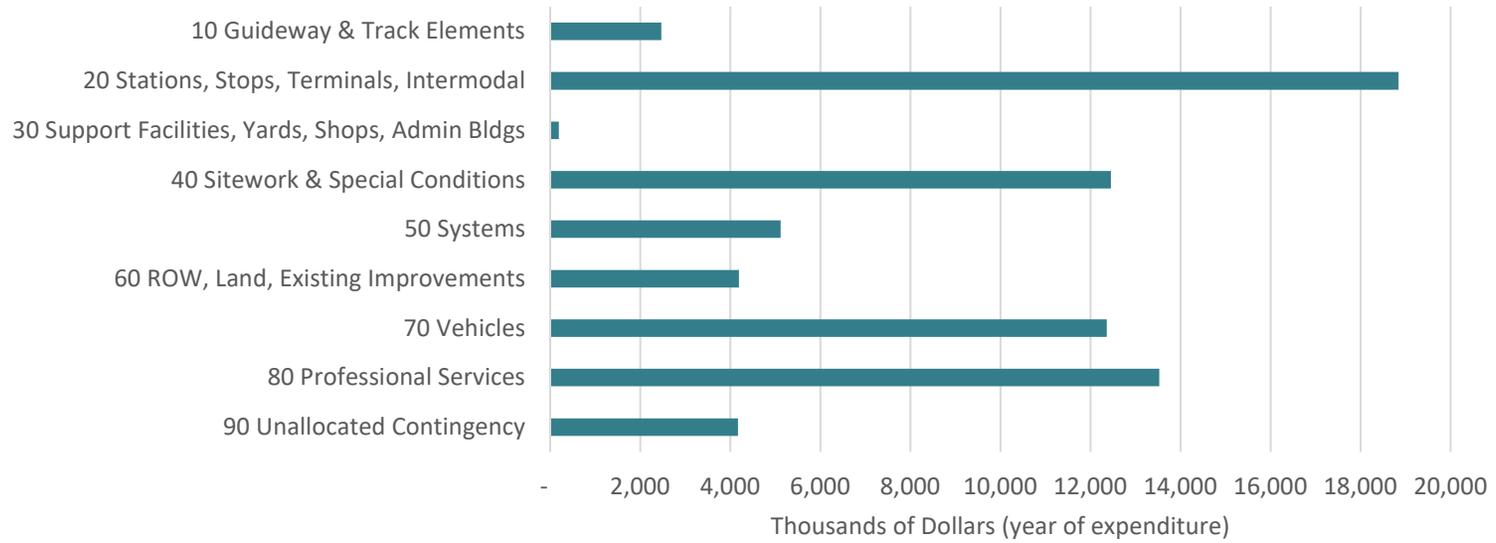
under budget. The agency used most of the unallocated contingency to combat construction costs.

Lessons Learned

Community Transit staff provided the following lessons learned from their experience with the Swift BRT system:

- The FTA planning process is rigorous and subject to change, including during project development. Agencies should add time in their schedule if using FTA funds.
- The FTA is now more likely to approve a Small Starts Grant with a 50/50 split, rather than 65/35, so Community Transit is only requesting 50% for the Orange Line.
- Concrete pads are crucial for stations for durable level boarding but adds time and complexity.
- Construction will generally go over budget, so agencies should follow FTA's request to increase the contingency.
- Splitting the construction bids into different packages may make the project easier to manage.

Figure 33 Swift Green Line Estimated Cost by Standard Cost Category



Source: Community Transit Staff

ART (ALBUQUERQUE, NM)

Overview

The Albuquerque Rapid Transit (ART) is a Gold-Standard BRT service in Albuquerque, NM, operated by ABQ Ride, the city's transit department. The service operates along the center of an 8.5 mile corridor, and continues with lower-frequency service along two legs, one 5.4 miles (Green Line) and the other 3.7 miles (Red Line), as shown in Figure 34. The main trunk has 19 center stations with level-boarding and off-board fare payment. Buses run every 7 to 10 minutes on weekdays from 5:30AM to 10PM (with Fridays to 11PM), every 10 minutes on Saturdays from 5:45AM to 11PM, and every 15 minutes on Sundays from 6:15AM to 7PM. The station catchment population for ART contains 74,024 residents and 81,157 jobs.

The service began partial operation in November 2017 and full operation in November of 2019, delayed due to vehicle issues. The capital cost for the project was \$133.67 million total, or about \$15.2 million per mile. 55% of the funding was from an FTA Small Starts Grant, 25% was from other federal grants, and 20% was funded locally. Operating costs are estimated to be about \$6.2 million annually.

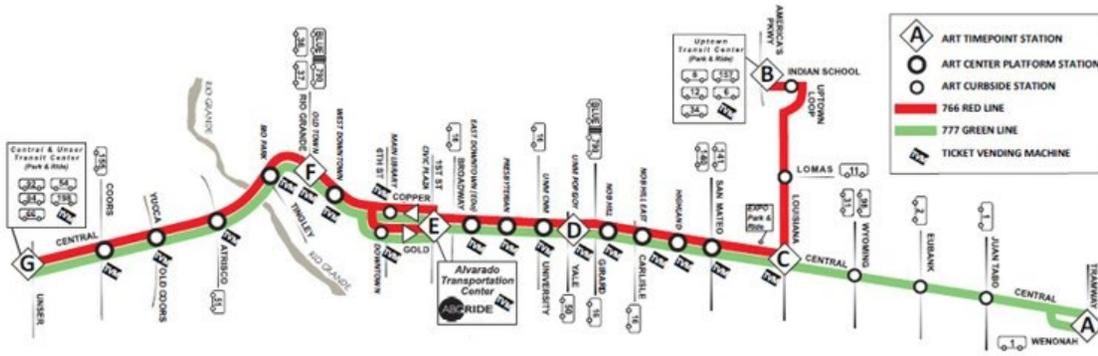
Schedule

Project development and construction of the ART corridor and stations were mostly on schedule, but the service experienced major delays in its official opening date due to issues with the battery electric buses ABQ Ride was planning to use. Figure 35 shows the changes to the schedule at different points in the project.

In 2015, ABQ Ride expected to start service in mid-to-late 2017. After designs and scopes were refined and an all-electric vehicle fleet was selected for the project, the timeline shifted by a few months for an expected opening in late 2017. However, near the end of 2017, the city began experiencing issues with the battery electric buses and their manufacturer. Only 15 out of 20 buses ordered had been delivered. The buses experienced mechanical malfunctions during test runs, such as bolts flying off doors and air conditioning outages. The batteries also did not charge as expected, and buses could only go 177 miles before recharging, rather than the expected 275 miles.

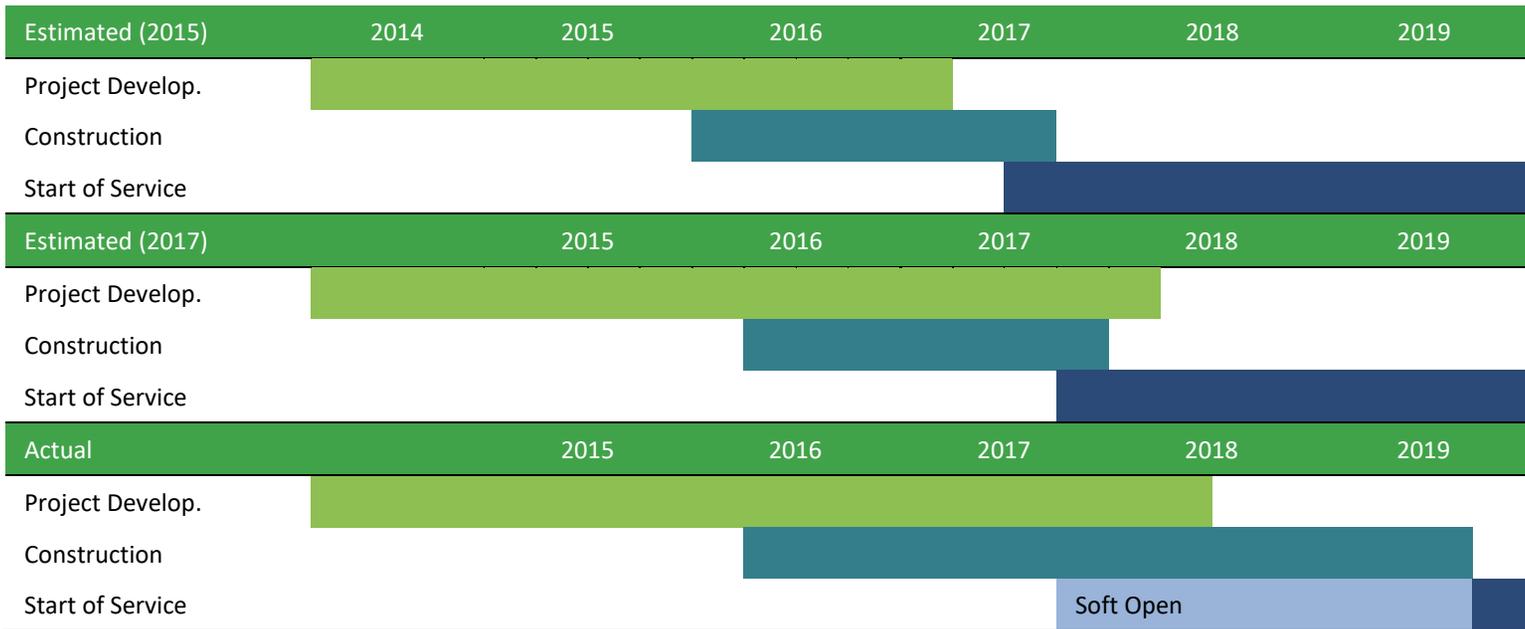
The service still had a soft opening at the end of 2017 since construction on the stations and dedicated bus lanes had finished and the mayor was at the end of his term. For the next two years, local buses ran along the corridor. The city sued the battery electric bus manufacturer and ordered new diesel buses instead. Those buses were delivered 18 months later, and ART finally opened for service at the end of 2019.

Figure 34 ART Map



Source: ABQ Ride

Figure 35 ART Schedule Changes



Source: FTA Albuquerque Rapid Transit Project Profile, ABQ Ride

Costs

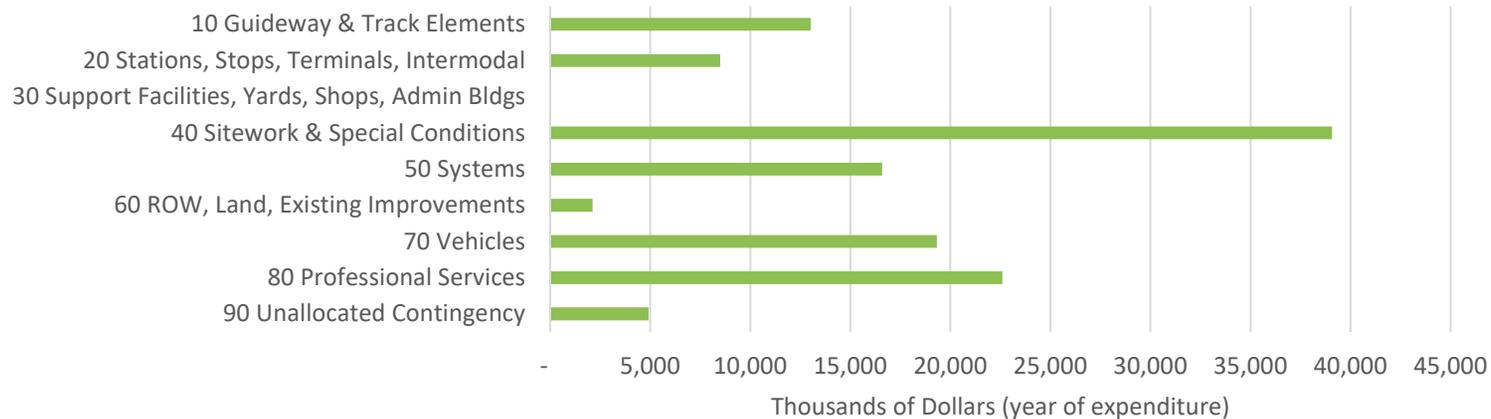
Costs increased slightly through the planning process of ART. When ABQ Ride submitted their FTA Small Starts Grant proposal in 2015, they estimated the total cost to be \$126.16 million, shown by Standard Cost Category in Figure 36. By the next year's FTA Small Starts evaluation, costs had risen to \$133.67 after finalizing the design and selecting to use an all-electric vehicle fleet. The Small Starts funding request also increased slightly, as did the size of the FTA grant. ABQ Ride maintained this budget to the end of the project.

Lessons Learned

The development process of ART provides the following lessons learned for the City of Raleigh and Wake Transit:

- The timeline was rushed so that the project could open by the end of 2017, which was the end of the mayor's term. This led to unintended consequences that could have been avoided with a longer process and timeline:
 - The entire corridor was constructed all at once, rather than in phases, which was economically disruptive to the city's central corridor.
 - More public outreach would have been helpful, especially since many businesses were impacted or were perceived to have been impacted by the construction.
- Battery electric buses are complicated to implement.
- If possible, use physical separation between the bus lane and car lanes. When full BRT service started, there were many cars in the bus lane, as well as car/bus crashes, especially while turning at intersections.

Figure 36 ART Estimated Cost by Standard Cost Category



Source: ART Standard Cost Category Workbook (2015)

