Wake County’s Transit Choices
A Wake County Transit Investment Strategy Report
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Chapter 1: Introduction

The Wake County Transit Investment Strategy seeks to define a new vision for transit in one of America’s fastest growing and most dynamic urban regions.

The ultimate outcome of this study will be a financially-constrained transit network expansion plan for Wake County, North Carolina. It will be considered for approval and funding by the Wake County Commissioners, Capital Area Metropolitan Planning Organization Executive Board, and Triangle Transit Board of Trustees. This plan could form the basis for a voter referendum to fund the transit system expansion.

Wake County’s Transit Choices is the first report in the study. It presents the known facts about the region, its economy, and its transportation demand, and also explores the nature and relative costs of the transit tools and how they might be applied.

The last chapter of this report synthesizes that material to present a series of questions that Wake County citizens and elected officials must think about in deciding their own transit future.

The study is led by Wake County and in partnership with:

- City of Raleigh
- Town of Cary
- Triangle Transit
- Capital Area Metropolitan Planning Organization (CAMPO)
- Research Triangle Foundation
- NC State University
- Raleigh-Durham International Airport
- Outlying and unincorporated areas of Wake County (represented by the county in decision-making)

The remaining tasks of the study will be as follows:

- Governance Framework – This will be a list of recommended actions that could be completed to address existing and future governance concerns.
- Finance and Investment Strategy – This strategy will show how a future plan would be funded, along with currently available resources and potential and realistic future funding sources.

- Transit Network Service Plan – Defining the proposed transit plan will be the bulk of the study effort. This process will integrate technical analysis and discussions with key agencies and the broader public. It will include a phase where multiple alternative networks are presented for public discussion, and where the feedback will provide direction on the shape of the final plan.
Chapter 2: How We Got Here
2. How We Got Here

History should not be our sole guide in planning for the future. However, some readers may find it helpful to review how public transit in Wake County arrived at its present form, with four major fixed route agencies and one rural access service operating in different areas. This chapter briefly describes the existing agencies, with more detail provided in Appendix C. This chapter also reviews the past planning efforts leading up to the present study. The chapter concludes by reviewing this study’s mission, and how it will both build on, and differ from, the previous ones.

The timeline shown in Figure 1 summarizes the history of transit planning in Wake County, from its inception in 1997 through 2014. More detail about the history prior to 2011 is in Appendix C.

**Public Transit Providers**

There are four fixed-route transit providers serving Wake County:

- **City of Raleigh Capital Area Transit (CAT)** is funded by the City and primarily provides service within Raleigh and to adjacent destinations.

- **North Carolina State University Transit (Wolfline)**, funded by student fees, provides services on and between the various NC State campuses.

- **Town of Cary Transit (C-Tran)** is funded by the Town and largely provides circulation within Cary.

- **Triangle Transit** operates service connecting Raleigh, Cary, and the RDU Airport with all-day service, and Garner, Morrisville, Wake Forest, Apex, Knightdale, Wendell, Zebulon, and Fuquay-Varina with peak period commuter services. Connections to Durham, Chapel Hill, and Research Triangle Park are available through Express routes or connections at the Regional Transit Center.

- **Wake County Transportation and Rural Access (TRACS)** provides demand-responsive service to outlying areas.
2. How We Got Here

Major Transit Projects Considered from 1997 to 2011

The Triangle region’s initial project in 1998 was a proposed rail line connecting Durham, RTP, Cary, NCSU, downtown Raleigh, and north Raleigh with service every 15 minutes during peak periods, and every 30 minutes off-peak. In 2006, when it became clear that the proposed project would not be competitive for federal funding under the rating system in effect at that time, the project was withdrawn from consideration for federal and state funding.

The Special Transit Advisory Commission (STAC) was an advisory group of elected officials and stakeholders appointed by the Capital Area Metropolitan Planning Organization (CAMPO) and the Durham-Chapel Hill-Carrboro (DCHC) MPO to determine the next steps on transit. Four key elements came out of this group:

• The plan to connect the region with rail is reaffirmed
• More local money is needed (such as a 1/2 sales tax)
• Bus expansion in early years is important
• Connecting the region with rail must be completed in phases

The 2011 Alternatives Analysis studied three corridors in the region:

1. Durham-Orange Corridor – This project led to the Durham-Chapel Hill light rail project now under development.
2. Durham-Wake Corridor – This proposed 37-mile commuter rail line follows the NCRR corridor from the Duke Medical Center in Durham, through the Research Triangle Park, Cary, Raleigh, and Garner to the Wake-Johnston County Line.
3. Wake Corridor – This study extended from Research Triangle Park along the NCRR corridor to downtown Raleigh, where it turns northward, continuing on the CSX corridor almost to Triangle Town Center.

Draft Wake County Transit Plan (2012)

The 2012 Wake County Transit Plan began with the assumption that an increased ability to get around and be connected, specifically through transportation options, is an important element in maintaining and strengthening the local economy. Population and employment in Wake County had been growing and was projected to continue to grow. Existing bus ridership had also grown annually, but the report notes that bus service may not have been adequate based on anticipated growth rates. A multi-modal strategy of buses and trains was proposed to build a more complete transportation system.

The Wake County Transit Plan strategy took the recommendations from the previous plans and organized them into two potential funding scenarios:

• The Core Transit Plan is based on funds that can be predicted with confidence assuming local voter approval. This includes money available through local funds, assuming addition of a ½-cent sales tax, additional $10 vehicle registration fee per car, and rider fares. It also includes existing basic federal and state funding that is currently available. The commuter rail portion would require a funding partnership with Durham County. Plan elements include new and expanded bus service, shelters, and park-and-ride lots, particularly in the short-term (2013-2017). Commuter rail service would be added in a longer-term horizon.
2. How We Got Here

(2019-2020) since rail transit typically takes longer to plan and design, and is more expensive than bus service. Commuter service is proposed in the existing NCRR right of way for 37 miles from Garner to West Durham, with 12 stations.

• The Enhanced Transit Plan assumes that a new federal and state funding source will be available. Elements include light rail service in addition to the same services included in the Core Transit Plan. Light rail service is proposed between downtown Cary and north Raleigh, covering 13.9 miles with 16 stations. Light rail service would require additional time to secure appropriate funds, and is projected to be operational by 2022 at the earliest.

Two interlocal agreements (ILA) were proposed to govern the Plan, one ILA between the County and the 12 municipalities, and one ILA between the County, Triangle Transit, and CAMPO. The ILAs would establish Triangle Transit as the agency responsible for implementing the approved Plan, and require that future plan updates and amendments be approved by the Triangle Transit Board of Trustees, the Transportation Advisory Committee of CAMPO, and the Wake County Board of Commissioners.

Events Since the 2012 Draft

In 2012, Triangle Transit and Wake County staff presented the draft Wake County Transit Plan to each municipal board. Each municipal board was again informed that they will be asked to sign an ILA.

There was general agreement among stakeholders and the public that although the plan had many positive aspects, it did not fully reflect the direction the County wanted to move in. Questions remained regarding other options that had not been considered. Several stakeholder groups submitted specific comments or concerns related to the report, and the plan has been on hold until further studies can be completed.

The Wake County Board of Commissioners released a list of questions about the draft plan. Many of the questions requested general clarification, but some raised concerns about the technical and financial feasibility of the plan.

In December 2012, CAMPO approved the 2040 Metropolitan Transportation Plan (MTP), which incorporated projects from the Draft Wake County Transit Plan but based the implementation schedule on federal horizon years to allow further community discussion on transit investment. This was a joint plan with the DCHC MPO.

In June 2013, the NC Legislature implemented House Bill 817, Strategic Transportation Investments, which changed NCDOT’s Strategic Prioritization process and funding policy in a way that impacts and limits public transportation funding.

The Regional Transportation Alliance (RTA), a Chamber of Commerce-based business group, developed a paper entitled “Research and Observations on Transit in Other Markets, and a Proposal for a Bus Rapid Transit-Based Approach as an Alternative to the Current Draft Plan” (draft, August 2013). The paper rejected the framework of the draft 2012 Wake County Plan, instead recommending that Bus Rapid Transit (BRT) options be developed for multiple corridors to provide a comparison of investment costs and benefits.

In September 2013, the Wake County Board of Commissioners convened a transit panel of three recognized national transit experts. These experts had concerns about how the resources were allocated and
2. How We Got Here

potential options and solutions that had not been considered.

At the November 4, 2013 County Commissioner meeting, the Chair of Triangle Transit’s Board of Trustees asked that the Draft Wake County Plan be “refreshed” based on the age of the plan.

In May 2014, another national transit expert was brought in by the Urban Land Institute (ULI) to provide a small-group workshop and presentation. Reviewing the Draft Wake County Transit Plan and the status of national and international transit investment, this expert noted concerns with the amount of resources focused on light rail and the lack of service vision (i.e. how investment will provide better access to communities in the county).

Based on this input, the Wake County Board of Commissioners decided to launch the current project, the Wake County Transit Investment Strategy, to take a fresh look at current information, opportunities, and next steps considering local needs and available county-wide funding sources.

Role of This Study

As the previous sections make clear, Wake County has seen an abundance of transit studies. The work has not been as repetitive as this summary may sound, because each study has built on the previous ones, framing past analyses and adding new ones.

At the same time, ideas proposed in earlier studies have met objections that have caused the need for rethinking. Every study is based on assumptions and sometimes these assumptions change. Up to a point, this is a normal part of a democratic planning process. However, it is understandable that many Wake County residents feel frustrated at the ratio of study to action when it comes to transit issues.

The Wake County Transit Investment Strategy was initiated to restart the conversation about the future of transit in the County. It does not reject previous work, but incorporates it to the extent that it is relevant to the goals of the new study.

Since the Draft Wake County Transit Plan was completed in 2012, many members of the public, local and state agencies, and advocacy groups have voiced concern over the assumptions and conclusions of the draft Plan. The purpose of the current study is to take a step back from the detailed transit planning process, beginning instead with development of a strategy for identifying and allocating transit investments.

The many past efforts related to transit planning have continued to improve local and regional transit options, but have not established a consensus on the viable long-term, strategic investment strategy for Wake County.

As part of this process, the conversation will be broadened to include more stakeholders and members of the public. Past ideas, proposals, and studies will be reviewed and evaluated. Opportunities and issues will be identified and discussed in detail. Finally, concepts, strategies, and scenarios for transit investment will be recommended.
Chapter 3: What We Know Now
3. What We Know Now

One of the main reasons to invest in transit is to manage the impacts of major change. Wake County residents know that their region is growing and changing fast. Some view this with eager optimism, but others have concerns about the effect of this growth on their ability to have the kind of lifestyles, communities, and opportunities that they value.

This chapter explores how Wake County lives today but especially how it’s growing and changing in ways that are relevant to transit access. Many of these changes are in directions that tend to lead to higher demand for transit and higher levels of public interest in having a good transit system. These include direct impacts – such as the higher demand arising from more people living in the region – as well as indirect impacts that could be even larger in ultimate magnitude. Indirect impacts include anything that will change the factors that guide someone’s choice of how to travel, such as:

- More urban and walkable styles of development, which are more conducive to cost-effective and attractive transit.
- Severe traffic congestion (even if all funded roads are built) that always increases demand for transportation alternatives. Similar pressures will apply to parking, making it either more expensive or harder to find.
- Advances in technology for transportation, communications, and information.
- Increased or more volatile prices for car ownership, fuel, etc.

Many of these are impossible to predict, so it is important to think not just about one projected future but also about the region’s ability to prosper in a range of possible futures – in a word, resilience. A resilient city relies not just on a single prediction of these unknowns, but on thinking about how to thrive in a range of possible futures.

How We Live and How We’re Growing

Wake County Demographic Trends

At nearly 1 million people, Wake County is the 7th-fastest-growing, large urban county in the US (of counties with more than 500,000 in population). Wake is also the fastest growing county in North Carolina, and includes two of the ten most populous municipalities in the state.

The County is estimated to increase in population by 62 people per day, about 2/3 of which results from net migration into Wake County.

Figure 2: Wake County Population Growth (Data Source: NC OSBM State Demographics, October 2014)
3. What We Know Now

From 1980 through 2010, U.S. Census Bureau figures show that Wake County grew by roughly 600,000 people. As of July 1, 2013, the U.S. Census Bureau estimated 974,289 residents in Wake County, and trends indicate that the County will exceed 1 million people in 2015.

As Figure 2 shows, estimates from the State’s Demographics branch put the county at 1.2 million people by 2025.

Age is an important indicator for transit to respond to, because the youngest and oldest among us do not have the option of driving. Of particular concern is the “age dependency ratio,” which is the population under 18 or over 65, divided by the population between those ages. The ratio has consequences in many areas of public policy, because youth and seniors tend to be net consumers of public resources, paid for largely by taxes on working-age adults.

The ratio is rising in Wake County (Figure 3). Long term trends for the US suggest that the ratio will continue to rise, although the effect may be mitigated if seniors remain vigorous and retire later in life.

The density mapping presented here must be viewed with some caution, however, because what really matters to most transit is the density right around a stop. In areas where most transit access is by walking, the big zones used in population and employment mapping may not capture this precisely. For example, a huge apartment complex right on a transit line signifies very high density of demand, but if it is in the same analysis zone with many low-density subdivisions, the average density of the zone may appear low even though transit potential is high.1 A good rule in viewing these maps is that very large zones of one

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1. This is also why the average density of an entire urban area says little about the area’s transit potential. What matters is how much density there is around potential transit stops.
3. What We Know Now

color are more likely to be misleading about the exact transit potential.

With this caution, Figure 4 on page 14 and Figure 5 on page 15 are maps showing density of population and employment. In Wake County, significant population density exists around the center of Raleigh and north of downtown between the I-40/440 and I-540 freeway loops. Smaller pockets of population density are found in Cary and Garner.

Employment density is similarly most concentrated in central Raleigh, particularly between downtown and NC State.

Other major sites of employment density include near Research Triangle Park, several major hospitals, and along the Capital Boulevard corridor.

Density is a critical measure of a place’s ability to support transit because it allows us to compare the relative concentration of people in areas of the city. Where there are more people living or working per unit area, there are more people who can choose to use transit.

Projected Development

Existing density does not tell the entire story of why and where transit may be needed. After all, the speed of current growth in Wake County means that the data used in these maps (2008-12 for residential, 2010 for employment) is already somewhat out of date.

What is more, transit helps to support further development of high-density and walkable communities in areas where local government wishes to encourage them. Maps of existing density are therefore not the whole story; they indicate where the community is now, but do not reflect how it could be further shaped by high-quality transit services.

Because of the rapid growth rate in Wake County, the plans for where growth will occur will have a major impact on the potential for transit to succeed. Transit, in turn, can be expected to increase the viability of the urban (dense and walkable) forms of development that are currently planned, particularly if that type of development is designed in a way that is sensitive to the qualities that can help transit succeed as a competitive travel mode.

Development in Wake County is guided by planning and zoning documents of the cities and the County. Some cities have plans encouraging density and other transit-oriented characteristics in various locations, usually places that are already favorable to transit.

In addition to existing development and currently developing areas of the county, many large mixed-use developments are proposed and/or in early development stages in Wake County. These include Veridea in Apex, 5401 in Raleigh, and Wendell Falls in Wendell, just to name a few. These developments and many others are part of the story of future transit needs in Wake County.
3. What We Know Now

Figure 4: Population Density Map

Data Source: American Community Survey 2008-2012 5-year estimates

Population Density (people/sq mi)
- 100-2500
- 2500-5000
- 5000-10000
- 10000-24550 (max)

County Lines
3. What We Know Now

Figure 5: Employment Density Map
3. What We Know Now

People in Poverty

Figure 6 on page 17 shows the density of people in poverty. This information is important because transit is sometimes asked to focus some degree of its resources towards enhancing mobility for low-income people.

The highest concentrations of people in poverty in Wake County are found in the census block groups containing the various public housing developments. More generally, higher densities of people in poverty are found in southwest Raleigh (likely influenced by the presence of many NC State students) and the east side of Raleigh, roughly between downtown and the inner freeway loop.

Median Income

The median annual household income in Wake County as of 2013, as estimated by the US Census, is $66,006. Figure 7 on page 18 shows the median income for each of the block groups within Wake and surrounding counties. Median income is illustrated both to provide general information across the county, and as a method of identifying low-income areas, particularly those where people are not concentrated at high densities.
3. What We Know Now

Figure 6: Density of individuals in poverty
3. What We Know Now

Figure 7: Wake County Median Income Map

Median Income of Households
Wake County’s Median Income = $66,000

- Less than $30,000
- $30,000 to $50,000
- $50,000 to $80,000
- $80,000 to $120,000
- $120,000 to $233,438 (max)
- Less than 200 people / sq mi
- 200 to 500 people / sq mi
- No data

Data Source: American Community Survey 2008-2012 5-year estimates
3. What We Know Now

Zero-Vehicle Households

4.6% of households in Wake County have zero vehicles available to them. Zero-vehicle households are important to transit because without regular access to a personal automobile, people must find other reliable ways to get around. According to a 2011 Brookings Institution analysis\(^2\) of US Census data on vehicle ownership, commuting rates, and household income, these households are both more likely to be low-income and more likely to commute via public transit than other households.

Figure 9 on page 20 displays the rate of households with zero vehicles for block groups in Wake and surrounding counties. The areas with the highest rates (above 41%) are found near the center of Raleigh, Chapel Hill and Durham, particularly near the three major universities; there are also numerous block groups in the 18-41% range in central Raleigh within the I-40/440 freeway loop. Areas with relatively high rates of zero-car households are scattered throughout Wake County, with particularly high rates near Zebulon, Fuquay-Varina, Garner, and in Raleigh along Falls of Neuse Road.

### Wake County Household Vehicle Availability

<table>
<thead>
<tr>
<th></th>
<th>Total Households</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households with no vehicles available</td>
<td>16,160</td>
<td>4.6%</td>
</tr>
<tr>
<td>1 or more vehicles available</td>
<td>332,467</td>
<td>95.4%</td>
</tr>
</tbody>
</table>

Figure 8: Wake County Household Vehicle Availability
(Data Source: ACS 2009-2013 5-Year Estimates)

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3. What We Know Now

Figure 9: Percentage of households with zero vehicles

Rate of zero-vehicle households (zero-vehicle households / households)

- 0% to 6%
- 6% to 18%
- 18% to 41%
- 41% to 86% (max)

Data Source: American Community Survey 2008-2012 5-year estimates

0 2 4 6 8 mi

County Lines

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3. What We Know Now

Wake County Diversity

Wake County continues to grow more racially and ethnically diverse. This factor typically is less relevant to transit. Where transit ridership seems to be related to race or ethnicity, it is often because of other factors, also tracking with race or ethnicity, that are better explanations.

Historically in Wake County, however, as in other areas of the country, minority populations have been underrepresented in the transit planning thinking. It is also possible that residents that have lived in places with more robust transit systems have different perspectives on transit and transit use.

As part of the enhanced public outreach element, the current transit planning process will reach out to racially and ethnically diverse populations in Wake County. Wake County also continues to grow more ethnically diverse. Minority population increased from approximately 34 percent in 2005 to 39 percent in 2013, as shown in Figure 10.

Figure 11 on page 22 is a map produced by the Weldon Cooper Center for Public Service at the University of Virginia, showing the population of the United States by race and ethnicity. This map uses a technique called “dot-density” to represent each person in a 2010 Census Block as a single dot, color-coded by the race or ethnicity by which they identify themselves. Where many dots are very close together, the overall density of people is higher. Where dots of a single color are predominant, people of a particular race or ethnicity make up most of the area’s population.

The highest densities of African American people are found in southeast Raleigh and Garner, with a smaller significant concentration in northeast Raleigh between the two freeway loops.

While people identifying as Hispanic make up 10% of the population of Wake County as of 2013, they are relatively dispersed. There are several small areas of Wake County where density of Hispanics is quite high – these are found in northeast Raleigh, near NC State (where population density in general is high), and in Cary near the intersection of Maynard and Kildaire Farm Road.

Population density of people identifying as Asian is greatest near NC State and in western Cary and Morrisville.
3. What We Know Now

Figure 11: Wake County Racial Dot Density Map (Courtesy of Weldon Cooper Center for Public Service at the University of Virginia)
Walkability
Most transit trips start out as walking trips. While some people will ride transit from park-and-ride lots or are dropped off at a stop, for most people, the trip begins when they leave their home and walk to a transit stop.

For transit, walkability is an important issue because it controls how easily people can access a stop. Simply put, if you cannot easily, quickly or safely walk to a stop, you are less likely to use the transit service available there.

The walkability of an area often centers around three aspects:

- Connectivity. Are there streets or paths available to walk between the transit stop and other places nearby?
- Infrastructure. Are there sidewalks or paths, and are these paths maintained and useable by people with varying levels of mobility?
- Crossings. Are there safe crossings available, so that both directions of the transit service are useful?

Wake County contains places that are both highly walkable (in that they incorporate these features) and places that are less walkable. Figure 12 on page 24 compares several locations around the county, describing pedestrian environments that make accessing transit easier or more difficult.
3. What We Know Now

Street connectivity

The gridded street network of downtown Raleigh makes it easy to reach many different bus stops (dots).

The lack of street connectivity along Creedmoor Road in North Hills, Raleigh, limits available walk paths to reach bus stops (dots).

Sidewalks

Sidewalks, represented by the blue-green lines, are available on many streets for riders to use to reach their bus stops (dots). Areas around Old Wake Forest Road in North Hills, Raleigh, provide plenty of sidewalks for riders.

Stretches of Capital Boulevard in Raleigh lack sidewalks (blue-green lines), forcing riders traveling to and from bus stops (dots) to walk along the shoulder of a busy arterial.

Crossings

This intersection in Southwest Raleigh includes marked crossings, allowing riders to easily reach their bus stops and destinations.

A lack of marked crossings along US-70 in South Raleigh makes it difficult for riders to reach their bus stops and destinations.

Figure 12: Walkability – Comparisons from Wake County
3. What We Know Now

How We Move
People get around Wake County in many different ways: on foot or bicycle, or by personal car, public transit, or taxi, to name just a few. These various options for getting around are called “modes.” This section discusses these modes in the context of Wake County.

Figure 13 displays data from the US Census on Wake County workers’ travel modes used for their journeys to work. It is important to note that the journey to work is not the only kind of travel or even the predominant one, but it is the one that the Census asks about. As a result, these data do not offer a full picture of peoples’ mobility needs and choices, but are the best data available. They do offer some useful insight into how mode choices are made.

Travel Modes
While the private automobile is the dominant commuting travel mode in Wake County, almost one in five commuters makes a different choice, and there are areas of the county where other modes are substantially more relevant.

### Transit
While transit is used by just 1.1% of commuters across the county to get to work, there are small areas – generally those with higher density, walkability, and transit service – where this rate is much higher. Figure 14 on page 26 maps the rate of transit commuting across Wake County and surrounding areas.

For example, in the residential areas south of NC State, which have frequent service via Wolfline, up to 21% of people use transit to get to work. Along CAT’s high-frequency corridors (Capital Boulevard and New Bern Avenue), surrounding block groups have transit commuting rates exceeding the county average, some greater than 10%.

Transit ridership, in short, is strongly responsive to transit service, and cannot be assessed in isolation from it.

<table>
<thead>
<tr>
<th>Travel Mode</th>
<th># Workers</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Alone</td>
<td>369,403</td>
<td>80.1%</td>
</tr>
<tr>
<td>Carpool</td>
<td>42,301</td>
<td>9.2%</td>
</tr>
<tr>
<td>Public transportation</td>
<td>5,264</td>
<td>1.1%</td>
</tr>
<tr>
<td>Taxicab</td>
<td>869</td>
<td>0.2%</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>703</td>
<td>0.2%</td>
</tr>
<tr>
<td>Bicycle</td>
<td>1,461</td>
<td>0.3%</td>
</tr>
<tr>
<td>Walk</td>
<td>6,861</td>
<td>1.5%</td>
</tr>
<tr>
<td>Work at home</td>
<td>30,717</td>
<td>6.7%</td>
</tr>
<tr>
<td>Other means</td>
<td>3,518</td>
<td>0.8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>461,097</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Figure 13: Wake County Workers’ Means of Transportation to Work (Data source: ACS 2009-2013 5-Year Estimates)
3. What We Know Now

Figure 14: Percentage of workers who travel to work by transit

% of workers’ journey to work by transit

Data Source: American Community Survey 2008-2012 5-year estimates

- 0-1%
- 1%-10%
- 10%-25%
- 25%-51% (max)
3. What We Know Now

ACTIVE MODES

Every transit rider is also a pedestrian, at one end of the trip, if not both.

Density is one indicator of strong transit potential, but another is the ease of walking in an area. Wake County includes apartment developments that are dense but not conducive to walking. While walkability really lies in the nature of the built environment, as discussed later in this chapter, one crude measure of walkability is simply how much walking is happening now. Cycling is also of interest, as areas that are favorable for walking tend also to be more favorable for cycling.

Active modes help to underscore the way that existing development patterns that favor walking (such as the historic street grid of downtown Raleigh) are combining with density to generate walk activity even now, especially where the development includes both residences and jobs in close proximity, as at NC State or inner-city Raleigh.

Active transportation modes (cycling and walking) are also used by a very limited number of commuters countywide (1.8%, either walking or cycling), but similarly, small areas can be identified where they are more relevant. Figure 15 on page 28 maps the percentage of workers traveling to work using active modes (cycling and walking).

In most of the geographical area of the county, commuting by active modes is minimal or nonexistent, less than 1%. Where densities are very low, destinations and job locations are likely to be far apart, requiring lengthy commutes not suited to walking or cycling.

However, in central Raleigh and the older core of Knightdale, higher densities and a greater mixture of uses generate a higher rate of use of active modes for commuting. In the Hillsborough Street corridor between downtown Raleigh and Blue Ridge Road, up to 26% of people commute to work by walking or cycling, and nowhere in this area is the rate below 10%.
3. What We Know Now

Figure 15: Percentage of Workers who go to work by walking or bicycling
3. What We Know Now

Traffic Volumes and Congestion
Where roads are projected to be highly congested in the future, people will be looking for alternatives, as evidenced by the experience of more congested cities. Congestion for 2010 is shown in Figure 16 on page 30, while projections for 2040 congestion are shown in Figure 17 on page 31. This data come from the Triangle Regional Model, and includes all TIP and LRPT road projects.

The most congested roads in Wake County are I-440, I-40, and many of the “spokes,” including US-1, US-401, and NC-50. By 2040, even with implementation of the fiscally constrained roadway projects included in the 2040 MTP, the congestion on these roads is expected to worsen. In addition to the roads currently congested, other roads will begin to exceed capacity during the peak periods including I-540, Wade Avenue, and more of the network inside I-540.
3. What We Know Now

Figure 16: 2010 Congestion Map
3. What We Know Now

Figure 17: 2040 Congestion Map

2040 Future Year Congestion
- Below Capacity (v/c < 0.80)
- At Capacity (0.8 < v/c < 1.0)
- Above Capacity (v/c > 1.0)

Source: Triangle Regional Model
3. What We Know Now

Travel Patterns

Figure 18 on page 33 and Figure 19 on page 34 display travel throughout Wake County based on data from the regional travel demand model, which provides daily vehicle volumes for intra- and inter-county trips in the Triangle region.

Figure 18 shows major zone-to-zone trips for Wake County. The highest traveled movements are between the inner Beltway and north Raleigh, north Raleigh and north-west Raleigh, and the inner Beltway and the Cary/Apex areas. There are also substantial volumes traveling between the outer rural areas or smaller municipalities and the more urban Raleigh and Cary districts.

Figure 19 presents the total number of trips within each district and the percentage of trips that are internal (trips that stay within the district) and external (trips that go to another district). North Raleigh and the Cary/Apex districts have the most even split of internal versus external. The area within downtown Raleigh is only 3% internal, indicating that approximately 3,000 of the 94,300 daily trips stay within that area. Most areas have a greater number of external trips than internal trips. The only exception is the Cary/Apex district, which retains 55% of the trips internally.
3. What We Know Now

Figure 18: Zone to Zone Travel Movements
3. What We Know Now

Figure 19: Travel Movements Within Zones Map
3. What We Know Now

Transit Service and Performance

Current transit in Wake County is limited. Apart from NC State circulators, only two lines run frequently all day, while even dense and transit-oriented parts of Raleigh are served only once an hour. Many developed areas are linked only at rush hour, including Knightdale, Apex, Wendell, Zebulon, Fuquay-Varina (effective January 12), and most of Garner and Morrisville. Two municipalities, Holly Springs and Rolesville, have no fixed route transit service at all.

Frequency: A Key Feature of Transit

Frequency means how many times per hour the bus comes to each stop on a route, or how many times per hour a person can board a transit vehicle at a stop. Frequency is a remarkably powerful feature of transit. In particular, the perception that service is always coming reasonably soon is fundamentally liberating to the potential customer. It allows both for complexly scheduled lives and spontaneity. The frequent transit line can be used more the way you would use a road, which is available anytime you need it, whereas infrequent services are more like occasional events around which you must arrange your life.

The more often a bus comes, the less time a customer will have to spend waiting, and the less their travel will be determined by a schedule.

Frequency also governs how easy it is to connect from one route to another, so it is a crucial “glue” that makes a pile of routes work together as a network. However, the more frequent a route is, the more expensive it is to operate.

Variation in frequency is a primary way that transit responds to different land use conditions. Compact, high-density development presents a good market for transit, since many people are available to use the service. If many people need to use the service, the capacity required by high-frequency may be needed. Low-frequency transit is a common response to low density, where some service must be available, but where high frequency is unlikely to generate productive ridership since few people are there to use the service.

Frequency is therefore an especially critical feature of transit, one that is often overlooked unless it is emphasized in mapping. Because of its high cost and transformative benefits, we emphasize frequency in all of our maps.

Showing frequency in this way allows us to view the overall level of investment in each route (as expressed through the number of trips per hour), as well as the usefulness of the service for customers.

For all bus service maps in this report and throughout this study, colors will have these meanings:

- **RED** means Frequent Service, defined as service that comes every 15 minute or more often, through both peaks and the midday. For the customer, these are the lines that can be used without consulting a schedule, where a bus is always coming soon. These are also the lines where it’s easy to connect from one line to another without schedules needing to be timed to one another.

- **BLUE** means every 30 minutes all day.

- **GREEN** means every 60 minutes all day. Most local service in Wake County is of this type, including most service within Raleigh. This frequency is so limited that the customer experience is one of planning your life around the bus schedule. Hourly service is usually attractive only to people with relatively few options, and is usually useless for generating high ridership.
3. What We Know Now

• **ORANGE** means peak-only, focusing on commuter service to major employment centers during the AM and PM rush hours.

Figure 20 on page 37 shows transit frequency for all of Wake County. Most of the urbanized area of the county is served by 60-minute routes or by peak-only express connections amongst the regional job centers and suburban municipalities. All-day service at better than 60-minute frequency is limited to Wolfline routes, CAT routes on Capital and New Bern, and CAT routes south of downtown Raleigh.

Outside of the urbanized area of the county, the TRACS dial-a-ride system provides basic access to transit for people who are not served by a fixed route. While this is a minimal service requiring a 24-hour reservation, TRACS performs an important function by guaranteeing that people in rural parts of the county have at least some sort of transit mobility. TRACS is shown in purple on the countywide map.

CAT, Triangle Transit, and C-Tran each provide paratransit services as well for persons with disabilities, though these are not open to other members of the general public as is TRACS.

Figure 21 on page 38 shows the frequency of routes inside the central area of Raleigh, roughly south of I-540, north of Tryon Road, east of Cary and west of New Hope Road. This inner area is where all of the existing high frequency service in the county is located, and where most of the high density residential and employment areas are found.

These maps reflect services provided as of December 2014.
3. What We Know Now

Figure 20: Wake County Transit Frequency Map

Wake County Transit Networks
Midday Frequency
- 15 min or better
- 16-30 min
- 31-60 min
- Peak express
- CAT routes
- Triangle Transit routes
- C-Tran routes
- TRAC dial-a-ride zones

See Central Raleigh Network Map

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Wake County Transit
Midday Frequency

- **15 min or better**
  “Transit is always there when I need it.”

- **16-30 min**

- **31-60 min**
  “I have to plan my life around the transit schedule.”

- **Peak express**
  “Only for commuting at rush hour”

- **One way route or segment**
  “I can get there, but it’s sometimes hard to get back.”

CAT routes

Triangle Transit routes

C-Tran routes

Figure 21: Central Raleigh Transit Frequency Map
3. What We Know Now

Productivity Analysis

Transit routes in Wake County vary widely by frequency, and by the types of places they serve. These range from high-frequency routes serving dense employment and residential areas in inner Raleigh, which carry many people, to infrequent suburban feeder routes in low density, mostly residential areas, which might pick up just a few people per hour. To evaluate route performance, we examine the level of ridership per service unit – passenger boardings per revenue hour, where a revenue hour is one bus operating for one hour. This is a good approximation of a route’s “bang per buck.”

It is important to understand that productivity is a measure of how effectively a transit route generates ridership, but that it is not a single criteria for whether a route is succeeding or not. Low productivity can be expected of routes in places with few important destinations and low-density land use (where there are simply fewer people nearby who might choose to use the service). The purpose of these routes is often to provide mobility to people who may have few other options or to serve an important destination (such as a hospital or social services institution), and not to generate high ridership. A route can be successful without being highly productive if its purpose is to provide basic access to the transit system, rather than generate ridership. We will return to this “Ridership-Coverage tradeoff” later in this report.

Frequency Costs More, Yet Delivers More “Bang Per Buck”

Frequency is a fundamental aspect of transit. How often a vehicle serves a given stop along a route is one of the most important aspects of both how useful the service is for customers and how expensive it is for the transit agency to operate.

A striking fact about frequency is that although it is expensive (doubling frequency doubles cost) it often correlates with high productivity. Doubling frequency doubles cost, which cuts productivity in half. But if deployed in the right place, serving high-density land uses and important destinations, the result can be higher productivity over time, as revealed in the relative productivity of frequent services as opposed to infrequent ones.

This does not mean that doubling frequency will increase productivity, but it does mean that if frequency is focused in places where the built environment is favorable, it can be among the best investments, in terms of ridership outcomes, that a transit agency can make. This is somewhat visible from Wake County data, but this data is limited by the small number of examples of frequent service. The relationship is very obvious in the data of peer cities where high-frequency service is common.

Figure 22 on page 40 compares the prevailing midday frequency of Wake County transit agencies’ routes on the x-axis, compared to productivity on the y-axis. Each point is sized by the total daily revenue hours of each route. In most transit agencies, we can observe a general correlation between frequency and productivity. Note that not all 60-minute and peak-only routes are labeled.

Here, the highest-performing routes, carrying the largest number of passengers, are the high-frequency routes serving NC State and central Raleigh. (Note that because high frequency is a low number of minutes between buses, it is to the left on these graphs.)

From Figure 22, we can identify high-volume, high-productivity routes like Wolfline’s route 9 (one of the several campus circulators), or CAT’s routes 1-Capital on Capital Boulevard and 15-WakeMed on New Bern. We can also locate routes like CAT’s 13...
3. What We Know Now

and 22, short routes serving inner southeast Raleigh, which perform well relative to a smaller overall level of ridership, indicating a good return on a smaller investment.

This visualization can also help us identify routes which are performing at a level above or below most of their peers in terms of frequency. Very productive low-frequency routes often indicate that some element of the route offers the potential to generate high ridership. Unproductive high-frequency routes should also be evaluated carefully, since frequency is a major investment that transit agencies can rarely afford to waste. It may be that only a portion of the route supports the frequency.

There is a strong positive correlation between frequency and productivity. The average productivity of routes operating at better than 15 minute frequency, all day long, is nearly 64 boardings/revenue hour, buoyed in large part by Wolfline’s frequent campus routes. For routes between 15 and 60 minute frequency (most of which are 30-minute), average productivity drops to 30.9 boardings/revenue hour; for 60 minute routes, 20.5. Peak-only routes are even lower, at just 12.1 boardings/revenue hour on average.

Figure 22: Wake County Transit Route Productivity/Frequency Chart

3. r-value = 0.75. r refers to the correlation coefficient, a measurement of the linear relationship between two variables, ranging from +1 (perfect positive correlation) to -1 (perfect negative correlation). An r value of 0.75 means that increased trips per hour (frequency) is strongly positively correlated with increased level of productivity.
3. What We Know Now

This same correlation is observable among the routes of many other transit agencies, as shown in Figure 23. We have assembled a dataset of this information for routes of a number of cities around the US, subject to availability of data. Many transit agencies do not publish this information at the route level, and the information shown here is by no means a complete picture of transit routes across the US. Nevertheless, we can make some observations based on the several hundred routes operated in very different cities shown here.

Displayed in the same manner in Figure 23, the correlation between frequency and productivity (boardings per revenue hour of service) is clearly evident. Again, the prevailing midday frequency in shown on the X-axis, the route’s productivity on the Y-axis. More frequent routes are more likely to be highly productive routes, less frequent routes less so, though of course there are numerous outliers at both ends of the graph.

Figure 23: Transit Productivity by Frequency – Data from 15 Transit Agencies
3. What We Know Now

Service Characteristics by Transit Agency

The following sections briefly describe the general service and productivity of each of the four transit operators in Wake County.

CAT (Raleigh)

CAT’s network is mostly made up of hourly routes throughout the core area of Raleigh, with a limited number of 15- and 30-minute routes. The network is almost entirely radial from downtown Raleigh, and many routes feature mid-route or end-of-line loops.

Radial routes are useful for directly connecting destinations and corridors to downtown, but without crosstown connections, travel can be very difficult for people who do not wish to go downtown. Some connections are possible via the CAT Connector routes, but when frequencies are low, attempting to use the service in this way may require people to wait a long time to transfer, extending the overall time it takes to make the trip, and diminishing its utility as a reasonable way to travel from one point to another.

Loops are also a common feature of routes in CAT’s network. Many routes include an end-of-line loop used to turn around, and several include mid-route loops. One-way service is an economical way of extending some transit service to a larger area, but it comes at the cost of utility. Some riders’ trips are made longer, because they are forced to ride around a loop rather than a straight path. It may also be inconvenient to use a route that only travels in one direction if the two directions are a long walk apart, or if making a return trip means a long ride around a loop.

CAT’s frequent routes are on average more productive than its infrequent routes, but there are numerous 30 and 60 minute routes which are performing well. This reflects the fact that 60-minute service is offered in several corridors where the density, walkability, and economic features should indicate very high ridership potential.

Nowhere is this more striking than in the low frequency between downtown and NC State, the strongest transit market in the city. In comparable state capitals with big universities (Columbus, Madison, and Austin, for example), the downtown-University market is among the busiest of all transit links. In addition, a corridor like Glenwood (Crabtree Mall to downtown via a number of dense and walkable nodes) stands out as one that would be expected do well with much more frequent service.

There are several other routes where low frequency seems partly to explain the low ridership, because they run in relatively dense, walkable areas with positive indicators for transit potential. This is the case of the 22-State Street and 13-Chavis Heights, two routes serving inner southeast Raleigh. These routes efficiently generate ridership given their half-hourly service level, but carry few people when compared to more frequent routes. It also matters that these routes are short. Productivity is based on ridership rather than passenger-miles traveled – one reason why this is not the only metric of transit outcomes.

CAT’s highest-productivity route, the 5-Biltmore Hills, has these features as well, and like the 13, serves the Chavis Heights area, as well as additional medium-density housing and a shopping plaza off Rock Quarry Road just south of I-440.

The 7-South Saunders (serving Saunders and Wilmington south of downtown Raleigh), a 30-minute route, is one of the most productive CAT routes, with the highest average daily boardings of all routes in the system save the frequent 1-Capital and 15-New Bern Avenue. The route serves a number of major
3. What We Know Now

destinations, including downtown and a series of large retailers on Wilmington. These are features of a corridor that have the capacity to generate substantial ridership, particularly with an investment in high-frequency service.

Triangle Transit (Regional)

Triangle Transit routes are predominately nonstop peak-only expresses between regional job centers or smaller municipalities, with a few routes continuing service throughout the day to the most important locations in Durham, Wake, and Orange counties. The productivity of this type of point-to-point nonstop service generally depends on the overall density of population or jobs at the places where service is available. These services are most useful for long trips where the convenience of direct transit can compete with the car.

However, a limitation of these services is that they often run in the same congestion that they are trying to liberate passengers from. Triangle Transit’s BOSS (Bus On Shoulder System) addresses this issue by running on shoulder pavement on congested segments of I-40 and Wade Avenue as permitted by NCDOT, which provides some level of relief from private auto traffic. Even without such lanes there is some market for these services, partly because work can be done while riding transit that cannot be done while driving.

Express service productivity is also constrained by the very long trip distances it is serving. Because expresses need to be fast to compete with driving, they cannot stop very often; however, this means that the total number of people each trip can serve is much smaller, since people are not getting on and off the bus throughout the route.

Triangle Transit’s most productive routes are those connecting the major regional employment centers of Raleigh, Durham, Chapel Hill, and the RTP. Peak-only services are most useful to people whose travel demand matches the 9-to-5 rush hour cycle. Likewise, among Triangle Transit’s all-day services, the most productive are those serving the same major destinations, such as the 700-Durham-RTC (Triangle Transit’s Regional Transit Center), or the 100-Raleigh-Airport-RTC, the only all-day connection between the airport, the Regional Transit Center, North Carolina State University and downtown Raleigh.

NC State Wolfline (NC State Campus in Raleigh)

Major state universities are among the reliable engines of heavy transit demand.

By far the most productive services in all Wake County are NC State’s Wolfline routes. NC State, like most universities, is a very high-density area of mixed land uses – employment, student residences, and the multitude of commercial establishments serving the student population. These routes are free (the lack of fare handling time helps them run more quickly) and they are also highly convenient because they come so frequently. This means that for people traveling around NC State, they rarely have to consult a schedule to get where they are going- even if they miss a bus, the next one is coming just a few minutes later.

In many respects, major universities simulate the kinds of transit demand found in much denser and more diverse cities. Wolfline is a primary example of how high-frequency transit serving a dense area can be expected to generate significant ridership. While it is easy to explain campus ridership based on student demographics, the governing features of the campus environment – high density, walkability, parking costs, and all-day
3. What We Know Now

everywhere-to-everywhere travel demands – are all features of dense and walkable places in general.

NC State tightly regulates on-campus parking, since the demand for parking at the university outstrips supply. Permits are required throughout the campus (with the exception of a limited number of day-use spaces), for both employees and students. Students’ and employees’ parking permits generally cost in the $200-400 annual range, with cheaper options available in the farthest lots near Carter-Finley Stadium. Pricing parking provides a financial incentive for people to use the Wolfline system, since its cost ($0) is much lower.

C-Tran (Cary)
The C-Tran system is made up entirely of hourly routes circulating around the town, providing a basic level of mobility but not competing for a diverse market as higher frequency services would potentially do. The network is almost entirely internal to the town; with the exception of the 6-Buck Jones, Cary relies on Triangle Transit to connect it to adjacent destinations.

Four routes radiate out from downtown Cary, and two loop routes circle the town on Maynard. All of these are low-productivity routes in the regional context, because Cary is a relatively low-density place, and at the current level of development, there are few major generators of all-day transit demand within city limits.

C-Tran routes perform as expected for infrequent routes in this kind of environment, grouped together at the lower level of the productivity chart. C-Tran’s routes are an example of routes whose purpose is not to generate high ridership, but to provide coverage – basic access to the transit system to as many people and jobs as possible. We will explore this trade-off more fully in Chapter 5.
3. What We Know Now

Peer Review

Several simple measures can be used to compare the availability and relevance of transit in Wake County to peer cities.

We surveyed comparable urbanized areas via the federal National Transit Database (NTD) for 2012, the most recent year for which data was available for all peers. These areas were chosen based on their size, location, and economic similarities relevant to transit, such as the state capital and major university.

Among these cities are obvious regional peers in terms of metro size, competitive proximity (Durham, Charlotte), the presence of the state capital and a major state university (Austin, Columbus, Madison), and the presence of a major tech sector.

There is no one right level of transit investment or ridership. Cities and regions make choices to provide more or less transit service, and people make decisions to use it based upon how relevant it is to their own mobility needs. This peer review is included in order to place Wake County in the context of other urban areas, between which there is substantial variation in their transit choices and outcomes.

Peer reviews are an opportunity for the reader to think about what kind of metro area Wake County aspires to be. Austin and Madison stand out in all of these charts as comparable metros that are slightly larger than Wake County, and that combine a state capital, major state university, and a substantial knowledge-based economy with very high transit investment and transit outcomes. If Wake County would rather aspire to the outcomes of less transit-rich state capital regions – such as Richmond, Columbia, and Nashville – it can choose to aim closer to that level of investment and outcomes.

Durham-Chapel Hill outperforms all of the other urban areas surveyed here in terms of abundance and relevance, and is near the top (below only Madison) in terms of productivity. High performance on all three of these indicators means that Durham-Chapel Hill has heavily invested in transit and has realized a strong return on investment in terms of ridership, as measured in terms of productivity and relevance to the population. Durham-Chapel Hill is now in the process of planning for light rail between the two cities. However, it is impossible to tell at this point how such a major operational and capital investment will affect the area’s performance on these metrics.

Note that the measures of total ridership and revenue hours do not include privately operated systems, including private university systems such as that operated by Duke University. Most other public university circulator systems are not reported to the NTD, so an assessment of the total quantity of fixed-route transit service in an urban area may exclude systems of this type. For this reason, we have shown Wake County both including and excluding NC State Wolfline service.

The extent to which university ridership is on the citywide transit system, as opposed to a university circulator, varies from one metro area to another, and it is impossible to control for this completely. In the Durham-Chapel Hill case, Duke University’s transit system is excluded, but UNC’s circulator is provided by the Chapel Hill local transit system, so it is included. The difference between the two Wake County bars gives a sense of the difference that this factor makes; it is substantial but not to the extent that its inclusion or exclusion dramatically changes the urban areas to which Wake County is most comparable.

4. Each urban area was compared to Wake County (not to the Raleigh urban area), since Wake County is the subject of this study, but the difference between the two is very small. In 2012, the year for which NTD is available, there were only about 16,000 people in Wake County but not the Raleigh UA (their populations were 905,573 to 889,134, respectively).
3. What We Know Now

Transit Service Abundance

Service abundance refers to the sheer quantity of public transit available – the total number of annual revenue hours of service (excluding all paratransit and vanpool service) per person within the area served. Figure 24 shows this data for the various peer cities, as well as Wake County.

This indicator is arrived at by dividing the total annual revenue hours of all transit agencies within an urbanized area by the total number of people living within that area. This number represents the level of investment in the transit system relative to the number of people in the urban area.

Also shown is the level of service abundance excluding Wolfline. While Wolfline represents a small portion of the total revenue hours available in the county, we wanted to filter this service out since other large university systems were generally not included in data for other urban areas.

Because many of Triangle Transit’s routes operate outside of Wake County, it was necessary to include only the fraction of the agency’s total revenue hours attributable to service within the County. Based on consultation with Triangle Transit staff, for 2012, the year used for this comparison, 47% of Triangle Transit revenue hours are assigned to Wake County.

When Wolfline is included, Wake County’s Transit Service Abundance is 0.38 revenue hours per capita. This is comparable to the level in Memphis or in Charleston, SC.

Four of the comparable urban areas we surveyed had dramatically higher levels of transit abundance. These are Austin (0.97), Durham-Chapel Hill (1.25), Madison (0.95), and Pittsburgh (1.03).

Only Columbia, SC (0.22) and Greenville, SC (0.22) had substantially lower abundance of transit than Wake County; these are also much lower-population urban areas.
3. What We Know Now

Transit Service Relevance
A high-level measure of transit use is ridership divided by population. In broad terms, it captures how relevant transit is to the overall life and economy of the community.

Triangle Transit ridership was allocated to Wake County based on the percentage of its average daily boardings located within the boundaries of the county.

Including Wolfline, Wake County’s transit service relevance is 9.6 trips per capita. This is most similar to Richmond, VA (10.5), Nashville (10), and Memphis (9.2).

In other urban areas including major research universities – including Austin, Durham-Chapel Hill, Pittsburgh, and Madison – a higher level of investment generates a much higher level of relevance. Two of these metros are also state capitals, like Raleigh.

Urban areas with the same general level of service abundance (0.3 - 0.6 revenue hours per capita) were closely grouped in relevance, between 9 and 13 boardings per capita. With NC State’s Wolfline included, Wake County’s transit relevance is comparable to peer cities like Richmond, Nashville, and Memphis, but still far below state capitals with large universities and strong knowledge-based economy sectors, such as Austin and Madison.

Figure 25: Peer City Transit Productivity
Productivity

Ridership divided by cost of service is called productivity. This uses the same unit, boardings per revenue hour, as we previously used to gauge individual route performance. The difference is that here, we assess the overall productivity of all routes of all transit networks operating within an urban area. This provides a simple metric to compare the total performance of each area’s transit networks—how many people ride per unit of service provided. This can be thought of as “bang per buck,” although as we discuss in Chapter 5, ridership is not the only reason that transit is valued and locally supported, so ridership may not be the sole measure of whether transit is meeting local goals.

The most comparable peer cities in terms of productivity are Virginia Beach (21.2), Nashville (23.6), Memphis (24.3), Louisville (28.7), Cincinnati (22.5), and Charleston (23.3). When Wolfline routes are excluded, Wake County transit is slightly less productive than several of these peers.

Several peer urban areas had very high network productivities; many of these, such as Madison (38.2) and Pittsburgh (36.7), are also places where transit is substantially more relevant and abundant.
3. What We Know Now

Geographic Patterns of Ridership

Figure 27 on page 50 shows the rider-ship by stop for each of the four transit agencies. The size of the circle represents the total number of people who board a bus at that stop on an average weekday, while the color of the circle indicates the transit agency. Because this map shows boardings, it does not represent people’s final destinations, but rather where they began their trip and any transfer to another route.

The graphic clearly shows the major transit destinations on the existing system. Lines of medium-sized circles are frequently located on corridors where there is sustained residential and employment density throughout.

Note that this map includes Triangle Transit ridership at stops in Orange and Durham counties. Local transit for Orange and Durham counties is not shown in Figure 27.

Obviously, this is ridership on existing transit services, not a map of ridership potential. Where there is no service, or service is too infrequent or runs too briefly to be useful to most people, no ridership can be expected. For that reason, this map can be reviewed in conjunction with Figure 20 on page 37 and Figure 21 on page 38, which show the levels of service on which this ridership is achieved.

At the regional level, the pattern of ridership is clear – central Raleigh, from I-540 in the north to Tryon Road in the south, and from New Hope Road in the east to I-40 in the west, and particularly NC State, account for the great majority of high-ridership stops and corridors. Central Raleigh includes the highest population and employment density in the county, is the largest transit market, and is where the majority of the county’s transit ridership is located.

Outside of central Raleigh, the other regional centers of Durham and Chapel Hill, as well as the Regional Transit Center, are sites of major activity in Triangle Transit’s network.

Moderate stop activity is visible in Wake Forest, around the Wake Forest Loop route, as well as at the northern end of the WRX-Wake Forest-Raleigh express. The CAT stop at Wake Tech Community College’s main campus on US-401 near Fuquay-Varina is another outlying stop that generates high activity (100-200 boardings per day).

In Cary, employment and commercial activity is concentrated at a few nodes, such as downtown Cary, Cary Towne Center and Northwoods shopping centers, or the shopping center at High House and Maynard. These destinations are generally where the higher-ridership stops in C-Tran’s system and on the Triangle Transit service in the area are located. Busier stops are also found where there is greater residential density, as at Highland Village at Chatham Street and High House Rd.

Figure 28 on page 51 displays the same information for the core area of Raleigh and Cary, where most of Wake County’s transit service and ridership are concentrated.

Downtown Raleigh is a primary destination for riders of CAT and Triangle Transit, reflecting both its importance as a job center and the large amount of service concentrated here. The radial corridors extending out from downtown are sites of relatively sustained activity, particularly along New Bern, Wake Forest/Capital Boulevard, Lenoir, and Hillsborough.

CAT and NC State stops around the central academic and housing area of the university campus also enjoy sustained high ridership. West of Gorman Street, ridership drops off, corresponding to the less frequent service available there.
3. What We Know Now
3. What We Know Now

Figure 28: Central Raleigh Stop Ridership

Total Ridership by Stop
Average Daily Boardings
- 1-10
- 11-25
- 26-125
- 126-250
- >250

Transit Agency
- CAT
- Triangle Transit
- CTran
- NCSU Wolfline

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Outside of downtown, CAT’s high ridership stops are most commonly found at major destinations like hospitals, malls, and big-box stores. There are several high ridership corridors, such as Wake Forest Road/Falls of Neuse (served by the 2, a top-five 60-minute route in terms of productivity, and the 60-minute route with the second highest average daily ridership), or Capital from Downtown to Triangle Town Center, where there is sustained boarding activity throughout. These corridors generally serve areas of significant population or employment density. Where there are few destinations and little density, transit ridership is rarely substantial.

Necessary Conditions for High Ridership

The necessary conditions for high-ridership service are not a mystery. National and international experience show the same correlations that we see locally.

Most ridership variations can be explained by the usefulness of a transit service, compared to its alternatives, to as many people as possible.

Usefulness from the passenger perspective lies in a range of variables that the next chapter will explore, but critical ones are:

- Frequency
- Span (duration of service)
- Directionality (two-way service is preferred)
- Speed and reliability

These variables largely determine how soon transit can get a customer to a destination or the range of places they could get to. The next chapter explores these features in detail.

However, the cost of providing these things to customers varies massively depending on their location, so high-ridership transit focuses on places with geographical features that indicate transit can succeed. These features mark places where it is easy for many potential customers to access a transit service and find it useful, which tends to correlate with high ridership.

Figure 29 on page 53 shows these features. They are:

- **Density.** There are many reasons to travel to and from the area around each stop, and there are simply more people in the area who might choose to use transit if it is useful for the trips they need to make. Big destinations, or high density areas generally, are the dominant sources of ridership.

- **Walkability.** The people around the stop can easily walk to the stop, which includes being able to cross major streets at the stop.

- **Linearity.** Transit can run in reasonably direct paths.

- **Continuity.** Relatively short distances are cheaper to serve than long ones, so all other things being equal, ridership per unit cost is higher for shorter trips.
3. What We Know Now

**Four Geographic Indicators of High Ridership Potential**

**Density**
How many people, jobs, and activities are near each potential transit stop?

- Many people and jobs are within walking distance of transit.
- Fewer people and jobs are within walking distance of transit.

**Walkability**
Is it possible to walk between the stop and the activities around it?

- The dot at the center of these circles is a transit stop, while the circle is a 1/4 mile radius. The whole area is within 1/4 mile, but only the black-shaded streets are within a 1/4 mile walk.
- It must also be safe to cross the street at a stop. You usually need the stops on both sides for two-way travel!

**Linearity**
Can transit run in reasonably straight lines?

- A logical transit line is a direct path between any two destinations on it.
- Destinations located off the straight path force transit to deviate, discouraging those who want to ride through.

**Continuity**
Does transit have to traverse long gaps?

- Short distance between many destinations is faster and cheaper to serve.
- Long distance between destinations means a higher cost per passenger. (Distance-based fares can compensate in part.)

Figure 29: Geographic Indicators of High Ridership Potential
3. What We Know Now

There are some other special cases that engender high ridership:

- Commute express services, often linking Park-and-Ride to work sites, do well where there is a strong disincentive to driving, such as congestion (bypassed by transit) or parking costs.

- High levels of infrastructure and amenity, such as in rail or busway services, encourage ridership in two ways. First, if the infrastructure makes the service faster and more reliable, this attracts riders. Second, it may make the service more comfortable, legible, and pleasant in ways that attract ridership.

### Strong Evidence of Suppressed Ridership Potential

There are many indications that the poor productivity of transit in Wake County arises from there being too little service. In other words, if more service were added in places that are highly conducive to ridership, there is reason to believe that ridership would grow more than service cost, yielding higher productivity overall.

Hints to this end come from several directions:

First, similar peer cities (see “Peer Review” on page 45) invest more in service, generate much higher ridership, and therefore have higher productivity.

Second, the same observation arises from looking at frequencies and noting how they tend to correlate with productivity (Figure 23 on page 41). High productivity often arises from high frequency service. The variance in that relationship arises from a third factor: frequency succeeds most when following patterns of high demand (Figure 29 on page 53).

The fact that frequencies are currently low in areas that match this description (including such corridors as Glenwood and the link between downtown Raleigh, NC State, and Cary) also suggests that more intensive service would generate higher overall productivity despite the cost.

### Unmet Needs for Access and Service

This discussion has talked in terms of ridership, but ridership is not the only purpose of transit. Transit is usually also expected to provide basic access to connect people to jobs and opportunities if they have no other transportation options. It is also common to see an expectation that a successful plan would serve each municipality and community in the county. (These “coverage” goals are in tension with goals for high ridership, a tension we explore in Chapter 5 of this report.)

Currently, even people living in fairly high-density parts of Raleigh, where the conditions for transit are favorable, have limited options for accessing basic needs and opportunities. As Figure 21 on page 38 shows, most of the current bus network is hourly all-day at best, which limits its usefulness even for riders with few options.

Meanwhile, as Figure 20 on page 37 shows, many parts of the county have no all-day service at all, apart from the limited countywide Dial-a-Ride service provided by TRACS. TRACS excludes all of the incorporated municipalities, even though the outer, smaller towns have no comparable service. The limited commute-period services provided to some parts of the county have little relevance to most people who are trying to access basic needs and opportunities without a car. CAT, Triangle Transit, and C-Tran each provide paratransit services (direct door-to-door transit for people who cannot use the fixed-route transit system) within their respective service areas.
3. What We Know Now

Summary
The data presented in this chapter do not mean that Wake County should take any particular course of action. The county and its voters are free to decide whether to expand transit, what kind of transit to develop, and how to balance transit’s different purposes.

This chapter has surveyed some highly relevant facts. Notably:

- Wake County is growing rapidly.

- The youth and senior segments of the population, who tend to depend most heavily on transit, are growing faster than the population as a whole.

- Real estate prices, locally and nationally, are signaling high demand for denser, more walkable forms of development. This type of development permits lower reliance on cars and tends to generate higher transit demand.

- There are strong indications that a larger transit system could be a more productive one – in terms of ridership per unit of cost – than the existing one. These indications are both in existing service performance and in the performance of transit in similar cities.

This last point does not mean that transit would be profitable; it would still have to be justified by its benefits to the region. But it has the potential to deliver these results more cost-effectively than the transit that exists today.
Chapter 4: The Transit Planning Toolbox
4. The Transit Planning Toolbox

Introduction
This chapter surveys the typical tools being used in public transit in developed-world metro areas comparable to Raleigh and Wake County, and to outline their relevance in various situations within the service area. This “Transit Toolbox” presents an array of transit service types which emerge from particular decisions made during the network design process.

Many people believe that vehicle technologies are the main transit tools. In this view, all buses are more or less alike, but are different from light rail, streetcars, or subways. There certainly are differences among these technologies, and we summarize them at the end of this chapter and in Appendix A.

In most cases, however, the features of a transit service that determine when a customer reaches a destination or whether they have access to jobs and opportunities, are not technology distinctions.

Buses and rail vehicles can both go as fast as it’s safe to go in an urban setting, and both kinds of technology can be frequent or infrequent, and reliable or unreliable, depending on how you implement them.

For that reason, we have organized this toolbox around the key features of transit that actually determine usefulness for the customer.

Transit tools can be distinguished by how they respond to these key factors to a customer’s choice to use transit or not:

1. It takes me where I want to go.
2. It takes me when I want to go.
3. It is a good use of my time.
4. It is a good use of my money.
5. It respects me in the level of safety, comfort, and amenity it provides.
6. I can trust it.
7. It gives me freedom to change my plans.

If we think about transit in these terms – classifying transit not by technology but by how it gets people where they’re going – we can sort most transit services based on the mobility options they can deliver.
### 4. The Transit Planning Toolbox

**Key Distinctions**

If you open a building contractor’s toolbox, you’ll often see a grid of little plastic compartments organizing various things that might be needed. Transit has a similar grid of tools, shown in Figure 30 on page 59, which describes the customer outcomes connected to each of the dimensions of transit tools.

Each cell in this grid is a distinct type of service. The grid is organized based on some key distinctions that matter enormously to whether, and when, the customer gets where they’re going. The key dimensions are:

- **Availability WHERE it’s needed.** Service must exist at a stop within a reasonable distance to travel by walking, biking, or driving to the origin and destination of a trip. This is a feature of the network design, not the individual tools, so it does not appear in Figure 30.

- **Availability WHEN it’s needed.** This crucial feature of transit is represented by columns of Figure 30. Fewer stops generally mean higher speed, but a longer walk, cycle, or drive to access the service.

- **Spacing of stops or stations.** The options here are represented by rows in Figure 30. Fewer stops generally mean higher speed, but a longer walk, cycle, or drive to access the service.

- **Exclusivity of Right-of-way.** Transit that can get stuck in traffic, or impeded by random traffic events such as accidents and double parking, will always be much less reliable and less fast, than transit that has its own right-of-way. In Figure 30, exclusive right-of-way services are noted in red.

- **Capacity.** The vehicle must have room for all passengers. Frequency and exclusive right-of-way, discussed above, also improve capacity. Where very high capacities are needed, the answer is usually larger vehicles. Very high capacity needs are one of the strongest arguments for rail. Vehicle technology choices are discussed at the end of this toolbox, and in an appendix.

**Exploring the “When” Distinctions**

The first group of distinctions, about Frequency, Span, and Direction, deal with whether service is there when you need it.

When you look at a transit map, it’s easy to imagine that the lines are like roads, always there whenever someone needs them. Transit lines are not like roads at all. Unlike roads, transit must exist when it is needed, not just where. If it doesn’t, it doesn’t exist for you as a customer.

The key measures of existence in time are:

- **Frequency.** Does the service come reasonably close to when you want it?
- **Span.** Is the service running at all when you need it?
- **Direction.** Is the service running in the direction that you need to travel?

Frequency, span, and directionality are not just features of a transit service. They refer to whether the service exists at all for a given market. For this reason, no transit...
## 4. The Transit Planning Toolbox

### The Transit Toolbox

<table>
<thead>
<tr>
<th>Frequent</th>
<th>Infrequent</th>
<th>Peak 2-way</th>
<th>Peak 1-way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>All-day, evenings, 7 days/week</td>
<td>Plan trip around schedule</td>
<td>Based on demand</td>
</tr>
<tr>
<td>Span</td>
<td>All-day, evenings, 7 days/week</td>
<td>All-day, weekdays</td>
<td>Rush-hour only</td>
</tr>
<tr>
<td>Direction</td>
<td>2-way</td>
<td>2-way freeway express</td>
<td>1-way (peak direction) freeway express</td>
</tr>
<tr>
<td>Speed</td>
<td>Nonstop</td>
<td>Other all-day express</td>
<td>Freeway express with 2-way lanes</td>
</tr>
<tr>
<td>Nonstop</td>
<td>Rapid Bus, “BRT-lite”</td>
<td>Commuter rail; Freeway express with 2-way lanes</td>
<td>Freeway express with reversible lane</td>
</tr>
<tr>
<td>Rapid</td>
<td>Rapid Transit (subway, LRT, true BRT); Commuter Rail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>Frequent local bus service</td>
<td>Infrequent local with frequent peak service</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>Some BRT and LRT segments with very close stops; North American streetcar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>Flexible</td>
<td>Flexible services</td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>Personal Rapid Transit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Uncommon in North America

### Flexible Local Rapid Nonstop

- **Direction:** All-day, evenings, 7 days/week
- **Span:** All-day, weekdays
- **Frequency:** Based on demand

*Exclusive Right-of-Way

*Mixed Traffic

The Transit Toolbox proposal can be evaluated without clear definition of these features.

While there are many gradations of frequency and span, developed-world best practice planning seems to recognize two distinctions as fundamental:

- **High vs. low frequency.** While there is a wide range of frequencies, the key distinction is whether it feels as though service is coming whenever it’s needed, or whether the limited transit schedule forces the customer to plan their schedule around transit’s availability.

- **Peak-only vs. all-day span.** While peak service is relevant to the “nine to five” commute, and may seem most related to congestion management, there are reasons to use transit throughout the day, and many commutes, especially in the service sector, happen at other times of day. All-day service is also essential if people are to voluntarily choose lifestyles that rely more on transit and other sustainable modes.

A third distinction, relevant mainly to peak-only services, is direction – while the overwhelming majority of transit is...
4. The Transit Planning Toolbox

Exploring the Stop Spacing Distinctions

Stop or station spacing refers to how fast a public transport vehicle runs, and how often it stops. Fewer stops always make a service run faster, so there is a trade-off between the speed of the service and the distance someone must walk, bike, or drive to access it. There are four broad categories, in a spectrum from fastest (with the longest access distance) to slowest and easiest to access.

- **Nonstop** service has a long segment with no stops. Freeway express service or express commuter rail is the most common example. Nonstop service requires a very concentrated market all making the same nonstop trip, so it is less common outside of the peak period.

- **Rapid** service makes regular but widely-spaced stops, typically in the range of 1/2 mile or more. (The word “station” rather than “stop” is often associated with a Rapid service.) A common bus-industry term for Rapid service is limited-stop, but that term emphasizes the negative. The term “Rapid” is used here to emphasize the positive: limited stops mean faster operation. Light rail usually falls in this category, along with many possible bus services.

- **Local** service usually stops every 1/4 mile or less along most of its length, with the purpose of providing continuous access within walking distance of every point on the route. Note: there

Organization of Columns
These distinctions enable us to divide services into the following large categories, represented by columns. Each category represents a profoundly different kind of usefulness for the customer, and is capable of delivering a different set of mobility outcomes.

- **The Frequent Network** refers to service that (a) runs so frequently that you do not need to refer to a timetable, usually every 15 minutes or better, and (b) runs for a long service day, usually at least 15 hours per day, 7 days per week. Many transit agencies in North America are defining bus services in this category as a distinct brand which forms the backbone of the public transit network in high-density areas.

- **Infrequent** refers to all-day service at lower frequencies, usually 30-60 minutes. It runs at least 12 hours a day on weekdays, but evening and weekend service may be limited. This service level is appropriate for areas of low demand spread across the day. Most low-ridership services operated for social purposes fall in this category.

- **Peak-Only** is any service that runs only for a few hours a day, to serve a market of brief high demand. Commuter express service and school service are two examples. We further divide peak-only service into two-way and one-way services, reflecting the demand patterns of the transit market.
4. The Transit Planning Toolbox

is an important grey area between Local and Rapid. While a typical Rapid stops about 1/3 to 1/4 as often as a Local, and thus functions quite differently, there are also services at a range of intermediate spacings, and any of these may make sense in certain situations.

• **Flexible** service encompasses all services that deviate on demand in order to provide service in hard-to-reach or low-density areas, or to provide door-to-door service to persons with mobility limitations. By their nature, door-to-door services are slow and often circuitous. Flexible services represent an approach to provide access at the expense of speed.

As with frequency and span, there are many fine distinctions in speed and access, but those outlined above seem to be the most fundamental in industry practice. Transit tools are differentiated based upon the combination of attributes described in the previous sections.

**Exclusive Right-of-Way**

Finally, a profound distinction among transit services is generated by the exclusivity of right-of-way. A service that cannot be stuck in traffic, or encumbered by other delays, runs faster during peak conditions and is substantially more reliable than a service that is exposed to traffic congestion and delay.

Exclusive right-of-way is not related to whether a service is run with buses or trains. While most rail-based transit technologies (with the exception of the North American streetcar) are built largely in exclusive right-of-way, the same type of protection from traffic delay can be accomplished for buses with exclusive lanes. In fact, a very limited example of this already exists in Wake County – the Bus On Shoulder System (BOSS) that some Triangle ...

**Stop Spacing: Speed Vs. Access**

- **Speed**
  - Stops less often, so a smaller area is within walking distance. Stopping less often means that the route has to spend less time picking up and dropping off passengers.

- **Nonstop**
  - Stops a few times, then proceeds to destination without stopping.

- **Rapid**
  - Stops less often, at important destinations and transfer points to improve speed.

- **Local**
  - Stops often along the route, usually less than every 1/4 mile.

- **Flexible**
  - Area where customers can request door-to-door service ahead of time.

**Figure 31: Stop Spacing Distinctions**
4. The Transit Planning Toolbox

Transit routes use during periods of peak congestion. This can improve travel times during these times by allowing the bus to use space on the roadway where private automobiles are prohibited, allowing it to avoid the normal traffic friction that occurs during the peak periods.

BOSS is an example of an intermediate form of exclusive right-of-way often referred to as “managed” or “express” lanes. These are travel lanes that limit traffic to high-occupancy vehicles during peak congestion periods to keep traffic moving.

Protecting transit from traffic achieves a dramatic difference in speed and reliability. Traffic impacts on transit are a major source of delay. In many cases, the effect comes not just on speed, but on reliability. The problem is not always traffic congestion, but rather the friction caused by traffic movements such as turns, drop-offs, double-parking, crashes, and so on.

Friction is a major reason that curbside transit lanes are generally much less effective than median lanes in protecting transit from traffic delay. Curbside transit lanes are the site of merging and turning movements by traffic that tend to cause significant disruption to transit, though of course they are better than no lanes at all. Median transit lanes (bus or rail) tend to involve better separation from traffic. Whereas curb lanes tend to be affected by continuous right turns for local access, median transit lanes can usually be designed around a limited number of left turn pockets that make traffic and transit easier to separate.

Transit’s ability to use road space more effectively to transport people is the core...
4. The Transit Planning Toolbox

reason for giving it priority. From that point of view, high-capacity transit, which transports more people per unit of road space than private cars, justifies a higher level of priority.

Once a logical service pattern has been selected, there are several reasons to consider exclusive right-of-way:

- Speed and reliability. Where higher reliability is desired, protecting transit from traffic congestion is one of the best ways to achieve that. Where a roadway is prone to congestion, exclusive transit right-of-way can be crucial to speed and reliability.

- Fair use of public right-of-way. Where transit vehicles carry large numbers of people, then it is fair to grant them priority over cars as a way of maximizing the total number of people who can move down a corridor.

- Greater economic activity at a given level of congestion. Transit that can avoid congestion permits more travel at a given level of congestion, which means more economic activity along a corridor or transit market.

- Right-of-way capacity. In some cases, the need to move enough transit vehicles through a congested area to serve that area’s travel market becomes a reason for exclusive transit lanes, which enable transit to move through more quickly, thereby consuming less street and signal capacity.

- Right-of-way for transit is always expensive in one of two ways:

  - Political cost of shifting capacity from other modes, usually private cars. Introducing exclusive transit lanes, or other transit priority features, may inconvenience motorists and businesses who care exclusively about motorist access, creating political opposition.

  - Cost in dollars of infrastructure. The most expensive right-of-way infrastructure is elevated or underground structure, which effectively creates new right-of-way without reallocating surface space from existing uses.

Exclusive right-of-way is a critical feature of very high ridership and widely valued public transit systems. It is important to note, however, that exclusive right-of-way is more important to speed and reliability than whether a service is on rails or tires, because it determines the degree to which traffic can conflict with the transit service. Either rail or buses can be run in exclusive right-of-way. Either rail or buses can also be run mixed with traffic. Technology and reliability are different and largely unrelated distinctions.

Overview of Transit Tools

With these distinctions understood, let’s look at the various cells in the toolbox of Figure 30 on page 59. This section talks through the key categories or tools, generally proceeding from left to right. The location of each category is shown in the small diagrams at the beginning of each section, corresponding to cells of the toolbox matrix.

Rapid Service: Frequent and Fast

The word rapid usually just means fast, but in transit, rapid has come to mean fast and frequent. This is because the real goal is not to ride in a fast vehicle, but to get where you’re going quickly, and this is the result of the combination of frequency (which
determines waiting time) and the speed of the vehicle. Also, because speed trades off against stop spacing, rapid in transit almost always means relatively widely spaced stops, as opposed to a local bus or streetcar that stops every few blocks.

**“RAPID TRANSIT”: FAST, FREQUENT, EXCLUSIVE**
The term Rapid Transit, especially when capitalized, usually means service that is frequent, with widely spaced stops, and in an exclusive right of way. Examples include:

- Heavy rail “subways” like those of Atlanta and Washington, DC.
- Light rail lines\(^5\) such as the one planned between Durham and Chapel Hill.
- Busways and other exclusive-lane Bus Rapid Transit (BRT).\(^6\)

**“RAPID BUS”: FAST, FREQUENT, NOT EXCLUSIVE**
Exclusive right-of-way is often not available where rapid transit is desired, or at least not in the early stages of transit development. For this reason, it is increasingly common to see “Rapid Bus” services which are as fast and frequent as they can be in the absence of exclusive lanes.

The most extensive network of this product, and the oldest, is the Metro Rapid in Los Angeles, developed in the late 1990s and progressively implemented over the past decade. Metro Rapid features not just a consistent high frequency and a stop spacing of 1/2 mile or greater, but also distinctive bus signage, vehicles, stop designs, and transit signal priority to expedite these buses through traffic as much as possible without an exclusive lane.

In the US, these services are often federally-funded capital projects, which provide high-quality stations, advanced and attractive buses, and other features, but the key service idea is simply to run as quickly and frequently as possible given that service will still be affected by private vehicle congestion.

Rapid transit, however, is just a subset of another important category, the Frequent Network.

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5. But not North American streetcars, which tend to run in mixed traffic with close stop spacing. See Appendix A for further discussion.

6. In North America, not all Bus Rapid Transit is in exclusive lanes, and there is robust debate internationally about whether the term BRT should be used for these services. Federal Transportation Administration “BRT” grants often go for projects in mixed traffic, but the Institute for Transportation and Development Policy’s Bus Rapid Transit Standard is adamant that exclusive right of way is one of the most defining features of BRT. See https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/. See Appendix A for further discussion.
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that is increasingly common in many people’s lives. The trend toward households where both parents work or to single-parent households, means that a working parent must also meet his/her children’s commuting needs, whether to school or daycare. Work may also involve time-sensitive travel during the day for meetings or other purposes. These factors can easily convince people that only their car can serve their needs.

A key purpose of the all-day Frequent Network is to provide a foundation where all of these complexities can be served on public transit – just as they are on major urban subway systems such as the London Underground. Just as a London commuter may choose a childcare provider in part for its proximity to an Underground stop, the Frequent Network is meant to be a preferred location for businesses that want public transit users as customers, and for the residences of those users. This in turn will support further development intensification that will put more of life’s daily needs on the network, so that public transit can be used for all kinds of trips during the day and evening.

Portland, for example, reduces parking requirements for development if it is on the Frequent Network, and encourages all land uses that will rely on transit to locate there.

The Frequent Network, in short, is not just a simplification or presentation tool. It is also a tool for helping people and institutions who value transit to locate where transit can succeed – thus permitting more informed free decisions by everyone who makes location choices. Over the past decade, many North American transit agencies have begun presenting their Frequent Network to the public as a distinct and superior product. The Frequent
4. The Transit Planning Toolbox

Network is typically highlighted in maps, and often at bus stop signs and elsewhere in the information system.

**Frequent Rapid Service**
We have already discussed Frequent Rapid service, which is usually called “Rapid Transit” if in exclusive right-of-way and “Rapid Bus” if not, though none of these terms is entirely stable in its meaning.

Frequent Rapid tends to be most relevant to corridors where there is sustained demand throughout, but where trip distances are long. It often overlays a less frequent local route which continues to serve short trips.

**Frequent Local**
Frequent local services are frequent but not necessarily so rapid. Its stop spacing is closer so that it serves the entire area along the line within a relatively short walking distance. Local service tends to be more acceptable where travel distances are shorter, since shorter trip distances make the customer more sensitive to frequency and less sensitive to speed. Frequent local services are major features of many transit systems in regions the size of Wake County, especially for internal circulation in cities the size of Raleigh or smaller.

**Infrequent All-Day Service: Fixed Routes**
Infrequent all-day service (generally running at frequencies worse than every 15 minutes all day) is necessary to cover areas that either:

- Have the potential to grow into Frequent Network services, or
- Lack the necessary features for frequent service, but that generate some ridership or are needed to cover certain areas for lifeline access needs; for instance, serving an important social services destination.

Because infrequent service tends to serve areas that cannot support a high level of transit investment, most such service is local-stop. Some services may cover large semi-rural distances and may thus be relatively rapid, but this is a feature of the area served rather than a core intention of the service. Infrequent routes in rural areas may have rapid-type stop spacing simply by virtue of the fact that densities are low and destinations are widely dispersed.

**Flexible Services**

**Infrequent Flexible: The Standard Model**
In today’s public transit business, flexible service means that the path followed by the transit vehicle can vary according to demand. Typically this means that a small bus or van operates in an area at a given time, and can be requested – by phone, web, etc. – to go to a particular place at a particular time to pick someone up or drop them off. They differ from commercial taxis in that they may carry multiple travelling parties who are travelling the same direction, and they tend to have restricted service areas to ensure that they (a) do not compete with fixed route services or (b) cover a larger area than the designated vehicle can handle.
4. The Transit Planning Toolbox

All flexible services have low ridership expectations, because deviating to serve each passenger requires a large amount of driver time per passenger. It is very rare for a fully flexible service to carry more than 10 boardings per hour, as this would require going to 10 different places during an hour with a single vehicle. By contrast, most fixed routes that are deemed successful achieve at least 20 boardings per hour, and in dense urban settings, even local buses can approach 100 boardings per hour.

Flexible services therefore tend to be used as a way of getting a basic transit service to areas that are geographically unsuited to more efficient fixed routes, such as rural areas or lower-density suburban areas with discontinuous street patterns and barriers to walking.

A large portion of Wake County is served by this type of service through the Transportation and Rural Access (TRACS). The purpose of this service is typically to provide some very minimal level of transit access to people living in rural or exurban areas where residential density is simply too minimal to justify a fixed route.

The Americans with Disabilities Act (ADA) also mandates that transit agencies must provide paratransit service within 3/4 mile of fixed-route transit at times when the fixed route is operating, only for people who cannot use fixed-route service for reasons of disability. This is a major added cost, especially for rural or intercity fixed routes that generate a paratransit requirement over a very large area.

Flexibility always trades off against productivity, and there are various points on the spectrum between them. For example, a flexible service may go directly to your door, or it may go only to a stop within 1/4 mile of your house, perhaps on the nearest collector street. Some routes are also part fixed and part flexible. For example a route may run outward from a transit center for a while, then enter a zone where it can deviate based on customer requests.

Our tables show flexible services in the infrequent all-day column because this is how most actual examples work. Because flexible services are generally aimed at basic access and coverage rather than ridership, they are usually not run at high frequency.

**THE QUESTION OF FREQUENT FLEXIBLE SERVICE: “PERSONAL RAPID TRANSIT,” UBERPOOL, LYFTLINE**

There is currently enormous private sector interest in the development of services that would be both frequent and flexible. Leading private companies such as Uber and Lyft both have products that claim to offer the option of a shared ride that can be ordered spontaneously; effectively it is the transit flexible services model, but at such a high level of abundance that it is effectively frequent.

These companies operate in a very different environment than public transit, particular with regard to acceptable rates of compensation and workforce regulation. They also have an unequivocal profit motive that differs from the mixed motives of public transit networks (see “ridership vs. coverage” in the next chapter.) As a result, they are able to provide more abundant services at lower cost. However, even if those factors were equalized, these services will only be “there when you need them” (the core idea of frequent service) in areas where demand is very concentrated.

“Personal Rapid Transit,” if it were perfected and scaled, would also fall into this category. This high-infrastructure approach is described in Appendix A.

While it is attractive to imagine a vehicle that comes whenever you need it and takes you nonstop to your destination, this is an intrinsically expensive thing to provide using vehicles with employees on board. The private sector will have to pass this cost on to the customer, producing services that...
are unlikely to be affordable to everyone even in the unlikely case that they could be made sufficiently abundant.

Transit succeeds in the opposite situation, where enough people are travelling in the same general direction that they can share a vehicle, and especially where the demand is so sustained, that this pattern of available vehicles can be made regular and abundant, as on the fixed Frequent Network. Private innovators will no doubt continue to expand our notions of urban transportation in useful ways, but the transit fixed route remains a very useful thing – a service that is coming at predictable times, does not need to be requested or negotiated with, and has a fare that is the same every time you travel.

**Peak-Only Service**

Peak-only services run only during the conventional peak period or “rush hour” on weekdays, and are thus specialized around people travelling at this time. This service responds to an abrupt surge in demand for a short period, but it comes with higher unit costs than all day service. Peak-only service requires drivers to work short shifts, which usually involve higher labor costs and reporting time. Peak-only service also requires a transit agency to own, store, and maintain vehicles that are used only briefly. Peak services are needed to meet peak demand, but these added costs explain why they are often held to higher standards than less expensive all-day service.

**PEAK NONSTOP SERVICE**

Peak-only commuter service refers to service similar to the existing express system operated by both CAT and Triangle Transit. Express routes provide nonstop trips to major employment centers from distant residential areas, or connections between major regional centers. However, this service must be planned together with the all-day network. Where a market is adequately served by an all-day service, there is no need for a commuter express bus to do the same thing.

**PEAK RAPID OR LIMITED STOP**

Peak Rapid means limited-stop services running only during the peak commute period. These tend to be on arterials rather than freeways. It has long been common in some cities for transit networks to have routes with limited-stop service running only during the peak commute period, sometimes just a few trips. Most of these have no particular branding, and exist as a demand-driven overlay on top of a local service.

**PEAK-ONLY LOCAL: SHUTTLE AND SCHOOL SERVICES**

Peak-only Local services are usually shuttles for short trips to destinations that produce high demand over a short period – typically business-park work sites and schools. Schools and work sites located on the Frequent Network will have the best access and will not require these shuttles to the same degree.

**Transit Technology Options**

Transit technology – especially the bus-rail distinction – rarely determines when and whether you get where you’re going. Most of the things that matter to that outcome – speed, reliability, and especially frequency – can be delivered by both rail and bus technologies.

However, some corridors possess attributes requiring a consideration of relevant technologies:
4. The Transit Planning Toolbox

- The nature of the corridor -- for example, a street vs. a rail line -- may make it easier to implement bus or rail technologies. In the US, these choices are also influenced by the regulatory environment associated with existing pieces of rail infrastructure as opposed to road infrastructure.

- Overcrowding for an extended period beyond the peak, despite very high frequencies, tends to favor rail, which can carry more passengers per driver.

- Most people find rail services to be more comfortable. Ride quality, in particular, is almost always better on rail than on buses.

- Some people associate rail with comfort, durability, and value. Many in the real estate and development industry associate rail with the ability to raise land value and build the case for financing urban styles of development.

The decision to deploy a particular transit technology in a corridor is primarily driven by a few key questions:

- Are transit vehicles overcrowded for a significant period? Is the additional capacity a critical need?

- Is there a case for exclusive right-of-way? This can be either a rail line or a busway, depending on the nature of the corridor.

- Is rail justified and supported, either for its greater capacity, ability to take advantage of existing corridors unavailable to bus, or other reasons related to perceptions of comfort, safety, and positive real estate outcomes?

The answers to these questions can help determine whether a corridor is a good candidate for a high-capacity technology. While the major purpose of this document is to describe the tools of transit as they relate to direct customer mobility outcomes, a range of potential choices are described in these terms in Appendix A.
Chapter 5: Our Transit Choices
5. Our Transit Choices

People approach transit debates from many points of view, and demand that it serve many goals. Some of these goals, like “sustainability,” “equity,” and “prosperity,” are vaguely defined, and may mean different things to different people.

To actually implement their goals, the people of Wake County need to think about the real trade-offs that arise in the transit planning task. If the community, through its elected leaders, can answer these questions, the result can actually be implemented.

The hardest choices that this plan will have to address fall into a few big questions that come up routinely in transit planning. This chapter discusses the two largest:

- Ridership or Coverage? Are we trying to maximize ridership, or provide access to everyone?
- Infrastructure or Service? Are we more interested in building major infrastructure, or in running a higher quantity of bus service?

Each of these questions defines a spectrum. You do not have to choose one extreme or the other, but it is necessary to find a point in between them. As you move toward one extreme, you move away from the other.

Ridership or Coverage?
The hardest choice around transit is whether you want high ridership, or for everyone in the County to have access to it (‘coverage’). This trade-off arises unavoidably from the nature of the transit product. This is not an either-or choice; no transit agency is at either extreme. But a position on the spectrum between these competing goals needs to be identified, for example by specifying what percentage of the plan’s resources will be devoted to each goal.

Ridership Goal: “Maximize Ridership”
Do you want transit to be designed for maximum ridership for the budget? This goal serves to several common intentions for transit, including:

- Low subsidy, because more of the revenue comes from fares.
- Vehicle trip reduction and emissions benefits.
- Support for dense urban development, because a focus on ridership tends to serve these areas well.

The Ridership goal is often what is meant by “running transit like a business.” Unlike government services, businesses are motivated by the goal of maximum profit. In the case of local transit, where the fare paid by each customer is reasonably constant, this would mean maximizing the number of customers at a given cost.

Government services have a more complex set of motives, but they do resemble businesses when they are trying to maximize the number of users. So it is important to understand both why transit sometimes runs like a business and why it sometimes, intentionally, does not.

Every private business chooses which markets it will enter based on where it believes it can realize the strongest return on investment. If Wake County wanted its transit to work in this way, this would mean deploying all of the service in places where the greatest number of people are the most likely to use it.

If transit in Wake County were designed for maximum ridership, it would focus only on serving areas where the built environment meets the necessary conditions for high ridership. The system would have far fewer routes, but they would be much more frequent. Large parts of the county’s area would have little or no service at all, just
5. Our Transit Choices

as a private business feels no obligation to offer its product in places with low demand for it.

Coverage Goal: “Access for Everyone”

It’s very common to hear that the goal of our transit services should be “access for everyone.” This goal reflects desires such as:

- Service to every city and every area of the County.
- Lifeline for people with severe mobility limitations, no matter where they live.
- Support for suburban and rural styles of development.

When you say “for all,” you implicitly say “every last one, no matter how expensive it is to get to them.” The resulting network would run less service in high demand areas so that it can run more service in low-demand areas, to ensure that everyone has some access. Service is spread out, which also means that it is spread thin. The resulting frequencies are low, and service may not run long hours. Because the service is not very useful, even in areas of high transit demand, ridership is typically poor.

Imagine you are the transit planner for this fictional town. The dots scattered around the map are people and jobs; the streets shown are ones on which transit can be operated. The buses are the resources the town has to run transit.

Before you can plan transit routes, you must first decide what you want transit to do.

Ridership Goal
“Think like a business”

This transit network is designed to generate high ridership as efficiently as possible. The transit agency has thought like a business, investing its resources only into the best transit markets.

Coverage Goal
“Access for all”

This network is designed to provide some access to the transit system for all people. The transit agency has divided its resources among many routes throughout the town, none very frequent.

Figure 37: How Ridership and Coverage Goals Produce Opposite Kinds of Network
5. Our Transit Choices

But while the Coverage goal is not what would motivate a private business, it has played an important role in the shaping of every North American public transit system. Excluding so much of a service area tends to be politically unacceptable. Concerns about lifeline access -- not high demand, but extreme needs experienced by small numbers of people -- are also a reason to devote resources to the coverage goal.

The Two Goals in Practice

Why does a Ridership goal cause service to be concentrated in the highest-demand areas? Because as we noted in Chapter 3, frequency correlates with high productivity (ridership per unit of cost). High-frequency service, serving a favorable built environment, consistently generates the highest “bang for buck,” that is, ridership per unit of cost.

High-ridership planning therefore starts with high all-day frequency and extends it as far as it will go, focusing on the places where the most people will benefit from it. That, in turn, means dense and walkable places where many people are near the stops and can get to the stops. A transit line along an already-busy corridor can also stimulate some new growth along that corridor, encouraging new retail, employment activity and residential growth.

In Wake County, a network designed for maximum ridership would be overwhelmingly focused in the City of Raleigh and especially inside the Beltline, with just a few links to major destinations like Cary, RTP, and Triangle Town Center.

So when transit extends beyond that limit, it is usually to pursue a Coverage Goal. In a few cases, it may be seeking to shape or lead future development, when that development is likely to provide a strong transit market in the future. New TOD developments, infill projects on currently underdeveloped land, or incoming large employers are examples of future land uses that might be served under the ridership goal.

Transit agencies often must fight the misperception that because they are delivering on one goal, they are failing at the other. For example, a low-ridership route in a low-density neighborhood may be providing an important social service in support of a coverage goal. The route is not necessarily failing to meet a high ridership goal, because it was never intended to attract high ridership. Because these two goals - ridership and coverage - are opposite possible uses of the same funding, it is important that Wake County have a conversation with the community about how to balance them.

So throughout this study, we will ask: What percentage of resources do you want to devote to the goal of Ridership, and what percentage to Coverage?

Infrastructure or Service?

Any new transit funding source will have to be divided between building transit infrastructure and operating service.

Transit’s ability to offer attractive service benefits from a range of infrastructure, including rail lines, busways, transfer facilities, and simpler things like stops and shelters.

But transit infrastructure is useless without transit operations, and the actual benefits that transit provides to people arise from transit being operated, not just being built.

This is a key difference between transit and common kinds of public infrastructure such as roads and buildings. Once you’ve build them, a road or a building can be used. But a transit facility has to be operated, and in transit operating cost is dominant.
5. Our Transit Choices

So while a road budget might be mostly about building roads, a transit budget has to be carefully balanced between infrastructure and operations.

Obviously, there is no point in building infrastructure that you can’t afford to operate, but this trade-off is bigger than that. Buses, the dominant form of transit service, don’t require much infrastructure, but are still a very efficient way to provide a high quantity of useful transit. For this reason, they are found in almost every urban area in the world.

So the tradeoff is this: The more a plan spends on major infrastructure, the less abundant and extensive its bus service can be. Major infrastructure often ends up competing with sheer abundance of bus service, when it comes to dividing up the funding provided by any new local source.

Major Infrastructure’s Many Benefits

Some infrastructure improvements save operating cost. They do this two ways:

- By saving time, which is money for transit. Most transit operating cost lies in the driver’s time. Anything that helps transit run faster (rails, busways, bus lanes, signal priority, and so on) saves operating cost. Faster fare-collection systems that speed up boarding are another example.

- By increasing capacity, so that you need fewer drivers to carry the same number of people. One of the main selling points of rail, once demand is high enough, is the much higher capacity in terms of passengers per driver. This means that at high frequencies, one train (and driver) replace several buses (and drivers). This is also why some transit agencies invest in large buses. Faster service is also intrinsically higher-capacity service, because available vehicles and drivers cycle the line more quickly.

Major infrastructure delivers many other benefits, of course:

- It can create a safer and more pleasant environment for customers. Rail in particular also provides a consistently better ride quality.

- In many cases, it may be the only way to deliver a high level of speed and reliability in an important corridor.

- It tends to increase the legibility of transit services, often because the built environment (rails, for example, or prominent busways) makes the route obvious.

- It is a signal of permanence, since significant public funds have been invested.

- Partly because of its obvious permanence and quality, it sends signals to the real estate market that helps to trigger urban development. This last point has become a major argument for rail transit investments, in particular, in the U.S., and Federal funding criteria now consider these outcomes. Many other kinds of expensive and durable infrastructure have similar “city-shaping” effects to various degrees, including sufficiently high-quality bus infrastructure.

- It has important aesthetic values in its role in the cityscape, which can also be relevant to redevelopment outcomes.

- The Federal government can provide large-scale assistance with funding major infrastructure, so these projects
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attract funding to the region. For example, the 2012 Wake County Transit Plan assumed a 50% Federal contribution for the light rail elements of that plan.\(^8\) Major infrastructure thus becomes a way to attract Federal dollars. (The process is competitive, however, so a plan that depends on these funds is not assured of success.)

Benefits of Low-Infrastructure Operations

While the benefits of transit infrastructure may be evident, there is also a benefit to operations that do not require such major infrastructure spending. Transit that doesn’t need infrastructure can spend more on operations, which often means service to more places, more frequently, and useful for far more potential trips.

This principle is why the bus is such a universal tool in transit agencies all over the world. While it too benefits from major infrastructure such as busways, it can function without it and therefore is a very cost-effective way of providing large quantities of transit.

The same principle explains why commuter and intercity rail is often relatively affordable to develop where rail lines already exist. These services use existing rails, and while they often need to add some rails and certainly stations, the cost are often lower than the cost of building a rail line from scratch.

Low-infrastructure operations are also intrinsically incremental. A service pattern can be created without waiting for the infrastructure. It is possible to create service patterns, see how well they perform, and then revise them over time. Successful bus lines do become permanent, but less successful ones [based not just on ridership but on the community’s preferred ridership-coverage balance] can be revised.

Summing Up the Trade-off

Wake County may get Federal or State help in building major transit infrastructure that this plan may propose. Of course, there will still be a substantial local cost (called the “match”), and the local funding source will also have to pay for operations, not just of the major infrastructure but the total transit system, including buses.

A major question for this plan, then, will be how much of the local revenues to set aside for the “match” needed to attract major infrastructure. Making this investment requires:

- Valuing the benefits of major infrastructure, listed previously, above larger quantities of low-infrastructure service.
- A preference for long-term over short-term outcomes. Major infrastructure takes years to get funded, environmentally cleared, and built. For example, the most optimistic estimate for a light rail line is that it could be running eight years after the plan is approved by voters.
- Accepting the risk of not succeeding in competition for the Federal funds, leaving the major infrastructure unfunded.

Exploring the Choices

The next steps of this plan will be to refine a series of alternatives that illustrate some of the choices. These alternatives will be developed in close consultation with the Advisory Committee, to ensure that they present vivid contrasts. Alternatives may differ by representing different balances of ridership and coverage. They may also differ in being focused on major infrastructure or focused on service.

These alternatives will also take into account public input received through an
5. Our Transit Choices

upcoming survey focusing on the trade-offs described in this report.

The alternatives will include maps showing what the transit system would look like under each alternative, including locations of major infrastructure, specific alignments of frequent bus lines and commute express bus lines, and general indications of the extent of service, including rural service levels.

The alternatives will help to make the trade-offs vivid so that people can form a view. The resulting feedback will form the basis for a decision about how to design the recommended plan. It is likely that the recommended plan will be different from all of the alternatives, but that it will be somewhere between the extremes that the alternatives have illustrated, based on the feedback received.
Appendix A: Transit Technologies
Appendix A: Transit Technologies

While previous sections of this report have avoided discussion of specific technologies in favor of a focus on description of service types by frequency, span, and stop spacing, some corridors possess attributes requiring a consideration of relevant technologies.

To the extent that the goal is maximum transit mobility, technology choice is primarily driven by capacity concerns. The map of the service toolbox differentiates service types independent of technology by what they do, and whether they support a goal of high ridership or high coverage. Because high-capacity transit technologies can carry many people, they are primarily used in the ridership service types explained in previous section, particularly in corridors where existing frequent service bus routes already have very high ridership.

Technology, among many other responses that affect ridership and can also help determine how transit shapes development. In particular, rail services provide a smoother ride, are more readily electrified, and are heavily associated with urban redevelopment in the eyes of many in the real estate and development industry.

This appendix describes a series of high-capacity transit technologies commonly used in situations with one or more of these criteria. See the “Transit Toolbox,” Figure 30 on page 59, to see how these tools tend to fit the various expectations of transit in different corridors. Similar to Chapter 4, each technology is accompanied by a diagram showing its typical position in the Transit Toolbox.

Rapid Bus without Exclusive Right-of-Way

The simplest, lowest-cost alternative is the high capacity bus running in mixed traffic. At the low end, this can mean simply using larger vehicles such as articulated or two-floor buses.

Often, larger vehicles are introduced as part of a “Rapid Bus” or “BRT lite” effort, featuring distinctive branding and other improvements (wider stop spacing, off-board fare collection, sometimes signal priority) meant to improve speed and reliability without taking an exclusive lane. The Rapid Bus can be used to provide any of the service tools detailed in the toolbox, because at its most basic implementation, it amounts of providing the same service with a larger bus in order to accommodate greater demand.

Using a larger vehicle to solve problems related to overcrowding is a technological solution that is well-suited to corridors where there is overcrowding, but where the case for exclusive lanes or rail is weak because of lower demand, political opposition, or right-of-way or funding constraints.
Appendix A: Transit Technologies

The Rapid Bus does everything to increase capacity that can be done, without an exclusive right-of-way, grade separation, or rails in the ground. Naturally, the Rapid Bus’ effectiveness is limited by the existing patterns of auto traffic in a corridor, as well as the vehicle size at which it becomes unfeasible to run a bus in traffic.

**Streetcar**

Streetcars are a high-capacity technology using an electric rail vehicle. While inspired by European streetcars that are often in exclusive lanes, most North American streetcars run in mixed traffic. They are best suited for short corridors where speed and reliability are not primary issues of concern. While streetcars can carry more passengers per vehicle than most buses, because they run in mixed traffic, they are vulnerable to the same issues of reliability created by the friction of many vehicles all traveling in close proximity to one another in the limited space available on surface streets. In mixed-traffic situations they are inferior to buses in one key respect affecting speed and reliability: When a disruption arises in the lane in front of the transit vehicle, a bus can often go around this disruption while the streetcar is trapped behind it.

Streetcars are often the technology of choice when there is strong political support for rail, but insufficient need for capacity, speed or reliability to support a technology which escapes mixed traffic.

Streetcar may be a preferred technology due to other reasons unrelated to capacity needs, such as perception of comfort, durability, value, or the expectation positive of real estate outcomes. In recent years, several North American cities have built new streetcar lines using modern vehicles, while others continue to operate historic systems established decades before.

**Bus Rapid Transit**

Where there is a need for greater capacity, and support for exclusive right-of-way, but where rail is either not needed for capacity or not supported politically, buses can be used as a high capacity technology. Buses run on dedicated bus-only roads, or exclusive curbside or median lanes on arterial streets. In some cases, a form of BRT may share HOV/HOT lanes with private auto traffic. Street-running BRT usually features some sort of charismatic articulated vehicle.

This technology is differentiated from the Rapid Bus by its exclusive right-of-way, but in reality, there is a spectrum of improved
bus technologies. Many BRT products in North America feature exclusive lanes for a portion of their routes, while running in mixed traffic in other sections. Bus-only lanes in areas of high congestion can effect meaningful improvements to speed and reliability. However, even if bus lanes are present in one segment of the route, their absence in other congested locations can produce significant limitations.

Exclusivity of right-of-way on arterial streets is a defining feature of true BRT, which is rare in North America (though several cities have projects in under construction or in the planning stage). Where there are exclusive lanes, they are either in the median or curbside. Median lanes require restricting left turns at key intersections, but protect the vehicle to a greater degree from auto traffic. Curbside exclusive lanes, while still an obvious improvement on running a bus in mixed traffic, force buses to contend with auto traffic turning right from the arterial onto local streets, either across the bus lane or in sections near intersections where bus and auto traffic is mixed. In pedestrian-heavy zones, a common source of delay in a curb-lane is the right-turning car yielding to parallel pedestrians at a signal; this situation can easily consume a signal’s entire green phase with the bus trapped behind the car. Curb lanes also introduce some danger because buses are trying to move at a constant speed between stops while cars view the lane as serving the acceleration or deceleration role. These two functions are naturally in conflict.

Finally, a distinction can be drawn between two types of arterial BRT: open, and closed. In open BRT, the exclusive lane is not physically separated from auto traffic, and local buses can interline with the BRT system where routes overlap. Closed BRT systems have lanes which are physically separated from traffic, and frequently use a special vehicle designed to interact with a unique station design. Both open and closed BRT can greatly increase the capacity in the BRT corridor, and either can provide a substantial increase in capacity, reliability, and speed. However, open BRT, if designed in a way that anticipates interaction with underlying local services, can provide these same benefits to all routes during the section running in the BRT corridor.

Commuter Rail

Commuter rail is a high-capacity technology that can use existing freight rail track. This often makes it less expensive to implement. Commuter rail that shares tracks with freight and other uses often cannot run frequently.

Commuter rail is used when there is a capacity need, a case for exclusive right of way, and support for rail, coinciding with an available existing track and demand that
Appendix A: Transit Technologies

Commuter rail has a relatively high operating cost per train, typically because there is more than one employee on board. This is part of why its North American applications have tended to be narrowly focused on the peak commute market, where they carry a large volume of passengers into or out of a downtown, regional center or point of connection to other parts of the transit system. If demand is sustained throughout the day, commuter rail can be used to provide an all-day frequent service. However, commuter rail’s ability to operate frequently all day generally requires two modifications of the typical model:

- There must be enough track capacity so that frequent commuter rail can share the line with other uses, such as freight and intercity passenger rail.
- The number of employees per train must be minimized.

A number of North American transit agencies are now studying ways to transform historically infrequent commuter rail lines into frequent services. A common tool is the Diesel Multiple Unit (DMU), a smaller vehicle than a full train with locomotive, and thus often more cost-effective. Electrification of commuter rail also becomes more viable as frequencies rise.

Light Rail

Light Rail Transit (LRT) is often used where exclusive right-of-way has support, and where high vehicle capacity is needed, but where the volume of transit ridership does not justify fully grade-separated technologies such as heavy rail or driverless rapid transit. LRT is defined by having...
its own lane or grade; otherwise, the more appropriate term is streetcar. LRT usually runs on arterial streets, but sometimes takes advantage of preexisting rail corridors. In some cases, LRT may include short mixed traffic segments, as when the rail lane is used as a turn lane for auto traffic, but these must be limited and signal timing must be designed so that the cars do not block the rail vehicle in normal operations.

LRT almost always has exclusive lanes in its on-street segments, but because it lacks full grade separation, it cannot deliver the highest levels of speed, reliability, and capacity. LRT is vulnerable to disruptions from traffic due to congestion at intersections (though signal priority can largely alleviate this), or from collisions with auto traffic. Additionally, at-grade LRT systems’ top speeds are limited by the presence of pedestrians.

**Heavy Rail**
In some situations, the need for transit service of extremely high speed, reliability, and capacity demands a rail rapid transit system that is fully grade-separated from other travel modes. Obviously, this requires a strong case for both exclusive ROW and rail. This full separation can be achieved by tunneling or elevated structures, land acquisition, or making use of existing right-of-way such as utility corridors.

Examples of heavy rail technology include the New York City subway system and Washington, DC, Metro. These are systems where the volume of passengers is sufficiently great to justify the expense of grade separation. Heavy rail is often what people mean when they refer to “rapid transit,” though in reality that term is sufficiently broad to encompass other technologies and has more to do with speed, reliability and grade separation than a particular type of vehicle.

**Driverless Rapid Transit**
The vast majority of transit services, including all of the services discussed in this report, have a paid employee on each vehicle. This employee’s compensation is typically the dominant element of operations cost and thus the thing that planning is always trying to deploy efficiently.
Appendix A: Transit Technologies

However, the world of rail transit does include a product that severs this link. Fully automated rapid transit systems have no driver in each vehicle, and can therefore run long hours at a high frequency at a relatively fixed cost. Many Americans have experienced this technology in the form of shuttles within airports.

Driverless rail transit – used as a high-capacity transit mode in cities -- has existed since 1986 in Vancouver, and also exists in Dubai and is under development in many other places where labor costs are an obstacle to sufficiently abundant service. Paris recently added a driverless line to its metro network, and is now converting its oldest and busiest metro line to driverless.

Driverless rail transit requires a fully exclusive right-of-way with no intersecting roads or tracks, so it is elevated or underground in most situations. Operations and customer service are handled from a control center rather than by on-board employees, though there is a roving staff that provides security and checks fares. (Often, control centers have a better view of incidents than an on-board driver does, and are in the better position to advise customers what to do.) When proposed, driverless lines inevitably raise public concerns about safety, but Vancouver’s has had fewer serious accidents than many human operated systems.

A separate conversation could be had about driverless vehicles that do interact with traffic, modeled on Google’s driverless car project. There is no reason in theory that the technology of driverless cars could not be extended to transit vehicles, whose movements are generally much simpler than those of private vehicles. This would completely transform the economics of transit, by severing the link between transit abundance and labor cost. However, there is no practical implementation of this technology to date.

Personal Rapid Transit (PRT)

The PRT idea is that a fixed guideway, often elevated, is served by a large volume of small driverless podlike vehicles that can be programmed to go directly to a specific station without stopping at other stations. PRT involves lightweight but still substantial infrastructure, typically achieving full separation from other vehicle traffic. PRT systems exist in some specialized environments, including Heathrow’s Terminal 5, and on a campus in Morgantown, WV.

PRT is quite rare compared to many of the other technologies discussed in this section. A technology that was first put in service in 1975 (in Morgantown, WV) has only four in-service examples in the world, and in several cases (including the recent
Appendix A: Transit Technologies

Heathrow Airport and Masdar, Abu Dhabi systems) plans for expansion beyond the starter line have been dropped.

The key problem with existing PRT examples, as identified by some transit experts, is that expensive infrastructure must be justified by a high number of passengers. The small pods connecting specific origins and destinations are intrinsically low-capacity. This is why existing PRT systems tend to turn into ordinary rail transit systems, making all stops along a line, during busy times of day; that has been the experience in systems as various as the rail-based Morgantown, WV campus PRT and the rubber-tired technology recently attempted at Masdar, Abu Dhabi.

Research is underway at NC State to dramatically reduce the cost of PRT guideways. Still, PRT’s tendency to turn into a fixed route when demand is high raises the question of its advantage over conventional fixed services such as driverless fixed-route rail transit. Ultimately, the distinctive feature of PRT is direct service without stops, and in some cases the idea of riding only with your own party. The case for PRT would require establishing that these benefits are of overwhelming importance to most potential riders.

Appendix B: Acronyms

ADA  Americans with Disabilities Act
BRT  Bus Rapid Transit
C-Tran  Town of Cary Transit Services
CAMPO  Capital Area Metropolitan Planning Organization
CAT  Capital Area Transit (City of Raleigh bus network)
DCHC MPO  Durham-Chapel Hill-Carrboro MPO
DMU  Diesel Multiple Unit. A transit vehicle that can share freight rail lines, using diesel fuel as the energy source.
EMU  Electric Multiple Unit. A transit vehicle using electricity as the power source, requiring no separate locomotive.
ILA  Interlocal Agreement (a contract between local governments)
LEHD  Longitudinal Employer-Household Dynamics, a US Federal data source on population and employment nationwide.
LPA  Locally Preferred Alternative (see AA).
LRTP  Long Range Transportation Plan
MPO  Metropolitan Planning Organization. MPOs are Federally mandated agencies made up of representatives of cities, counties, and other key government agencies in a metropolitan area. They have considerable authority around the flow of Federal funds to local transportation projects.
NCDOT  North Carolina Department of Transportation
NCRR  State-owned railway extending from Charlotte through the Triangle area to Morehead City.
NTD  National Transit Database, a national database on US transit systems and their performance
RDU  Raleigh-Durham Airport Authority
RTA  Regional Transportation Alliance, a program of the Greater Raleigh Chamber of Commerce
RTP  Research Triangle Park
STAC  Special Transit Advisory Commission (2008 body advising CAMPO)
TRACS  (Wake County Transportation and Rural Access) Rural lifeline transit service in Wake County
ULI  Urban Land Institute
Appendix C: History of Transit in Wake County
Appendix C: History of Transit in Wake County

History of Wake County Public Transit Providers

Between 1950 and 1960, the City of Raleigh Capital Area Transit (CAT) service began operations, building on services previously provided by power companies and private firms. CAT is confined largely to the City of Raleigh and adjacent destinations.

In 1980, the North Carolina State University Transit (Wolfline) service began operations, focused on moving students in and around university campuses. The network has grown substantially in both extent and frequency, but remains confined to NC State campuses and adjacent areas. Wolfline is NC State’s tool for giving the public access to all of the university’s offerings, even as the campuses have grown beyond the range of walking distance.

Town of Cary Transit (C-Tran) began operations as a door-to-door service for senior citizens and disabled people in 2000, expanding to include fixed route transit service in 2005. These services largely function as circulation within Cary and are primarily funded by the Town of Cary.

Triangle Transit is the region’s main transit operator for longer-distance travel, linking the cities of Orange, Durham, and Wake Counties, as well as RDU Airport and Research Triangle Park. In 1991, Triangle Transit was given the authority by the NC Legislature and each County Board to levy a vehicle registration fee of $5.00 per vehicle, which is used for regional bus operations, the vanpool program, and the transit planning program. In 1997, Triangle Transit was authorized to levy a 5% tax on rental car fees, which was dedicated for rail planning and development. In 2007, the Triangle Transit Board of Trustees adopted a policy allocating up to 50% of each year’s rental tax revenues to pay for expansion of transit operations, reserving the remainder for future fixed-guideway projects. Currently, Triangle Transit operates service connecting Raleigh, Cary, and the RDU Airport with all-day service, and Garner, Morrisville, Wake Forest, Apex, Knightdale, Wendell, Zebulon, and Fuquay-Varina with peak period commuter services. Connections to Durham, Chapel Hill, and Research Triangle Park are available through Express routes or connections at the Regional Transit Center.

Triangle Transit is operator of the regional transit information center handling customer calls for all transit agencies in the 3-county region. Since 2010, Triangle Transit also conducts the planning, marketing, and management oversight for the local bus services in Durham under contract with the City.

In 2001, Wake County Transportation and Rural Access (TRACS) began providing service to the residents of the non-urbanized areas of the County. Operating funds for TRACS come from multiple sources: state programs aimed at rural access trips, particularly where there are no other options; programs supporting shared rides with elderly, disabled, or employment-related trip purposes; and several Wake County municipalities.

The GoTriangle brand was established cooperatively in 2003 to provide a common umbrella identity for customer information services for all of the region’s public bus, vanpool, and transportation demand management services. This work has been a cooperative partnership, administered by Triangle Transit.” In March 2015, the program will re-brand CAT, C-Tran, and Triangle Transit as Go Raleigh, Go Cary, and Go Triangle, respectively.

In addition to the counties, cities, and transit operators, Metropolitan Planning Organizations (MPOs) are key players in transportation planning in the region. MPOs are federally mandated agencies made up of representatives from cities, counties, and other key government...
Appendix C: History of Transit in Wake County

agencies in a metropolitan area. They have considerable authority around the flow of federal funds to local transportation projects. The MPO for Wake County and portions of surrounding counties is called the North Carolina Capital Area Metropolitan Planning Organization (CAMPO).

History of Transit Planning, 1997-2011

Following incorporation of the Triangle Fixed Guideway Study recommendations into the two MPOs long-range transportation plans in 1997-1998, Triangle Transit began planning and designing for rail transit in 1998. The initial project was a rail route connecting Durham, RTP, Cary, NCSU, downtown Raleigh, and north Raleigh with service every 15 minutes during peak periods, and every 30 minutes off-peak. Triangle Transit used local funds to match state and federal grants for planning, engineering, and acquiring key right of way areas. In 2006, it became clear that the proposed project would not be competitive for federal funding under the rating system in effect at that time. Triangle Transit withdrew the project from consideration for federal and state funding.

In 2008, Capital Area Metropolitan Planning Organization (CAMPO) and the Durham-Chapel Hill-Carrboro (DCHC) MPO convened the Special Transit Advisory Commission (STAC), an advisory group of elected officials and stakeholders appointed by the two MPOs to determine the next steps on transit. Four key elements came out of this group:

- The plan to connect the region with rail is reaffirmed
- More local money will be needed (such as a 1/2 sales tax)
- Bus expansion in early years is important
- Connecting the region with rail must be completed in phases

Also in 2008, the NCDOT Rail Division announced plans to increase rail service from Raleigh to Charlotte to four trains each way per day. This announcement sparked an idea of “express rail,” a concept to add local trains to the state plan to provide inexpensive and frequent service between Raleigh, Cary, Research Triangle Park (RTP) and Durham.

In 2009, Triangle Transit’s Board of Trustees approved funding for an Alternatives Analysis along three corridors in the region:

- Durham-Orange Corridor – This project led to the Durham-Chapel Hill light rail project now under development.
- Durham-Wake County Corridor – This proposed 37-mile commuter rail line follows the NCRR corridor from the Duke Medical Center in Durham, through the Research Triangle Park, Cary, Raleigh, and Garner to the Wake-Johnston County Line.
- Wake Corridor – This study extended from Research Triangle Park along the NCRR corridor to downtown Raleigh, where it turns northward, continuing on the CSX corridor almost to Triangle Town Center. Light-rail was previously identified as the most appropriate technology. While this corridor overlaps the Durham-Wake corridor, this study was focused on more frequent service with more stations than commuter rail would provide.

The Alternatives Analysis was completed in July 2011.

In May 2009, CAMPO and DCHC MPO approved the 2035 Long Range Transportation Plan (LRTP), which included transit investment elements based on the recommendations of the STAC process.
Appendix C: History of Transit in Wake County

In August 2009, the NC Legislature approved House Bill 148, the Congestion Relief/Intermodal Transport Fund, which allowed a local option sales tax, county vehicle registration fee, and increase regional vehicle registration fee. This legislation forms the legal basis for any voter-approved funding measure that may be proposed as a result of this plan.

Beginning in 2009, Wake County began development of a County Transit Financial Plan. The Board of Commissioners set a clear expectation that a financial plan will be linked to a detailed service plan, and stipulated that each Wake County municipality must agree with the service plan and agree to the tax sources. In 2010, Wake County constructed a new financial model to predict how revenues and spending will work, based on assumptions consistent with Wake County-accepted norms.

Also in 2010, Triangle Transit and Wake County jointly presented a concept of the transit planning process to each municipal board. The municipal boards were told that they would be asked to sign an interlocal agreement (ILA) agreeing to the tax sources and service plan. Wake County staff also met with the municipal managers to discuss related issues such as bus service expectations, concerns about funding fairness, willingness to spend local money on transit, and overall support for transit investment.

The same year, CAMPO and the City of Raleigh funded a 2040 bus plan detailing bus service expansion opportunities. Staff from all Wake County municipalities, Triangle Transit, Triangle J Council of Governments, and from the MPO worked together in the development of this plan. A base assumption was that extensive bus service and facility expansion would occur in early years.

In 2011, Triangle Transit completed the Durham-Wake Alternative Analysis (AA) and the Wake County Alternative Analysis. The Durham-Wake AA recommended commuter rail along the NCRR rail line. The Wake County AA led to a recommended light rail alignment running from northwest of downtown Cary through NC State and downtown Raleigh to the Triangle Town Center area.

Subsequently, elected officials from all three counties met to develop a complete plan for funding the three rail projects and the 2040 bus plan. This was the basis of the Wake County Transit Plan of 2012, the first effort to build a complete, fundable plan for transit expansion based on revenue sources to be approved by the voters.
Appendix D: Photo Attribution

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