MULTIMODAL NORFOLK

TRANSIT SYSTEM REDESIGN

Transit Choices Report

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For

THE CITY OF NORFOLK

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Introduction and Summary

What is Multimodal Norfolk?

The City of Norfolk is developing a Multimodal Transportation Master Plan to help define the direction that the City's transportation system will take over the coming years. This Plan will provide the framework for both large and small transportation decisions about projects, priorities, coordinated planning with respect to land use decisions, public/private initiatives, other infrastructure projects, and more.

What is the Transit System Redesign?

As part of Multimodal Norfolk, the City is studying a full redesign of the public transportation system. This study will evaluate and recommend important policies related to transit funding and stop spacing, and particularly recommend how and where transit services should be provided in the city. As part of the redesign many types of transit services will be considered, including traditional fixed route services and on-demand options.

Why think about transit?

After losing population for 30 years, the City of Norfolk has been growing since 2000 and continues to increase in population and employment. Adding people and jobs means increasing density. That makes public transit essential because there is simply not room for everyone's car. While not all of Norfolk is dense, large parts of it are, and like all places with high density, Norfolk presents features that make transit essential, and require that it be highly efficient:

- *Severe road space limitations.* Across many parts of Norfolk, the road-width is fixed and will never be wider. Efforts at widening roads in built-up areas are extremely costly, frequently destructive, and actually counterproductive—research shows that widening roads does not reduce congestion due to induced demand. Curb space is also limited and cannot be readily expanded.
- *Intensification of land use.* In response to growing demands for housing and commercial space, both central and outlying areas are growing more dense. More and more people are living within the same limited area.

These two factors combined mean that more and more people are trying to use a fixed amount of road space. If they are all in cars, they simply will not fit in the space available. The result is congestion, which cuts people off from opportunity and strangles economic growth.

Figure 1: The road space required to move the same number of people using public transit, bicycles, and cars.
Photo copyright We Ride Australia

Figure 1 shows how much space the same number of people take in cars, bikes, and buses. ***In a growing city that is getting more dense, relying on bikes and transit as major modes of transportation is the only way to have room for everyone.***

The only alternative to congestion is for a larger share of the population to rely on public transit and other modes that carry many people in few vehicles, or that take far less space per person than cars (i.e. bicycles). This requires services that most efficiently respond to the city's changing needs, as well as corridor improvements to give buses a level of priority over cars that reflect the vastly larger numbers of people on each bus.

Doesn't HRT handle transit for us?

The City of Norfolk is the second largest city in the Hampton Roads region, but it is the densest. Since transit demand rises so steeply with density, Norfolk will experience more urgent transit needs than the larger and less dense jurisdictions in the region.

Hampton Road Transit (HRT) is a region-wide transit provider but primarily functions as a provider of service that local governments sponsor. While HRT is a regionally-organized, independent organization, its governance structure and financing mean that each local government determines how much service operates within its boundaries. Every dense city that is inside a larger region of lower density experiences a problem of mismatch between regional willingness to fund and operate transit relative to the local need within the dense, congested central core. Thus, many core cities are taking a more active role in managing and funding their transit systems, no matter who operates the service.

In addition, city governments control transit outcomes at least as much as the transit agency does. Transit is the result of how a service interacts with land use and street design, both of which are largely under city control. The land use pattern determines whether many people and destinations are in places where transit can serve them, while street design determines both how reliably transit can operate and how easy it is to walk to it. As in all dense cities, city leadership is essential for a transit system that matches the city's development goals to be achieved.

What is the Purpose of this Report?

This Choices Report is the first step in the Transit System Redesign portion of Multimodal Norfolk. It is mean to spark a conversation about transit needs and goals in Norfolk for the short-term. The Choices Report helps lay out relevant facts about transit and development in Norfolk, and draws the reader's attention to major choices that these facts force us to weigh. The goal of this report is to assess the existing transit network and the geometry of today's city and engage the public, stakeholders and elected officials in a conversation about the goals of transit in Norfolk.

Before we do any network planning, The City of Norfolk needs to hear from the public about what the priorities for transit service should be.

The Transit System Redesign is short-term, focusing on things that can be accomplished in the next few years. This report focuses mostly on bus services because those services are relatively easy to develop or revise quickly. The goals articulated by the public, stakeholders and elected officials through this project will be carried forward into future long-range planning.

The Transit System Redesign is part of a larger multimodal planning effort that looks at all modes of transportation in Norfolk, and is considering longer-term investments across all modes to achieve the mobility and access outcomes that the city wants. Thus, while the redesign effort is focused on what can be done in the next few years, there are opportunities to consider longer-term investments and changes throughout this Multimodal Norfolk process.

What are the recent trends?

Like many transit agencies across the country, HRT has seen ridership decline in the last few years. Figure 2 shows the total annual ridership across the entire HRT system from 2010 to 2018. Ridership peaked in 2013 at about 18,300,000 annual riders and has declined to about 13,300,000 in 2018. The result is about a 22% decline in ridership from 2010 to 2018. This raises a number of questions about what may be behind the decline. Are there issues within the control of HRT or the City of Norfolk that could affect this decline?

A key driver of ridership is total service hours provided. This measures the quantity of transit service available to potential customers. A service hour is one bus operating for one hour. More service means more transit is available for people to ride. Figure 3 shows the total service hours provided for fixed-routes (bus, rail, and ferry) from 2010 to 2018. Overall service hours have increased, though they did decline from 2017 to 2018. Since 2010, total service hours are up about 5%. Thus, the quantity of service is not the primary driver of the decline in ridership.

A key outcome of this increase in service hours and decline in ridership is that the overall service "productivity" is declining. Productivity is a transit industry term for what lay-people might call "efficiency." If ridership is an outcome people care about, then ridership relative to cost describes how "productive" an agency is towards that outcome.

The productivity ratio is:

$$\textit{Productivity} = \frac{\textit{Ridership}}{\textit{Cost}} = \frac{\textit{Boardings}}{\textit{Service Hours}}$$

In 2010, the average productivity of all HRT services was 18.7 boardings per hour. With ridership increases, productivity peaked in 2013 at 20.7 boardings per hour. By 2018, productivity had declines to 15.8 boardings per hour.

Declining ridership is always a concern for a transit agency or city, but ridership declines are not always attributable to things that a transit agency or city can control. Redesigning service to be more useful would certainly help, but would not be enough to reverse this trend alone.

Multiple research papers have shown that the changes in the cost of car ownership and use can have a significant effect on transit ridership. Over the course of the second half of 2014, gas prices in the US fell about 50%, remaining relatively low ever since.[1]

A Mineta Transportation Institute paper looking at 2012 ridership for many cities found that gas prices were the most powerful external variable (i.e. outside the control of the transit agency) affecting ridership. That analysis also showed that changes in gas prices affected transit ridership in all urban areas similarly.

The significant decline in gas prices is probably the factor that explains the fall in ridership in Norfolk and Hampton Roads, which began at the same time. It often takes time for behavior patterns to change, so even though gas prices fell suddenly, they may still explain some of the drop in later years.

The impact of ride-hailing (Uber, Lyft, etc.) is hotly debated, but it probably caused some ridership loss among more financially comfortable riders. Estimates of the impact of ride-hailing vary, but a recent UC Davis study indicates that 21% of adults in major American cities use ride-hailing. This study also indicates that when people start using ride-hailing their use of transit declines by 6%.[2]

While these external factors are likely to blame for much of the loss in ridership recently, Norfolk and HRT are not powerless to affect ridership. There are many factors within the City's control that can help improve the attractiveness of transit. The City controls the density of land by determining the zoning and approving development. The City sets parking policies, which dramatically affect both the density of land use and the cost of competing modes. The City and State control walkability through the management of streetscapes, signal timing, and crossing locations. The City manages street priority by allocating lanes among competing uses. Overall, cities have as much control, if not more, over the success of transit than transit agencies.

1 Alam, B, Nixon, H, Zhang, Q. "Investigating the Determining Factors for Transit Travel Demand by Bus Mode in US Metropolitan Statistical Areas," Mineta Transportation Institute. May 2015.

2 Clewlow, R, Mishra, G. "Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States," Institute of Transportation Studies, University of California, Davis. October 2017.

Figure 2: Ridership across the entire HRT system has been declining since 2013.

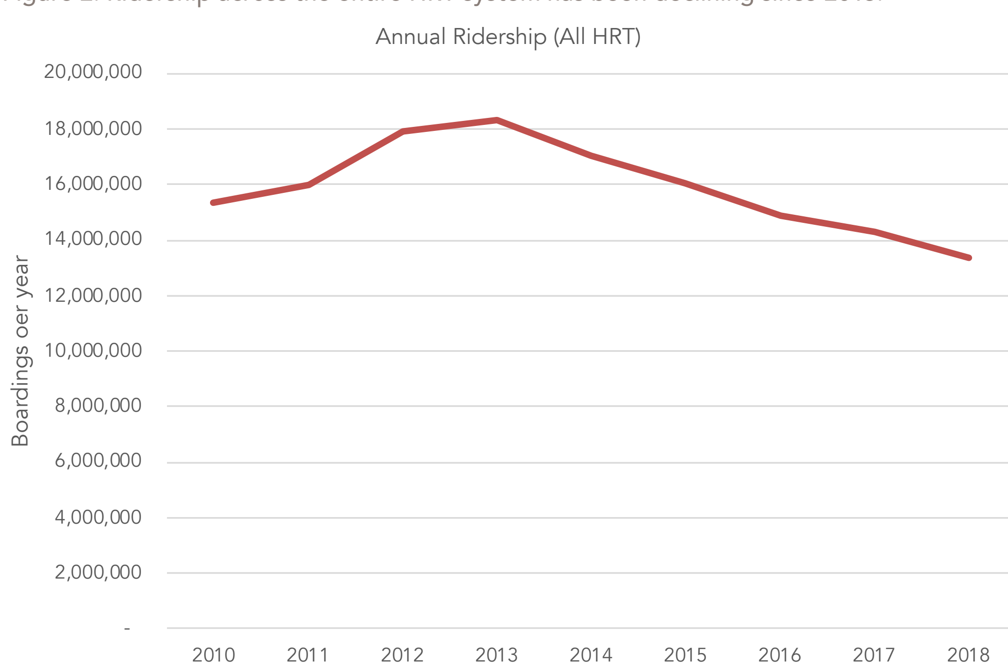


Figure 3: While ridership has declined, total service levels have gone up.

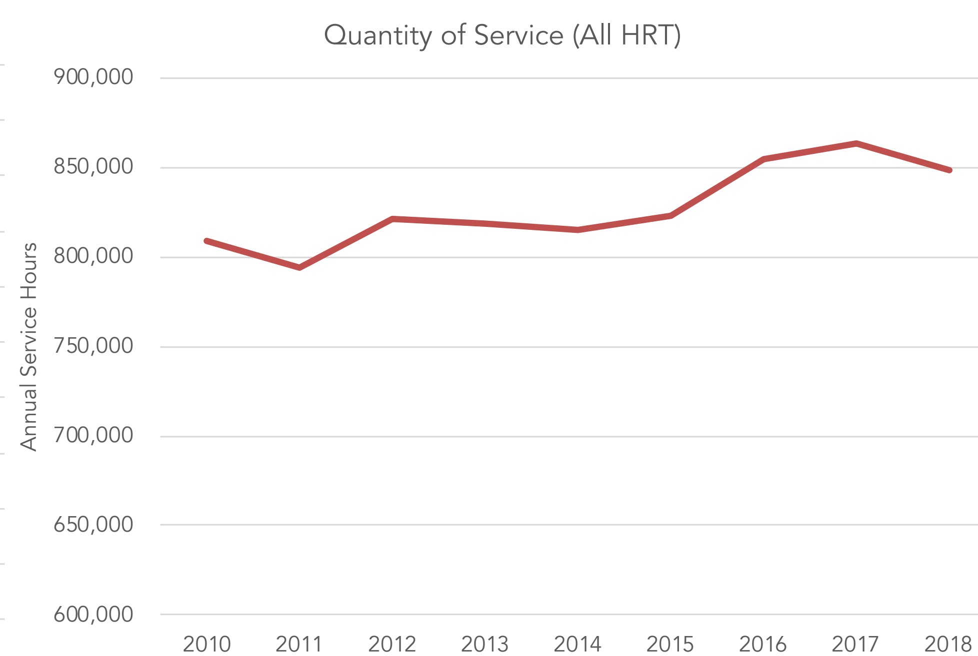
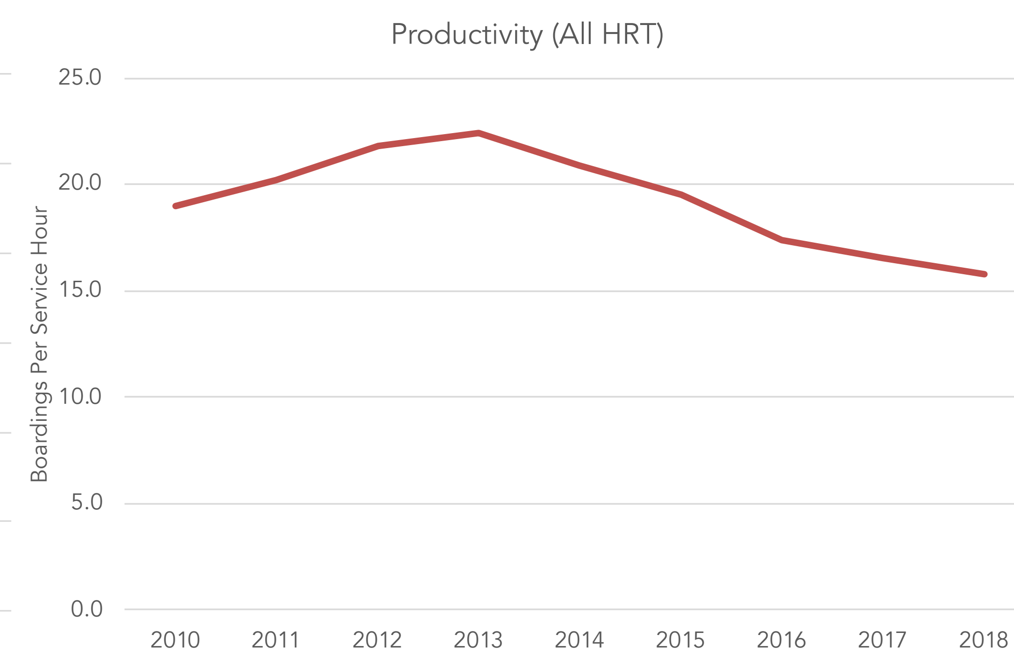


Figure 4: Fewer boardings and more service means productivity has declined since 2013.



What else is in this report?

Transit Geometry

In Chapter 2, we summarize the basic principles of transit geometry, how they affect the access and opportunities that transit can provide to residents, workers, and visitors, and how the underlying geometry forces cities to grapple with some key value trade-offs in the design of its transit system.

RIDERSHIP OR COVERAGE?

Ridership means attracting as many riders as possible by concentrating our most useful services in the places where the most people can take advantage of them.

Coverage means being available in as many places as possible, even if not many people ride, by spreading service out so that everyone gets a little bit.

Why not BOTH? Spreading service out means spreading it thin. If HRT buses need to go absolutely everywhere in the city, we have to run lots of routes. When we spread our limited budget over all those routes we can't afford to run very much service on each of them. That means those routes won't be very effective in getting high ridership, because they won't run often enough, or late enough, to be there when you need them.

Ridership goals and coverage goals are both very popular. But no transit agency can pursue both goals with the same dollar, because the goals require very different kinds of bus networks. HRT, like every agency, has to decide how much of its budget it will spend pursuing ridership goals, and how much it will spend on coverage goals. There's no right or wrong answer to this question: It depends on what your priorities are. This report aims to help you think about this choice.

Markets and Needs

In Chapter 3, we assess the markets for transit in Norfolk, the potential for high ridership in the city, and the areas where the need for transit is high but the density of demand is not.

By "market" we are referring specifically to the demands for transit that result in high ridership relative to cost. This way of thinking about a transit market is similar to the way a private business thinks about its market for sales – how many potential customers there are, how useful they will find the product, and how well the product competes for their business.

High transit ridership satisfies a number of commonly-held values, like:

- If a city wants its transit system to compete successfully with cars to achieve environmental benefits (such as cleaner air and reduced carbon emissions) a Ridership goal is the path to that achievement.
- For transit to act as an economic stimulus, by providing job access to large numbers of workers, it must attract ridership. These interests are therefore also served by a Ridership goal.
- If leaders are concerned about government efficiency, they will want to maximize fare revenue relative to costs (and therefore reduce subsidy per rider), and they will also be drawn to a Ridership goal.

Existing Network

In Chapter 4, we analyze the fixed route transit network performance including the frequency of service, productivity of service and how the network performs on measures like access to jobs. We also assess some key challenges and opportunities for improving transit service in the city.

Imagine you are the transit planner for this fictional neighborhood.

The dots scattered around the map are people and jobs.

The 18 buses are the resources the town has to run transit.

Before you can plan transit routes, you must first decide: What is the purpose of your transit system?

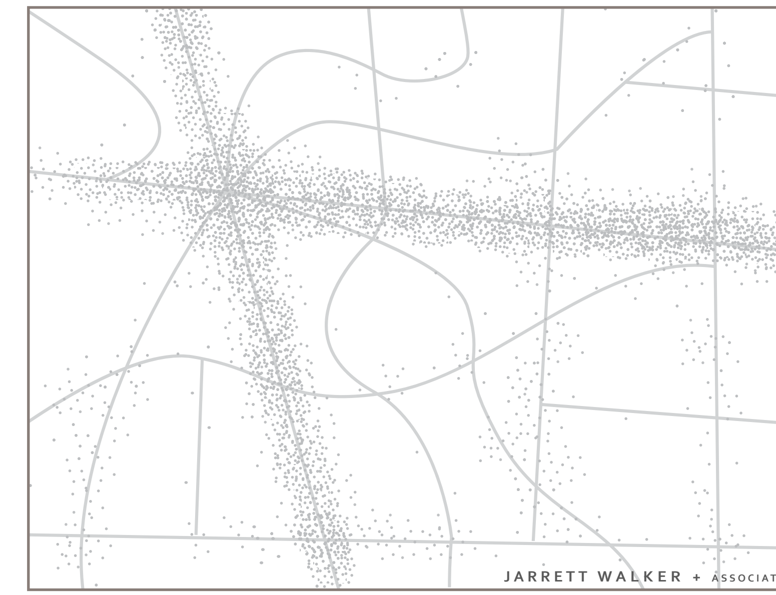
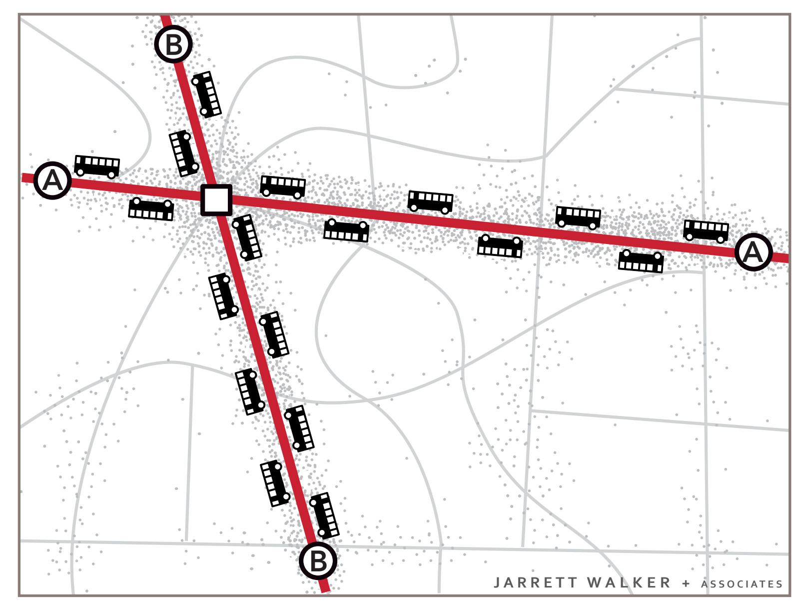
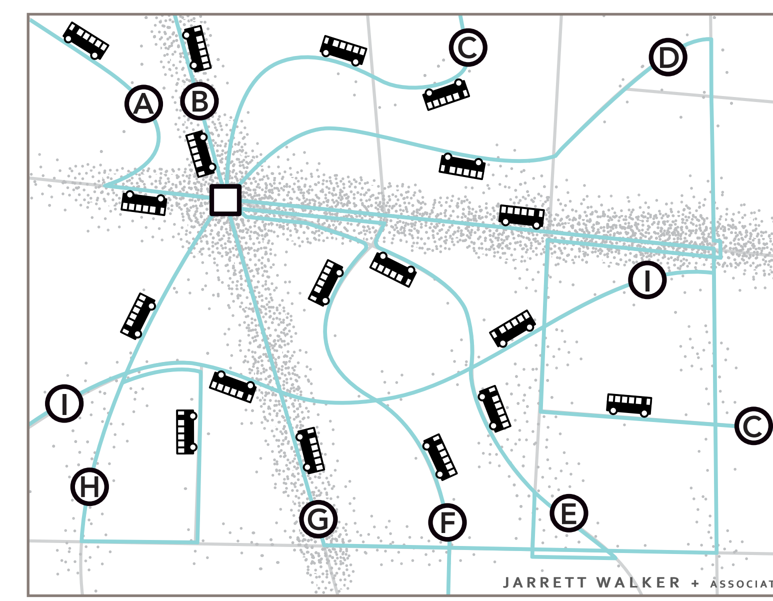


Figure 5: Ridership and coverage goals, both laudable, are in direct conflict within a fixed budget.



All 18 buses are focused on the busiest streets. Waits for service are short but walks to service are longer for people in less populated areas. Frequency and ridership are high but some places have no service.



The 18 buses are spread around so that there is a route on every street. Everyone lives near a stop but every route is infrequent, so waits for service are long. Only a few people can bear to wait so long, so ridership is low.

Key Choices

In Chapter 5, we summarize key value choices that only the community and its leaders can make about how transit should serve the city. These value choices cannot be answered by technical experts because they are questions about what goals and values the communities prioritizes. There is not a technically correct answer to these value questions.

Balance between Ridership and Coverage?

1. What should the balance between ridership goals and coverage goals be? Divide 100% between these goals:

a. **Maximizing ridership by providing high-frequency, useful services to dense places.** This will put more people near the most useful services, but the number of people across the city with access to transit may be reduced.

b. **Maximizing coverage by extending lower-frequency services to reach more of the city.** This will increase the number of people across with access transit service, but reduce the number of people with access to frequent services.

For Coverage Service, Where?

2. If you think we should run coverage service, what goals for that service are most important to you?

a. **Transportation options for people who can't drive.** This goal would cause the City to put coverage services only in places where many people don't own cars -- especially places with large numbers of low income, elderly, or disabled persons.

b. **Service to everyone who pays taxes.** If this is the goal, Norfolk would ask HRT try to serve every part of the city, even where there are relatively few people who need the service.

c. **Service to newly developing areas, where the community geometry will support ridership eventually.** If this is the goal, coverage service would focus on places where denser development is occurring.

Walking or Waiting?

There is a limit to how much a transit agency can increase ridership, within a fixed budget, without increasing walking distances to service and thereby increasing frequencies. This choice, between walking and waiting, relates to a larger choice about how to balance ridership and coverage goals.

If Norfolk wanted to increase ridership within its fixed budget for transit, then route spacing would become more consistent across Norfolk's neighborhoods, particularly in eastern Norfolk where route spacing is relatively close. Some people who are very close to (infrequent) service today would be asked to walk a little farther but this would mean higher frequencies and longer spans on many routes. Within a fixed budget, increasing frequency also means consolidating service and into fewer routes, thereby increasing walking distances.

Rush-Hour or All-Day Service?

Today, HRT operates some routes only during rush hours, and also offers higher frequencies during rush hours on all-day routes.

Rush-hour-only routes are sometimes designed to target the highest-demand time of the day. Yet, as we will discuss in this report, peak-only routes are less productive than most all-day routes.

All people, regardless of their income, value flexibility and spontaneity. If a transit service does not support a midday trip home to pick up a sick child, or a late night at the office finishing a report, more affluent people can easily respond by using a private car. Even very low-income people who need to travel at uncertain times will find another option (such as a ride from a family member, or a very inexpensive car) if the transit network does not offer them flexibility. Only a few people are willing to build their lives and their commutes around a peak-only route and few are willing to live around service that is rarely available outside peak times.

The City may want to ask itself whether its transit service is a rush-hour-transit-system that runs some service at other times, or an all-day-transit-agency that supplements service during periods of high demand. (Periods that may or may not line up with the traditional morning and evening traffic peaks.)

A separate but related question is about weekend service. While professional jobs are most intense Monday through Friday, service jobs are most intense on weekends. Other types of work and activities happen 7-days-a-week: health care commutes, shopping and errands, trips to visit or worship, and all the other types of trips that people take as part of a full life. The existing HRT service in Norfolk is much lower on weekends than on weekdays.

Next Steps

This Choices Report represents the first step in a three phase process of thinking about redesigning Norfolk's transit system. This report serves as a basis of information for public meetings, surveys, and outreach for what we call the "Choices Phase" of the Multimodal Norfolk: Transit System Redesign. The public, stakeholders, and riders will be invited to respond to these key questions and provide other input on their preferences around how transit served Norfolk. This input will be gathered through open public meetings, an online survey, and a survey of riders on the bus. For more information about the surveys and public meeting dates, go to www.norfolk.gov/4776/Multimodal-Norfolk.

The input received will help guide city staff in designing "Conceptual Alternatives" that show how network designs based around different values could look and how they would lead to different outcomes for access to jobs, proximity to service, and other factors. These "Conceptual Alternatives" will be the basis for a second round of outreach, surveys, and meetings to get input from the public, stakeholders, and riders to guide the development of a Draft Transit System Plan.

1 Geometry of Transit

Access and Freedom

Public transit can be described from many points of view, but there are some basic geometric facts about how transit works and how it interacts with the layout of a city. This chapter explains these key ideas, which provide important context for understanding the material that follows.

Public transit ridership arises from the combination of three things:

- **Access (or freedom).** Where can you get to on public transit in a reasonable amount of time, compared to your alternatives?
- **Pricing.** What does transit cost compared with its alternatives?
- **Preferences.** These include everything else, all the subjective factors that govern decisions about how to travel, as well as reactions to other aspects of the transit experience.

Network design and planning mostly determine access, so let's look at that concept in more detail.

Access (or Freedom)

Wherever you are, there is a limited number of places you could reach in a given amount of time. These places can be viewed on a map as a blob around your location. Figure 6 shows an example of this type of visualization of transit access.

Think of this blob as "the wall around your life." Beyond these walls are jobs you cannot hold, places you cannot shop, and a whole range of things you cannot do because it simply takes too long to get there. The technical term for this is accessibility, but it's also fair to call it freedom, in the physical sense of that word. The extent of this blob determines what your options are in life: for employment, school, shopping, or whatever places you want to reach. If you have a bigger blob, you have more choices, so in an important sense, you are more free.

How Transit Expands Access

When using transit, the extent of access is determined by:

- The transit network: This includes the frequency, speed, and duration of the transit lines. These features determine how long it takes to get from any point on the network to any other point.
- The layout of the city. For each transit stop on the network, this determines how many useful destinations are near the stop or within easy walking distance. For example, higher density around a given stop means more access, both because there are more useful destinations around the stop, and balso because good access from that point is of more value to more people.

Access is a Matter of Geometry

The way these factors combine and determine access is a matter of geometry. That's because freedom (and access) is about what you could do, not predictions of what you will do. Access is a basic driver of ridership, but it can also be considered a worthy goal in itself by many people. For example:

- Access to jobs helps keep people employed.
- Access from a particular location is something that gives that a location value. Real estate firms routinely study where you can get to by car from a particular development parcel, and we can do a similar analysis using transit.

If you are deciding where to live based on whether you can get to your job, school, or relatives, you are asking about access.

From Access to Ridership

Ridership arises from both access and human behavior. Human behavior is heavily impacted by pricing, and also by many other features that psychologists and social scientists study.

So while access is not, in itself, a prediction of ridership, it is a foundation of it. It is also the aspect of ridership that transportation planning mostly influences, and it can be described geometrically in a way that gives us a high degree of confidence. It's also directly relevant to a range of other issues, such as unemployment and real estate value. This is why we recommend focusing on access as a useful measure of transit outcomes.

Building Access: The Network and Frequency

A transit network is a pattern of routes and services, in which each line has:

- a path,
- a duration or span—what hours and days it runs,
- an average speed, and
- a frequency—how often a transit vehicle serves a stop.

Of these, frequency is the one that is often invisible and easy to forget, yet it is usually the dominant element of travel time, and therefore, access in a given amount of time.

Where can I be in 60 minutes via walking and riding transit from Downtown Norfolk Transit Center?

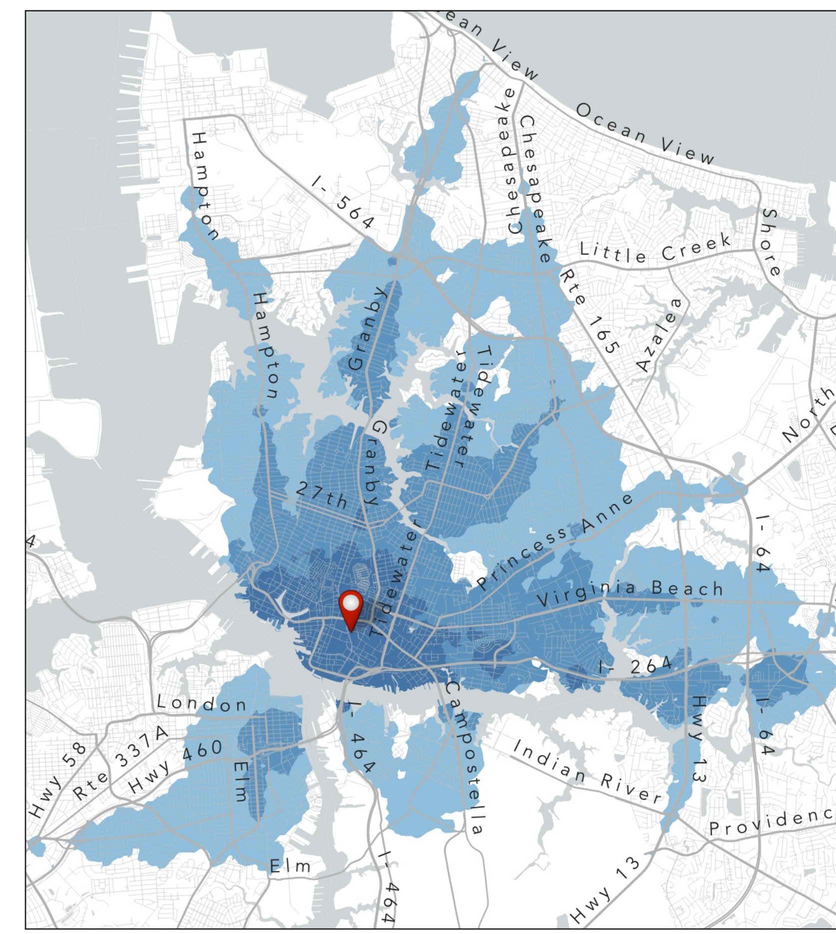


Figure 6: 60-minute access via walking and transit from Downtown Norfolk Transit Center.

Frequency is Freedom

Frequent service provides several related benefits for customers. These include:

- **Short Waits.** The average wait time for a 15-minute service is just 7.5 minutes.
- **Fast Connections.** Transferring between routes lets a rider reach a multitude of places that may not be all along one route. Connections are the glue that combine a pile of routes into a useful network, and frequency makes connections easy, because the next bus is always coming soon.
- **Easier Recovery from Disruption.** Frequent service is more reliable because if a bus breaks down, the next bus is always coming soon.
- **Spontaneity.** Rather than building your life around a bus schedule, customers can show up at the stop and go.

The payoffs of frequency are non-linear, with the highest ridership benefit usually being found in 5 to 15-minute frequencies. Figure 7 plots the frequency and productivity of routes operated by 24 transit agencies across North America. The horizontal axis shows frequency (better, more useful frequency means a lower wait time, so more frequent service is to the left). The vertical axis shows productivity—how much ridership occurs compared to the quantity of service. A dark hexagon means that lots of transit routes share a particular combination of frequency and productivity, while a light hexagon means less route examples share a particular frequency and productivity combination. Following the pattern of hexagons, particularly the darker ones, across the plot, we can see that ridership relative to cost rises with frequency even though better frequency costs more and pulls the productivity down.

How much frequency is enough? Two points should be noted:

- For most urban purposes, **a frequency of 15 minutes or better has the best chance of being useful**, and it's at these better frequencies that the non-linear payoff begins to appear.
- Adequate frequency depends on average trip length, because **it doesn't make sense to wait a long time to travel a short distance**. Very short downtown circulators, for example, don't usually make sense unless they can be run at frequencies well under 10 minutes. If the bus isn't coming very soon, it's probably quicker to walk the whole way.

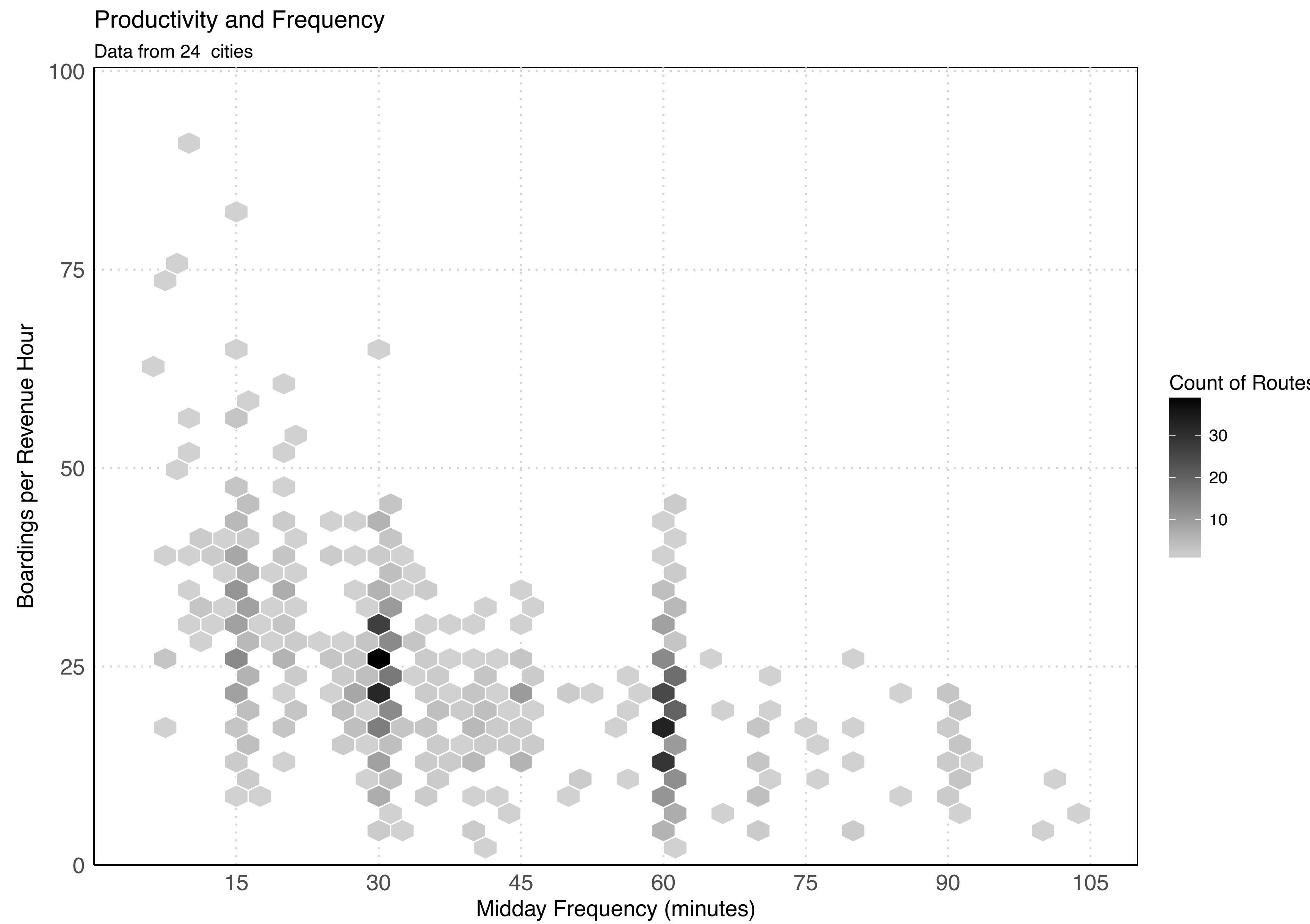


Figure 7: Transit Productivity and Frequency

Frequent service is strongly correlated with high ridership per unit cost.

Development Patterns Affect Ridership

Since frequency is expensive, it can't be offered everywhere. The greatest access arises from focusing frequency in the places where it can benefit the most people.

- **How many residents or useful destinations can be easily reached from each transit stop?** This question looks for density and walkability. High density means more people will find a stop useful, and high walkability means that people over a larger area will find the stop easy to walk to.
- **Are stops with high demand concentrated along a logical line?** This question looks for linearity (can the line be straight?) and proximity (does the line have to cross empty gaps with no demand?).

These geometric facts result in a difficult political challenge around transit. A transit system designed to maximize ridership serves its city very unevenly, concentrating service where demand is high, yet even in areas where demand is low, some people value transit and will ask for service to their area. This means that it is common to hear complaints about equity no matter what network design is proposed. People who live in places that are dense, walkable, and linear are cheaper to serve, on a per-rider basis, than those who live in places with lower density, walkability, and linearity.

Imagine that Ms. Smith lives in an apartment downtown (dense, walkable, linear, proximate) while Ms. Jones lives in a large house in a cul-de-sac on a peninsula on the edge of the city (not dense, not walkable, not linear, not proximate). The objective fact is that it would cost much more to serve Ms. Jones than to serve Ms. Smith. Is it fair to give them the same level of service regardless? Or is it fair to spend the same amount serving each of them, which would mean very little service for Ms. Jones? The answer depends on the goals for that transit system.

A good way to visualize how these factors impact ridership and costs is to ask: "How far does a bus need to go to serve 1,000 people or jobs?" The farther you have to go, the more expensive it is to provide service to the same number of people.

Four Geographic Indicators of High Ridership Potential

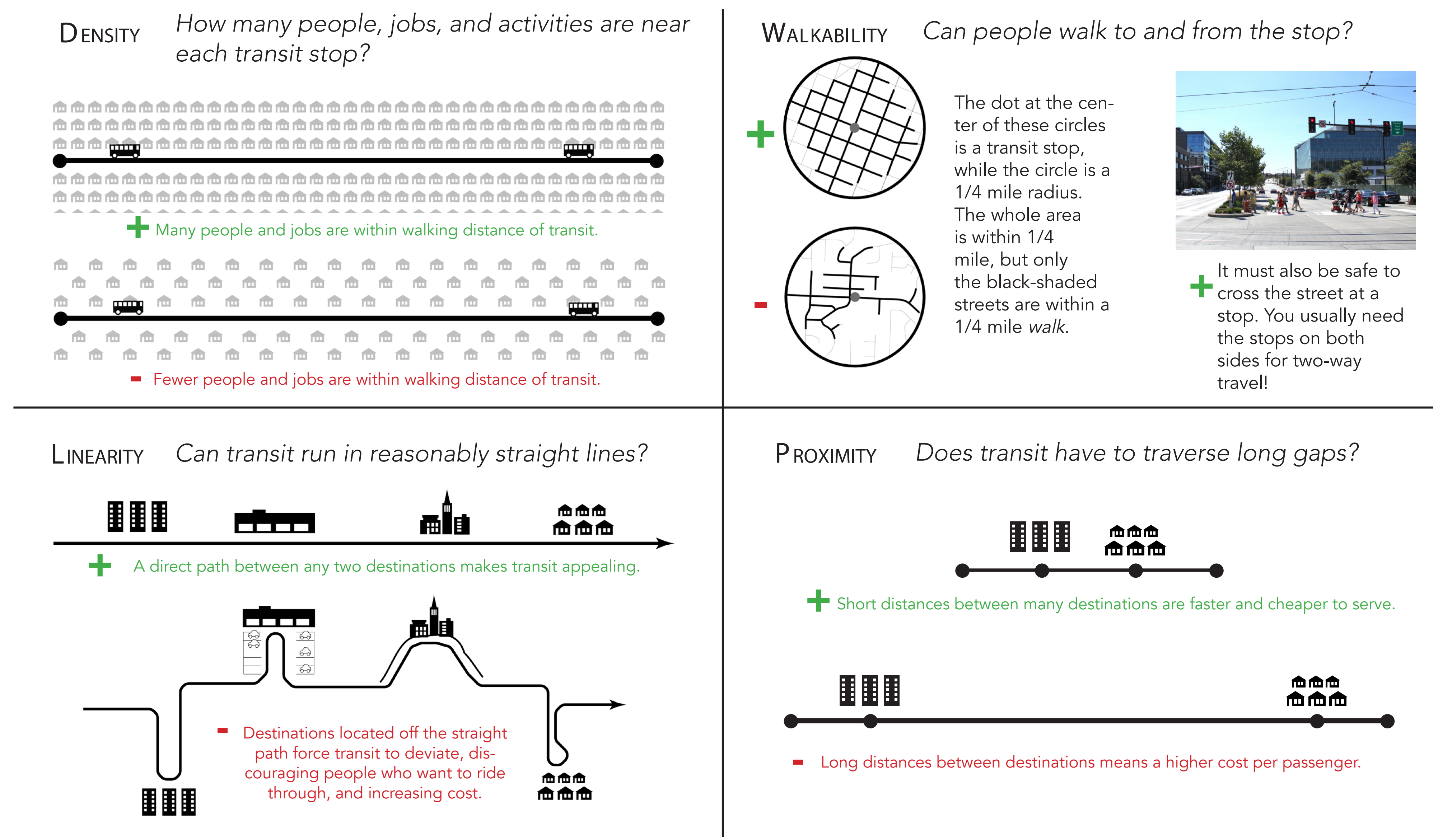


Figure 8: Community Geometry - Four Geographic Indicators of High Ridership Potential

Goals of Transit

Transit can serve many different goals. But different people and communities value these goals differently. It is not usually possible to serve all of them well all the time.

Possible goals for transit include:

- **Economic:** transit can give businesses access to more workers, and workers access to more jobs. Transit can also help attract certain industries, new residents, tourists, or other economic contributors.
- **Environmental:** increased transit use can reduce air pollution and greenhouse gas emissions. Transit can also support more compact development and help conserve land.
- **Social:** transit can help meet the needs of people who are in various situations of disadvantage, providing lifeline access to services and jobs.
- **Health:** transit can be a tool to support physical activity by walking. This is partly because most riders walk to their bus stop, but also because riders will tend to walk more in between their transit trips.
- **Personal Liberty:** by providing people the ability to reach more places than they otherwise would, a transit system can be a tool for personal liberty, empowering people to make choices and fulfill their individual goals.

Some of these goals are served by high transit ridership. For example, the environmental benefits of transit only arise from many people riding the bus rather than driving. The subsidy per rider is lower when ridership is maximized. We call such goals Ridership goals because they are achieved in part through high ridership.

Other goals are served by the mere presence of transit. A bus route through a neighborhood provides residents insurance against isolation, even if the route is infrequent, not very useful, and few people ride it. A route may fulfill political or social obligations, for example by getting service close to every taxpayer or into every political district. We call these types of goals Coverage goals because they are achieved in part by covering geographic areas with service, regardless of ridership.

The City of Norfolk receives many different comments requesting changes to the service in order to pursue these goals, but the City of Norfolk has a limited budget, so doing more of one thing can mean doing less of another. That’s why we need hear what your priorities are.

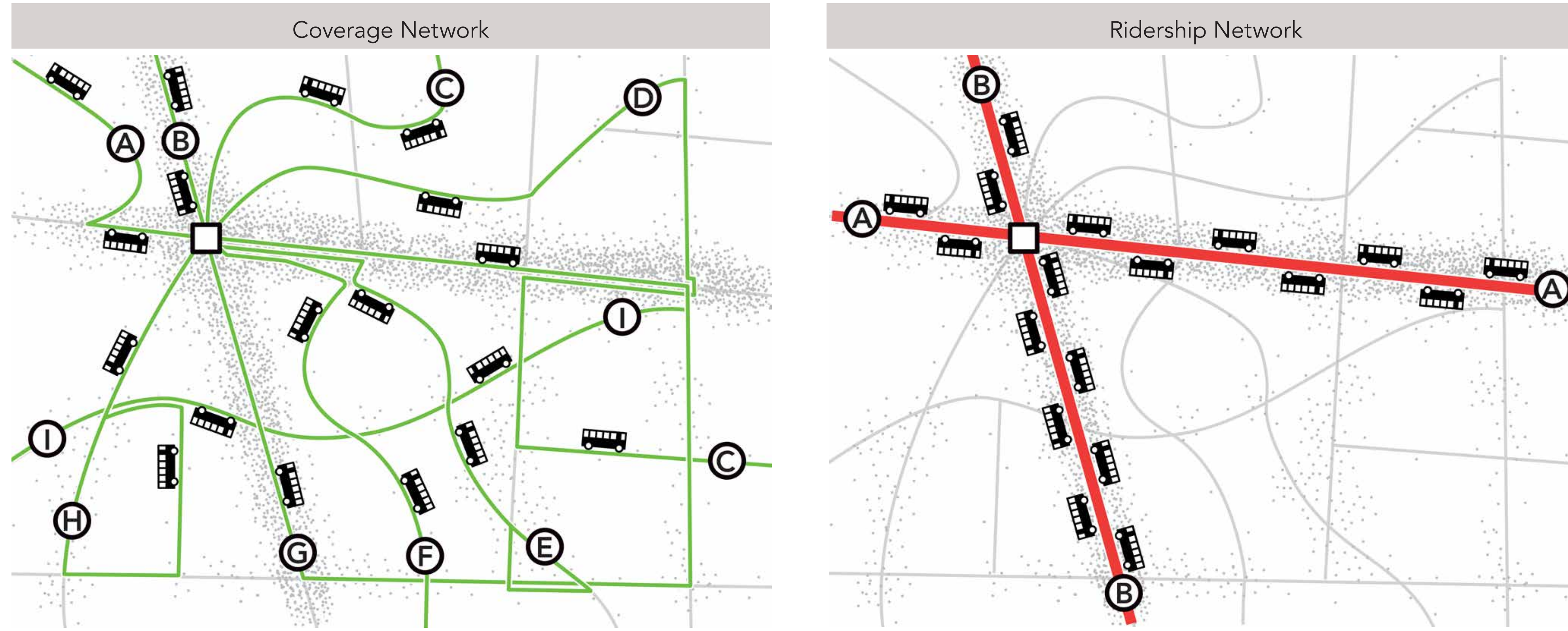


Figure 9: The network on the left is prioritizing coverage goals, while the network on the right is prioritizing ridership goals.

Ridership and Coverage Goals are in Conflict

Ridership and coverage goals conflict. Within a fixed budget, if a transit agency wants to do more of one, it must do less of the other.

Consider the fictional town in Figure 9. The little dots indicate dwellings and commercial buildings and other land uses. The lines indicate roads. As in many towns, most activity is concentrated around a few roads.

A transit agency pursuing only ridership would run all its service on the main streets because many people are nearby and buses can run direct routes. A high ridership network allocates frequent service to areas with favorable urban development patterns, forming a connected network. This would result in a network like the one at top-right.

If the transit agency were pursuing only coverage, it would spread out so that every street had some service, as in the network at top-left. All routes would then be infrequent, even on the main roads.

These two scenarios require the same number of buses and cost the same amount to operate, but deliver very different outcomes. To run buses at higher frequency on the main roads, neighborhood streets will receive less coverage, and vice versa.

An agency can pursue ridership and provide coverage within the same budget, but not with the same dollar. The more it does of one, the less it does of the other.

These illustrations also show a relationship between coverage and complexity. Networks offering high levels of coverage—a bus running down every street—are naturally more complex.

The choice between maximizing ridership and maximizing coverage is not binary. All transit agencies spend some portion of their budget pursuing each type of goal. A particularly clear way for cities and transit agencies to set a policy balancing ridership and coverage goals is to decide what percentage of their service budget should be spent in pursuit of each.

The “right” balance of ridership and coverage goals is different in every community. It can also change over time as the values and ambitions of a community change.

What about On-Demand Transit?

You may have heard about new service concepts consisting of small vehicles that pick you up when and where you request them, rather than running fixed routes. You may hear these called "microtransit" or "TNC partnerships," where "TNC" (Transportation Network Company) refers to companies like Uber and Lyft.

The basic idea isn't new. Taxis have always responded to customer requests, and shared-ride demand-response services, often called Dial-a-Ride, have been used for decades by US transit agencies. Special services for the disabled, called paratransit, also work this way.

The Trouble with Fixed Route Transit

There are obvious inconveniences in relying on fixed transit routes:

- **Long Walks.** Depending on where you are located, it may not be easy to get to the nearest transit stop. It might be far away, or require you to walk down streets where you don't feel as safe as you'd like.
- **Long Waits.** Even on frequent routes, you may have to wait 10 to 15 minutes to get a bus or streetcar. On some routes, you could wait an hour or longer. And you'll wait twice if your trip requires a transfer.
- **Travelling out of direction.** Using fixed routes means staying on the bus' path, even when it's not taking the fastest way to your destination.

The Trouble with On-Demand Transit

It may seem obvious that transit would be more convenient if it were provided on-demand, precisely when and where each person wanted to travel. It would then be more like a taxi or traditional "dial-a-ride" transit. Smartphones have raised the possibility that more transit could be this responsive, with great real-time information. Apps have made these service more responsive, so that they can be called on shorter notice.

There is an argument that transit is better when it is provided on-demand because it removes the problem of walking and traveling out of direction. It's more convenient, some might say. But that makes sense only if we don't account for the cost. The main source of operating cost for transportation (fixed route, on-demand or even local freight delivery) is the time the driver and vehicle spend on the road. Neither apps nor sophisticated dispatching software change that cost.

The costs of a fixed route are fixed, so more useful services are cheaper (per rider) to operate. HRT knows how much a bus route costs to operate, because the schedule tells us how many vehicles are needed, how many miles will be driven, for how many hours. **So the more people ride, the less expensive it becomes to provide each ride.**

In contrast, the costs of on-demand service tend to rise as more people find it useful. There is a low ceiling on how many rides per hour an on-demand vehicle can serve, even with the best possible dispatching. Imagine driving your car (or a bus) around Norfolk, picking people up and dropping them off in different places. How many times could you do this before an hour passed?

On-demand services run by public agencies generally report averages of no more than 6.5 boardings per vehicle per hour. Some private operators have reported as high as 9 boardings per hour in mid-sized North American cities. In contrast, even low-performing fixed-route buses in Norfolk handle 10 boardings per hour on average over a weekday. Moving fewer riders per hour means a service is more expensive per passenger.

For these reasons, demand-responsive services are never high-ridership services, when accounting for the full costs and the lack of scalability. These service may be relevant in low-demand areas, or at low demand times, like late at night, but as coverage services, where maximum ridership is not the goal. Use of these kinds of services will be explored in this Transit System Redesign, but the basic geometric challenge of their use and role should be clear from the beginning of the process.

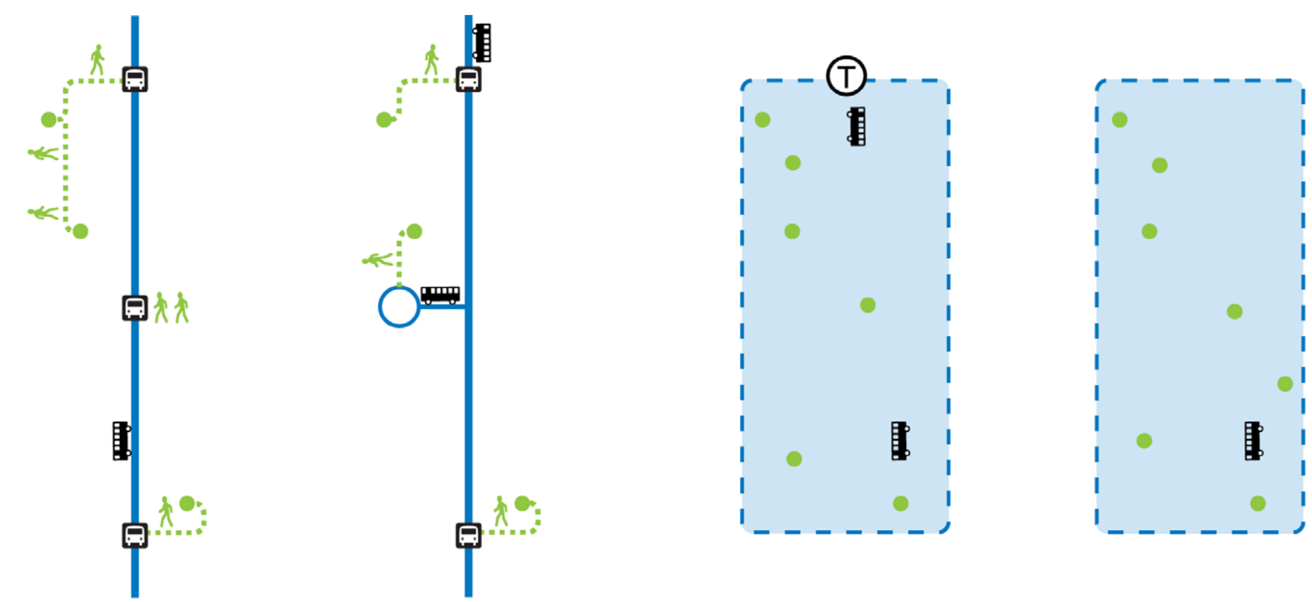


Figure 10: The spectrum of service, from a traditional fixed route to a fully on-demand service.

As service becomes more flexible, it takes longer to serve each passenger, because each rider's destination is rarely on the way. The longer it takes to transport each passenger, the higher the cost of each ride.

2 Market and Needs

Market and Needs Assessment

In this chapter, we present and discuss data that inform two different types of considerations in transit planning:

- Where are the strongest markets for transit, where ridership is likely to be high relative to cost?
- Where are there moderate or severe needs for transit, regardless of potential ridership and cost?

These two types of considerations help us design transit networks that picks a balance between the competing goals of high ridership and wide coverage.

Market Assessment

The transit market is mostly defined by WHERE people are, and HOW MANY of them are there, rather than by WHO they are.

On the following pages, these maps help us visualize the transit market:

- Residential density
- Job density
- Activity density
- Density of low-income residents

None of these data alone tell us that a place has high ridership potential and is therefore a strong transit market. Rather, we must consider them in combination.

If you asked a transit planner to draw you a very high-ridership bus route, that planner would look mostly at densities of all residents and jobs; at the walkability of streets and neighborhoods; and at the cost of running a bus route long enough to reach them. Only secondarily would that planner look into the income or age of those residents or workers.

However, the "who" attribute that has the strongest influence on transit ridership potential is income. This is especially true in suburban areas where driving and parking cars is so easy. Low income people are, as individuals, more likely to choose transit. That said, the density of all people (including low-income people) around a transit stop will still be the overriding factor in predicting whether that stop gets high ridership. All else being equal, density trumps income (and age) if you are trying to predict where transit will get high ridership.

This is not to say that who people are is not important. It is extremely important, especially when designing transit services to achieve a coverage goal.

Need Assessment

We learn about transit needs by examining WHO people are and what life situation they are in.

If you asked a transit planner to draw you a route that met as many needs as possible, that planner would look at where low income people, seniors, youth and people with disabilities live and where they need to go.

While the densities at which these people live would matter because at higher densities a single bus stop can be useful to more people in need, the planner would still try to get the route close to even small numbers of people. In fact, the more distant and scattered people are, the more isolated they can be and the more they might need access to transit.

On the following pages, these maps help us visualize where transit needs are in Norfolk:

- Density of low-income residents
- Median household income
- Density of zero-vehicle households

These measures cannot by themselves tell us that a person has a severe need for transit. For example, some people in a zero-vehicle household can afford to hire drivers, or rarely drive but are comfortably retired. We must consider these measures in combination to understand where in Norfolk people's needs for transit are likely to be severe.

One map included in the Need Assessment pages does not relate directly to people's need for transit, but does speak to a type of coverage goal, and that is the map of the race or ethnicity of Norfolk residents. A person's race or ethnicity does not tell us if they need transit, or if they have a propensity to use transit. However, we know that race and ethnicity are correlated with income.

Understanding the race or ethnicity of Norfolk residents is crucial to understanding whether transit service changes will affect people equitably. Unequal treatment on the basis of race or ethnicity is illegal under the Civil Rights Act of 1964. (Unequal treatment on the basis of other characteristics, including income and age, is also prohibited by law.) Thus, an examination of where non-white people live in Norfolk is less part of a "Need Assessment" than part of a civil rights assessment and a consideration of racial equity.

Figure 11: Regional Residential Density

Market: Residential Density

While not all trips start or end at home, nearly everybody makes at least one trip starting or ending at home on most days . Further, places with many households are also destinations for other people, whether for visiting, worship, caring for family or home-based work

In the City of Norfolk, average residential densities are relatively high (over 4,600 people per square mile), with even higher densities near downtown.

Areas built before World War II

Figure 11 maps residential density across Norfolk and its surrounding areas. From this map, we can see that the largest cluster of residential density is northwest of downtown, including Old Dominion University, Ghent and Ghent Square. This area has a traditional development pattern, with smaller lots, a gridded street pattern and more street network connectivity and is easy to serve by transit.

Residential density drops at the boundaries of industrial areas, particularly along old railroad corridors such as West 23rd Street. The City of Norfolk has several large military and industrial areas with few or no residents - the Norfolk Southern Rail Yard, Norfolk International Airport, and the Norfolk Industrial Park.

Suburban Development

East of downtown, the traditional grid- style development shifts to more post-war suburban development with larger lot sizes, a clearer separation of uses, and a more disconnected, looping street patterns, particularly east of Ballantine Boulevard. These areas tends to be more difficult to serve by transit.

For example, the dense Crown Point neighborhood is located near a main road with relatively good transit service but is only accessible from a secondary street- Raby Road. As a result, its residents must walk a circuitious route, up to half a mile long to reach a bus stop on Virginia Beach Boulevard. Alternatively, transit could be designed to make a deviation into the neighborhood, but that would be costly and inconvenient for people riding through the area.

Pockets of High Density

There are pockets of higher residential density further from downtown on major roads like Little Creek Road, Hampton Boulevard, Chesapeake Boulevard, Ocean View Avenue (US 60), Baker Road, Shore Drive and Virginia Beach Boulevard. These higher-density developments do not require transit to leave a main road but they do require running transit through lower density areas between pockets of density, which costs more per rider.

Residential density is an important way to assess the strength of transit markets, since most people's daily travel behavior begins and ends at home. Transit designed to get high ridership will seek to offer very useful services in places with high residential densities. Coverage services will try to reach all or most residents, even in areas with low-density development pattern where few people live near any given stop.

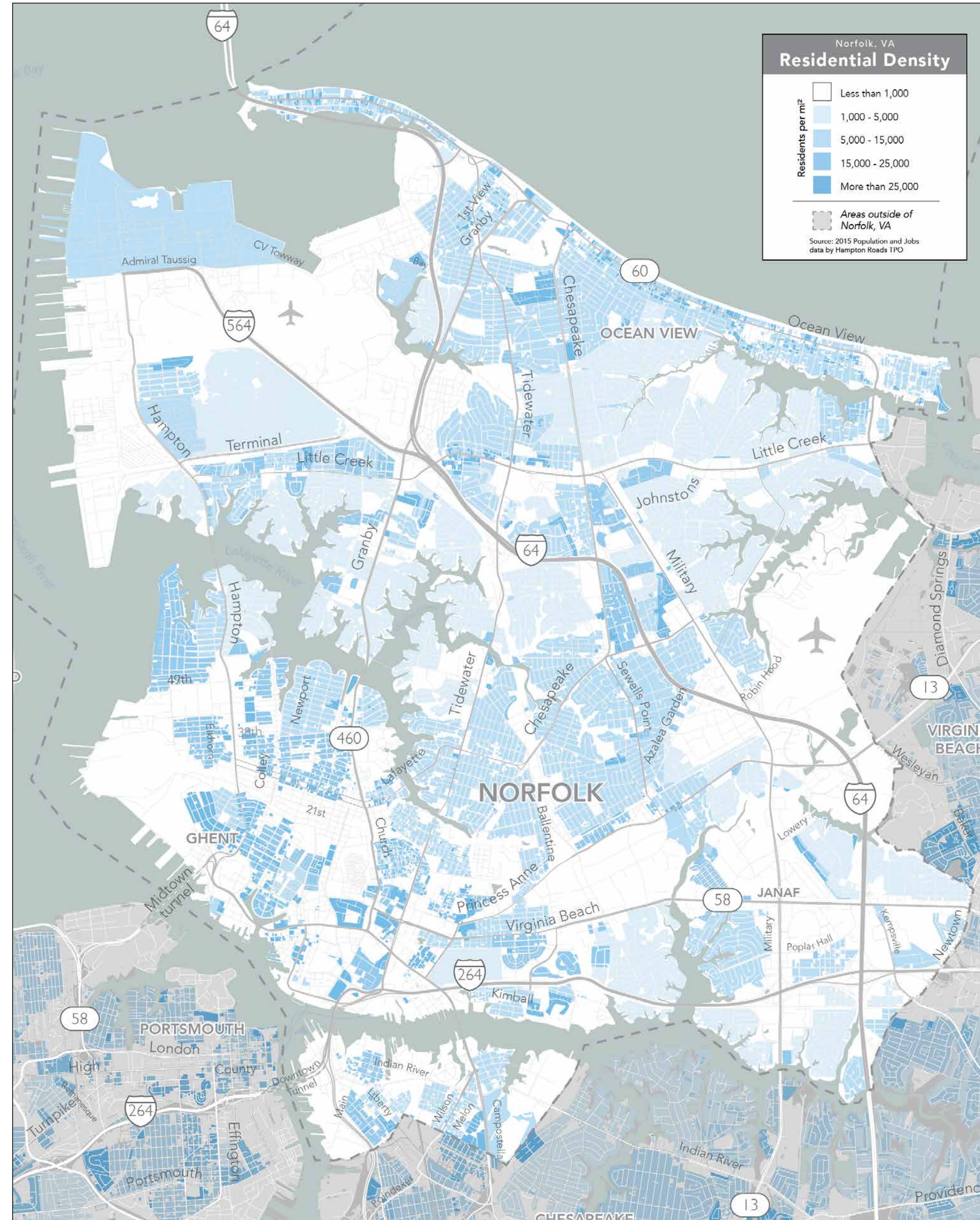


Figure 12: Regional Employment Density

Market: Job Density

A map of job density shows us not only the places people travel for work, but also places people go for services, shopping, community, health care, and more . A person's workplace may be, throughout the day, a destination for dozens or even hundreds of people.

Areas of High Employment Density

The map to the right (Figure 6) shows the current job density of Norfolk. The majority of job density in the city is in and around the downtown core - from Old Dominion University and Ghent to Calvert Square.

Apart from this concentration of jobs, there are pockets of jobs density in shopping centers such as Newtown Baker Crossing and Cypress Point Shopping Center, in tourist-oriented corridors like along Ocean View Avenue and in commercial corridors like those along Lafayette Boulevard.

Shopping Centers Aren't Always Dense with Jobs

Despite having quite a few jobs, big box retailers, such as Southern Shopping Center, at Tidewater and Little Creek, typically only show up as areas of moderate employment density because they are located on large parcels with extensive parking areas that well exceed the building footprint of the retail space. This is illustrated on the right in Figure 13.

Job centers surrounded by large parking lots are more difficult to serve by ridership-oriented transit because in most cases, there is a long walk between on-street bus stops and the front entrance. In some cases, buses make a time-consuming deviation into thee shopping centers to allow a shorter walk, but that means all the other passengers on the bus must go out of their way, which makes transit routes slower and less attractive.

Large parking lots also reduce walkability because they force people to walk longer distances to reach their destination and are often not designed with the expectation that people will be walking through them.

Figure 13: Employment density in retail areas such as this Southern Shopping Center may not be particularly high because of the extensive parking areas that well exceed the building footprint of the retail space.

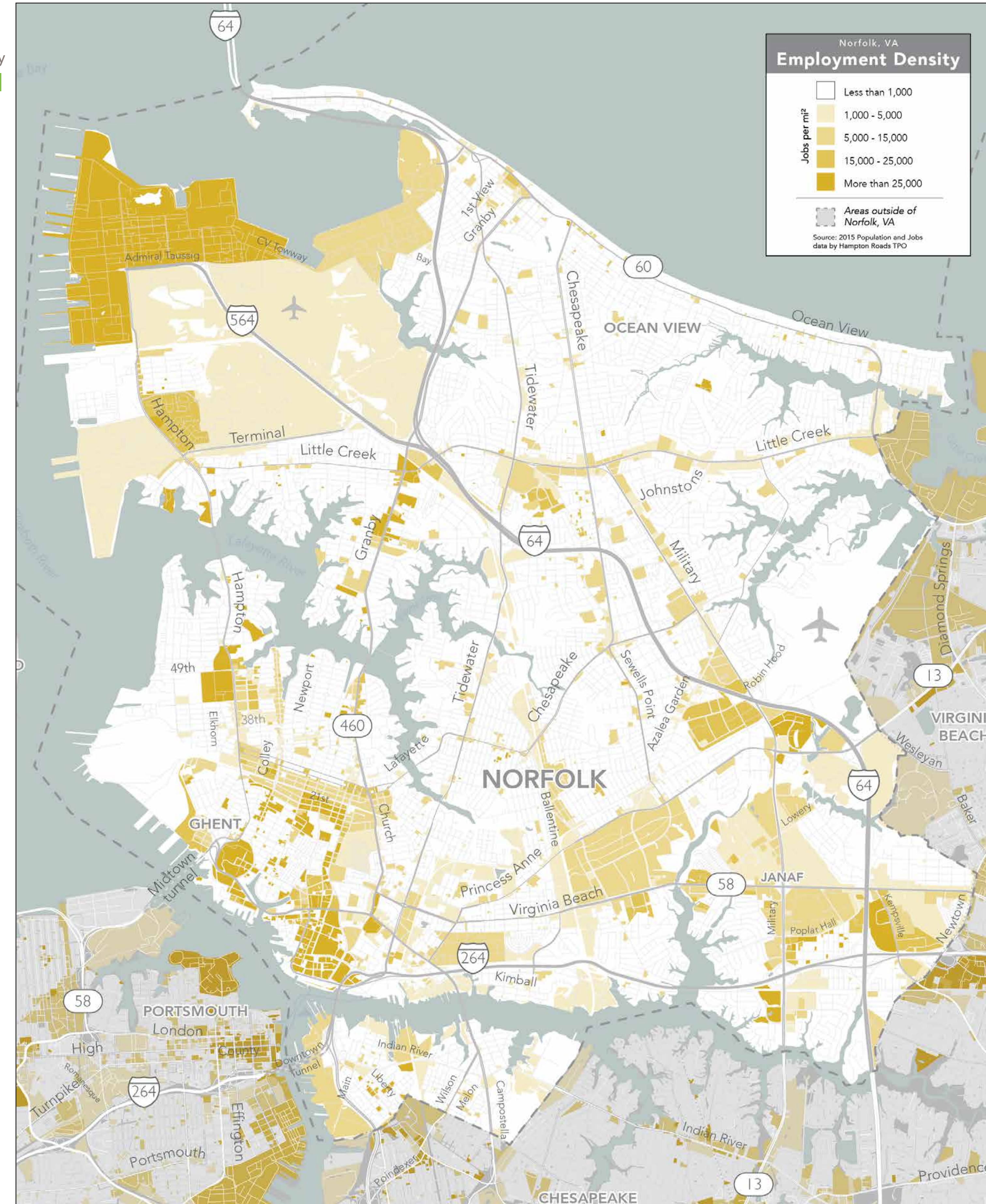
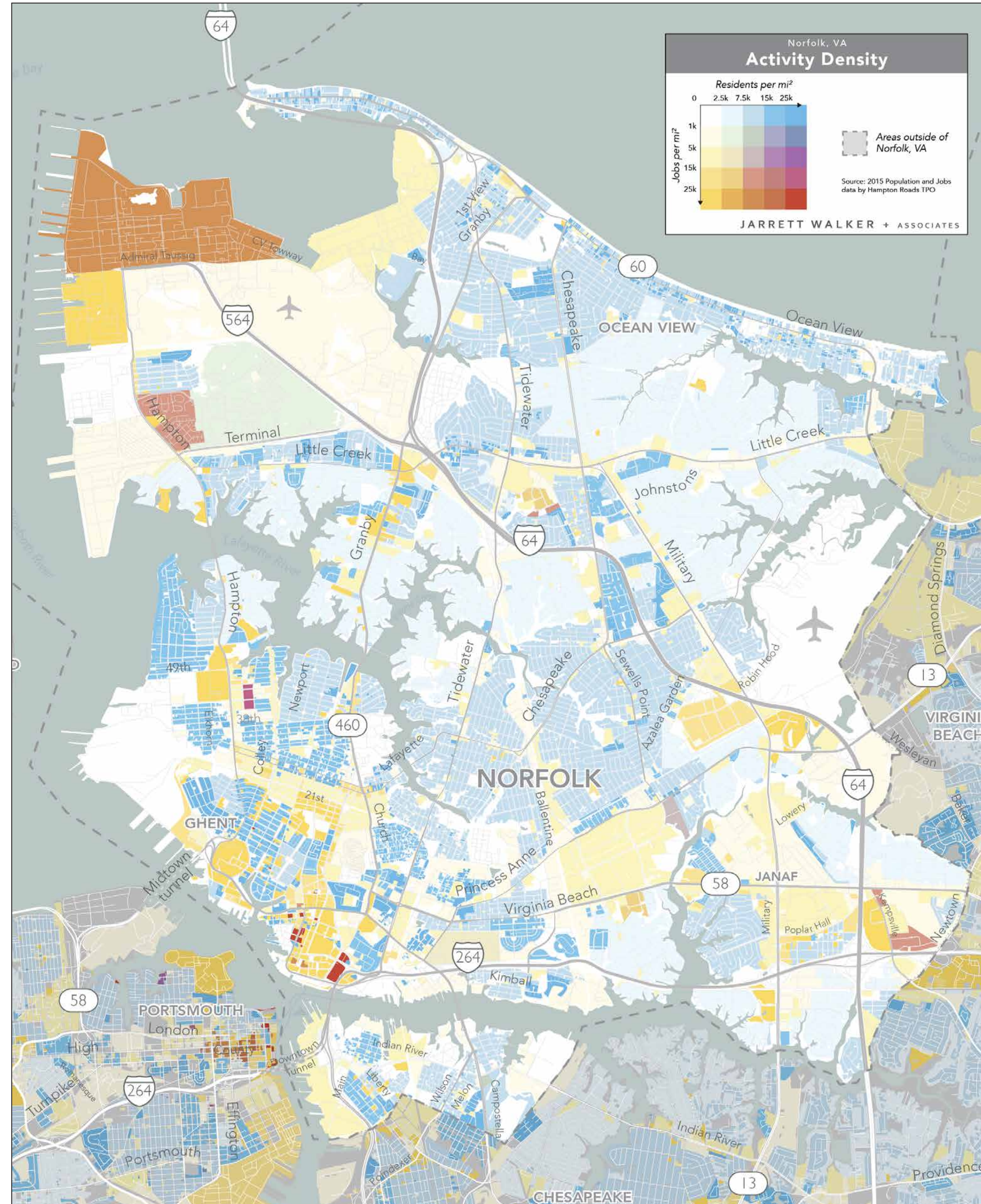


Figure 14: Activity Density in Norfolk



Market: Activity Density

Resident and jobs density are both critical measures of a place's potential transit market relative to other parts of the service area. Those two measures can be combined in a single map that shows the **activity density** - the density of both jobs and residents. Activity density helps visualize the overall potential transit market of an area. Figure 14 maps activity density in Norfolk.

Places with more residential density are shown in increasingly brighter shades of yellow; areas of high employment density, in brighter shades of blue. The areas shown with increasing shades of red are places where there are high densities of both jobs and residents, and where there is likely to be a strong market for travel for most or all of the day.

Areas with the Highest Activity Density

In Norfolk, the areas of highest activity density, with the most homes, jobs and services, are found in and around downtown, near Old Dominion University (ODU) and around Norfolk Naval Base. These areas are the strongest transit markets in terms of density, capable of generating substantial travel demand throughout the day and possibly even weekends.

There are numerous smaller pockets of dense residential or commercial/employment activity along Virginia Beach Boulevard, Military Highway, and Chesapeake Boulevard, and Little Creek Road. For these corridors, there is a mixture of commercial development and moderate to high density housing, often as apartments, but the uses are generally separated from each other.

Mixed Land Uses allow for Higher Transit Productivity

IN addition to high density, the **mix of uses** along a corridor affects how much ridership transit can achieve, relative to cost. This is because an area with a mix of housing, retail, services and jobs tends to generate more even demand for transit in both directions, throughout the day.

Transit serving purely residential neighborhoods tends to be used in mostly one direction and mostly during rush hours—as residents leave in the morning, and return in the evening. Transit serving residential-only areas tends to have higher costs per rider because:

- If ridership is only high during the morning and evening rush hours, the transit agency must run mostly-empty buses during the rest of the day (or must pay drivers to take split-shifts, which are less desirable because they require working both early mornings and evenings each day with a long mid-day break.
- If ridership is only high in one direction during each peak, then the transit agency must run mostly-empty buses back in the other direction. The service may not even be advertised as two-way, but the operating costs are always two-way.
- Transit agencies who run lots of peak-only service must also buy and maintain extra buses for those few busy hours of peak service each day.

Buses serving a mix of jobs and residents can be full in both directions, leading to lower costs per-rider. If mixed-use areas include jobs from a diversity of sectors such as healthcare, education and retail- all extending beyond the typical 8-5 office schedule, transit also tends to see stronger all-day, 2-way demand.

Universities are often sources of all-day all-directions transit demand. This is partly because they are dense with jobs and housing. It also relates to the type of "job" done there: students come and go depending on their class schedules, from morning through the evening. Professional, retail and facilities staff have their own commute patterns. The sum of all these patterns is generally high demand, all day, every day .

Market: Density and Walkability

In almost all cases, transit trips begin and/or end by walking. Therefore, the ability to walk to transit is very important.

As mentioned in the previous pages, the more jobs and residents there are near a stop, the stronger the likely transit market. However, the size of the market is also limited by the street pattern, since that determines how much of the area around a stop is truly within a short walking distance. Figure 15 shows examples of areas with low and high street network accessibility.

A lack of sidewalks and safe crossings of major streets can also mean that fewer people and jobs are within a short walk of transit because people may have to walk further and less directly to cross the street to reach a bus stop.

For these reasons, walking distances to and from bus stops can far exceed "flying" distances.

- Areas with highly-connected street patterns provide short and direct path between any two locations.
- Areas with poorly-connected street patterns, often in "walled garden" developments, forces long and circuitous paths between locations and discourages walking.
- Low street connectivity tends to be accompanied by wide, fast arterial streets, because the few through-streets that exist have to handle all of the area's car traffic.

Walk network connectivity is a way of assessing how complete a place's pedestrian and street network is. To do this, the area accessible "as the crow flies" in a given distance from a location is compared to how far you can go in the same distance along the street and pedestrian network.

Figure 15 illustrates this concept. In each image, a transit stop is at the center and the circle is the distance within 1/2 mile "as the crow flies." The shaded area is where you can reach the stop by walking no more than 1/2 mile.

In the "Low Accessibility" example, a disconnected street network allows access to just 31% of the 1/2 mile radius around a transit stop, while in the "High Accessibility" image, over 60% of the radius is reachable. We call this measurement "effective walk radius". In purely grid street networks like that in the second example, the maximum effective walk radius is usually in the range of about 60-65% of the "as the crow flies" distance, though it can be higher if more direct paths are available.

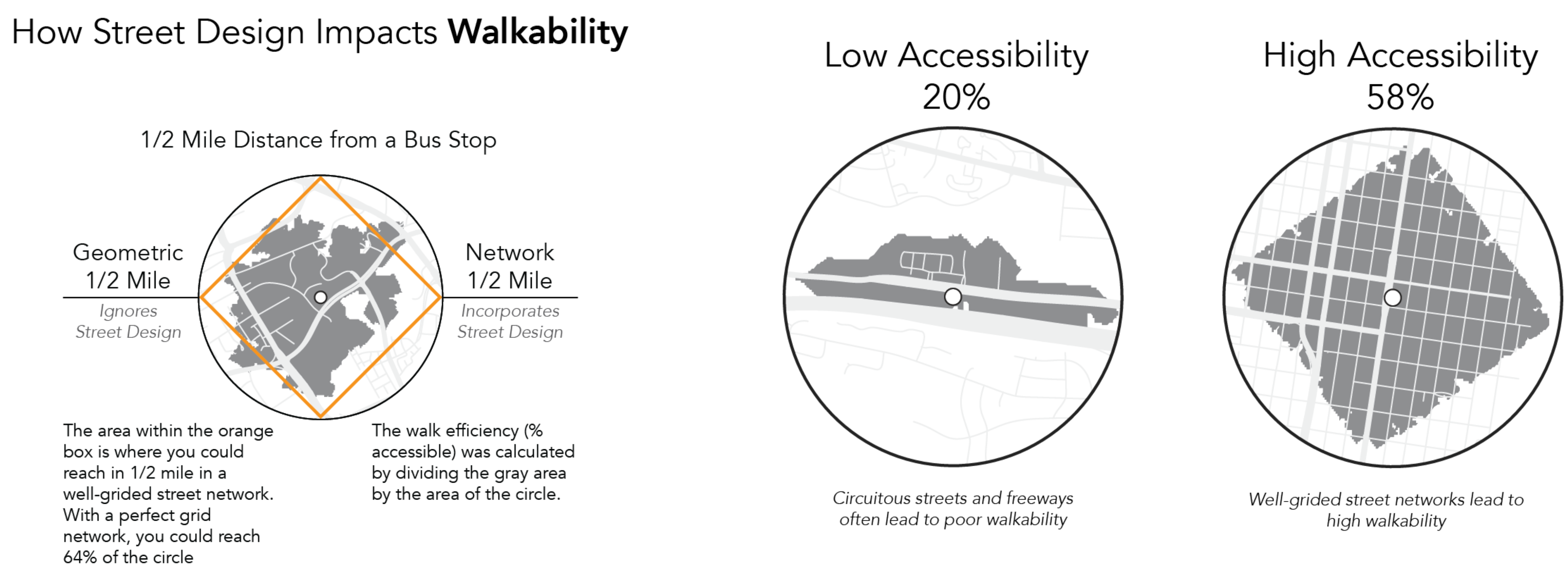
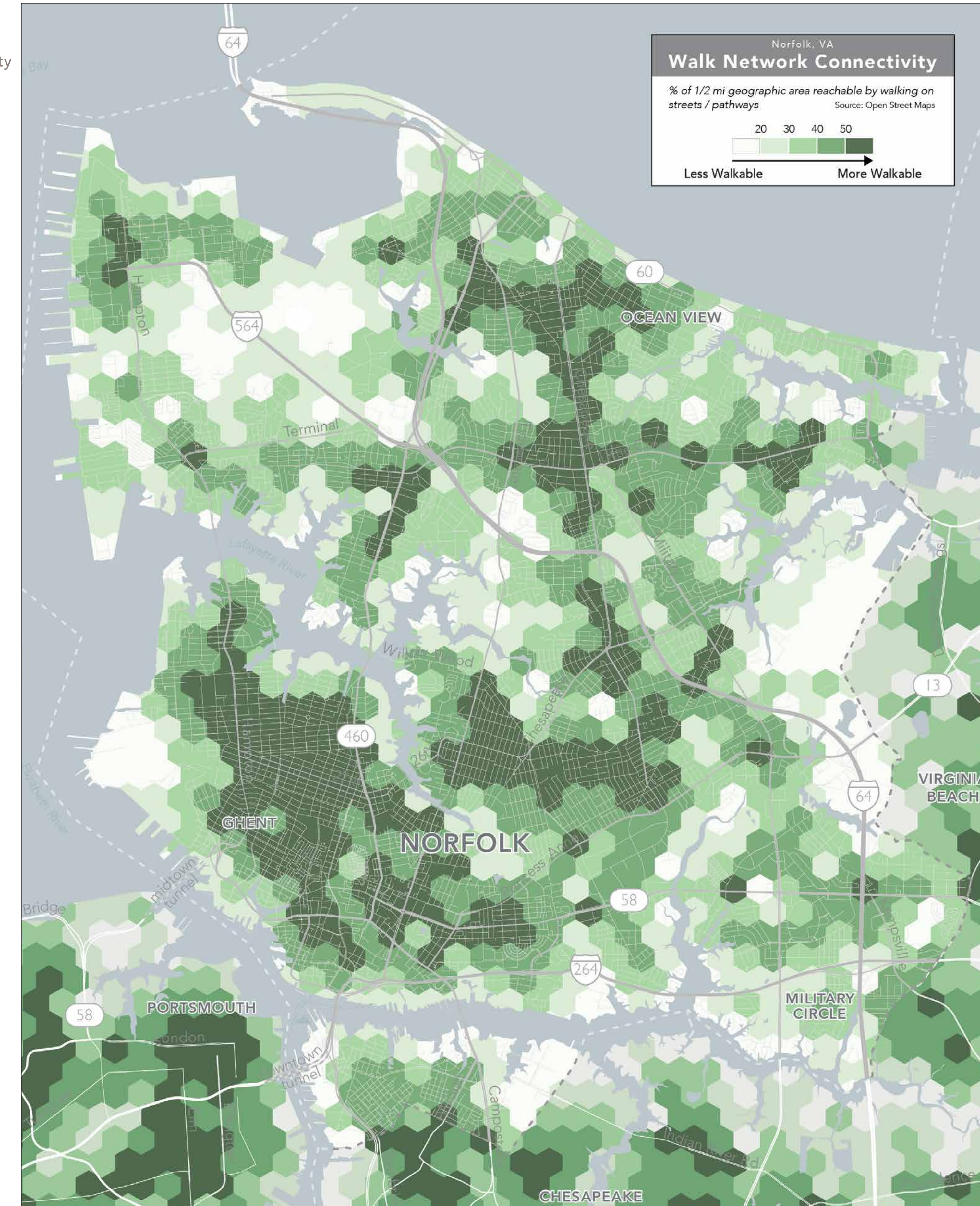


Figure 15: Walk Network Connectivity

Figure 16: Norfolk Area Street Connectivity



Market: Walkability

In the map on this page, we show where the effective walk radius, created by a well-connected street network, is relatively high or low[1]. The darker the contour on this map, the more the walk network resembles that in the "High Accessibility" example in page 19; the lighter, the more it looks like the "Low Accessibility" example.

Walk network connectivity does not measure the difficulty of crossing streets, which is often a major barrier to access. Some of the areas shown as having moderate walk network connectivity actually include major barriers to walking due to the small number of places where it is safe to cross a major street.

The highest walk network connectivity in the region tends to be in areas developed in the first half of the 20th century or earlier. The largest high-walkability area in the region is between Old Dominion University and downtown in neighborhoods like Ghent, Lamberts Point, Colonial Place and Park Place, which are laid out in a relatively complete grid. Their small block length and complete grid combine to produce walkable areas similar to that in the High Accessibility example. Several neighborhoods northeast of Downtown, such as Lakewood, Willard Park, Fairmount Park and Lafayette-Winona also boast relatively high walkability.

Large swaths of Portsmouth are also highly walkable due to a relatively complete street grid and small block length. In Chesapeake, there are pockets of walkable development, such as in Berkley, Avalon, and in the area surrounding Hawthorne Drive.

1 This map is created by taking an effective walk radius measurement for each of a finely spaced grid of points, then generating a heatmap and plotting based on relatively high or low values.

Market and Need: Low-Income Residents

Transit is often tasked with providing affordable transportation for low-income people. Federal laws also protect people with low incomes from disparate transportation impacts, which can lead agencies to provide transit service in places where poverty is high even if it does not maximize ridership.[1]

Low-Income residents only use transit if it is useful

In some built-environments, serving low-income people can meet a ridership goal. Transit can be an attractive option for lower-income people due to its low price and low barrier to entry so in medium to high density areas, with walkable street networks, service to low-income people can be a powerful ridership generator.

However, an area with low-income residents doesn't necessarily get high transit ridership just because it served by a transit route. If transit isn't actually useful for the type of trips people need to make, in a reasonable amount of time, even lower-income residents will not use it. Most people can find other travel options, even if those other options, such as taking out a high-interest loan for a used car, cause them financial distress.

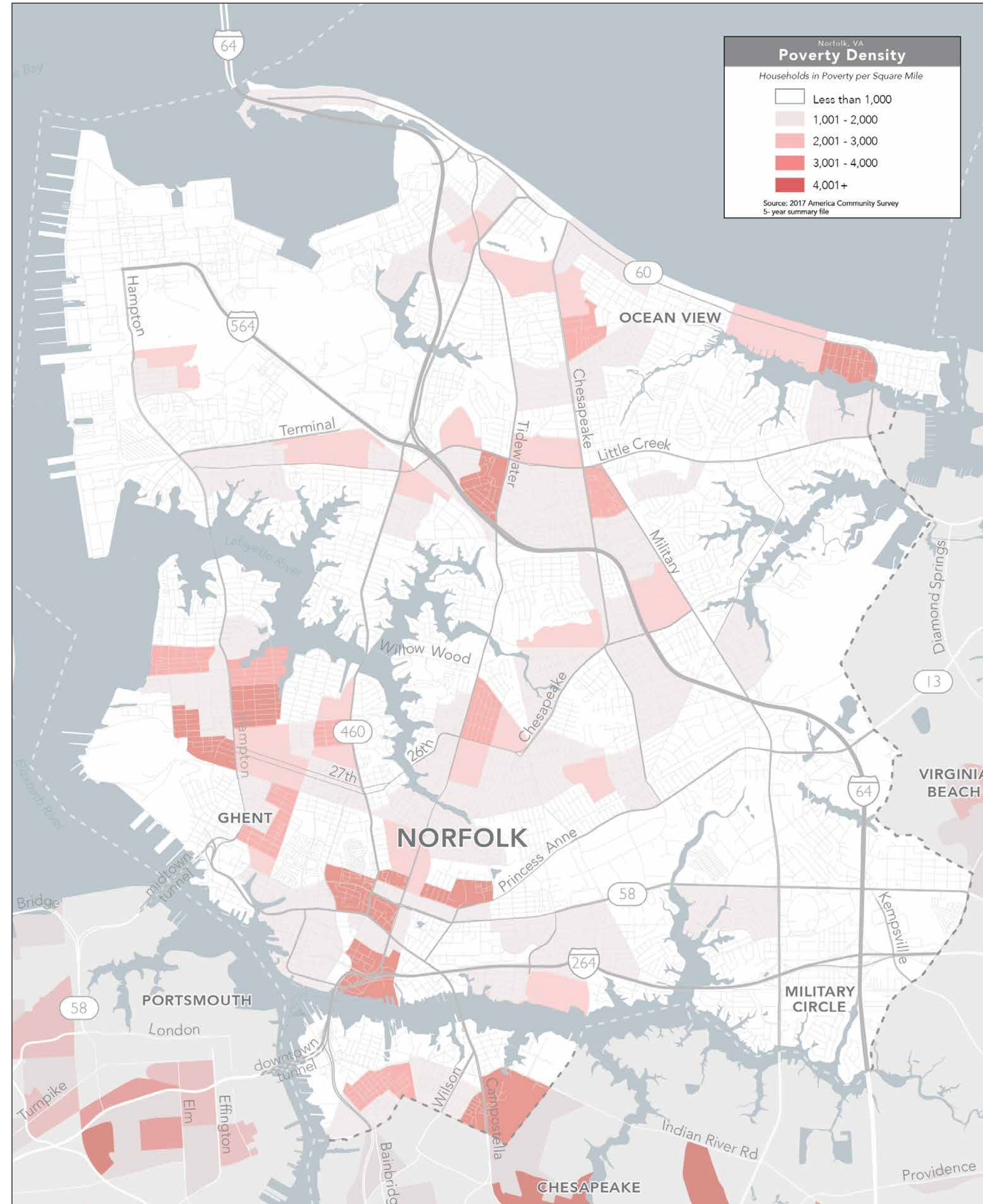
Some areas with many low-Income residents are easier to serve than others

Figure 17 shows the density of residents in poverty[2] in Norfolk. The highest concentrations of Norfolk residents in poverty are located in or near downtown and along key, linear corridors, like Hampton Blvd. Some of these areas include students, who, although likely just temporarily poor, still are more likely to use transit. These areas can be served more easily with useful service that connects many destinations because of their proximity, linearity, and density.

When low income people are located in distant, harder-to-reach areas, the additional distance to reach them means that the cost per ride to serve them is much higher. There are several high-poverty neighborhoods which are more geographically isolated and thus harder to serve with cost-effective transit.

One example is the East Ocean View neighborhood, located on the far northwestern edge of the city, between Little Creek and the Bay. Bus routes must first travel through much of Norfolk, including some lower ridership areass, before reachingthe neighborhood.

Figure 17: Regional Density of People in Poverty (100% of federal poverty rate)



1 Title VI of the Civil Rights Act of 1964 and Executive Order 12898 require transit agencies that receive federal funding to ensure that service and fare changes do not have a disproportionate negative effect on protected populations, including racial and ethnic minorities, low-income people and those with limited English proficiency. Every transit agency sets its own specific policies for addressing these federal requirements and each agency is subject to regular reviews of its policies and their implementation .

2 Here, "poverty" means a family income below the federal poverty level for each size of household.

Need: Residents without Cars

Not everybody has ready access to a personal automobile, and people who have less or no access will need to use other modes when they need to travel. This might include walking, cycling, getting a ride from a friend or family member, or, if it is available when they need to travel, and useful for their trip, transit.

If transit does not present a realistic travel option, then people without cars will find other ways of reaching the places they need to go. People in households without vehicles are not necessarily "transit-dependent" but do have a greater inclination toward transit use because they don't have a car in their driveway, always ready to go .

Figure 18 maps the regional density of households with zero vehicles. Few people in Norfolk live without a car, so overall densities of zero-car-households is low in all parts of the city. Despite that, there are a few clusters of zero-car households in isolated pockets across most of the service area. The highest levels are found within and immediately around downtown Norfolk, where non-car options (transit, bike share and bike infrastructure, etc) are richest.

Beyond this area, zero-car household densities are high in the Kensington, Park Place and Ghent Square areas, in a neighborhood near Old Dominion University which likely houses many students.

More isolated neighborhoods with high concentrations of zero-car households include Glenwood Park near the Naval Station, East Ocean View, Waterford Apartments, Willoughby Spit, Oakmont/Tanners Creek and the neighborhood South of Wesleyan Drive and East of Newtown Road.

Figure 18: Regional Density of Zero-Vehicle Households

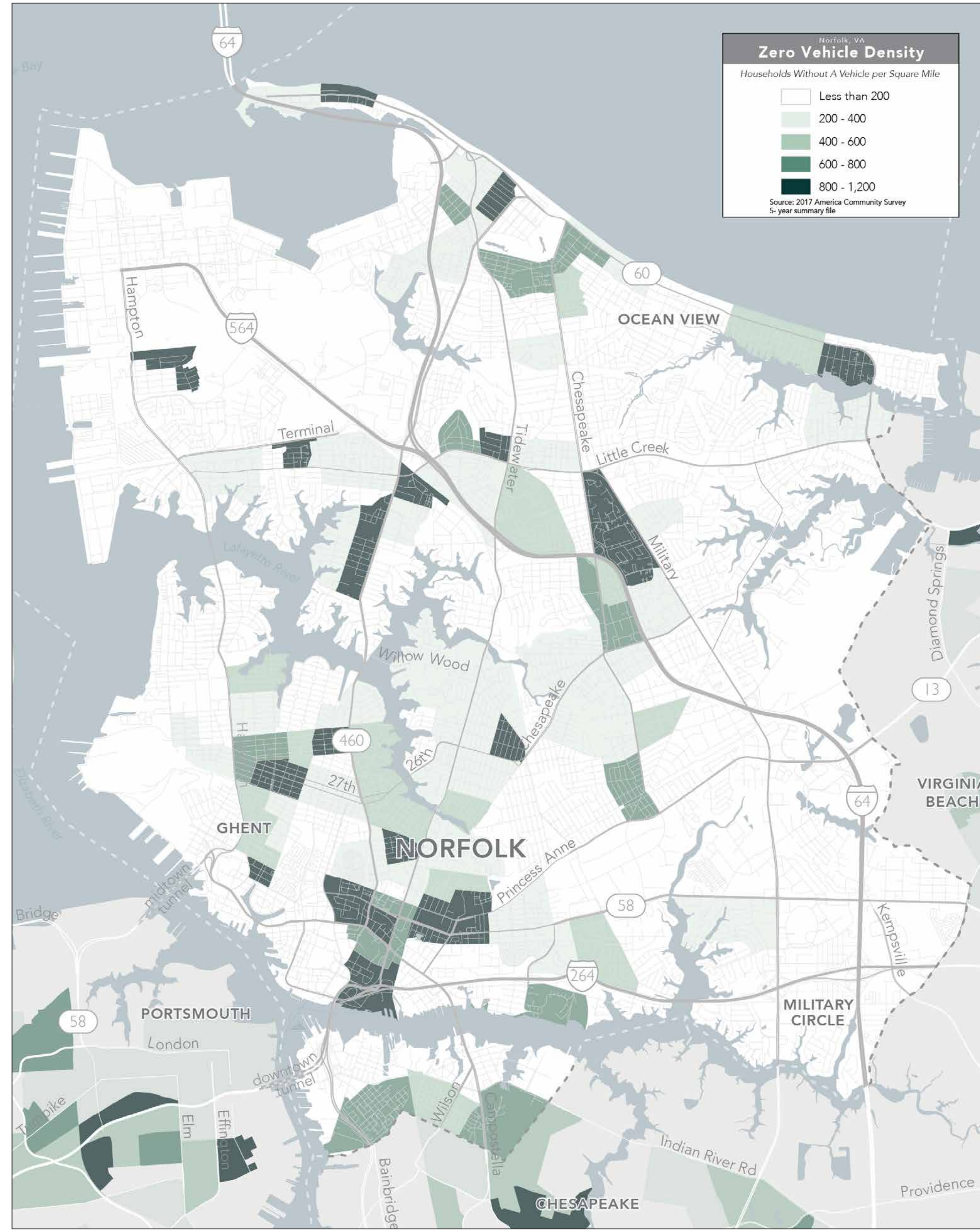


Figure 19: Regional Density of Seniors

Need: Seniors

Seniors (persons age 65 and above) are an important constituency for transit because a major value of transit coverage is providing service for people who cannot drive, no matter where they live.

Some seniors cannot drive and are therefore more likely to use transit

As a demographic group, senior-headed households are less likely to own cars than the general population, a built-in advantage for transit in places where other characteristics for high ridership (such as density, walkability) are present.

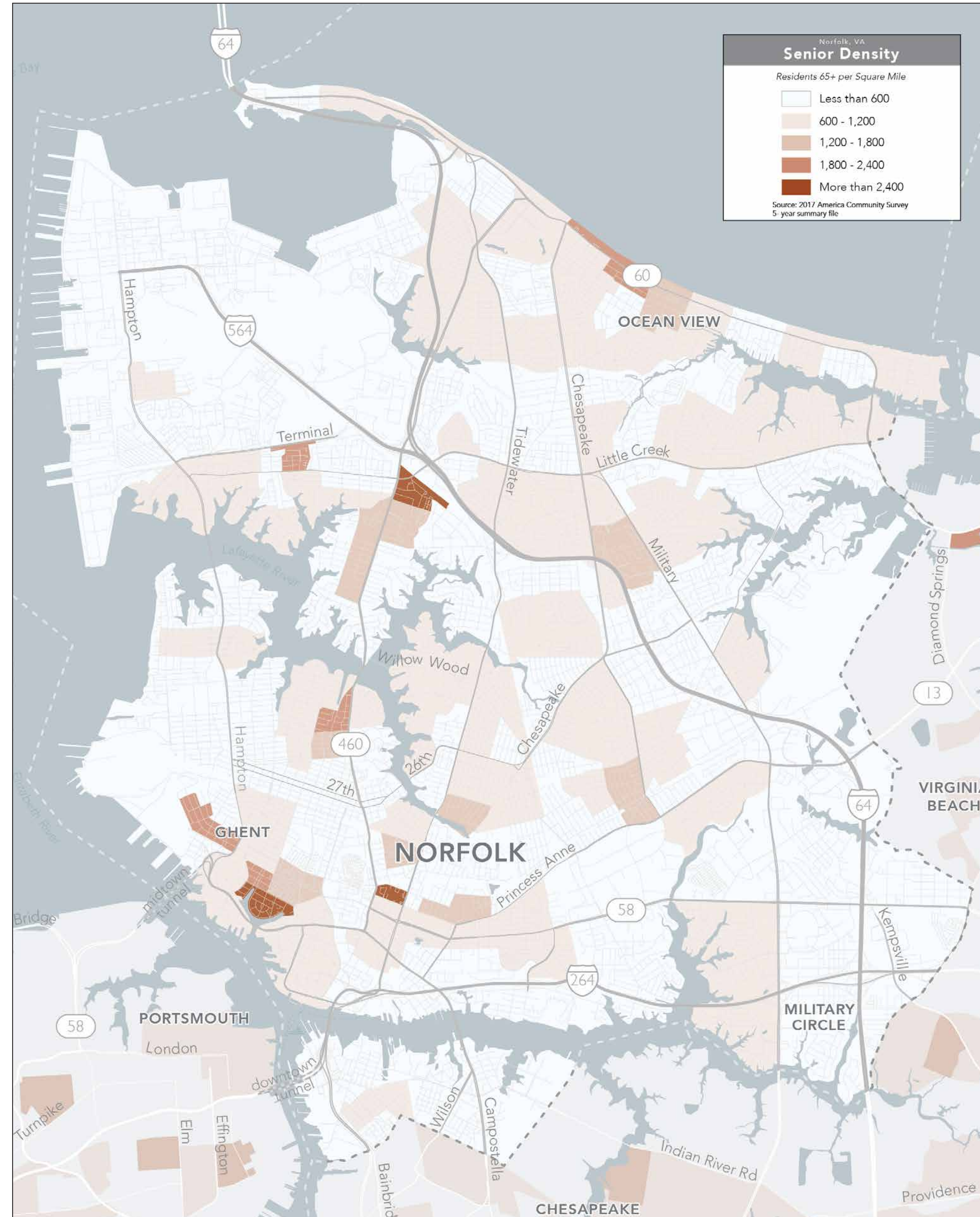
The map at right shows the density of senior residents in Norfolk. The highest concentrations of seniors are in Barberton, Suburban Acres, and Ghent Square. There are also high concentrations in Oceanview, Wards Corner, Colonial Place, West Ghent and the Waterford Apartments.

Seniors have different preferences for transit

Seniors' needs and preferences are, on average, different from those of younger people. Seniors tend to be more sensitive to walking distance, because of limits on their physical ability, or concerns for their personal safety.

Seniors also tend to be less sensitive to long waits for transit, because they are less likely to be employed. For the same reason, seniors are, on average, less likely to be discouraged by slow or indirect routes that take them out of their way.

Because of these factors, **transit service designed primarily to meet the needs of seniors rarely attracts high overall ridership**. Most riders who are employed, in school or caring for kids in school will find service with long waits to be intolerable. Thus, the amount of focus that transit agencies place on meeting the needs of seniors should be carefully balanced with the needs and desires of the community.



Civil Rights Assessment: Minority Residents

Norfolk is quite diverse, with large populations from many different racial and ethnic groups. However, it is more segregated by neighborhood than most U.S. cities.[1] This means that, for an average resident, the percentage of people in their residential neighborhood who belong to a different ethnic or racial group is lower than is true for the average resident in other U.S. cities.

This means that when Norfolk makes decisions about where to provide transit service, down which streets and in which neighborhoods, those choices have a racial dimension. Norfolk cannot (and does not) assume that any bus route going down a road serves people of all different races, just because Norfolk is a "diverse" city.

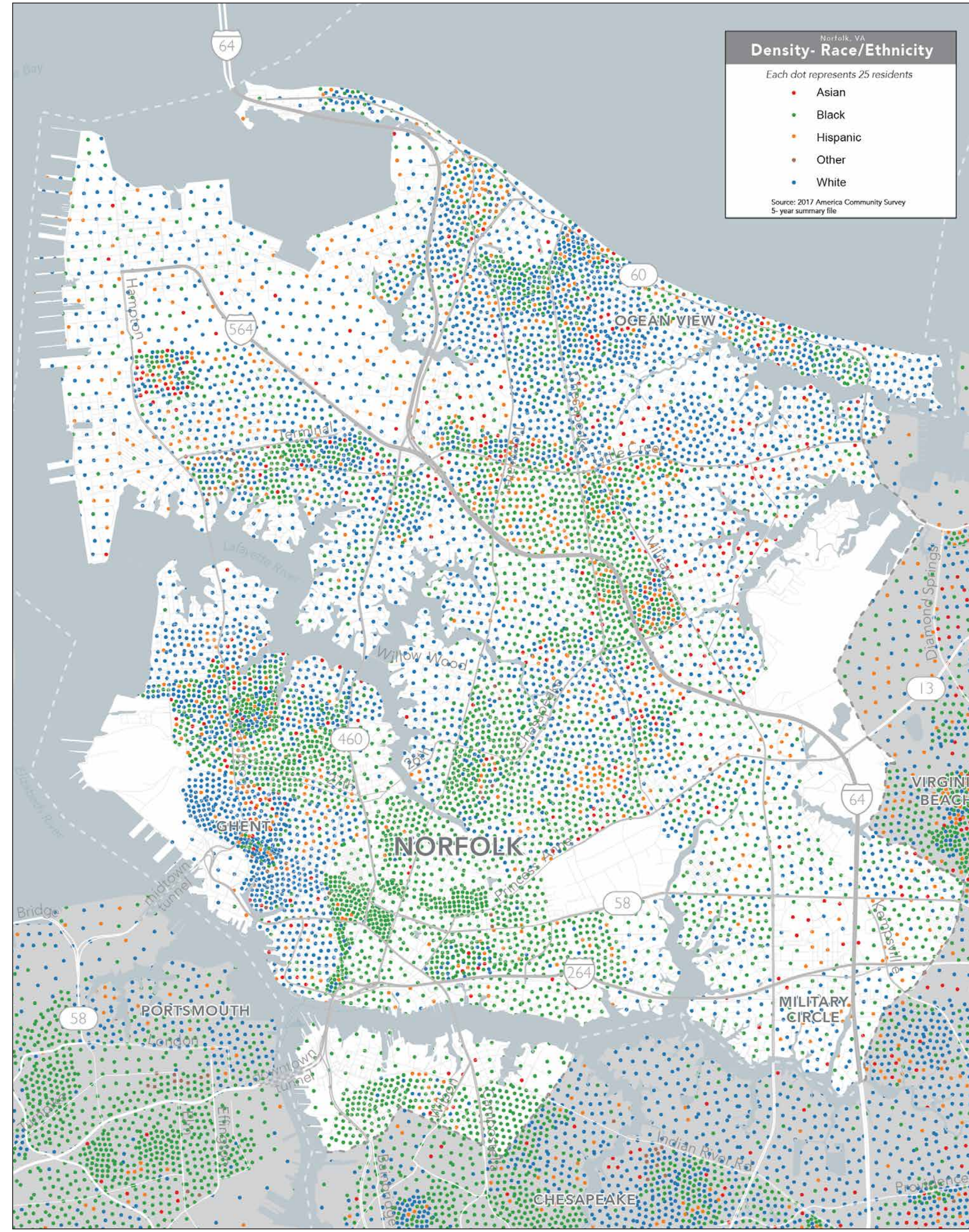
Figure 20, at right shows where people of different races and ethnicities live Norfolk and its surrounding areas. Each dot represents 25 residents. Where many dots are very close together, the overall density of residents is higher. Where dots of a single color predominate, people of a particular race or ethnicity make up most of that area's residents.

While information about people's income tells us something about their potential interest in or need for transit, information about ethnicity or race do not alone tell us how likely someone is to use transit. However, avoiding placing disproportionate burdens on minority people, through transportation decisions, is essential to the transit planning process.

Transit agency policies that protect minority people from negative impacts are one type of coverage goal, because they pursue an outcome that is valuable regardless of ridership. Such policies might state, for example, that service to high-density and high-minority neighborhoods should be prioritized even if such service would not maximize ridership.

It is also important to understand where large numbers of non-white people live, so that public outreach during this project can be sensitive to language and cultural barriers, and so that service changes can be evaluated in light of impacts to protected people.

Figure 20: Dot Density Map of Population Density, Race / Ethnicity



1 On a "Segregation Index" scale of -19 to +11, on which zero represents the average degree of integration in U.S. cities, Norfolk received a -1.4. Chicago, with -19, is the most segregated city in the U.S., despite being one of the most diverse. Irvine and Sacramento, CA, are the most integrated, with scores of +10 and +11. This Index is explained, and a table of major U.S. cities is provided, at fivethirtyeight.com/features/the-most-diverse-cities-are-often-the-most-segregated/.

3 The Existing Transit Network

Where is useful service today?

In transit conversations there is always a great focus on where transit is provided. Sometimes not enough attention is paid to when it is provided.

The "when" aspect of transit service is:

- "Frequency" or "headway." How many minutes are there between each bus? How long of a wait is required?
- "Span" or "duration." How many hours of the day is service running? Does it run on weekends? Holidays?

Low frequencies and short spans are one of the main reasons that transit fails to be useful because it means service is simply not there when the customer needs to travel.

Frequent service:

- Reduces waiting time (and thus overall travel time).
- Improves reliability for the customer because if something happens to your bus another one is always coming soon.
- Makes transit service more legible by reducing the need to consult a schedule.
- Makes transferring (between two frequent services) fast and reliable.

Frequency is especially important for transit lines that go only a short distance. For short trips, time spent waiting can be more than time spent riding!

Figure 21 shows the transit network in the City of Norfolk by the frequency of service at midday, while the map on the following page shows the detail of the network in and around downtown Norfolk.

Most route in Norfolk operate every 30 minutes

In this map, the prominent red line is The Tide, the region's only service operating every 15 minutes or better throughout the rush hours and middle of the day. The network is dominated by blue lines, which run every 30 minutes and light blue lines, which run every 60. Tan lines represent routes that do not operate during the middle of the day (approximately 11:00 a.m. to 1:00 p.m.), or which run a very limited number of trips throughout the day.

The network in Norfolk covers most major streets, so that most of the population and jobs are near some kind of transit service, but the low frequency of service means that most people are waiting a long time for a bus.

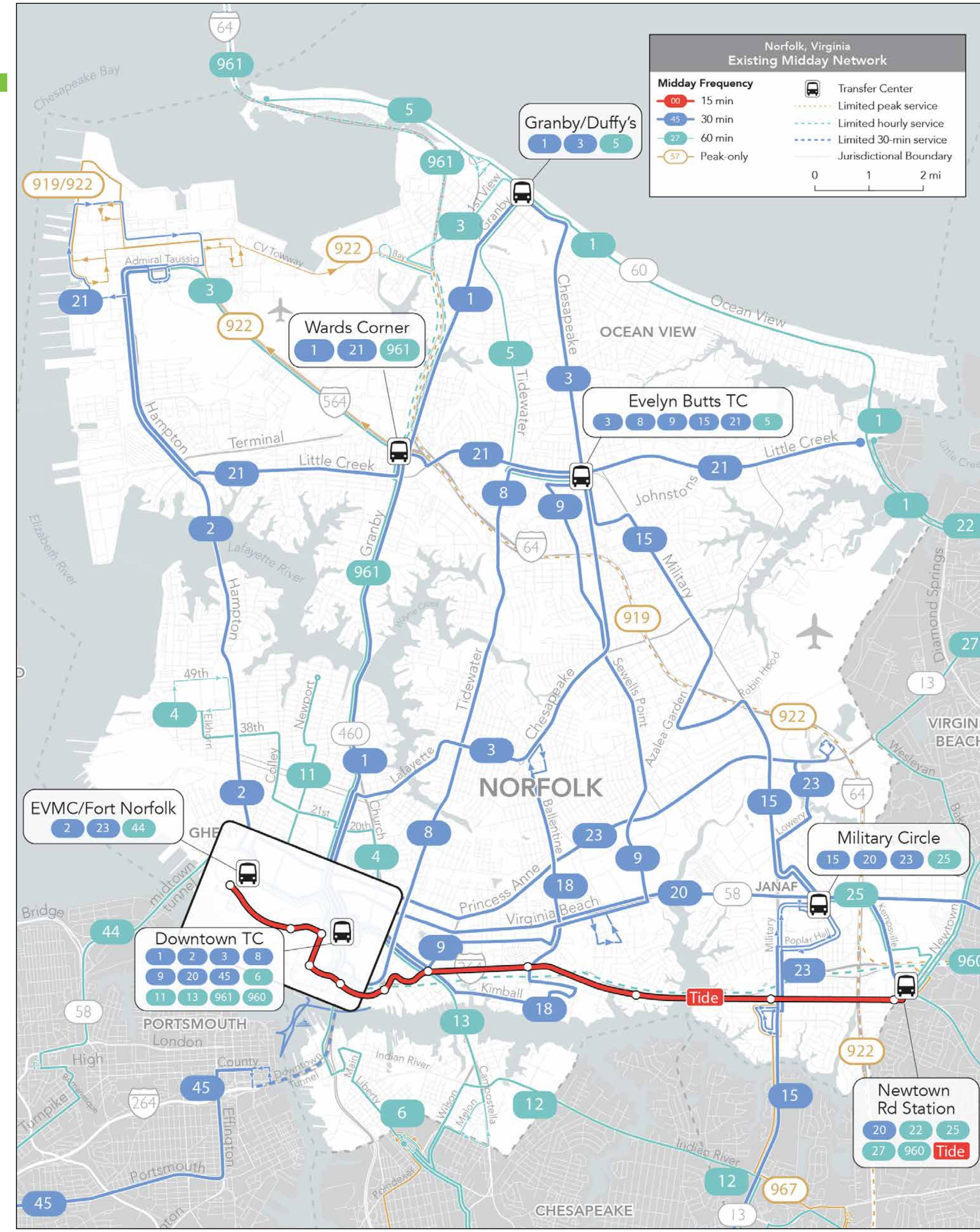
Radial Network

Most of the network is radially-oriented to and from downtown Norfolk, like routes 1, 2, 3, and the Tide.

Most of the routes that come downtown gather at the Downtown Norfolk Transit Center. In low-frequency transit networks it is common for routes to gather at a central station for a regular "pulse" or timed connection, so that people can transfer between routes without a long wait. Norfolk's transit network stands in contrast in that it does not offer a consistent all-day pulse downtown. For more information about pulsing, and how it might be used in the Norfolk network, see page 39<DT>.

Two routes stand out for being oriented in an orbital pattern, Routes 15 and 21. These routes provide connections between the radial routes, and are also useful for people who want to travel around the edges of the city, instead of toward downtown. This kind of network design can make it easy to get to lots of places easily, if the frequency of service is high enough that transfers are easy, with short waits. Yet most routes run every 30 minutes, meaning that connections between radial and orbital routes are difficult because waits are long when the timing of connections is random.

Figure 21: Norfolk Existing Transit Network - Midday Frequency



Downtown Norfolk

Most bus routes in Norfolk converge at the periphery of downtown at the Downtown Norfolk Transit Center, but they don't all connect well with the core of downtown. The densest core of the downtown area is centered around MacArthur Square and extends from the waterfront to Brambelton Avenue to the north and St. Pauls Boulevard to the east. The map to the right shows the pattern of how routes enter the larger downtown area and a couple of key patterns emerge when looking at how routes circulate around the larger downtown area:

- **Many key routes never reach the densest core of the downtown area** and riders must walk about 1/2 mile from the Transit Center to reach the central core. This creates a significant barrier for many riders who want to reach one of the densest and most active parts of the city where there are many jobs and opportunities.
- **Routes 44 and 23 never reach the downtown core**. Route 44 from Portsmouth ends at Eastern Virginia Medical Center, which is a Tide LRT stop. This pattern forces two transfers to connect with other major routes, like Route 3. Route 23 stays far north of the downtown core, on Princess Anne Road. While transfers to most other routes are possible, this patterns forces a transfer to go a short distance to reach the densest activity center in the city.
- Not visible from the map, but visible from the schedule of service, is that **buses that meet at the Downtown Norfolk Transit Center are not timed to meet in a pulse**. For a network where most routes are low frequency, it is common to create a pulse where such a large majority of routes meet at a central location, so that waiting times for transfers can be minimized for the maximum number of riders.

Figure 22: Existing Transit Network in Downtown Norfolk

When is service available?

The table to the right summarizes each route's frequency and span of service for the existing network.

Less Service on Weekends

While the maps on the previous pages showed the weekday network, this graphic makes it clear how much less service is available on Saturdays and Sundays:

- Some bus routes don't run at all on weekends (Peak only routes like 919 and 920)
- Four routes run on Saturdays but not Sundays (Routes 5, 9, 12, and 18).
- Frequency of service on Sundays is much worse, with all routes except The Tide running only hourly.

Consistent all-week frequency is often part of a high-ridership strategy. However, even The Tide, which remains frequent 7-days a week, has a lower span of frequent service on Saturdays, and service does not even begin until 10 am on Sundays.

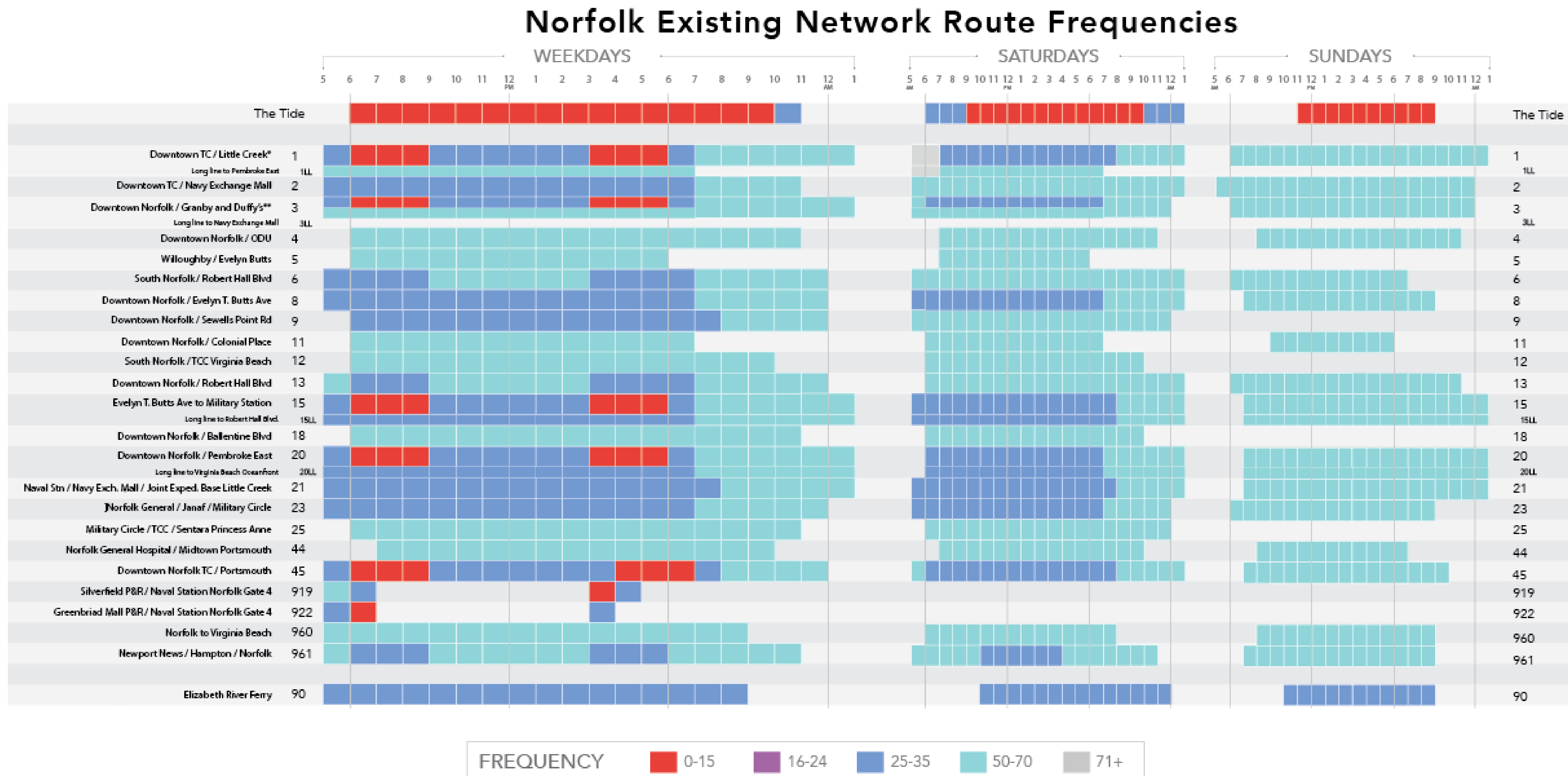


Figure 23: Frequency of Service by Route, Day of Week, and Hour

The transportation profession has long been focused on the weekday peaks, because those are the times when our road capacity is most-used and congested. Yet, people need to travel at all times of day and week.

Service workers tend to work from very early in the morning to midday, or from midday to late at night. Most people working in retail or restaurants are only offered a job if they can commit to work on both weekend days. A route that doesn't exist on weekends is not useful to service workers, since weekends are when many retail businesses and restaurants are "all hands on deck".

In addition, anyone taking an evening class, pursuing a hobby, going to worship, or staying late at work to finish a report needs a bus ride home outside of the traditional 8-to-5 workday.

When transit agencies cut late-night and weekend service (often their first resort, during budget crises), they typically see ridership losses at all other times of the week. The inverse is also true: transit agencies that restore late night and weekend service see ridership gains, as more households forgo cars because the transit network is there for them whenever they need it.

Evening and Weekend Network

Another way to visualize the frequency by time of day and day of week is to see maps at different times. The maps in Figure 24 show the frequency at different times and on different days for each route in Norfolk using the same color scheme as the main map on page 26.

At peak times many routes operate more frequently, in particular Routes 1, 3, 15, and 20. With more frequent service on radial routes 3 and 20 and orbital route Route 15, it is much easier to make a connections to go across a large part of the city at peak times.

Yet, many people, particularly retail and service workers, need to travel on weekends and in the evenings. Weekday evenings, however, frequency on most routes drops to hourly by 8 pm. At this frequency, timed connections between routes are critical to make travel time across the city reasonable for most trips. And even with timed connections, if your bus leaves your work at 8 pm or 9pm, but your shift ends at 8:30 pm, your wait for a bus home will be quite long.

Saturday service at midday is similar to weekday midday, except that a few routes have reduced frequency, such as Route 2 (Hampton Boulevard). Sunday midday service is quite low, with most routes running every hour, and some routes truncated in length. While the number of people commuting to work is much lower on weekends than weekdays, many people still do travel for work and for other reasons. In fact, according to the 2016 American Time Use survey[1], while 46% of the population engaged in travel to work on weekdays, 14% of the population do so on weekends as well.

While the volume of work travel is lower on weekends than weekdays, transit networks designed to maximize ridership often continue to provide a high level of service to places that carry high demand through the weekends, such as dense residential areas, and retail or service-oriented employment areas.

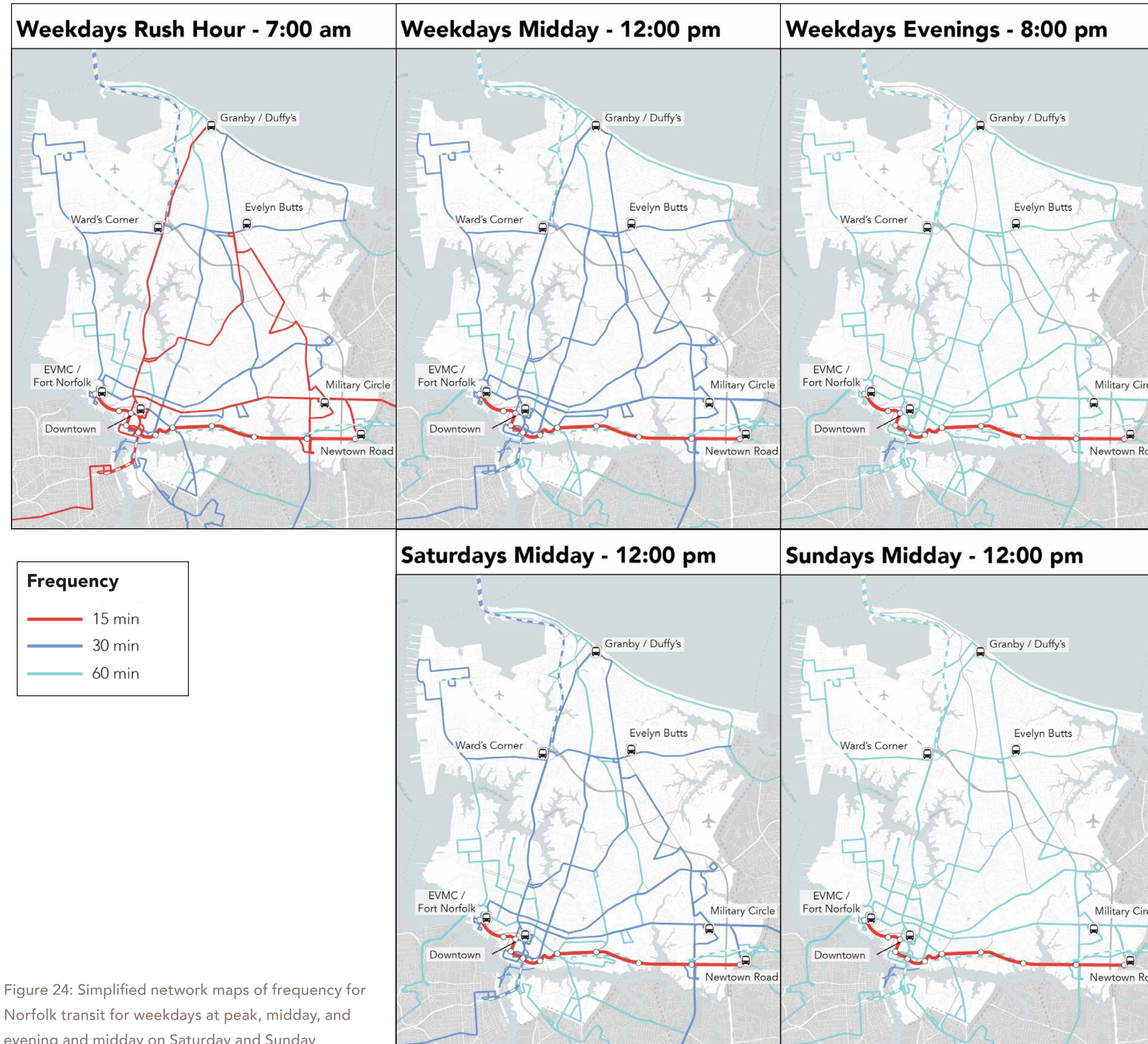


Figure 24: Simplified network maps of frequency for Norfolk transit for weekdays at peak, midday, and evening and midday on Saturday and Sunday

1 American Time Use Survey, Table A-2A. Time spent in detailed primary activities and percent of the civilian population engaging in each activity, averages per day on weekdays and weekends, 2016 annual averages, total. 2016.

How many people are near service?

Coverage goals for transit are served when transit is available to people, whether or not they ride it in large numbers. Figure 25 shows the coverage provided by the existing HRT routes to residents and jobs within Norfolk.

This chart measures coverage by any service as well as to frequent service. The distinction is important because frequent service is most likely to attract high ridership relative to its cost.

For all residents in Norfolk, about 22% are within 1/4 mile of frequent transit service at midday, which represents the number of people near the The Tide, the only frequent service in Norfolk. Nearly all residents are near some kind of transit, with 67% served by a route that arrives about every 30 minutes (dark blue) and 10% served by a route that arrives about every 60 minutes (teal). Only about 1% of residents are more than 1/4 mile from a bus or transit stop, but most residents are near low frequency service, so ridership expectation should be low.

Since a high proportion of jobs are concentrated in downtown, more jobs are near frequent service, with 31% of jobs near The Tide. Most jobs, 61%, are reachable only by a bus that arrives every 30 minutes at midday.

Non-white residents are slightly less likely than all residents to live close to frequent transit service, with only 17% near The Tide, but are slightly more likely to live near a bus that arrives at least every 30 minutes (76% versus 67% for all residents). Residents in poverty are just as likely to live close to some service and they have the same access to frequent service as all residents. The disparity in proximity to frequent service for non-white residents is relatively small but still worth considering as the Norfolk residents consider changes to the transit network.

These conditions are not static and may change in coming years as a result of a changing economy and a changing city. Changes in the pattern of demand for housing or location of jobs may shift the patterns of who has access to what kind of transit, without any changes to the transit network. Many cities have seen an increasing housing demand near transit and in walkable, urban areas. If this increasing demand is not matched by increases in the supply of housing, then people living on low incomes may move away from frequent transit or any transit service to seek lower housing costs. Land use planning, growth permitting, and affordable housing policies at local jurisdictions have as much of an impact in the long-term on access to useful transit as does the transit service itself.

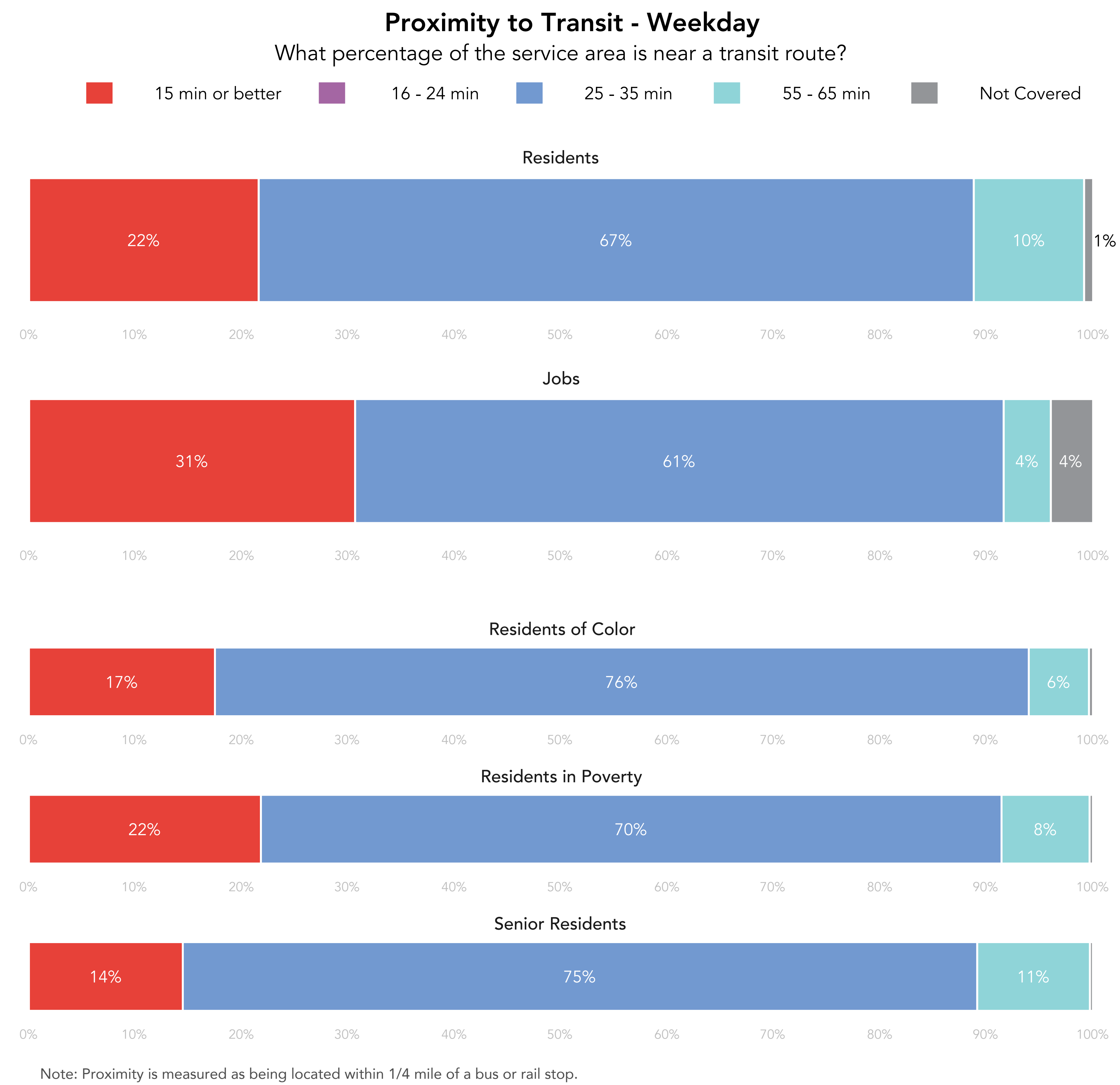


Figure 25: Proximity of Residents, Jobs, and Communities of Concern to Transit

Where are people riding transit?

One measure of transit performance is the sheer amount of ridership it attracts. This can be made visible with a map of boardings at each transit stop, as shown at right.

High ridership routes and areas can appear in two ways on this map: either as large dots or as multiple medium-sized dots that are very closely spaced. Looking for those patterns we can observe that the highest boardings occur:

- At most Tide Light Rail Stops, where the frequency of service is high.
- Near hospitals, universities and malls, in general.
- On Monticello Avenue south of 26th Street, where multiple routes provide a combined higher frequency of service.
- On Virginia Beach Boulevard between Ballantyne Boulevard and Military Highway.
- On Little Creek Road, particularly between Military Highway and Granby Street.

There are also smaller clusters or large dots, or single large dots, that are farther away from other large boardings dots. Most of them are attributable to big apartment buildings or social service providers.

Looking at this map, we must keep in mind that *not every stop is offering the same level of service*.

- Some of these stops are served just three times a day. Some are served every 15-30 minutes on weekdays.
- A small dot on a low-frequency route may simply reflect the low level of service.
- A small dot on a more frequent route would suggest low demand for transit near that stop.
- A large dot on an infrequent route means that ridership is high despite a low level of service, which suggests that nearby transit demand may be high.

The way we discern between these situations is described on the next page – we compare the amount of ridership on a route to the amount of service supplied to that route.

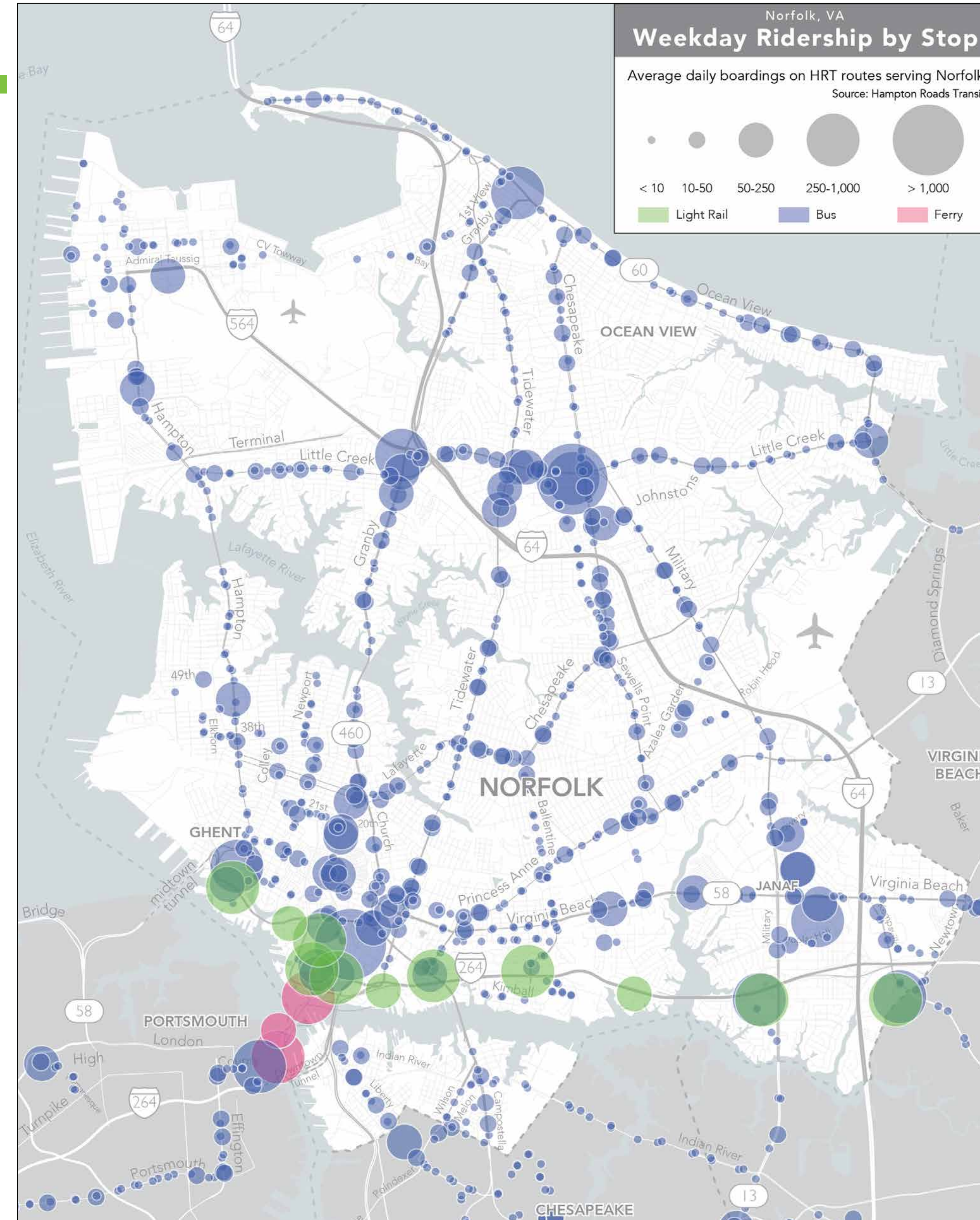


Figure 26: Norfolk Ridership by Stop for an Average Weekday

Productivity and Frequency Relate

When deciding where to add service or reduce service, transit agencies don't simply look at total ridership – they look at ridership relative to cost.

Every public dollar the City and HRT are spending to provide transit in one way is not being spent in another way. An important part of public accountability is saying not only how many riders use a service, but also how much it costs to serve them. This helps everyone make their own judgment about whether the service is worthwhile as it is, or whether more good could be done for more people by spending those public resources in a different way.

The official transit word for "ridership relative to cost" is "productivity." Productivity is the number of people who boarded buses, divided by the number of hours buses were on the road.

The scatterplot at right shows individual routes from 26 mid-sized cities, plotted according to their weekday frequency and their productivity. There is an upward curve to the left, showing that more frequent routes are likely to be more productive.

HRT routes in Norfolk are shown as orange hexagons.

Productivity represents boardings divided by service hours, which are the hours that each bus and driver are on the road, working a route. Service hours are the major component of a transit agency's operating cost for bus service.

Providing higher frequencies requires spending more service hours. And yet, more frequent services tend to have higher ridership not just in total, but also per service hour.

While a higher frequency increases service hours, the higher ridership it attracts often makes up for it, and then some. The result is higher productivity.

Turning up the frequency of just any route won't lead to higher productivity. This is evidenced by the long column of dots in the chart that have 15-minute frequency. Some of them have very low productivity levels.

On average, when frequent service is designed as part of a connected network, and made available to people in a suitably dense, walkable place, higher productivity is the result.

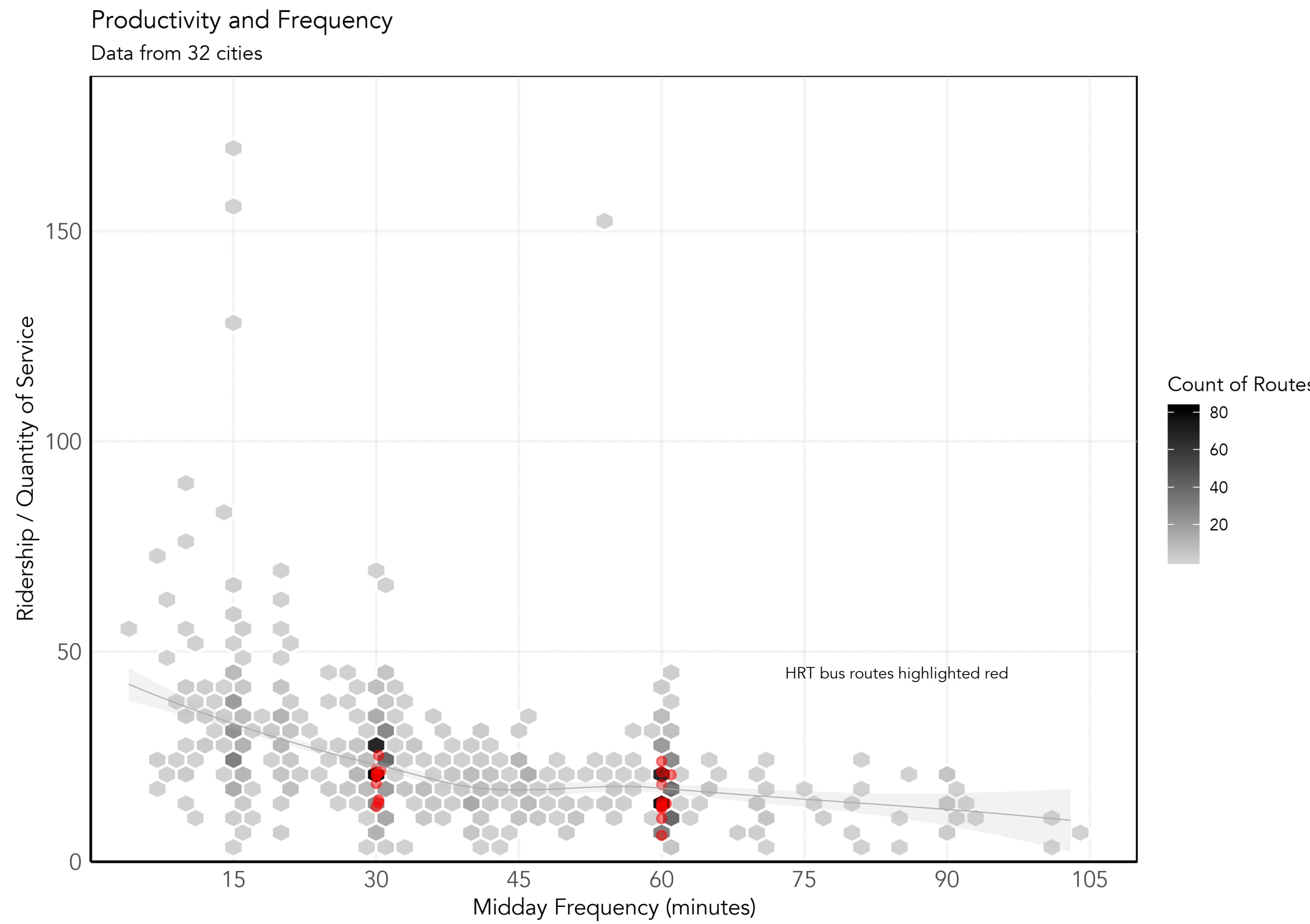


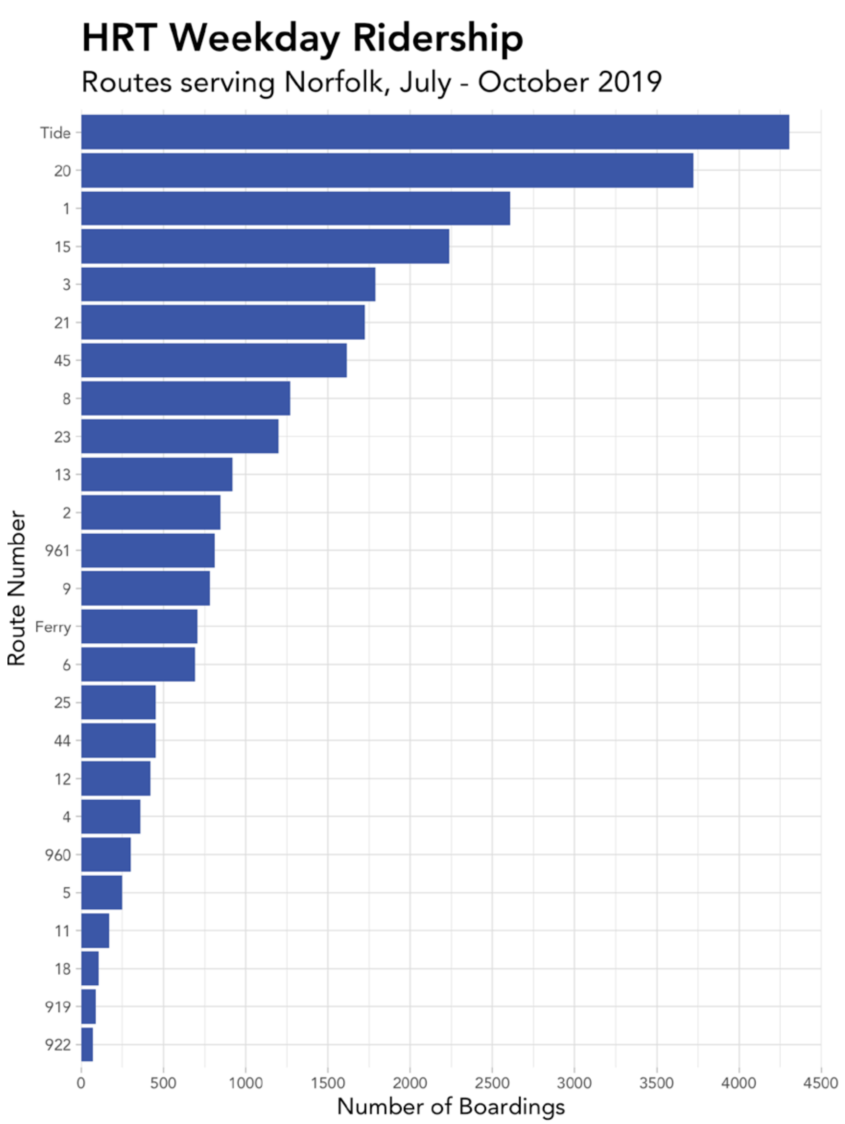
Figure 27: Frequency and Productivity - Data from Norfolk and 32 other US transit agencies

Where is productive service today?

People who value the environmental, business or development benefits of transit will talk about ridership as the key to meeting their goals. If that were the primary measure, then our attention would be focused on the routes at the top of the chart in Figure 28, which shows ridership total by route for the average weekday.

However, because any transit agency is operating under a fixed budget, the measure they should be tracking is not sheer ridership but ***ridership relative to cost***. They would not be satisfied simply by a large dot on the boardings map on the previous page until they knew what it cost the transit agency to achieve that large dot.

Figure 28: Average weekday ridership by route



Ridership relative to cost is called "productivity." In this report, productivity is measured as boardings per service hour.

Productivity = Ridership / Cost = Boardings / Service hour

The service hours provided on any particular route, and to any particular stop, will depend on a few factors:

- The length of the route.
- The speed of the bus (since a slower speed means that covering the same distance takes more time).
- The frequency of service along the route or to the stop. Higher frequency is delivered by increasing the number of buses being driven on the route at once.
- The daily and weekly span of service for the route (how many hours it is available).

Changing any of these factors for a transit route will affect service hours, the denominator of the productivity ratio. For example, doubling the frequency of service on a route will double the number of service hours being supplied. This means the denominator of the productivity ratio has been doubled. We might therefore expect that productivity of the route would be cut in half...unless the numerator of the productivity ratio (boardings) were to also increase.

Productivity is strictly a measure of achievement towards a ridership goal. Services that are designed for coverage goals will likely have low productivity. This does not mean that these services are failing or that the transit agency should cut them. It just means that their funding is not being spent with the purpose of attracting high ridership.

High ridership arises from the alignment of useful service and supportive land use. The result is high ridership per cost of service, or *productivity.* Figure 29 shows how frequency and productivity relate for HRT routes in Norfolk. In this chart, the x-axis shows how frequently each route comes at midday, while the y-axis shows how many passenger boardings each route generates per hour in operation.

In the City's transit network, the highest-productivity routes in the network are mainly the more frequent services in dense, high-demand places. This is a common trait in many transit agencies, since frequent services are both much more useful than infrequent service, and thus capable of competing for users, and consciously designed to serve the strongest markets.

Overall, the highest productivity service is The Tide, which sees about 50 boardings per service hour. The Tide benefits from directly serving the core of downtown and operating at a relatively high average speed across its full length, particularly its eastern half where it runs on dedicated right-of-way.

Lower-frequency, high-productivity outliers are often routes that operate in similarly dense environments, but at a lower service level. Low-frequency, high-productivity routes are often good candidates for improved service in the future.

Some of the notable high-performing routes include:

- In Norfolk, Routes 1, 8, and 20 are examples of high-productivity services operating on continuous, relatively dense commercial corridors. On these routes, more than 20 people board the bus each hour.
- Route 4 is an interesting outlier that over performs, given its frequency. It performs well in part because it serves a key commercial corridor (Colley Avenue) and Old Dominion University, and is relatively short. Shorter routes will tend to get higher productivity because ridership turns over more often.
- There are other very high-productivity routes operating at low frequency. These routes carry a small number of passengers compared to more frequent services, but they do so very efficiently. Route 13 is an example achieves relatively high productivity in part because it serves dense pockets of apartments in the City of Chesapeake where many people don't have cars and have relatively low incomes. Route 13 also serves Norfolk State University and gets about 100 daily boardings from stops near the university.

Is the existing bus network's goal ridership or coverage?

One of the most important questions this study poses to the public and elected officials is whether to change the balance of resources within The City of Norfolk's network between these two important goals. In order to have an informed opinion on this question, it is helpful to first develop a sense of how the network's resources are divided today.

To do this, we examined key land use and performance indicators for each route in the city's network, and divided the cost of each route (in terms of its weekly total hours in service) into two categories: Ridership-oriented service and Coverage-oriented service.

Across the city's bus network, we estimate that approximately 60% of service is focused on generating high ridership, and 40% on high coverage. Whether this is the right balance for Norfolk is a question to be answered by the community and its leaders as part of this Transit System Redesign process.

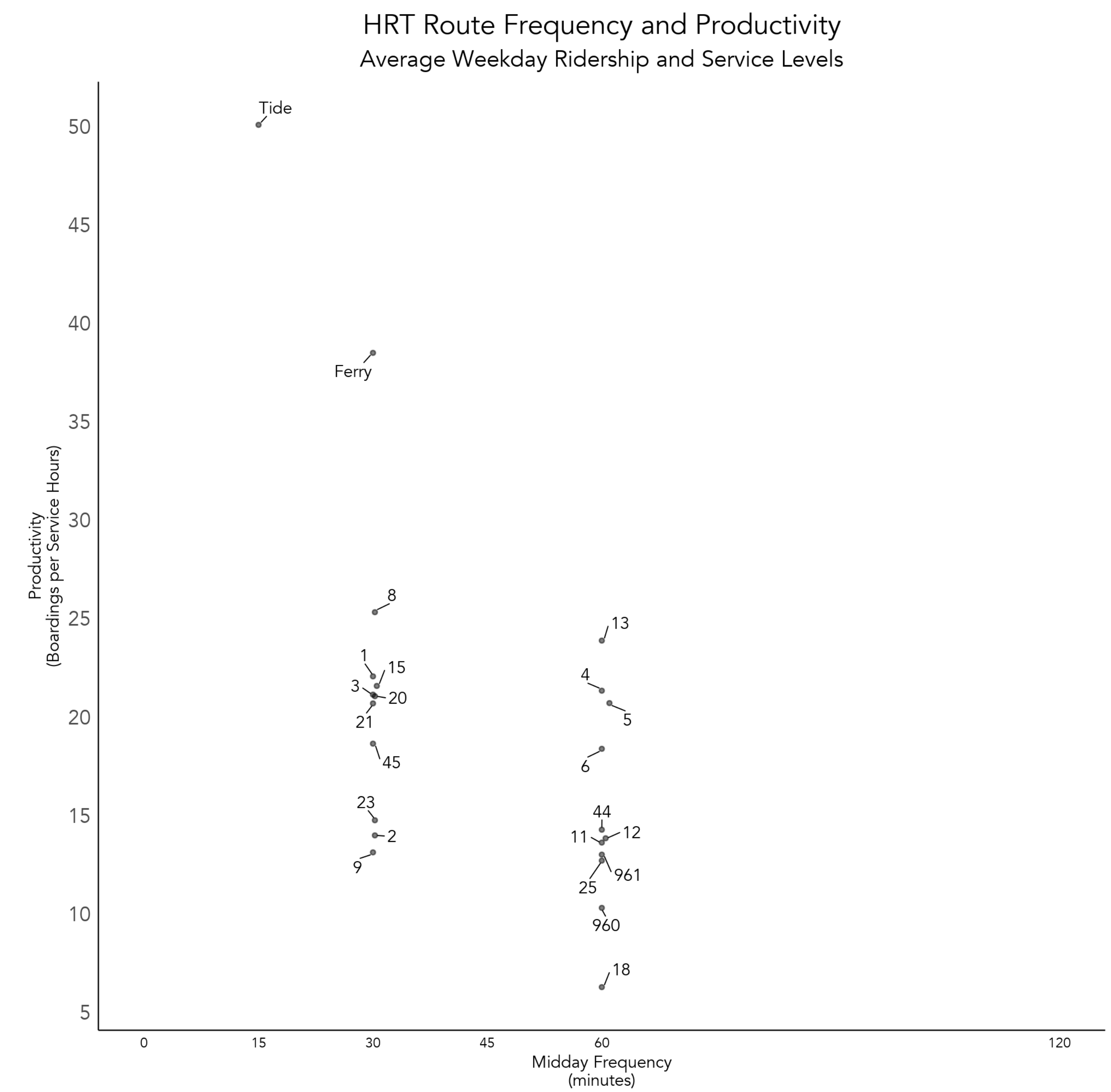


Figure 29: Route Productivity and Midday Frequency

Ridership Relative to Service Throughout the Day

During the rush-hour commute period, transit demand patterns change to a degree, and it's normal for service to change in response. HRT Routes 919 and 922 operate a few trips during rush hours only. Many HRT Routes offer higher frequencies during rush hours, and afternoons, than at midday. This extra service contributes to "peaks" in the number of vehicles that HRT deploys during rush hours in the City of Norfolk (and across much of its regional network).

Peaking has some extra costs that are often invisible to the public:

- Transit agencies must maintain a larger fleet of buses to handle the peaks, but those buses sit idle the rest of the day and week. For each extra bus that is run during peaks, an agency has to purchase the bus, store it and maintain it.
- Rush hour services are often provided using split shifts for drivers with less seniority. Split shifts often require drivers to be away from home in the morning and evening but with pay for only hours worked. These shifts can be difficult to keep staffed adequately.

The graph at right in Figure 30 shows compares the amount of service HRT is putting on the street in Norfolk throughout a weekday to the ridership attracted by that service.

- The blue line shows how many HRT vehicles are out driving routes. There are two peaks in vehicle deployments, at 7 am and 4 pm. At these times HRT has 75% more service on the street than on average over the whole day, and 50% more than at midday.
- The green line shows how many riders those vehicles attract within each hour. Ridership has peaks at 7 am, drops to 125% of average by 10 am and then begins rising again to the highest peak at 3 to 4 pm.
- The orange line shows ridership relative to vehicles. This is similar to the productivity measure discussed on page 34, but it changes from hour to hour. It is highest from 1 pm through 3 pm.

Rush-hour routes are sometimes thought of as targeting the highest-demand time of the day. Yet HRT's peak-only routes (the 919 and 922) are, as we can see in Figure 29 on page 34, among the least productive. The graph at right shows that ridership is actually highest in early afternoon, when service workers are changing shifts and students are getting out of school.

All people, regardless of their income, value flexibility and independence. If a transit service does not support a midday trip home to pick up a sick child, or a late night at the office finishing a report, more affluent people can easily respond by using a private car. Service and retail workers typically commute outside of rush hours. They, too, can choose another option (such as a ride from a family member, an inexpensive car, or a hired ride) if the transit network is not there when they need it.

As of the 2010 Census, 29% of U.S. workers did not work a traditional weekday, daytime schedule.[1] Add to them all the people who work a second job, are studying, or need to run errands in the evening, and we can imagine the proportion of Norfolk residents whose travel needs go far beyond the morning and evening weekday rush hours.

Given the extra costs of running more vehicles during rush hours, it would be reasonable to expect *higher* productivity, and to ask passengers to tolerate more crowded buses, during rush hours than at other (less expensive) times of day. Each rush-hour passenger is costing HRT more to serve than a passenger riding at midday, yet rush-hour passengers enjoy shorter waits.

If the City and HRT wish to increase ridership within its fixed budget, then shifting a little bit of service away from traditional rush hours in order to offer more consistent all-day schedules is a strategy worth considering.

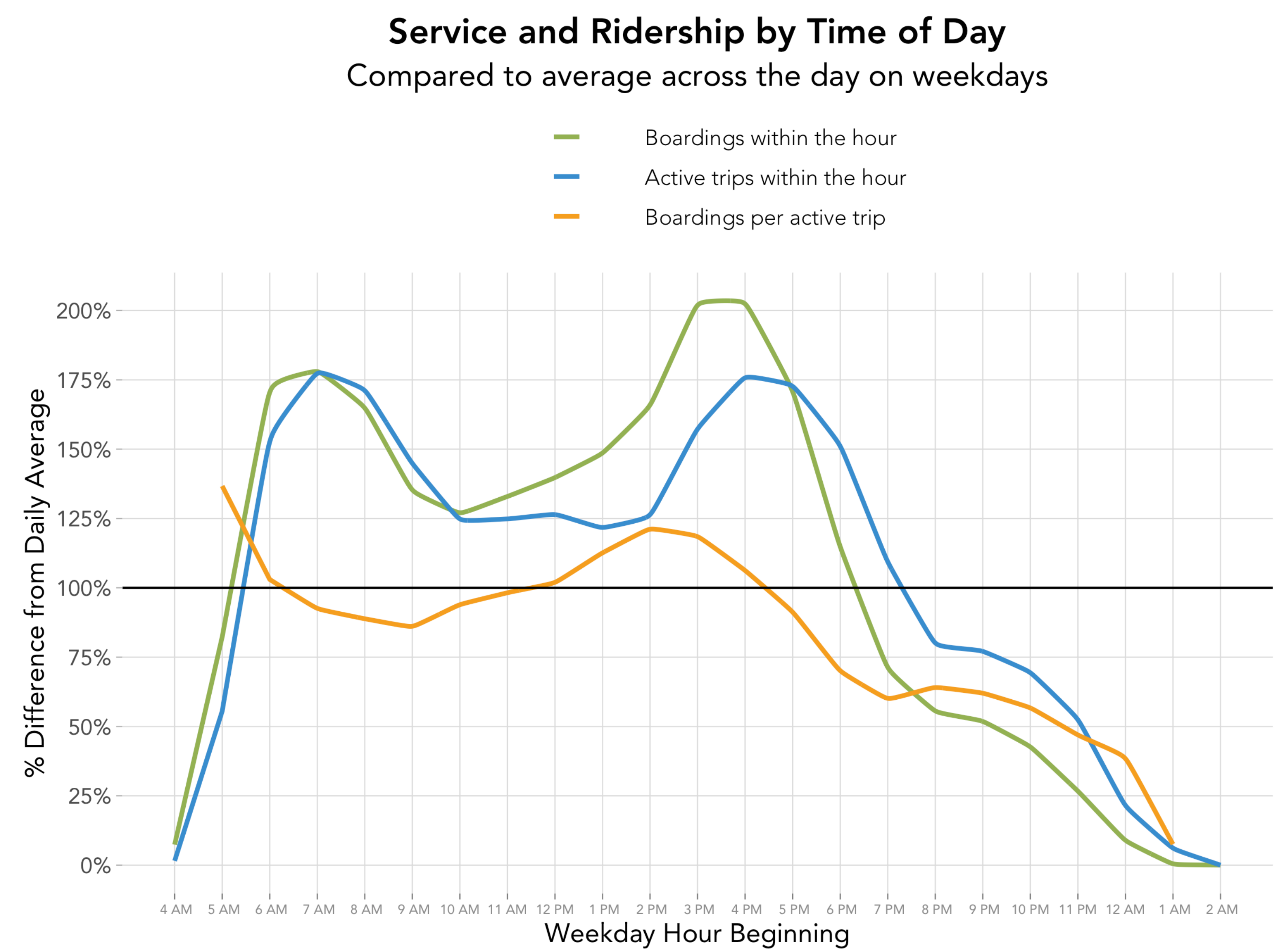


Figure 30: Service and boardings by hour show that boardings per trip peaks at 2pm

1 Visit npr.org/sections/money/2014/08/27/343415569/whos-in-the-office-the-american-workday-in-one-graph to explore the typical workdays of workers in different sectors.

Freedom and Access

Elements of the service like frequency and span tell us a great deal about how useful transit is, but they do not tell us everything about how service interacts with where jobs, people, and destinations are in Norfolk. A different way of assessing transit is to ask: "How useful is transit for getting you to a lot of places quickly?"

A helpful way to illustrate the usefulness of a network is to visualize where a person could go using public transit and walking, from a certain location, in a certain amount of time.

The map at right shows someone's access to and from downtown Norfolk, near the Monticello station, at noon on a weekday. Areas they can reach in less than 60, 45 or 30 minutes are shown in light, medium and dark blue, respectively. The technical term for this illustration is isochrone.

A more useful transit network is one in which these access bubbles are larger, so that each person is likely to find the network useful for more trips.

In this analyses, travel time estimates include:

- The walking time from the origin point to all nearby stops.
- Initial waiting time equal to 1/2 of each route's scheduled frequency
- In-vehicle travel time based on current schedules.
- Waiting time equal to 1/2 of a route's headway for all possible transfers.
- Walking time equal to the remainder of the travel time budget after arriving at each stop. Note that for this analysis, the total walking distance is limited to one mile.

We always account for time spent waiting, because even if you time your departure just right and don't wait at the bus stop, a lower-frequency route often makes you wait at your destination because it can force you to arrive very early (rather than be slightly late). Very few people have the liberty of arriving when they please for all their trips, so for most people, riding transit means waiting somewhere. The more frequent the transit, the shorter the wait.

Where can you go from Downtown Norfolk?

Downtown has the best transit access in the region, because it is at the center of the transit network, where many bus routes converge and because it is along the Tide light rail line, the only transit route that operates every 15 minutes throughout the day.

The power of the Tide's frequency can be seen in this isochrone, with the line bringing many areas of eastern Norfolk within a 30 minutes of downtown. The Tide's terminus, Newton Road Station, is reachable in within 45 minutes.

The impact of Norfolk's most linear 30-minute bus lines can also be seen in this isochrone. The medium blue area extending north on Chesapeake Boulevard shows how far someone can get on Route 3. The medium blue "arm" extending up Granby Street show how far you can go with Route 1.

This map helps show that you can go a shorter distance north on Hampton Boulevard within 45 or 60 minutes, because Route 2 takes a circuitous trip through EVMC and Fort Norfolk before going north toward Norfolk Naval Station.

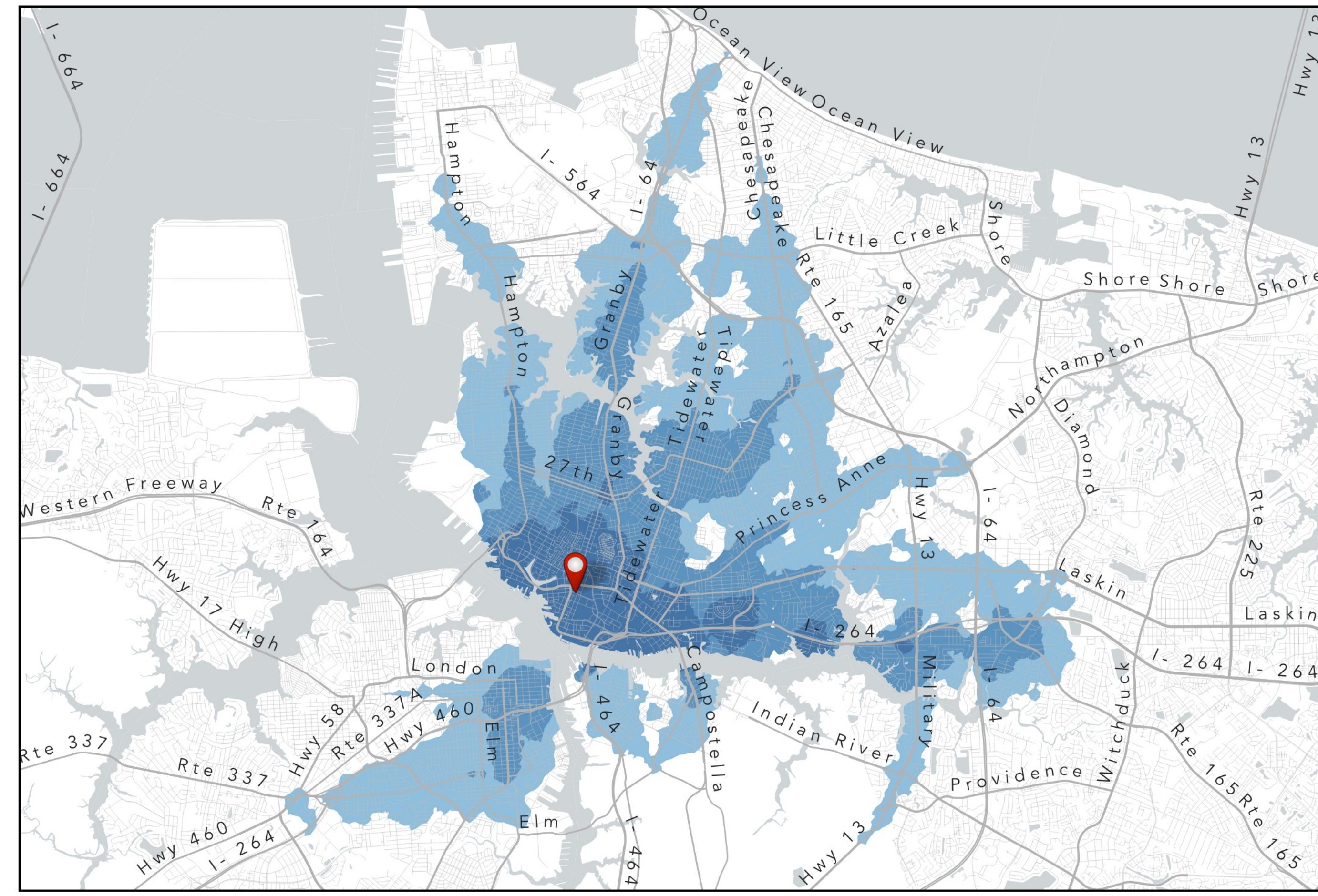
How many places can you reach reasonably quickly?

An isochrone map, like the one to the right may tell you where transit can take you within a reasonable amount of time, but what really matters is how many destinations you can reach in that time. For that, we measure job access—the number of jobs within the 30- 45- and 60-minute blue isochrone areas.

How far can I travel in 30, 45, and 60 minutes from

Downtown Norfolk

at noon on a weekday?



	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	25,100	83,410	176,310
Jobs Accessible	49,940	77,770	136,930

Estimates based on 2015 TAZ population and jobs data

Figure 31: An isochrone shows how far someone can go, in a given amount of time, by walking and transit. Access to and from Downtown Norfolk within 30, 45 or 60 minutes of travel is illustrated here.

We measure access to jobs because we have good data on job locations, but better access to jobs means more than potential places of employment. It also tends to mean more shopping, social, and educational opportunities can be reached, allowing for a richer life for people who choose to rely on transit.

In Figure 31, we can see that from Downtown Norfolk, a person is able to reach about 77,770 jobs in 45 minutes.

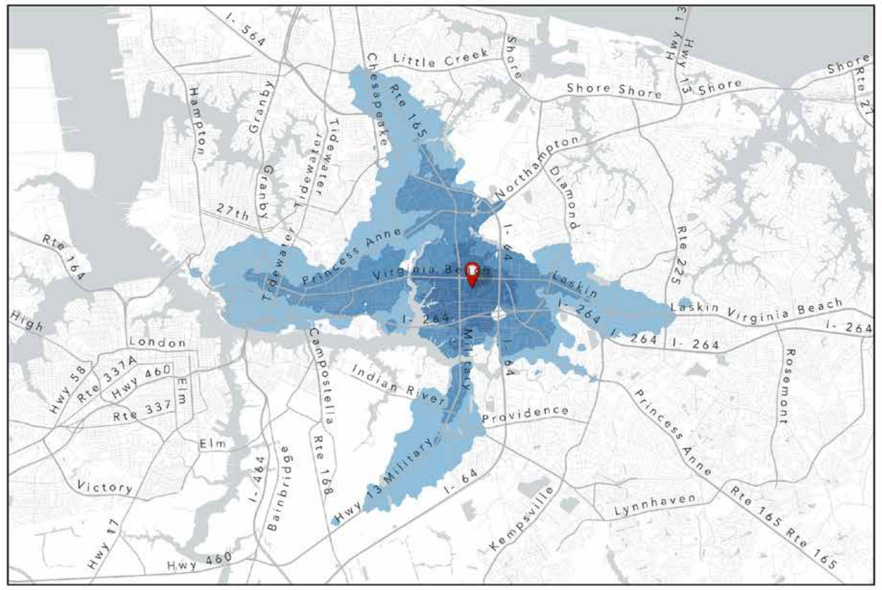
For a business trying to decide where to locate their storefront or office, they may be interested in comparing access to population, because higher access to population means a larger market of potential employees, and potential customers. From downtown Norfolk, a business is able to reach about 83,410 residents within 45 minutes.

The travel-time maps on the next page illustrates access to opportunity in different locations throughout the city.

How far can I travel in 30, 45, and 60 minutes from

Military Circle

at noon on a weekday?



	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	4,670	31,690	99,570
Jobs Accessible	12,100	41,880	107,290

0 1 mi

Estimates based on 2015 TAZ population and jobs data

How far can I travel in 30, 45, and 60 minutes from

Berkley Community Center

at noon on a weekday?

	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	3,730	7,330	28,180
Jobs Accessible	6,050	11,740	41,720

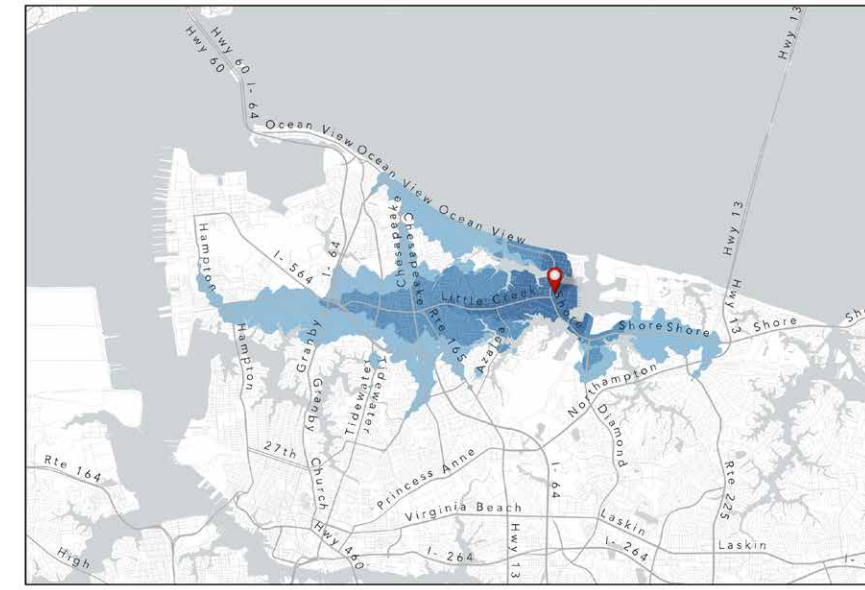
0 1 mi

Estimates based on 2015 TAZ population and jobs data

How far can I travel in 30, 45, and 60 minutes from

Joint Expeditionary Base Little Creek Gate 1

at noon on a weekday?



	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	5,700	25,290	65,120
Jobs Accessible	5,310	10,670	24,740

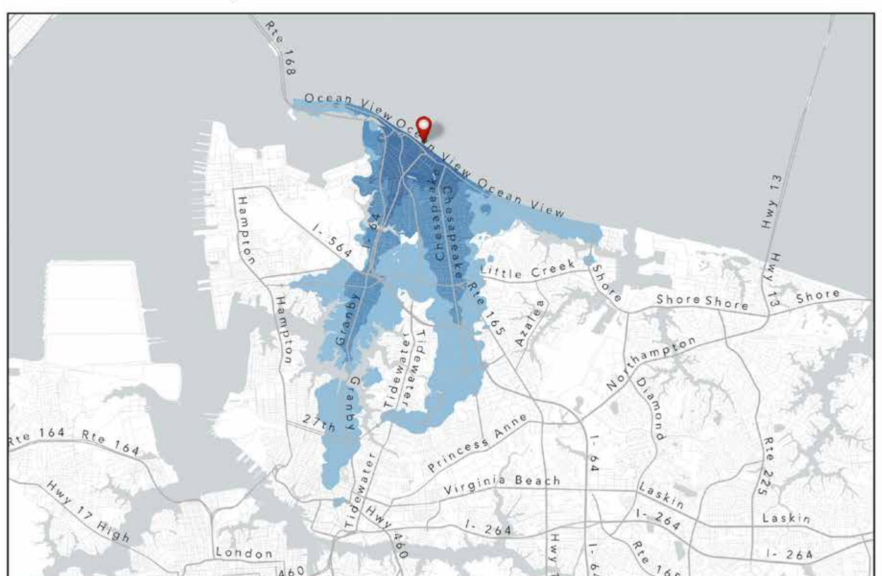
0 1 mi

Estimates based on 2015 TAZ population and jobs data

How far can I travel in 30, 45, and 60 minutes from

(West) Ocean View

at noon on a weekday?



	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	8,360	31,060	79,720
Jobs Accessible	1,170	8,800	21,830

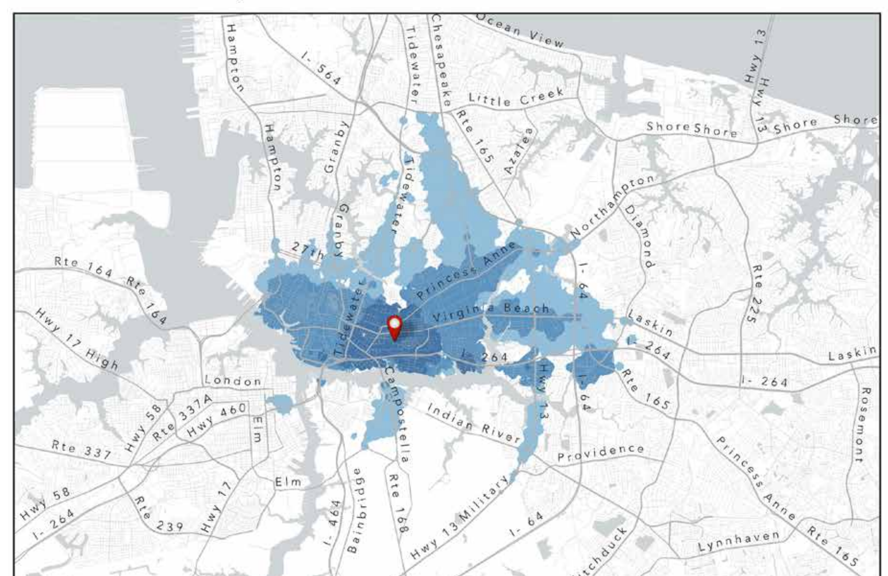
0 1 mi

Estimates based on 2015 TAZ population and jobs data

How far can I travel in 30, 45, and 60 minutes from

Norfolk State University

at noon on a weekday?



	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	14,800	51,990	99,400
Jobs Accessible	7,310	68,110	96,690

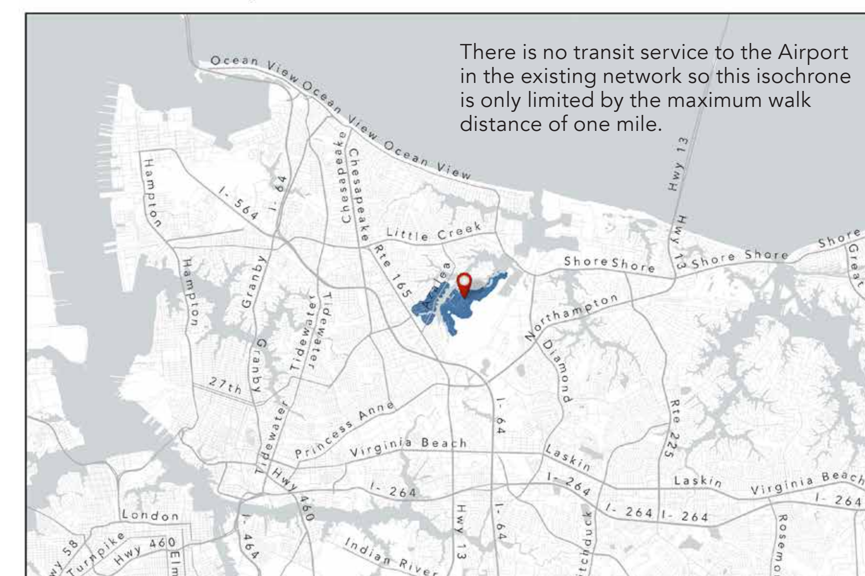
0 1 mi

Estimates based on 2015 TAZ population and jobs data

How far can I travel in 30, 45, and 60 minutes from

Norfolk International Airport

at noon on a weekday?



	in 30 minutes	in 45 minutes	in 60 minutes
Population Accessible	850	850	850
Jobs Accessible	400	400	400

0 1 mi

Estimates based on 2015 TAZ population and jobs data

Figure 32: Access to and from different locations in Norfolk within 30, 45 or 60 minutes of travel.

Existing HRT Network Access

Isochrones can show us the freedom and access for a given place, but to see the total freedom a network provides across the entire county, we have to run the isochrone measure for nearly every place and display the results by color. Figure 32 shows this result, specifically the number of jobs that can be reached from each hexagon, within Norfolk. People who live in the darkest pink areas can reach more than 55,000 jobs in 45 minutes by walking and transit. In white areas, residents can reach 5,000 jobs or fewer.

Many of the areas near the Downtown Norfolk, Downtown Portsmouth, and Norfolk Naval Station fall in the top three groups, where people can reach more than 55,000 jobs in 45 minutes. While some of this job access is the result of high density by itself- areas with many jobs within walking distance would have higher job access, even without transit- it is obvious that transit significantly expands access in many areas. In the Southeastern parts of Norfolk, the power of the Tide Light Rail can be seen in the high accessibility in areas around all the rail stations. The power of Norfolk's major bus routes is also clearly visible along Hampton, Granby, Virginia Beach, Chesapeake and Princess Anne corridors.

Figure 33 shows the average jobs accessible for different sub-groups in Norfolk. The average Norfolk resident can reach about 30,000 jobs by transit and walking in 45 minutes, as can the average Norfolk Resident of Color, and average Norfolk Resident in Poverty. The average Senior Norfolk Resident can reach just about 27,000 jobs in 45 minutes, likely because fewer senior residents are located near major transit corridors than the population average.

If Norfolk wishes to maximize its transit ridership, then a key goal would be to increase the number of jobs accessible to the average person, and it would do that by increasing the number of jobs accessible to the areas that have the most people in them.

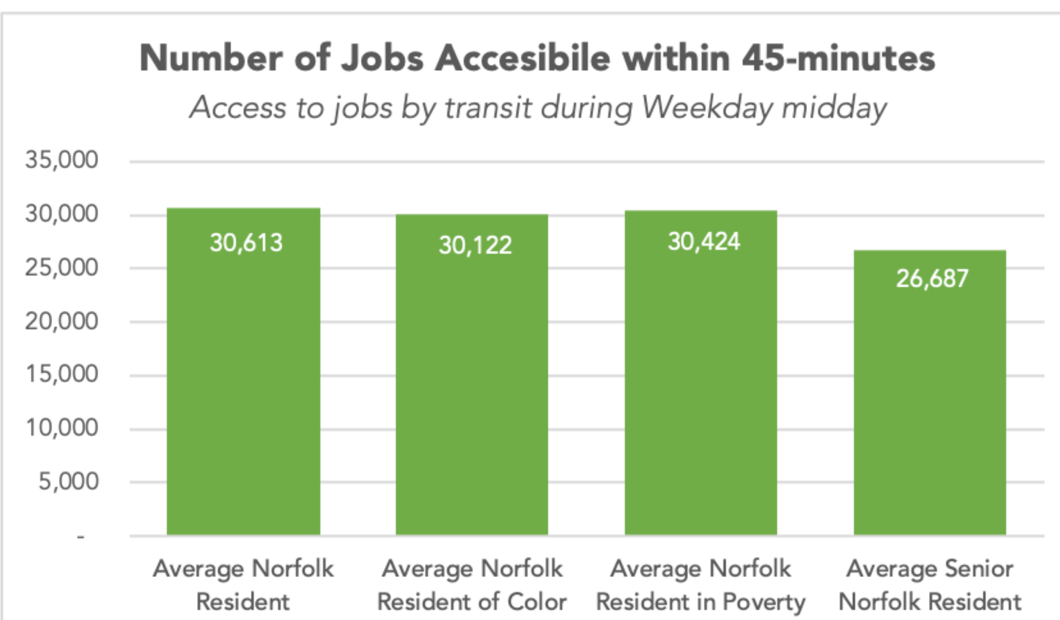
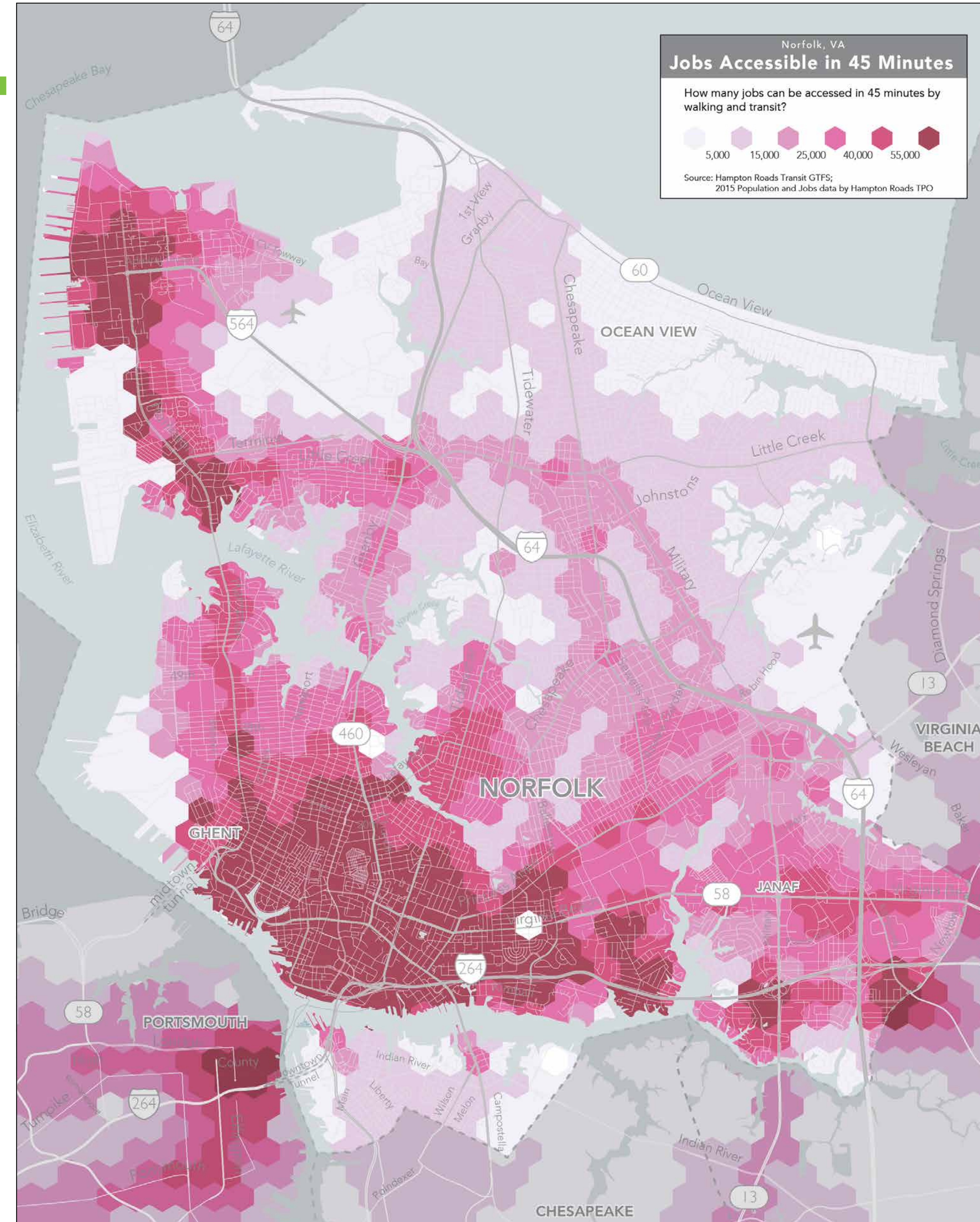


Figure 33: 45-Minute Job Access by the Average Resident, Residents of Color, Residents in Poverty, and Senior Residents.

Figure 34: 45-Minute Access to Jobs (Weekday Midday)



Pulsing

Connecting between routes—often called transferring—is an integral component of an effective transit system that allows a few routes to serve many possible trips across the city. The major transfer points in any city are the joints in the transit network, places where multiple routes converge or intersect one another. In Norfolk, these locations are formalized as "Transfer Centers" and include the Downtown Transit Center, Evelyn Butts Transit Center, Wards Corner, Military Circle, and Newtown Road Tide Station.

The amount of time a transfer takes depends largely on the frequency of the connecting routes. For an un-timed connection, transferring to a frequent route, like the Tide LRT, which comes every 15 minutes, would take on average just 7.5 minutes. Transferring to a route that comes every 60 minutes could require a 30-minute wait, on average, and in the worst case a 59-minute wait!

Small to medium sized radial networks are often operated with a "pulse" at a central location. To offer a pulse, an agency must design its routes to be a certain length so that buses can all arrive at the central hub at the same time, each hour or half-hour. The buses dwell together for a few minutes, passengers connect among them, and then they depart again. This can happen at any regular interval, though half-hourly and hourly pulses are common in most networks with a timed connections.

A pulse is an excellent way to create a network out of a set of low frequency routes, because it makes transfers less difficult and risky than they would be if they happened at random. If two 30-minute routes cross someplace in the city, and someone wants to transfer between them, their average wait will be 1/2 of the frequency, 15 minutes. Sometimes they will get lucky, and wait 1 minute; sometimes they will get unlucky, just miss their connection, and wait 29 minutes. On average, they will wait 15 minutes. This amount of waiting time, and degree of variability in trip time, is intolerable to most people, so hardly anyone will rely on such a connection.

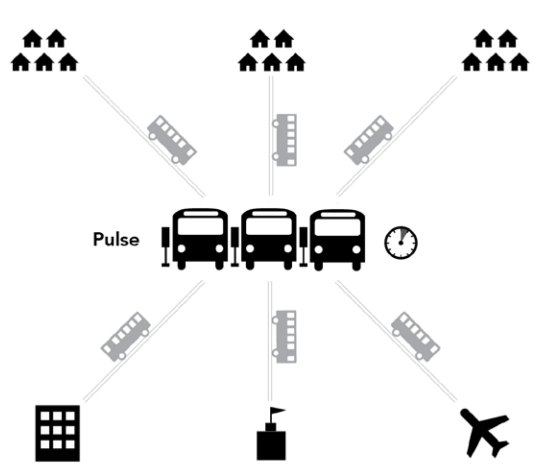


Figure 35: In a pulse, multiple low-frequency routes are scheduled to come together regularly, dwell for a few minutes so that passengers may transfer among them, and then depart again.

Instead, if the transit agency designs the network so that those two 30-minute routes pulse together at a transfer center, people's wait at the connection point will be reliably just a few minutes long. Many more people will be willing to transfer between low-frequency routes if the connection is quick and reliable.

There is a cost to pulsing. First, the routes must be designed so that they can make a round trip in the right amount of time to get back to the pulse with all of the other routes. This makes it hard to lengthen a route just a tiny bit in response to requests. It also means that any reduction in the speed of the bus can be threatening to the pulse, since that bus may not be able to do its round trip in the required amount of time.

Second, the routes must be given enough spare time to protect them against all of the predictable or unpredictable delays that happen on the roads. If two 30-minute routes are meant to pulse together, and one of them is often late and misses the rendezvous, then the transferring passengers face waits even worse than if the routes were connecting at random—they may often be waiting 29 minutes! The spare time added to schedules to protect against delays is called "recovery time," and it is essential for the reliability of a pulse. Radial networks are well-suited to pulsing, and vice versa.

Where are Norfolk's pulses located?

It is extremely difficult to schedule a system in a perfectly synchronized way that allows for timed connections throughout the day in many locations throughout the city. Differences in route lengths and travel times between routes typically mean that you can only schedule a pulse between many routes at one or two key locations. Many cities include a pulse connection downtown, where more routes connect than anywhere else in the network. However, HRT's routes in Norfolk do not offer a consistent all-day pulse at the Downtown Transit Center. Instead, they pulse at Evelyn Butts Transit Center and at Military Circle. This means that many people who transfer through downtown—the location with the most transit connections in the network — experience an un-timed connection, with potentially long waits.

Improving Norfolk's Downtown Connections

If Norfolk wishes to reduce transfer wait times for many people, it may be able to do so by redesigning the network in a way that allows for a pulse connection Downtown. This will be an important option to consider as long as bus frequencies remain low. However, if key routes that serve Downtown can be improved to offer high frequency throughout the day such that even un-timed connections can be made with just a short wait, a downtown pulse may be less important.

Thus, the choice to implement a pulse among routes downtown depends in large part on the value choices the community makes about how much to emphasize frequency and ridership goals versus coverage goals. If the community wishes to emphasize coverage goals, then most routes will run every 30 or 60 minutes. In a low frequency network, pulsed connections are the most valuable tool for reducing travel time across the city.

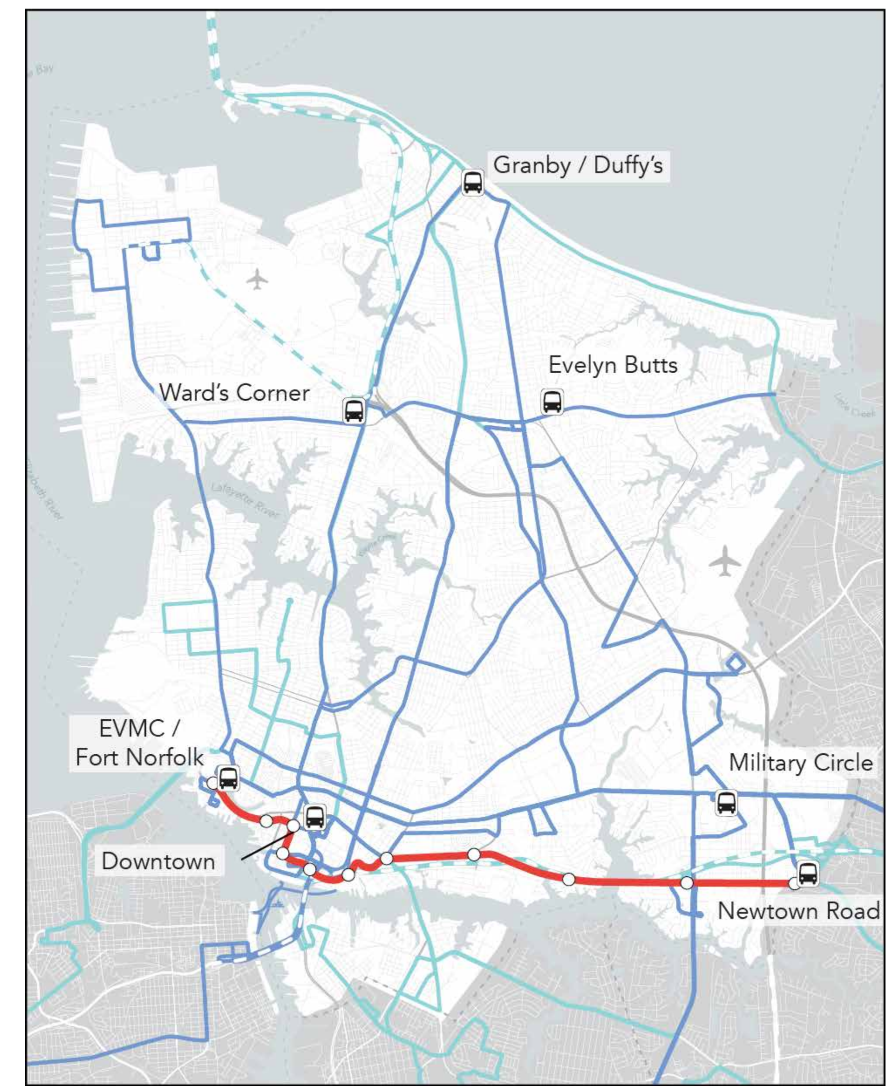
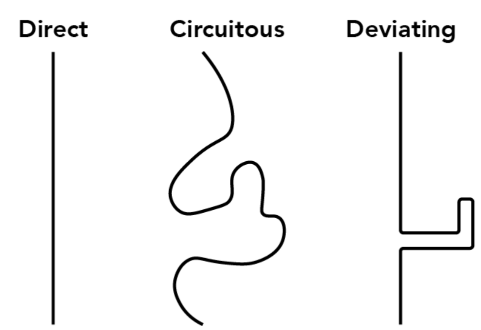


Figure 36: In the existing nework, "pulse" connections are available at Evelyn Butts Transit Center and at Military Circle.

Deviations

One source of complexity in HRT in Norfolk routes is deviations. People almost never want to be taken out of direction when they are on their way somewhere. This is part of the reason that linearity is one of the four geographic indicators of high ridership potential, as described on page 11.



Routes with deviations on them can only feel direct to the people who are bound for the deviation itself – for most other riders, they feel like an infuriating waste of time.

The other reason linearity is indicators of high ridership potential, is that circuitous and deviating routes are simply longer, and therefore cost more to operate for HRT and the City. (In the drawing above, imagine stretching out the lines of the Circuitous and Deviating routes. They would be much longer, and therefore take more time and money to drive a bus down, than the Direct route.)

The longer a route is, the lower the level of service it can offer for the same cost. The shorter a route is, the more can be spent on frequency or long spans.

Deviations are not always bad for ridership. Routes with deviations sometimes attract high ridership relative to their cost. The number of riders added thanks to a deviation is occasionally big enough to make up for the negative impacts on operating costs and on through-riders.

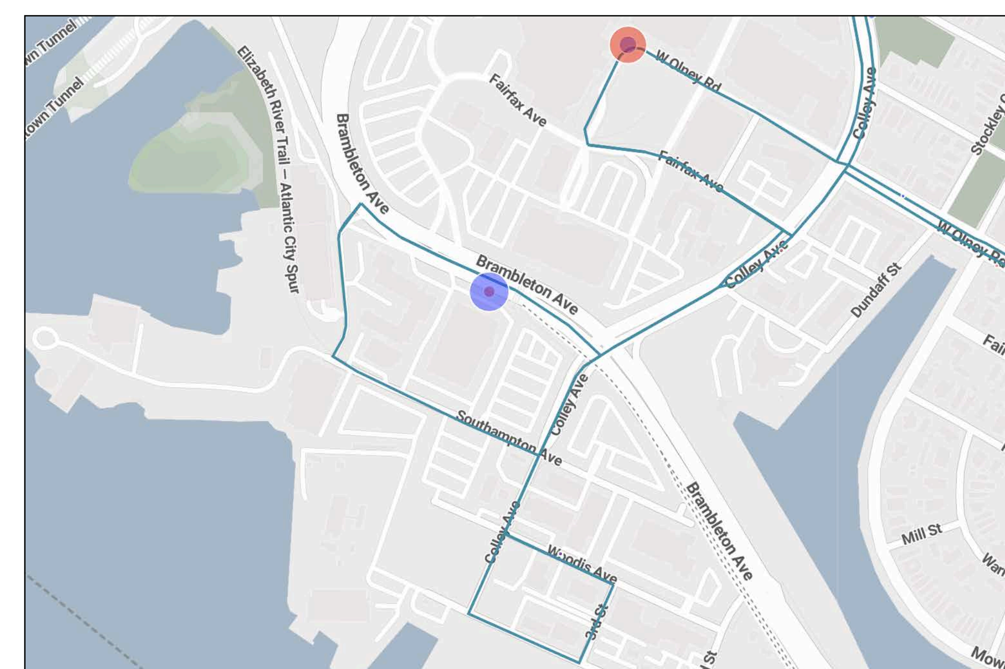
Deviations are often used as a coverage tool. They bring service close to a larger number of people and places. They reduce walking distances to bus stops. In most cases, they discourage more ridership than they attract, but ridership is not the goal of a coverage service.

One example of a significant deviation that is of questionable value is the long deviation that Route 2 takes through Fort Norfolk on its way downtown. The map at right shows the overall network in the area and how Route 2 circulates in a long deviation through EVMC, Fort Norfolk and then back north to Olney Road. This deviation requires about 8 minutes in each direction to navigate, compared to a more direct path from Olney Road to Colley Avenue.

The map at the bottom right shows the boardings by stop along this deviation. It indicates that there are almost no boardings within Fort Norfolk, south of Brambleton Avenue. The large boarding dots in front of Norfolk General suggest that this part of the deviation is worthwhile for ridership goals. There are also many boarding happening at the Fort Norfolk/EVMC Tide station. It is likely, though, that many of these boardings are transfers to or from light rail, as opposed to locally generated. If Route 2 were to take a different path to the Downtown Norfolk Transit Center that allowed it to connect with The Tide at another location where a long deviation was unnecessary, then much time could be saved for most passengers on this route. Also, more people would be likely to use Route 2, because it would be faster and more useful for more trips.

On the other hand, if there is a critical social need to serve the Fort Norfolk area, and the city believed it critical to serve that coverage need, then this deviation could be justified on the ground of coverage goals.

Figure 37: Deviation of Route 2 through Fort Norfolk has relatively low ridership.



Shorter Walks or Shorter Waits?

Much of the HRT network in Norfolk is radial, meaning that many of its routes go into a dense center of activity, downtown Norfolk. A radial network design ensures that anyone looking to travel downtown can make their trip without a transfer.

A natural, geometric consequence of radial networks is that as bus routes approach downtown, they are either routed onto the same streets or they run on very nearby parallel streets.

In Norfolk, for the most part the transit network does the latter: as routes approach downtown, they each run on a unique street, a very short distance from one another. This is most apparent just east of Downtown Norfolk, near Norfolk State University, where five routes run nearby one another, or partially overlap.

This part of the city presents a very strong market for transit—with relatively dense development, continuous over multiple miles, along linear and walkable routes plus a major university. It is reasonable for HRT to offer so much service there, given what a strong market for transit it is.

In the current arrangement, five parallel streets have one or more transit routes going down them. If someone wishes to travel to downtown and doesn't like to wait a long time, they must do a complicated survey of schedules (or use a transit planning app) to figure out which street to walk to. Once underway, if they miss that bus, they have to start again, and walk to a different street. Nearby, infrequent, parallel routes make trip planning more complicated for customers. Also, many riders will naturally go to the routes with the most frequent service and end up ignoring nearby lower-frequency services anyway.

Dividing transit service among more streets inevitably leads to lower frequencies on each street, and therefore longer waits. It also leads to shorter spans on each street, and therefore service may no longer be running when someone needs it.

If parallel routes can be consolidated onto a few main streets, frequency can be made better and waits can be shorter. However, more walking would be required. This is why walking distance and waiting time are inexorably linked in any transit network, and trade-off against one another.

These routes could, in the future, be designed and scheduled to have combined frequencies: if two routes on the same street come every 30 minutes, then they can be designed to arrive exactly 15 minutes apart, and someone traveling a short distance could wait at a single stop for either bus.

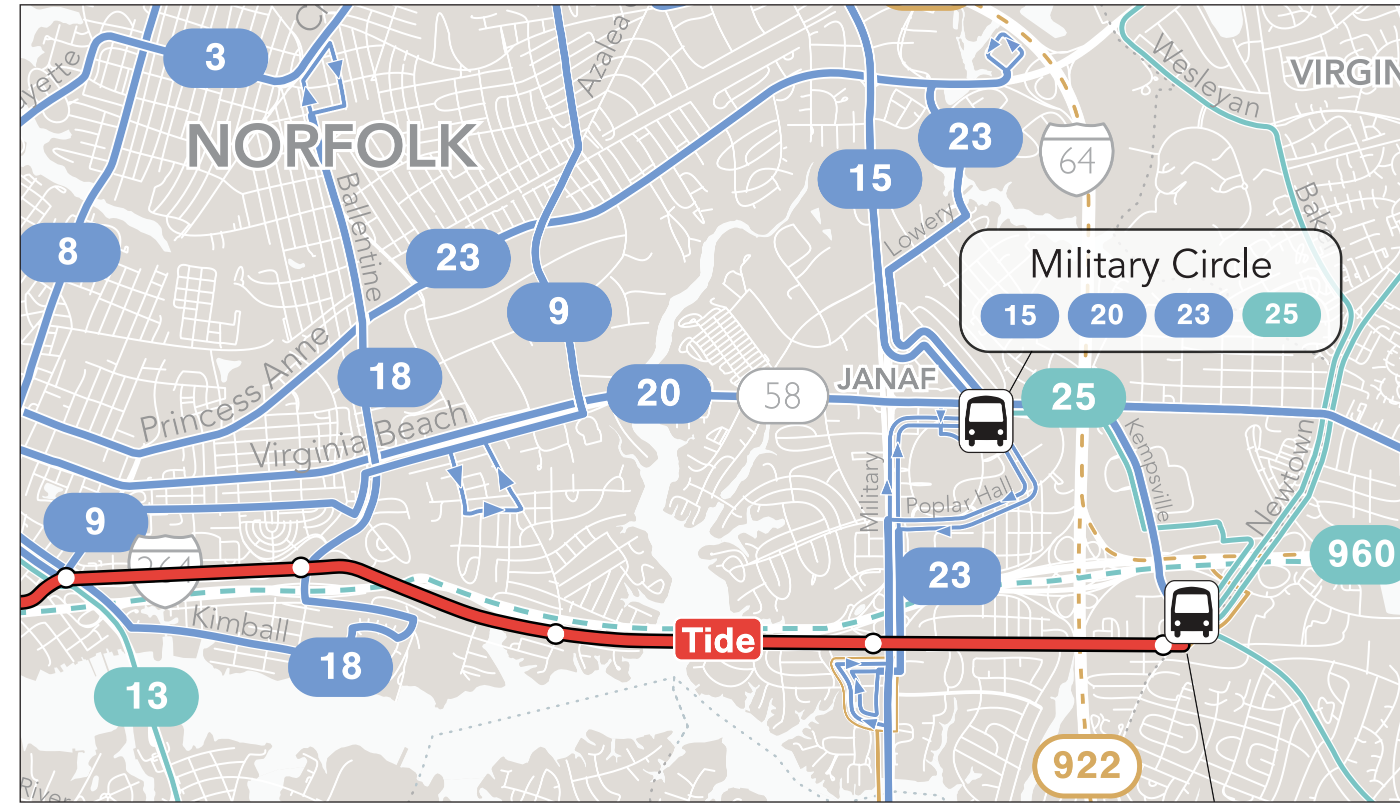


Figure 38: The route network in eastern Norfolk puts many low frequency routes on many streets, minimizing walks, but increasing waits.

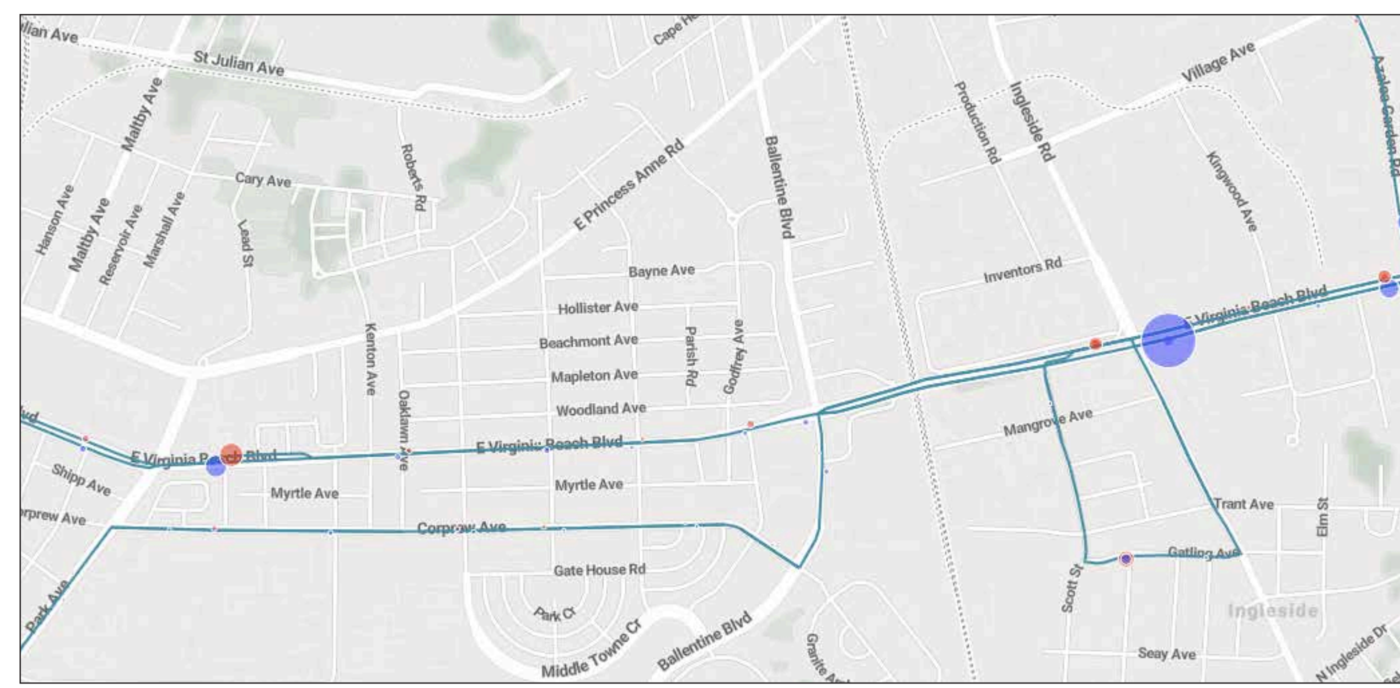


Figure 39: Boardings by stop for Routes 9 and 20 in the vicinity of Norfolk State University show that most riders prefer the service on Route 20.

On-Time Performance

On-time performance is a measure of how reliably buses depart when customers expect them to depart. Reliability is particularly important when a transit network is built of infrequent routes. If another bus is not coming soon, the timeliness of each bus is extremely important.

This is even more true when low-frequency buses pulse so that passengers can make a quick transfer, as some routes do at Military Circle, Evelyn Butts, and Wards Corner Transit Centers. If an arriving bus is late and misses the pulse by just a few minutes, that can cause passengers to miss their connection and be 30–60 minutes late to their destinations.

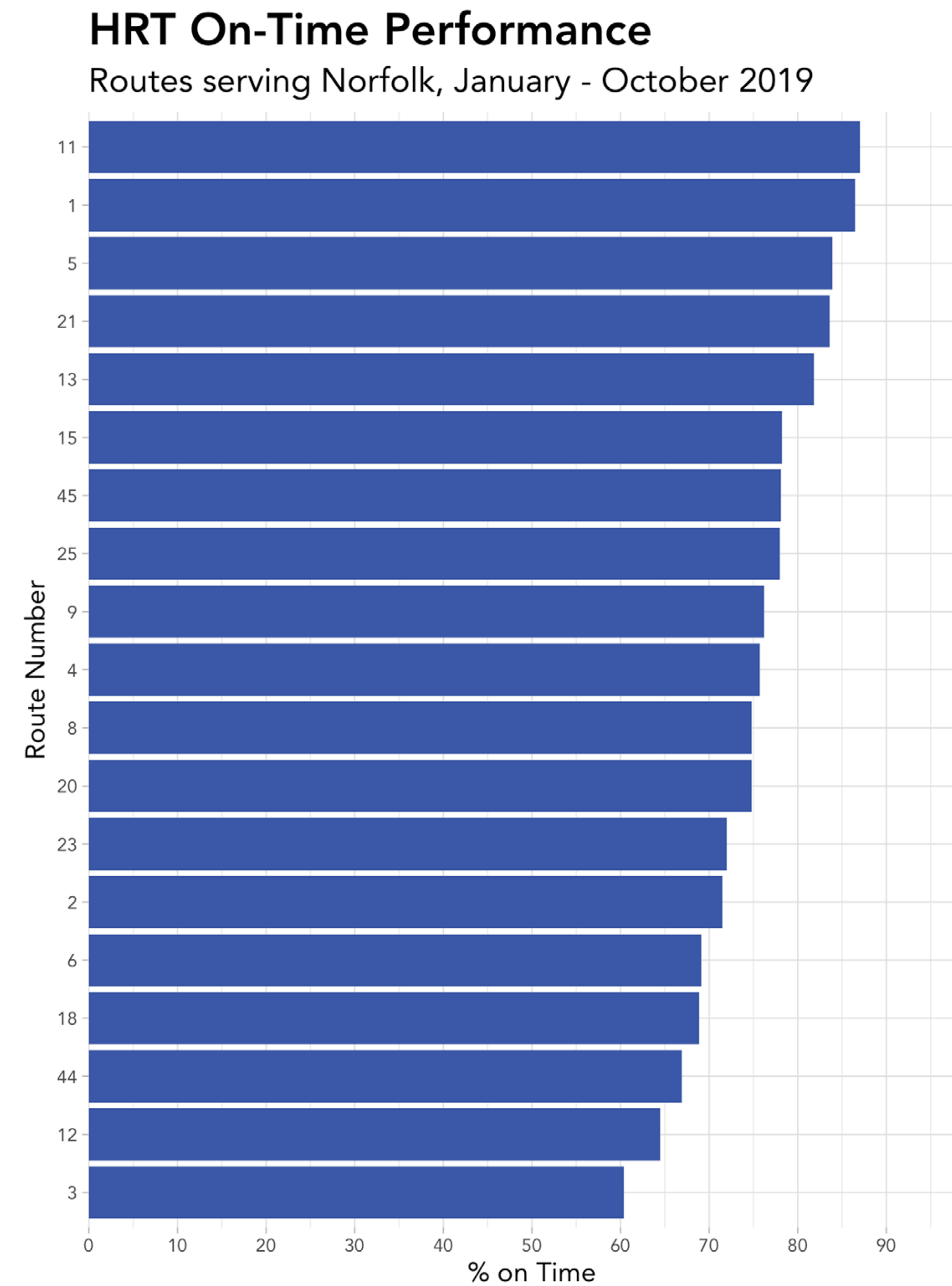
Currently, the average route in Norfolk is on-time about 72% of the time. HRT defines a bus as being "on-time" if it departs from a bus stop between 1 minute earlier to 5 minutes later than scheduled. For passengers, an early departure can be much worse than a late one. If a route that comes every 60-minutes is 8 minutes late, someone might be 8 minutes late to work, and that is bad. But if it's 8 minutes early, they probably weren't at the bus stop in time to catch it, and they have to catch the next bus...which means they are now 60 minutes late to work.

HRT's policy goal is to achieve 85% on-time performance across the entire system. Currently, only Routes 1 and 11 meet this goal. Other routes with relatively high on-time performance include the shorter routes, such as Routes 5, 21, and 11. In general, a shorter route can stay on-time more easily. For each one-way run there is usually a few minutes of layover and recovery time at the end of the route, and for shorter routes this layover and recovery time is often a larger percentage of the overall time that a route is running, providing a greater buffer against disruption. Thus, agencies will sometimes split longer routes as a way to improve on-time performance. Yet splitting longer routes creates other challenges, particularly for riders, as they may now have to transfer to continue a trip that was once a one-seat ride.

The HRT goal of 85% on-time performance is likely the highest reasonably achievable performance level, given how little control HRT has over unpredictable traffic congestion in the region. Improvements in speed and reliability often require local or state leadership to implement transit priority lanes or transit signal priority.

If the city chooses to continue offering a network of mostly low-frequency routes, reliability will be very important, and the low levels of on-time performance that HRT is currently achieving will be especially problematic. Routes that connect a pulse points in the network should be prioritized for interventions to improve on-time performance.

Figure 40: On-Time Performance of HRT Routes in Norfolk January to October 2019



Stop Spacing

There is a geometric trade-off between closer stop spacing and faster bus speeds. Figure 41 shows the basic trade-off in conceptual terms. As stops are placed farther apart, buses can travel faster and cover more distance in the same time.

This is because most of the time required at a stop is not proportional to the number of passengers served. When there are many stops, passengers spread themselves out among them, so the bus stops more for the same number of people. When passengers gather at fewer stops, stopping time is used more efficiently, resulting in faster operations.

This increased speed has two benefits. First, riders can get farther faster and reach their destinations sooner. Also, as speeds increase across the entire transit system, more service can be provided for the same cost. Since the primary cost of transit service is the cost for labor which is paid based on time worked, the faster buses operate, the more service that can be provided for the same cost. So, higher frequency can be provided or routes can be extended to go farther for the same cost.

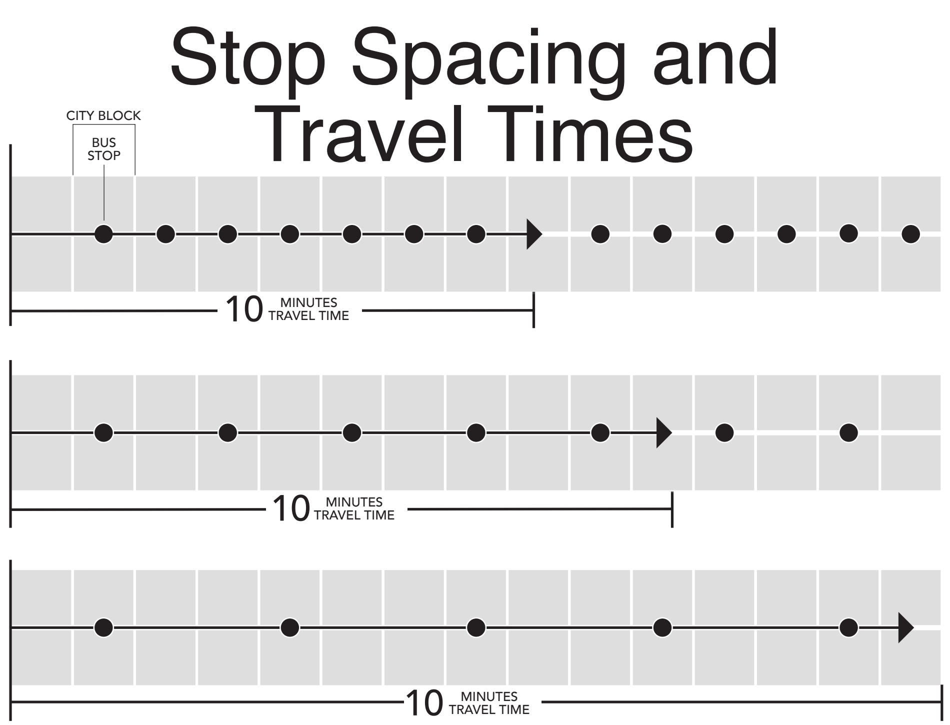
This is why standards for stop spacing in the US are generally in the range of 750 to 1,500 feet on high-frequency bus routes. HRT policy is that stops should be a minimum of 2/10 of a mile (1,052 feet) and maximum of 1/4 mile (1,320 feet) apart. Currently, this policy is not fully implemented on all routes in Norfolk. Figure 42 shows the pattern of distance between stops for all local routes and for Route 3 in Norfolk. The patterns show that there are many stops that are closer than 1,000 feet.

It is not always possible to space stops in a perfectly consistent pattern due to safety issues with street crossings or disruptions in development patterns from water features or railroad corridors. Nevertheless, the patterns shown in Figure 42 suggest that a more consistent stopping pattern for many routes could reduce the number of stops and speed up service, as there are approximately 60 stops along Route 3 that are less than 1,000 feet apart.

There are two major downsides to this potential change. First, some people have difficulty walking and will be inconvenienced by a longer walk, particularly seniors, and people with disabilities. Second, as stops are spaced farther apart, transit becomes less useful for very short trips. This is because walking distances at each end of the trip increase to the point that very short trips would be faster by walking or biking. Some cities and agencies view this as a good thing, arguing that the point of transit is to provide an alternative to driving, not an alternative to walking.

As always, the key to a successful revision of stop spacing is for it to be a consistent policy applied in all comparable circumstances across the city, and tied to a clear citywide benefit in travel times. Many transit agencies have successfully widened stop spacing where these benefits were clear.

Figure 41: Trade-off between stop spacing and travel time.



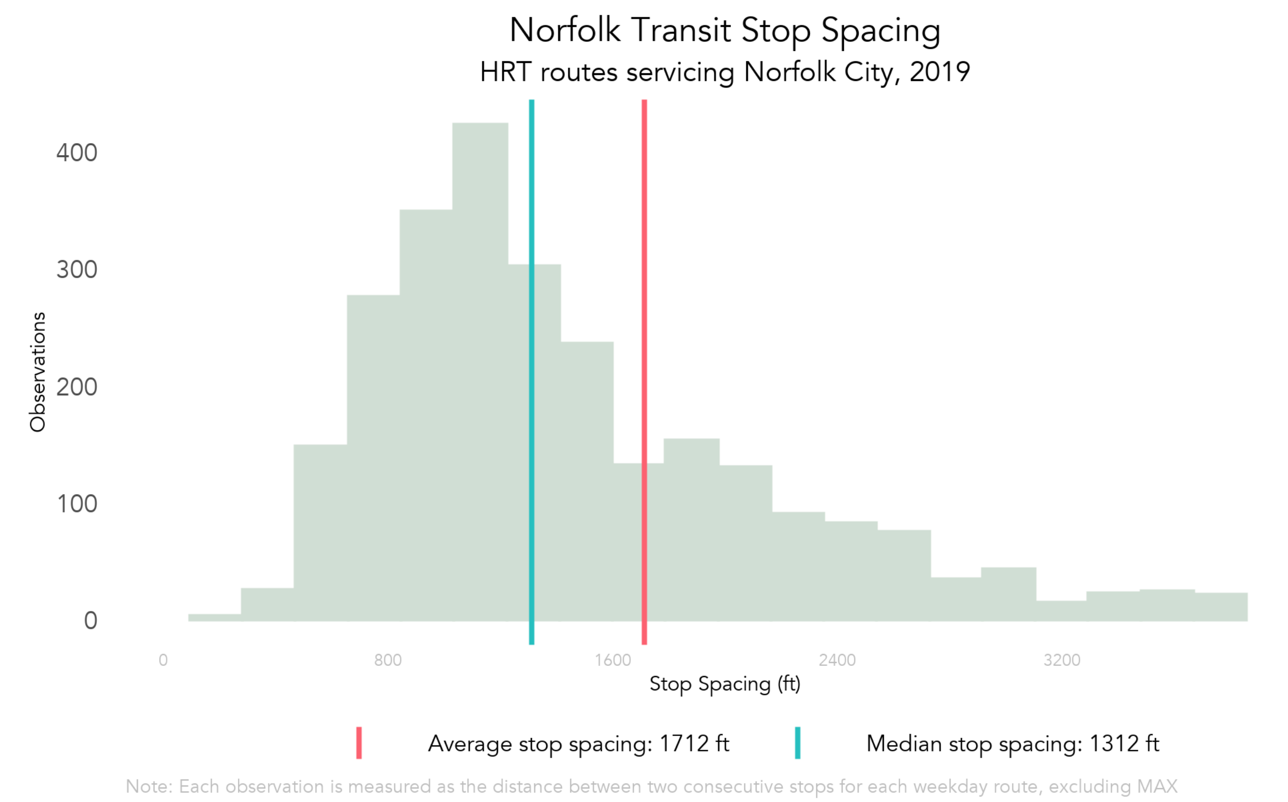


Figure 42: System-wide stop spacing patterns (above) and spacing patterns for Route 3 (below) show many stops are closer together than every 1,000 feet.

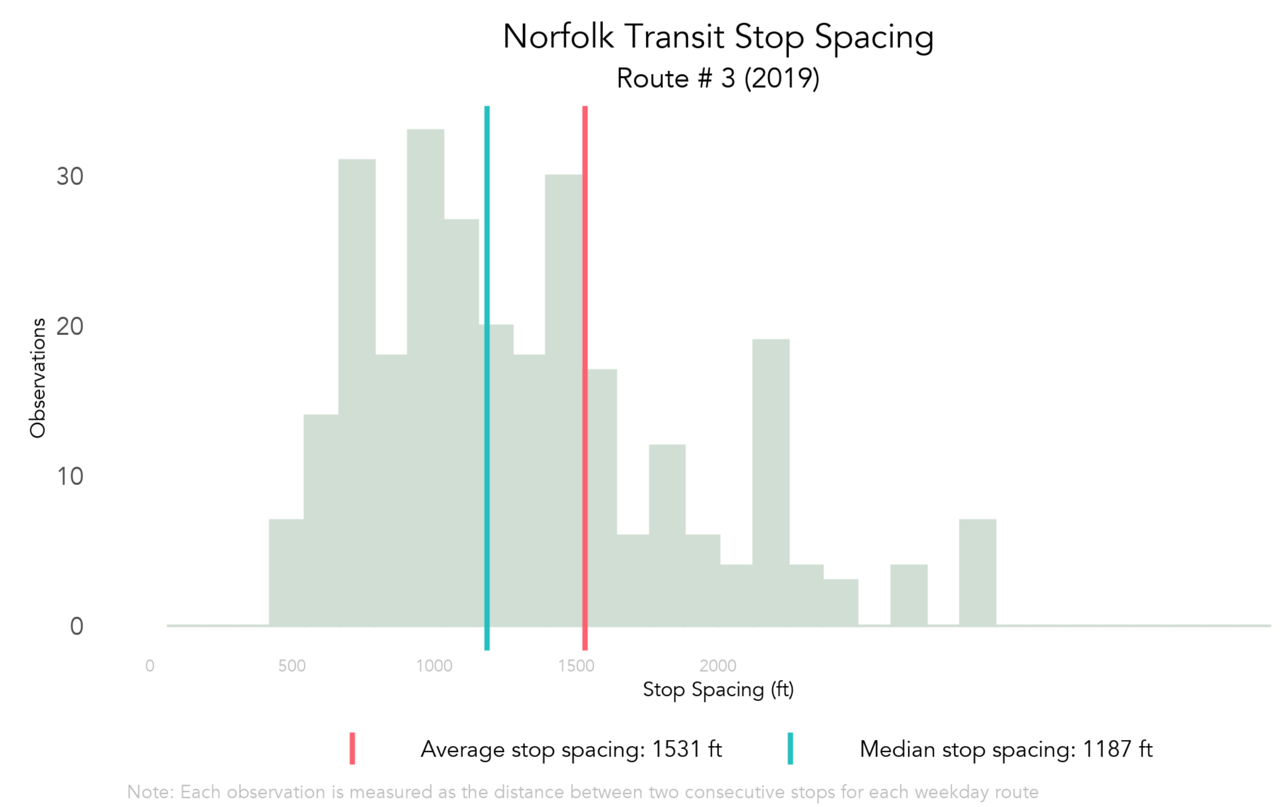


Figure 43: Bus Stop Amenity Analysis

Stop Amenities

Amenities at stops can be a key part of encouraging higher ridership. Research shows that riders at stops without amenities perceive their wait as more than double the actual time. When riders have shelters and benches at their stops, their perceived wait time drops to only 30% more than actual, and when real-time information is added, the perceived wait time is only 10% more than actual.

A University of Utah study found that stops with shelters, benches, and sidewalk connections had ridership gains compared to stops without such amenities. The same study also found that demand for paratransit service declined where amenities were provided at stops, suggesting that such amenities can shift disabled riders from paratransit to less costly fixed-route service.

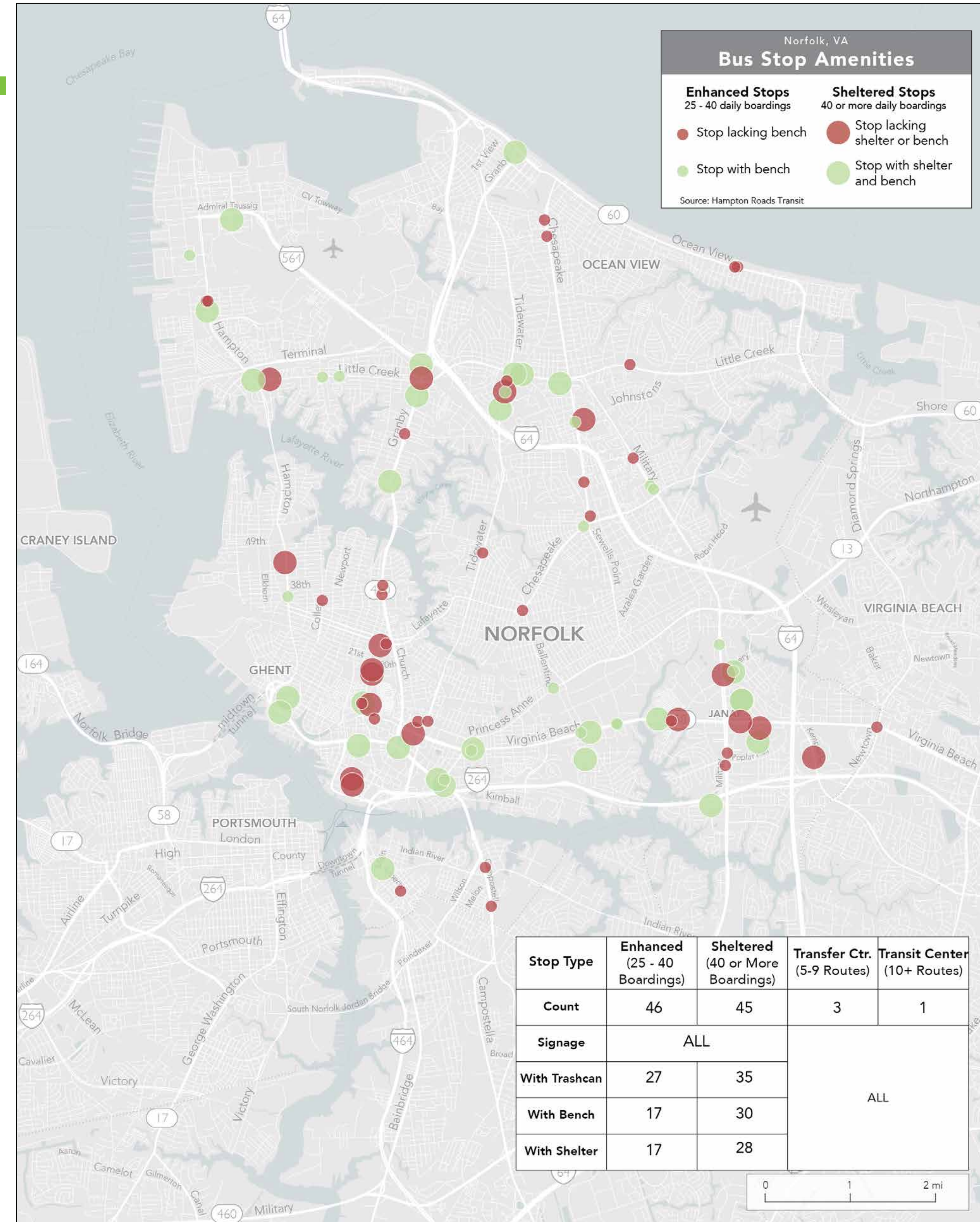
For the purposes of deciding what kind of amenities to provide at stops, HRT policy segments bus stops into groups based on the number of daily boardings at a stop and whether it is a transfer center (where 5 or more routes converge):

- Standard Stops (0-24 daily boardings) should have signage, a concrete pad for wheelchair boarding, and sidewalk access with 5' wide sidewalks.
- Enhanced Stops (25-39 daily boardings) should have all of the above plus a trash can and bench.
- Sheltered Stops (40 or more daily boardings) should have all of the above plus a shelter.

Using these criteria, Figure 43 shows stops that meet the Enhanced and Sheltered Stop categories and whether they include the minimum features. There are numerous stops on Monticello Avenue where Routes 1 and 3 operate that meet the Sheltered Stop category, but lack shelters. There are also five stops in the Military Circle area that have more than 40 daily boardings, but lack shelters. Numerous stops across the city meet the Enhanced Stop criteria, but lack a bench.

A common challenge in meeting the policy for distribution for amenities is the necessary street right-of-way. A bench of shelter must be placed on public right-of-way, or a property owner must agree to a permanent easement to place the bench or shelter. It can be a difficult administrative effort to determine the exact width of public right-of-way in some cases and close coordination with the local or state agency that manages the right-of-way is essential. In many instances, the right-of-way is too narrow and it is not always possible to place the amenities that a policy suggests are necessary.

Furthermore, placing amenities requires capital funding to purchase and install the amenities and ongoing maintenance of the amenities. Finally, a critical element in all amenities is the actual sidewalk access leading to and from a stop. This responsibility falls to local and state governments that manage the right-of-way for streets. In this respect, local and state governments fully dictate whether anyone has first or last mile access to transit.



Stop Type	Enhanced (25 - 40 Boardings)	Sheltered (40 or More Boardings)	Transfer Ctr. (5-9 Routes)	Transit Center (10+ Routes)
Count	46	45	3	1
Signage	ALL		ALL	
With Trashcan	27	35		
With Bench	17	30		
With Shelter	17	28		

4 On-Demand Service

What are on-demand services?

Thinking clearly about the purpose of "On-Demand" services

In this report, when talking about transit we have usually been referring to transportation where:

- Buses or trains (the mode),
- run between a defined set of places (the route),
- operate at published days and times (the schedule),
- load and unload passengers at defined places (the stops),
- that anyone can ride (the public) for a low price (the fare).

Fixed routes generally assume that there is enough demand in the immediate vicinity of the route and stops that people will walk to a stop and ride, so long as the schedule makes the service useful.

Deployed in the right environment and with the right level of investment, fixed routes can efficiently allow very large numbers of people to travel easily and fast to most of their destinations at a low cost per ride.

However, as we saw in Chapter 2, there are also inconveniences in using fixed routes, such as the requirement to walk potentially long distances, wait potentially long times, and travel on a potentially indirect path.

Furthermore, many parts of Norfolk have been developed at low densities and generate very low demand within walkable distances. These areas are far from ideal for the effective deployment of transit service.

Investment in fixed routes serving these areas has been limited, and the number of people riding the existing transit is generally low. These are all areas where public transportation would serve a coverage function rather than a ridership function. **So is there a better way to provide coverage to low-density areas than fixed routes?**

This question has come to the forefront in recent years, largely in response to the ride-hailing apps (such as Uber and Lyft) that have revolutionized the taxi business.

Recognizing that many people have benefitted from recent improvements in on-demand personal transportation, policy-makers are looking for way to extend the benefits of app-based ride-hailing to public transportation. The private sector has responded in kind, creating algorithms for shared use, deployed in services like Uber Pool and Lyft Line.

What does it look like?

In theory, an on-demand public transportation service could be any form of transportation managed for the benefit of the public that responds to specific individual requests for transportation rather than an assumed underlying demand.

In practice, there is strong interest in services that use smaller vehicles, can respond to requests within minutes, provide service to an area rather than on a route, and provide door-to-door service for a lower price than an individual taxi fare. On-demand services that tend in this direction are often termed "new mobility"[1].

But the more convenient and flexible an on-demand service becomes, the more expensive it becomes to provide. So managing an on-demand service is often about limiting who can ride, when they can ride, and where they can go, and where they can go, while also asking for a higher fare than a standard transit service.

Who operates and manages the service?

On-demand transit is often managed by the same agency that manages fixed routes. However, there are no hard and fast rules regarding who actually owns or drives the vehicles.

On-demand transit can be provided by the public transit agency in-house, or contracted through a taxi operator, a ride-hailing app, a private medical care transportation provider, or any other entity with access to licensed vehicles and drivers.

In-house operation by the public transit agency tends to come at a higher cost, while operation by private entities is less expensive but sacrifices some level of control over the service and introduces more complexity in how on-demand service interact with fixed route transit. When using private operators, there is an administrative burden to the agency in contract management, and this burden is multiplied as the number of private operators increases.

Who can ride?

Fixed transit routes serve the general public. Anyone with bus fare can ride. This can also be true of on-demand services, although in some cases eligibility might be restricted to reduce costs.

A good example of an existing on-demand service with limited eligibility is ADA paratransit provided by HRT. Only riders with a qualifying disability may use this program, which provides door-to-door service for $3.50 for trips that begin and end within 3/4-mile of a fixed route.

But other models also exist[2]: users might be restricted to those who live and/or work within a certain area; to people above or below a certain age (such as youth or elderly person); to students or participants in certain governmental programs; or to people with lower incomes or who qualify for certain government services.

When can you ride?

Private ridehailing and taxi companies generally provide service on-demand at any time and within minutes if a vehicle and driver are available. This is the most convenient way to structure the service for riders, but also the most expensive for the city or transit agency.

One way to limit costs is to require advance scheduling, as many transit agencies (including HRT) impose on disabled customers using ADA paratransit services. Advance scheduling may require trips to be scheduled within a certain time window, such as no less than 24 hours in advance but no more than two weeks in advance. Restrictions and penalties for no-shows, as with paratransit, can apply to these services.

Another way to limit costs is to set limits on when the on-demand service is available. Depending on the purpose and intended reach of the service, this can be as broad as providing on-demand service at the same times most bus routes operate, or as narrow as restricting service to hours that match a single driver's work shift, or even capping the number of rides a user can take within a given day, week or month.

Where can you go?

The City of Norfolk is about 53 square miles in area, and if an on-demand service allowed riders to go anywhere, it would likely be very expensive to operate per rider. As a result, it's likely any on-demand service will have to be restricted to certain areas.

In its most flexible form, on-demand transit can provide curb-to-curb service like a taxi. However, a common way to limit cost is to provide curb-to-hub service, where one end of the trip must be a transit center or bus stop.

For example, a common form of service picks up customers at their homes in lower-density neighborhoods and drops them off at the nearest transit center or bus stop, where they can access fixed-route service. This is less attractive than curb-to-curb service but may still

1 "New mobility" has also been used as a catch-all term for any transportation service, public or private, that has been introduced in recent years and is not provided by a traditional transit agency or taxicab company. This includes ridehailing but also docked and dockless bike-share and scooter-share systems, and sometimes also refers to various means of smartphone-enabled fare payment.

2 Although it is possible to limit eligibility in these ways, there are limits to such restrictions under civil rights laws; certain types of eligibility criteria may legally constitute discrimination.

provide an improvement where fixed-routes cannot be provided within walking distance. Since HRT already has multiple outlying suburban transit hubs, this model is a possible design strategy for on-demand service in Norfolk.

How much will you pay?

It's possible to charge the same fare for on-demand service as for fixed-route transit. But this doesn't take into account the generally higher cost of each on-demand trip. Many transit agencies treat on-demand service as a premium product with higher fares, while making adjustments for riders with limited incomes. Higher fares are also a way to control the consumption of an expensive service. Fare policies can generally take one of two forms:

- **Fixed-fare.** The total fare is capped, and the costs of longer trips are borne by the transit agency. For example, the customer might pay $3, with any cost beyond that covered by the transit agency, whether that cost is $1, $10 or $100. This can be very expensive for the transit agency.
- **Fixed-subsidy.** The subsidy provided by the transit agency is capped, and the costs of longer trips are borne by riders. For example, the customer might be responsible for a base fare of $3. The agency would contribute up to $7 in subsidy, but no more. This can be very expensive for riders who make long trips.

In some cases, it's also possible to vary fares according to who is riding. For example, in Kansas City rides on the RideKC Freedom On-Demand program are available to the general public, but at a higher cost than for disabled passengers who qualify for ADA paratransit.

Accessibility Issues

Challenges arise when considering app-enabled service and partnerships with ride-hailing companies. Many older and lower-income transit customers lack smartphones, data plans, credit cards, or all three.

One way around the credit card barrier is to use prepaid cards, which can be sold to customers who lack credit cards. For dispatching without smartphone apps, agencies can train their paratransit dispatchers to schedule ride-hailing trips by telephone call. In some cities, agencies have used local taxi companies as an alternative to ride-hailing to serve customers who lack either credit cards and/or smart phones.

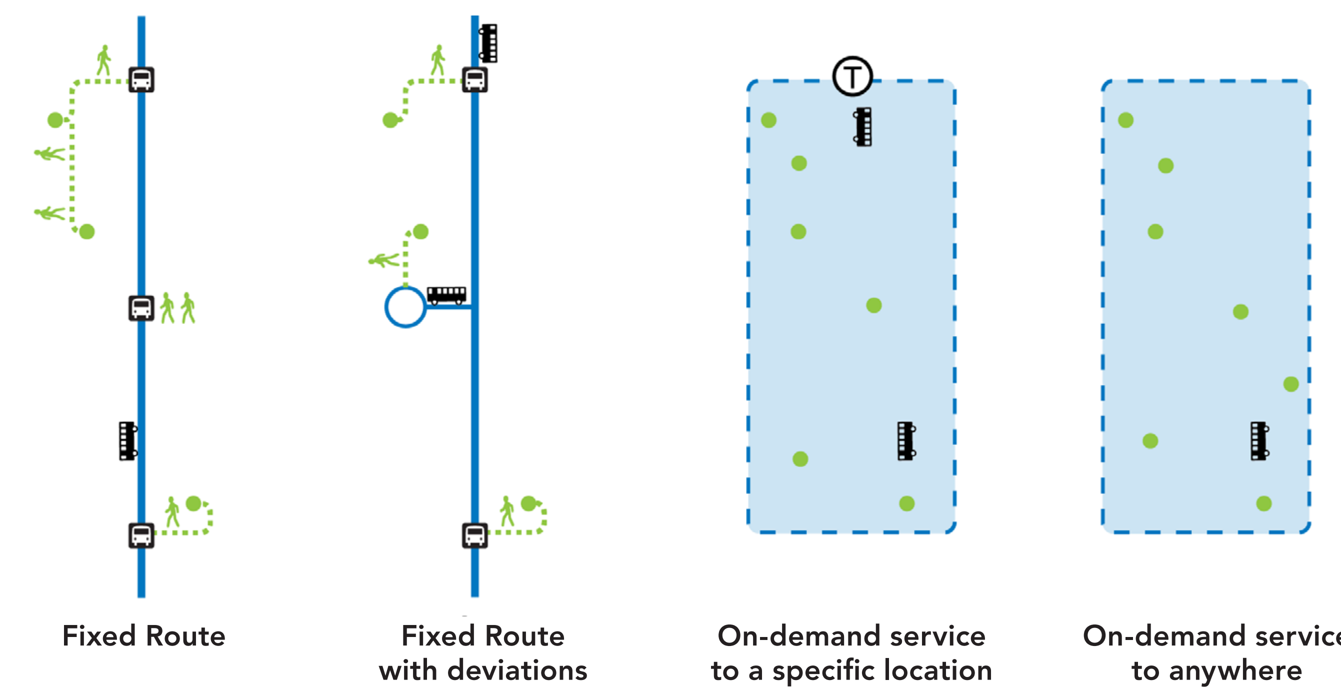


Figure 44: The spectrum of service, from a traditional fixed route to a fully on-demand service.

The more convenient on-demand service is, the higher the per-rider cost.

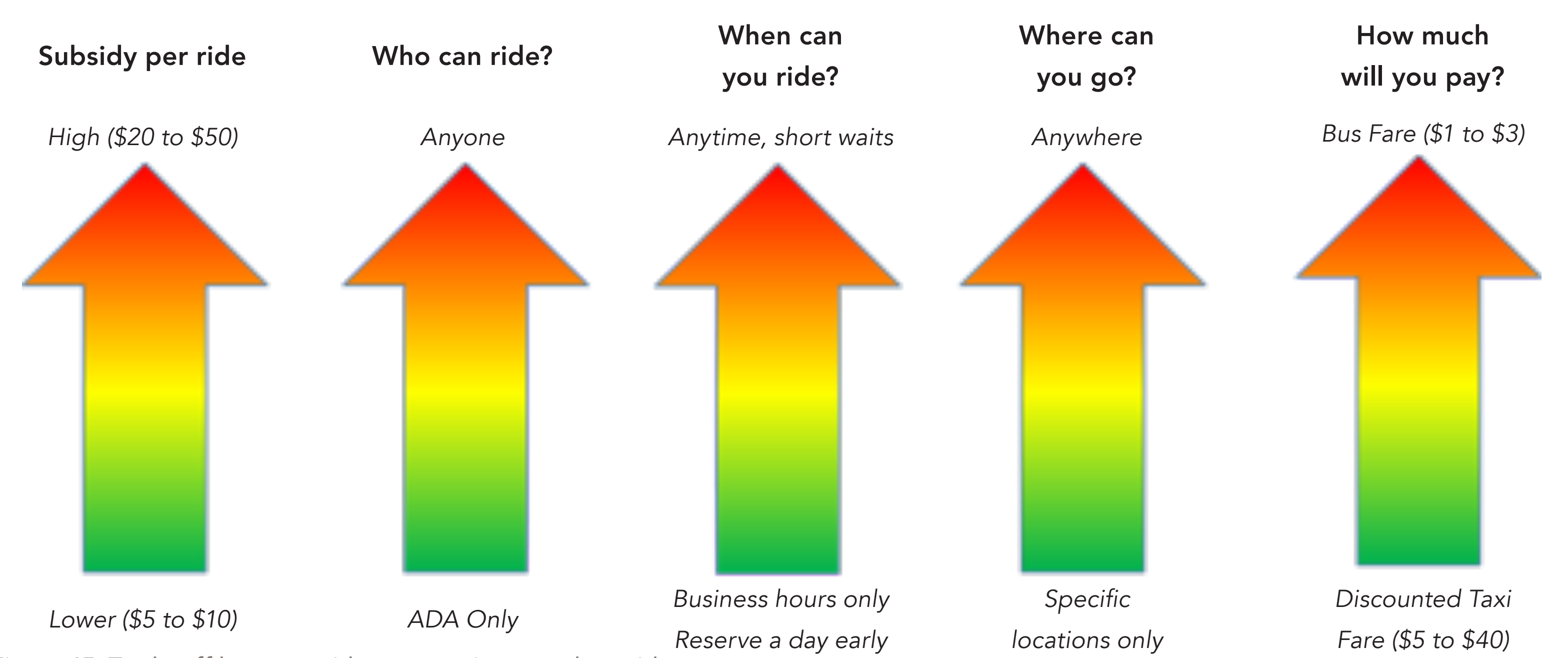


Figure 45: Trade-off between riders convenience and provider costs.

What lessons can be learned from other places?

It's useful to study what has happened in other places to learn more about what might be possible with different on-demand service types. For the purposes of this study, we reviewed on-demand services in two other places:

- Oakville, ON is a low-density suburban area of 200,000 people located outside of Toronto. The local transit agency is Oakville Transit.
- Pinellas County, FL is a county of 970,000 people in Florida in the Tampa-Saint Petersburg metro area. The local transit agency, Pinellas-Suncoast Transit Authority (PSTA) carries 14 million passengers per year, which is a similar scale to all of HRT service.
- Kansas City, a region of about 1.5 million people in Missouri and Kansas. The regional transit agency, KCATA, carries about 16 million passengers per year, a little more than all of HRT service.

The experiences of Oakville Transit, PSTA, and KCATA provide some insight into what happens when an on-demand service has different parameters. Key lessons include:

- **On-demand service can be effectively delivered by a ridehailing service, but data-sharing is likely to be a problem.** PSTA's experience shows that it is possible to provide a subsidized on-demand transportation service operated by Uber or other similar companies. Uber, Lyft, and Via have participated in a wide variety of pilot on-demand transit programs nationally through the FTA Mobility-on-Demand Sandbox program. At the same time, PSTA is not able to say much about the length or any other characteristics of Uber trips, as that data is considered a trade secret. This is not a unique situation among agencies that have partnered with ridehailing providers.
- **It's possible to limit the transit agency's costs by imposing a hard cap on subsidies, if you accept the program will mostly be useful for very short trips or connections to fixed routes.** PSTA's Direct Connect program subsidizes a flat amount of $5 for Uber or taxi rides, regardless of the trip length or final fare. The data available for taxi rides suggest that the average trip is in the range of 2 miles. Even if Uber rides are typically longer, the fact that the customer pays every cent beyond $5 means that many customers will avoid the service for longer trips.
- Where subsidy is not capped, the average subsidy per trip, in the examples where data is available, is in the range of $14 to $15. Different operating and contracting arrangements could potentially yield a slightly lower cost, but given the geometric limits on productivity of on-demand services, and the realistic lower limits on labor costs, its unlikely that significantly lower per trip costs could be achieved. **In comparison, the cost per boarding for all but one local route in Norfolk is below $8, about half of the costs from these examples.**

It may be possible to control costs by narrowly defining the places an on-demand service can reach. Oakville's Home-To-Hub program, PSTA's Direct Connect, and KCATA FLEX services have tight requirements, focusing on providing access to the nearest transit center. Limiting the number of destinations makes it possible to drive in straighter and more predictable paths; that makes it possible to serve more trips for every hour of service.

In addition, it may be possible to limit costs and maximize efficiency by limiting the time that on-demand services are available. Use of on-demand services in late night and weekend time periods, when the productivity of fixed route services may be below 6 boardings per hour on some routes, can be another strategy to use on-demand services as a cost effective coverage tool.

However, none of these lessons change the fundamental math of on-demand service: **to control costs to the public, a subsidized on-demand service can't be both highly desirable and available without limit.**

Service Parameters	Example On-Demand Transportation Programs			
	Oakville, ON Home-to-Hub	Pinellas County, FL Direct Connect	Pinellas County, FL TD Late Shift	Kansas City, MO FLEX
Who drives?	Oakville Transit	Uber Taxi companies	Uber Taxi companies	KCATA
Who can ride?	Anyone	Anyone	Eligible low-income riders	Anyone
When can you ride?	2 hours in advance by mobile app or phone Hours depend on zone, some service everyday	On-demand through mobile app and phone Everyday 6 AM to 11 PM	On-demand through mobile app and phone Every night 11 PM to 6 AM	24-Hour advance scheduling by phone Mostly on weekdays 6 AM to early evening.
Where can you go?	Stay within zones or travel to transit hub	24 designated bus stops/transit centers	Anywhere in the county	Stay within a zone of 5 to 40 square miles
How much will you pay?	$4.00	Uber or taxi fare, minus a $5 discount	$9 for up to 25 trips per month	$1.50
Daily Ridersip (avg.)	Unknown	50 to 100	50 to 100	200 to 250
Trip Cost (avg.)	Unknown	Uber: unknown Taxi: $7	$15	$15.83
Average Subsidy Per Trip	Unknown	$5	$14-15	$14 to $15

Figure 46: Examples of on-demand transportation programs in other locations.

5 Key Questions

The City of Norfolk has a unique opportunity to rethink the purpose of the transit network, and how transit relates to other ways of getting around such as walking, cycling and driving. The Multimodal Norfolk project presents the city and its residents with a chance to rethink how everyone can move around the city. The Transit System Redesign is an opportunity for everyone to carefully consider how Norfolk is spending its transit budget, and the goals and priorities for transit in the short and long-term

The focus of the Transit System Redesign is on what can be done in the next two years, so we can't assume that any new resources are available. This means some hard choices have to be made. This does not mean that the City thinks that the resources available to provide transit service today are adequate. Nor does it mean that transit couldn't be expanded in the future.

We would like the community to help us decide on the best use of the funds currently dedicated by the City of Norfolk to transit. Beyond this, the City sees great value in identifying new funding sources for transit and increasing the number and scope of partnerships to expand and improve transit in the city and the region.

Ridership or Coverage?

The Transit System Redesign is a unique opportunity for Norfolk to consider and clearly define the right balance between desirable but competing goals for transit.

The current transit network is a legacy of past generations, and has accrued years of good intentions, good ideas, stop-gap measures, and special requests. Much of the existing network may be worth keeping as is, perhaps because it suits the city and its values, or perhaps because it is known and familiar to riders, which is a value in and of itself.

It is also possible that since this transit network was last re-designed, the region has changed and grown enough to justify a fresh start. Transit networks are intricate, interwoven, living things, and adapting them incrementally over time is very difficult.

The most difficult choice for the public, elected officials, and stakeholders will be between providing high frequency, long-span services in order to attract high ridership and providing wide coverage.

Recall that high ridership serves several popular goals for transit, including:

- Competing more effectively with cars, so that the city can grow without increasing traffic congestion.
- Collecting more fare revenue, increasing the share of the transit budget paid for by fares.
- Making more efficient use of tax dollars by reducing the cost to provide each ride.
- Improving air quality by replacing single-occupancy vehicle trips with transit trips, reducing greenhouse gas emissions.
- Supporting dense and walkable development and redevelopment.
- Extending the most useful and frequent services to more people.

On the other hand, many popular transit goals do not require high ridership in order to be achieved, and instead are achieved through transit coverage of many places. These include:

- Ensuring that everyone in the service area has access to some transit service, no matter where they live.
- Providing access for people without access to personal vehicles.
- Serving newly developing places, even if they don't yet have the size or density to constitute a large transit market.

A transit agency can pursue high ridership and extensive coverage at the same time, but the more it pursues one, the less it can provide of the other. Every dollar that is spent providing very high frequency along a dense commercial corridor is a dollar that cannot be spent bringing transit closer to each person's home or reaching residential areas of the edge of the network, and vice versa.

A Transit Network Designed for High Ridership...

- Maximizes fare revenue and minimizes public subsidy per trip.
- Competes more effectively with cars.
- Supports dense and walkable development and redevelopment.
- Puts the most frequent and useful services near more people.

A Transit Network Designed for Maximum Coverage...

- Provides an affordable transportation option for people who can't drive.
- Serves everyone who lives in the district, regardless of where they live.
- Serves newly developing lower-density places.

How does a network designed for high ridership look different than one designed for high coverage?

Planning for either the ridership goal or the coverage goal produces very different networks, and decisions to shift the balance of service today or in the future could produce different types of changes to HRT's network.

To illustrate the general outcomes of this trade-off, we've created a fictional city, shown in Figure 47. This is an urban region centered around a dense downtown core, with several key activity centers at different distances from the core.

In this image, different shades of brown indicate different densities of development. The density legend illustrates the type of land use that could be encountered in each area. The darkest brown places are the densest parts of the region, where many people are in close proximity; imagine a major downtown core business area, or a large university's campus and surround commercial and residential areas.

As you move away from the core areas, density drops off, though as in most real cities in the United States, there are pockets of dense development capable of generating substantial transit demand outside of the center. For example, the very dense areas north and east of downtown could be major shopping centers, hospitals, or educational campuses. Just as in Norfolk, while the area encompassing downtown is the single largest trip generator, there are lots of other important places around the city that many people need to travel to.

The next ring out from the darkest brown might consist of pre-World War II, small-lot residential areas, with some mixture of apartment buildings and continuous commercial development along major roads. Or, a comparable level of density could be found in recently developed mixed-use areas, feature mid-rise residential buildings and storefront retail.

In the lower three density categories, residential lot sizes would increase as would the distance between homes, and density would decline towards the dashed line indicating the edge of the metropolitan region. Multifamily residential buildings would become less and less common the further down the density gradient you go, and because there are fewer people nearby, commercial nodes are likely to be smaller.

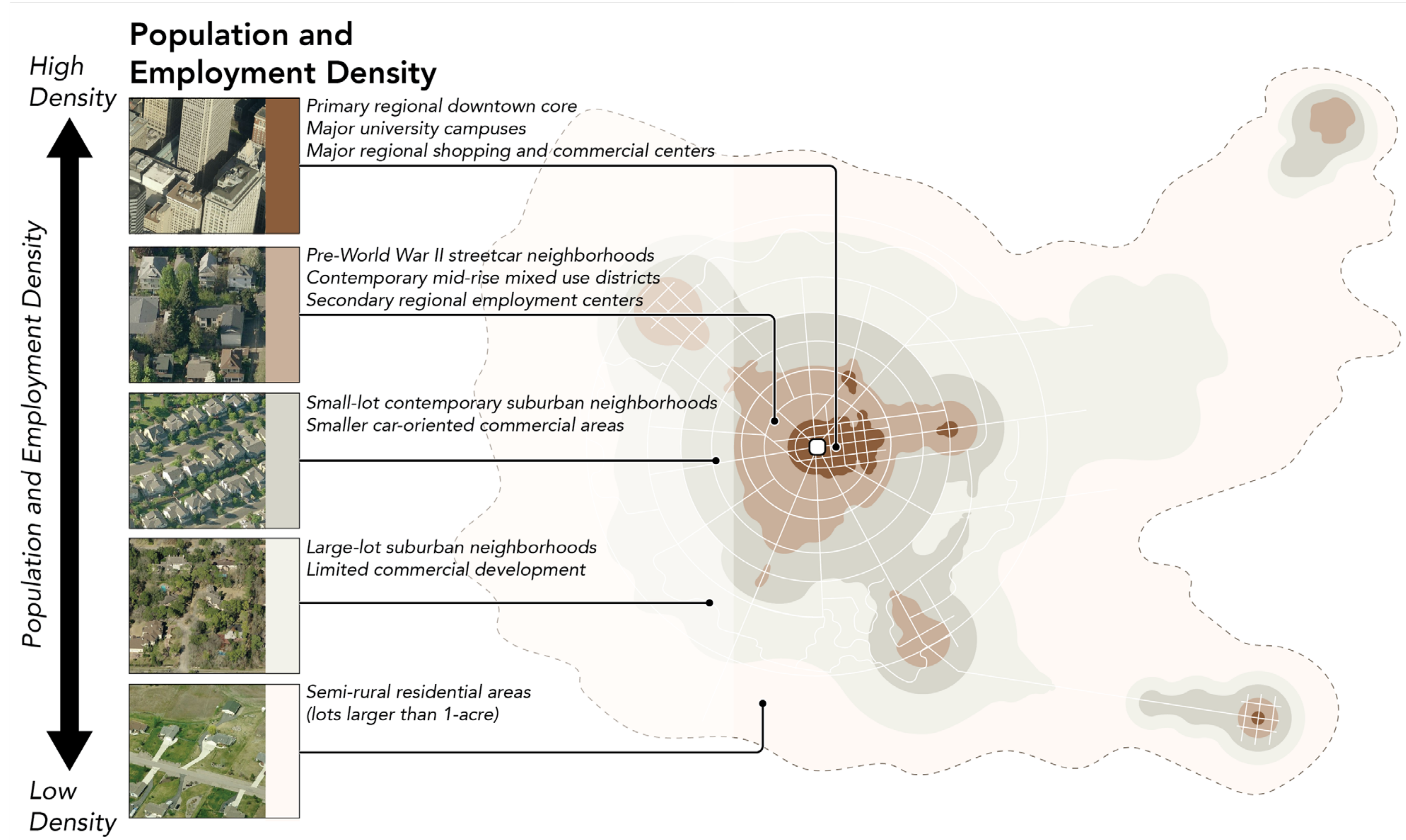


Figure 47: A fictional city, with some areas of high density, and some areas of low density

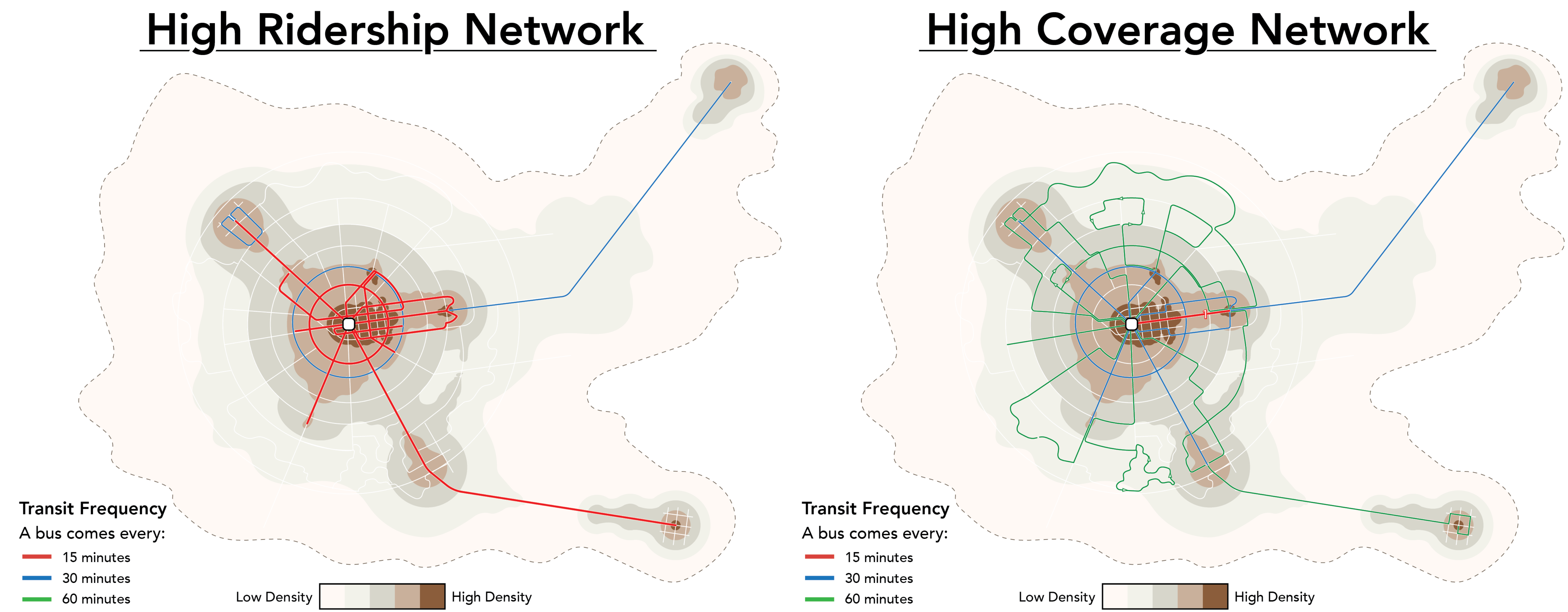


Figure 48: Planning for either the ridership or coverage goal produces different transit networks

Figure 48 illustrates the difference between a transit network designed for high ridership and a network designed for high coverage serving the fictional city shown on the previous page.

In the network designed solely for high ridership, almost all routes are concentrated in the highest density places, providing very frequent, convenient service. A few routes are extended to other dense areas in the region, but most low-density places have no transit service at all.

In the network designed solely to maximize coverage, many routes serve almost the whole developed area of the city, but none of them come very often. Most routes in the coverage network come only ever 30 or 60 minutes, save for one route serving the densest corridor east of the downtown core.

No public transit agency focuses solely on either of these goals. Most transit agencies have some direct, frequent, long-span routes on which ridership and productivity are high, and others which run at lower frequencies and more limited times, for specific coverage purposes.

Making the Decision

We suggest that people think about this choice not as binary, "yes-or-no" decision, but as a point on sliding scale that the community can help to set:

How much of the City of Norfolk's transit budget should be spent on the most useful service, in pursuit of high ridership? How much should be spent providing coverage?

This is not a technical question, but one that relates to the values and needs of a community.

One way to manage the conflict between ridership and coverage goals is to define the percentage of a fixed route budget that should be spent in pursuit of each one. Every agency spends a certain percentage of its budget pursuing these goals, even if the percentage is unstated. This project is an opportunity for the city, especially key stakeholders and elected officials, to think about how it currently balances these goals, and to hear from the public about how they might handle this question in its future planning.

We estimate that about 60% of the existing city bus network is designed as it would be if maximizing ridership were its only goal. The other 40% has predictably low-ridership, suggesting that it is being provided for other purposes.

A network plan designed for higher ridership would have fewer total routes, but with higher frequencies, over longer spans, with better weekend service. This would make it possible to operate a frequent grid, and provide everywhere-to-everywhere mobility on that grid with a single quick transfer.

A network plan designed to prioritize a high-coverage network for Norfolk would not concentrate service into fewer, more frequent routes. It would instead extend service across the city and provide service to places that currently have no access to the transit network, and provide all-day service in communities that currently are only served during rush hours or occasionally.

When we run coverage service, what should our priorities be?

The second critical question in this process is about the purpose of coverage service. There are many important social objectives of transit that can be served through coverage focused planning. None of these are goals that can be expected to generate high ridership, but all of them are important and valuable functions that the transit network can provide, if the public directs it to do so. But, a network plan's coverage component will look very different depending upon which coverage goal is the focus.

Transportation Options for People Who Can't Drive

The first of these, "access for people who can't drive", is about what people often call the social service function of transit: providing a transportation option to people with few other choices, and who are located in places where high-ridership service would not go.

This could include sites like senior living communities in suburban areas, isolated lower-income communities where vehicle ownership rates are low, or important destinations like community colleges or social service agencies that have chosen to build facilities in environments that are difficult for transit to serve efficiently. These are all places where some people need the service, however fewer would use the service compared to higher-density areas that are more efficiently integrated into the rest of the transit network.

The design process for a coverage network focused on this goal would identify the factors most associated with critical mobility needs, and design services targeting those places. That means a plan that is designed around the goal of providing access for people who can't drive. This includes responding to the density of seniors and senior-living facilities, zero-vehicle households, lower-income people, and places like sheltered workshops for people with disabilities, social service facilities, and other destinations located in places that would not otherwise be served if maximizing transit ridership were the only goal.

Some Service for Everyone Who Pays

Everyone who pays taxes to the city could reasonably expect some service in return. One of way of evaluating how fairly public transit resources are distributed is in terms of how many people direct access to service (regardless of whether that service is very useful), within a reasonable walking distance of their home. This is the second common argument for coverage services, and many agencies define a minimum coverage standard in response to this goal.

For example, services could be designed to try to ensure that 100% of all residents within the city are within 1/4 mile of a bus stop. That would be a measurable outcome of the success of network designed to meet this goal.

A service plan designed around this goal would be focused only on population density. It would seek to draw the most efficient lines to get as near to as many people as possible, even if frequencies were very low. This would have the impact of expanding the overall coverage area and number of people near a transit stop.

Supporting Future Suburban Development

The last reason is about the future. Offering a transit service today in places that are expected to develop in a way that will generate high ridership in the future. Developers of new neighborhoods often want transit to be there early, before there are many people, so that it is available right as people and jobs move in. This is a low-ridership service until there are enough residents or employees there. A service plan intended to support future development would be designed in response to information on where that development is likely to occur.

Walking vs. Waiting

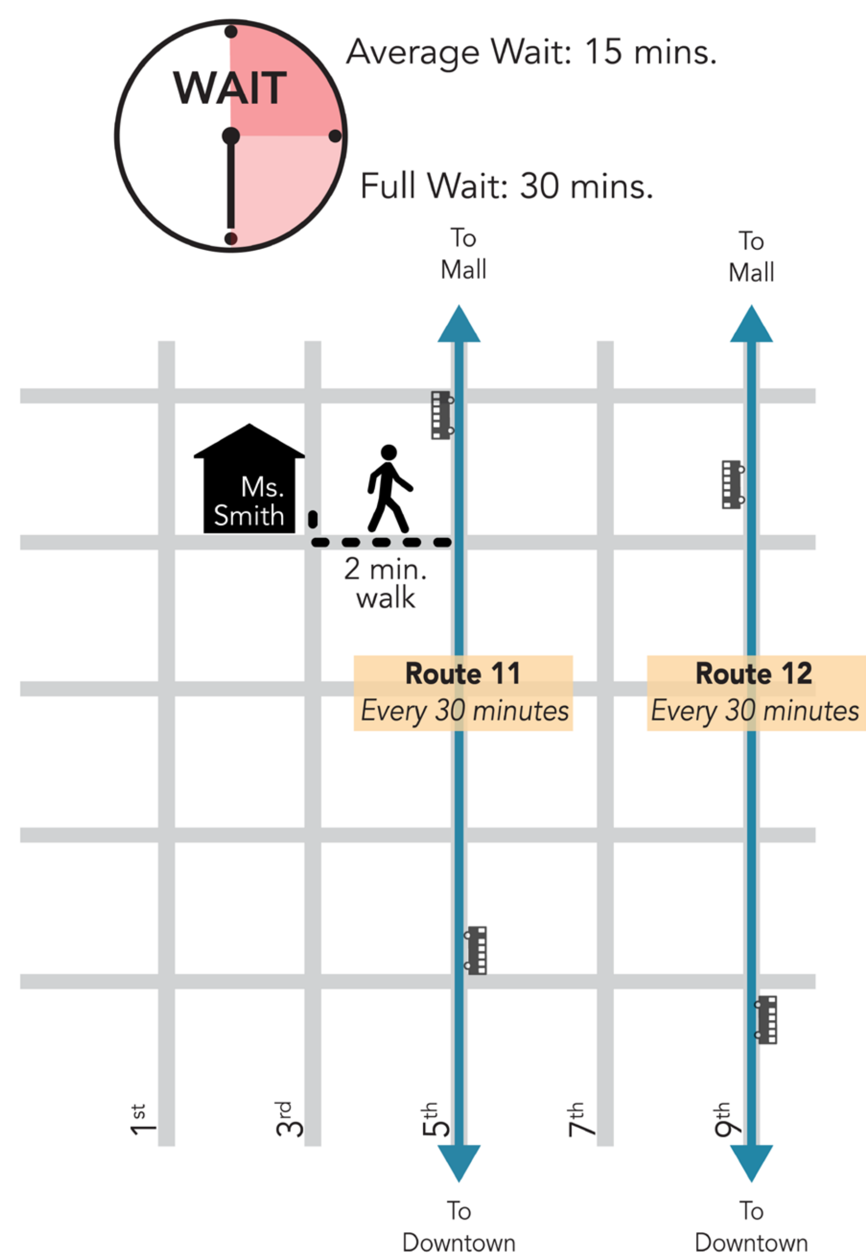
Another way to think about the question of ridership and coverage is to think specifically about how far a person should have to walk to reach a bus stop, and how long they should have to wait, on average, before the next bus comes.

Walking and waiting are important to consider on their own, because both of these activities add time and inconvenience to any transit trip, and different people have a wide variety of preferences regarding each.

For example, a young and fit person in a hurry might have no problem walking over a half-mile to a bus stop if the bus is always coming soon. An older or differently-abled person might prefer to have a bus stop much closer to their front door, even if it means they need to memorize the bus schedule or risk waiting a long time.

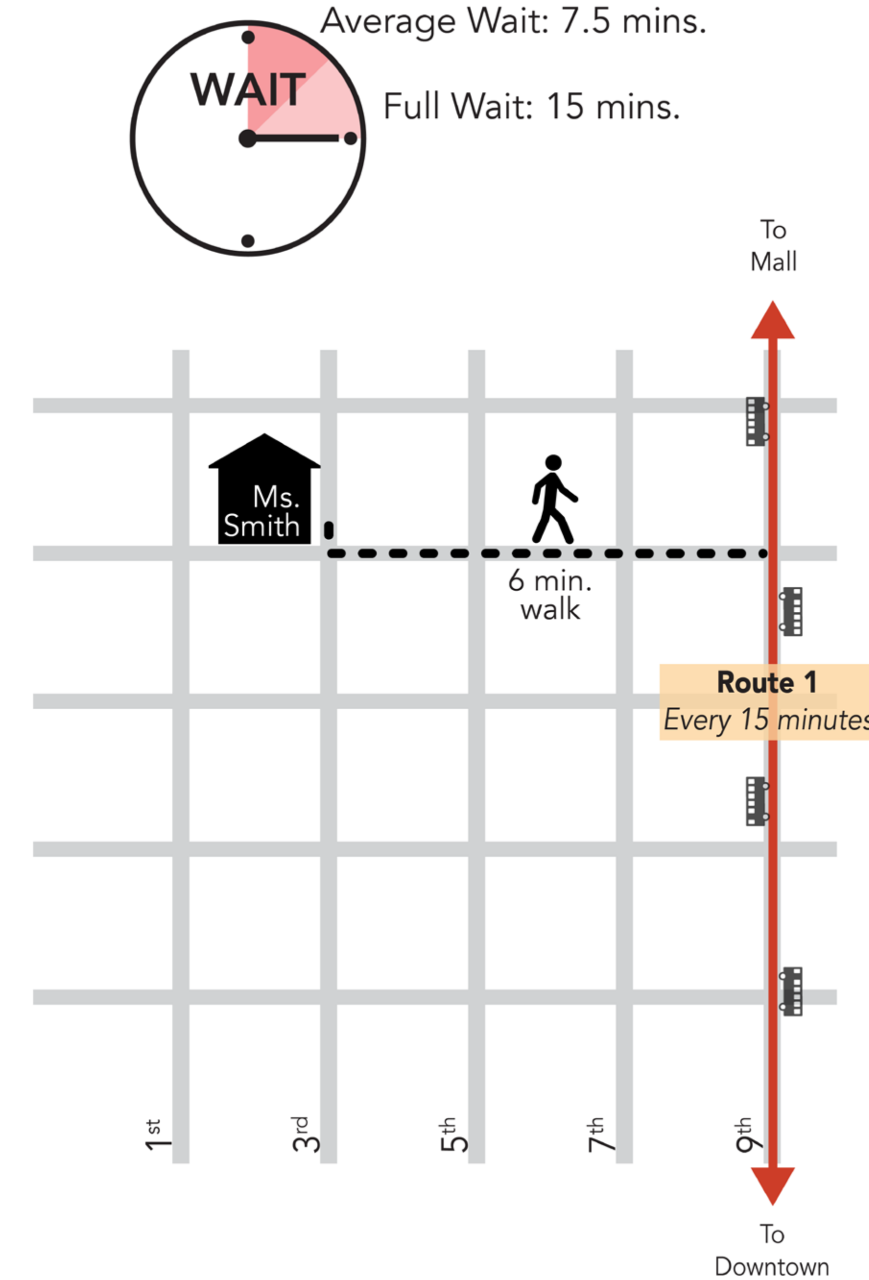
Minimize Walking

with closely-spaced routes coming every 30 minutes.



Minimize Waiting

with routes coming every 15 minutes, more widely spaced.



+4 MORE MINUTES WALKING
-7.5 FEWER MINUTES WAITING ON AVERAGE =
3.5 MINUTES FASTER ON AVERAGE

Figure 49: In some situations, consolidating parallel routes onto fewer streets can make the average person's trip faster. There may be opportunities to do this within downtown and midtown...but only if people value shorter waits and longer spans of service more than they value shorter walks.

Peak-Hour or All-Day Service?

Demand for transit service tends to be higher at peak periods during weekday mornings and evenings. These peak periods occur at similar times of day as peak traffic on a city's major streets and highways.

On a typical weekday in Norfolk, the number of transit boardings is highest between 6 and 8 AM, and between 2 and 5 PM. At the same time, there is always some demand for transit service outside peak hours and on the weekend.

There are distinct advantages to focusing a transit network on peak-hour services. For example:

- Peak-hour services have the most potential to produce full buses.
- Peak-hour services have the highest potential for traffic congestion relief on regional streets and highways.
- Peak-hour services have the highest potential to relieve individual riders of the stress of driving.

However, focusing on peak-hour services also has real disadvantages and costs, such as:

- Services focused on peak demand require transit agencies to maintain large fleets of buses that sit unused at most times. These buses must be purchased, maintained, stored and replaced on a regular basis.
- Peak-hour services tend to have a higher average cost per hour of service than all-day services because more time is spent going to and from the garage relative to time spent serving riders.
- Peak-hour services tend to require split shifts for operators, extending their work day, or forcing an agency to higher more operators so that their fleet is staffed at both ends of the day.
- Peak-hour service tends to focus on the commuting needs of full-time office workers. But there are many other reasons to ride transit and many other types of potential riders. If service is only (or mostly) available at peak hours, many potential transit riders may find that they are able to make a trip in one direction but not in another.

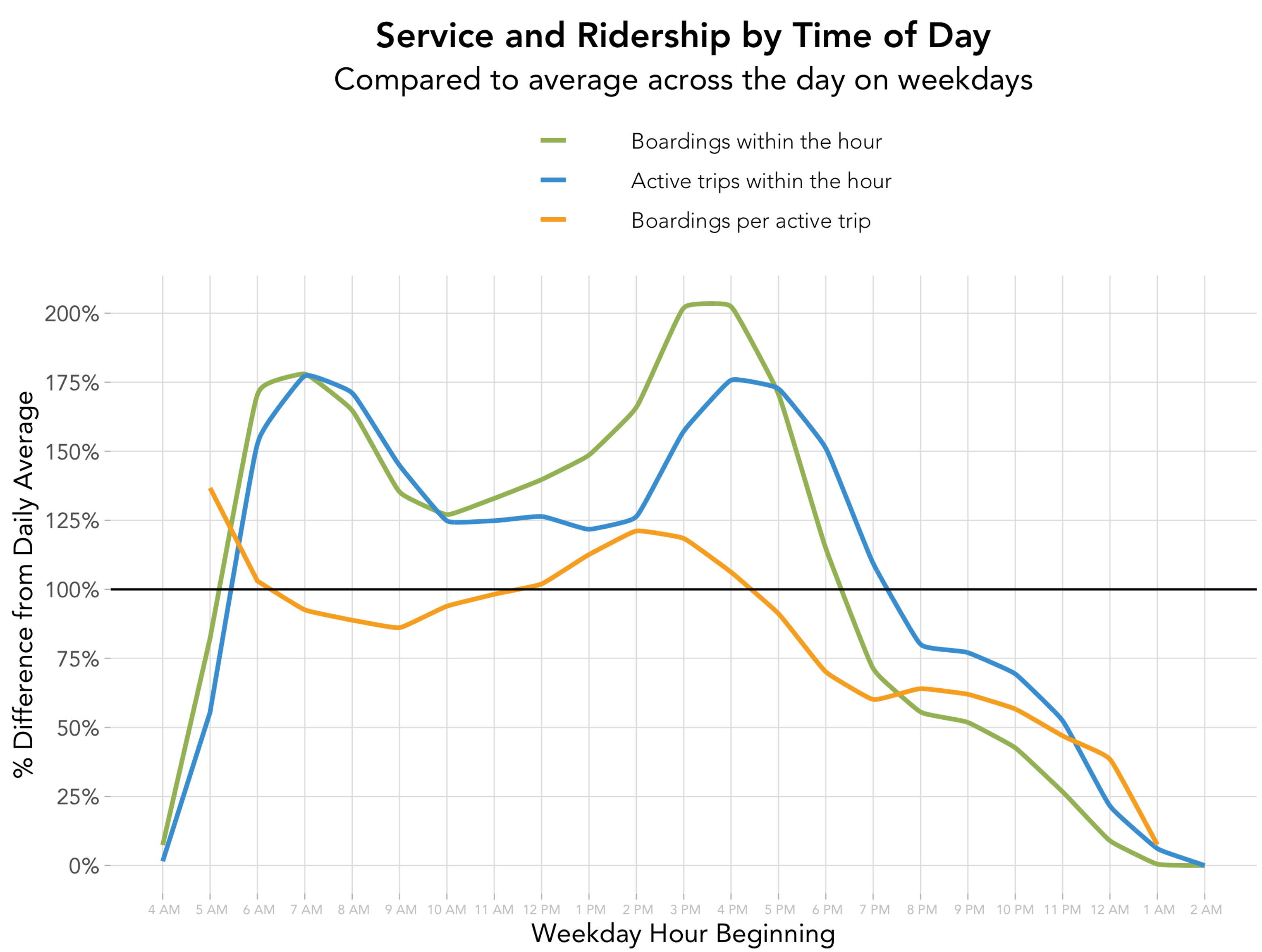


Figure 50: Service and boardings by hour show that boardings per trip peaks at 2pm

Most transit agencies, including HRT, have networks that draw some compromise between meeting peak-hour demand and maintaining some level of service for the many transit rides that occur at other weekday times and on weekends. However, it is worth asking the questions:

What is more important: fully serving higher demand at peak hours, or providing a useful level of transit service all day, everyday?

Next Steps

This Choices Report represents the first step in a three phase process of thinking about redesigning Norfolk's transit system. This report serves as a basis of information for public meetings, surveys, and outreach for what we call the "Choices Phase" of the Multimodal Norfolk: Transit System Redesign. The public, stakeholders, and riders will be invited to respond to these key questions and provide other input on their preferences around how transit served Norfolk. This input will be gathered through open public meetings, an online survey, and a survey of riders on the bus. For more information about the surveys and public meeting dates, go to www.norfolk.gov/4776/Multimodal-Norfolk.

The input received will help guide city staff in designing "Conceptual Alternatives" that show how different network designs could look and how they would lead to different outcomes for access to jobs, proximity to service, and other factors. These "Conceptual Alternatives" will be the basis for a second round of outreach, surveys, and meetings to get input from the public, stakeholders, and riders to guide the development of a Draft Transit System Plan.

Glossary

Access	The number of jobs or residents reachable from a starting location by transit and walking. Access is often calculated for many starting points in a network, based on some assumed travel-time "budget," and summarized on a map.
Arterial road	A high-capacity through road.
Bus Rapid Transit (BRT)	Bus-based transit providing enhanced speed and capacity comparable with rail-based transit modes, typically incoporating a degree of infrastructure such as exclusive lanes, transit signal priority, improved stops/stations, and queue jump lanes.
Circulator	Circulator is often used to describe a service that provides transit coverage to a low-density area, because the travel paths that result are so often circular in shape. In some places a circulator is also operated downtown. Large circular transit routes that offer high speed or high frequency and serve high demand areas, however, are generally referred to as loops.
Connection	A connection or transfer takes place when a person uses two transit vehicles to make a trip.
Coverage	Coverage can refer to the amount of geographic space, the proportion of people or the proportion of jobs that are within a certain distance of transit service. An assumption about how far people will walk to a given transit service—often ranging from 1/4 to 1/2 mile—must be made in order to estimate coverage.
Deadhead hours	The time a vehicle spends between the garage and the start or end of revenue service, or between the end of a trip on one route and the beginning of a trip on another route.
Dial-a-ride	Demand response service, usually requires booking a day in advance, over the phone.
Duplication	A characteristic of a transit network where multiple routes provide similar services along the same corridor or between the same set of destinations, without coordinating schedules to provide a higher level of frequency.
Express	Express can have a range of meanings when applied to transit. It most often describes a route with a long non-stop segment. It can also be used to describe a route with wide stop spacing and overall faster speeds, though that is more commonly called a rapid.
Farebox recovery	Farebox recovery is a measure (typically expressed as a percentage) of how much of a transit system, network or route's operating cost is recovered through fares.
Feeder	A local route that connects or feeds into a radial route. Low-frequency feeders sometimes pulse so that transferring is more convenient
Fixed route transit	Fixed route transit describes any transit service that is operated on the same predictable route. In contrast, paratransit and demand-responsive service may always or often follow different routes for each vehicle trip, as they serve different customers and their trips.
Frequency	The time interval between succeeding transit trips. Frequency is often expressed in minutes, i.e. a transit service where a bus comes every 15 minutes has "15 minute frequency." A more technical term for frequency is headway.
Grid Network	A network of routes that intersect all over the city. Grid networks are best suited for places with many activity centers, as opposed to radial networks, where most people are traveling to a central location.
Headway	Headway is the time between successive trips at a stop, a more technical transit term for frequency. A service that comes every 15 minutes can be said to have a "15 minute headway."
Investment	Service or revenue hours per capita, a measure of the relative level of transit service.
Isochrone	An illustration to help visualize where someone can go from a location, in a certain amount of time, using transit or by walking.
Land use	Land use describes the way a parcel of land is being used, for example as commercial, industrial or multi-family residential. Land use descriptions can be general or very specific. Land use is distinct from zoning, as land may be rezoned under existing uses and buildings long before changes to its use take place.
Layover	Time for driver breaks between trips. Usually included in revenue hours. Unlike recovery time, layover time sometimes cannot be skipped even when a bus is behind schedule.
Longline	Some routes have a more frequent inner segment and a less frequent outer segment. At the end of the inner segment, some buses turn around and come back, while others continue on to a more distant turnaround point. The outer, less-frequent segment is often called the "longline," though technically the longline is the longest path that buses on that route travel, and its length is the inner segment plus the outer segment. The inner segment is called the "shortline."
Microtransit	Demand response service, usually distinguished by same day or instant booking, often using a smartphone application.
Mobility	Mobility is generally used to express the ease with which people can move from place to place. It is distinct from access, which describes the extent to which people can meet their needs nearby. In some places, people have high access (they are able to meet all of their needs without travelling very far or at all) and low mobility (because traveling long distances is difficult or slow). In other places, mobility is high and access is low.
Mode share	Mode share is a technical term for the percentage of a population that uses a particular mode (e.g. transit, walking, driving) for traveling. Mode share information in the U.S. is generally reported for commute trips.
National Transit Database	The National Transit Database is a federal clearinghouse of general information about transit in the U.S. and information specific to each transit agency. Agencies of a certain size are required to submit financial and performance data to the NTD each year. https://www.transit.dot.gov/ntd/
One-seat-ride	A trip that requires boarding only one transit vehicle (no transfers).

Paratransit	Paratransit is a transit service that provides on-demand curb-to-curb travel for people with disabilities, per the American's with Disabilities Act. It is required by this U.S. law to be provided to people who have a disability that prevents them from using fixed route transit service, within 3/4 mile of fixed route transit, during all times when fixed route transit is operating.
Peak	The periods of the day with the absolute highest level of travel demand: typically during the morning and afternoon rush hours, as people travel to and from work and school. However, in many places travel demand peaks only once, in the midday or afternoon, as service shifts change and students leave school.
Peak-only	A transit service that is peak-only operates only during the morning and afternoon travel peaks.
Productivity	The word productivity is often used in transit to describe the number of people served per unit of cost. Productivity can be expressed for an entire transit system, a subset of the system, individual lines or even for segments of lines.
Pulse	A pulse takes place when two or more transit services arrive together at the same place at the same time, so that their passengers may transfer among them with minimal waiting.
Radial	A route or network design where most routes go to and from a central point (typically a downtown). As opposed to a grid network.
Rapid	Rapid can have a range of meanings when applied to transit. It most often describes a route with wider stop spacing and overall faster speed.
Recovery time	Extra time between trips to make up for a delay. Unlike layover, which is a driver's break time, recovery time can be cut short so that the next trip can depart on-time.
Relevance	Boardings per capita, a measure of how relevant transit is to the population it serves.
Revenue hours	The time a transit vehicle and its operator spend out in public, available to passengers and (potentially) collecting revenue. Usually includes layover and recovery time, but excludes deadhead.
Ride check	The National Transit Database requires that transit agencies regularly sample on all of their services to collect ridership and on-time performance information. This is often performed using surveyors on transit vehicles, though increasingly it is performed by automated counters and GPS devices on transit vehicles. It is sometimes called a ride check.
Ridership	Ridership refers informally to the number of boardings or trips taken on a transit system or a particular transit service.
Shortline	Some routes have a more frequent inner segment and a less frequent outer segment. At the end of the inner segment some buses turn around and come back, while others continue on to a more distant turnaround point. The outer, less-frequent segment is often called the "longline," though technically the longline is the longest path that buses on that route travel, and its length is the inner segment plus the outer segment. The inner segment is called the "shortline."
Span	The span of a transit service is the number of hours it operates during the day, e.g. a service that runs from 6:00 am to 11:30 pm would have a 17.5 hour span. Span can also describe the number of days per week and per year that a service is operated.
Street connectivity	The degree to which streets connect to one another, and multiple paths exist between any two points, is describe as that place's connectivity. Areas with many cul de sacs or loops and few through routes have low connectivity; areas with grid-like street patterns have high connectivity. Low connectivity discourages trips by slower modes (such as walking or bicycling), and presents challenges for transit routing.
Transfer	When a person uses more than one transit vehicle to make a trip, they transfer in between vehicles. This is also often called a connection.
Transit orientation	As with transit dependency, transit orientation is a spectrum, not a category. People who are living or working around higher activity densities, in places where walking to transit is safe and appealing, or who do not have easy access to an automobile may have some degree of transit orientation. Transit orientation can exist among poor and affluent populations alike.
Tripper	A tripper is a special type of transit service that makes only a few or a single trip each day. Transit agencies often send one or more trippers to relieve crowding on certain routes, or to provide direct service where none exists at other hours. Trippers often run at the start and end of school days or work shifts.
Vehicle hours	The time during which a transit vehicle is away from the garage, whether providing revenue service (represented by "revenue hours"), driving between the garage and the start or end of service (represented by "deadhead hours") or in layover and recovery time.