NORTHERN VIRGINIA TRANSPORTATION COMMISSION

Northern Virginia Transit through the COVID-19 Pandemic

August 2022

Table of Contents

Acknowledgements

This report was authored by Xavier Harmony and Sophie Spiliotopoulos with editing assistance from Mathew Friedman. Monique Blyther provided the front cover. The authors thank Rocco Visconti at Arlington County; Nick Ruiz and Christine Hoeffner at the Virginia Railway Express; Luis Ortiz at OmniRide; and Christian Soughe Bissai, Hejun Kang and Edward Reid at Fairfax County for their review and feedback. The authors also thank NVTC's Kate Mattice and Allan Fye for their feedback and guidance. Any errors are NVTC's alone.

List of Figures

1.0 Introduction

The COVID-19 pandemic has impacted the country in unprecedented ways, possibly permanently changing the ways people work, learn and play. Public transit is one of the areas that has been hit especially hard. With large changes in transportation mode choices[1] (including more people teleworking[2]) and significant swings in travel behavior[3], transit has seen ridership drop precipitously with a rocky and slow recovery. Although transit's recovery is important for regions across the US, it is of particular importance to the Northern Virginia region. While only about 5% of the country uses public transit for commuting, Northern Virginia residents commute using transit at almost twice the rate. As Figure 1 shows, almost every jurisdiction in the region uses transit more than the national average. Consequently, it is important to better understand how transit has changed during the pandemic, how ridership has changed during the pandemic, and how the region has adapted to these changes.

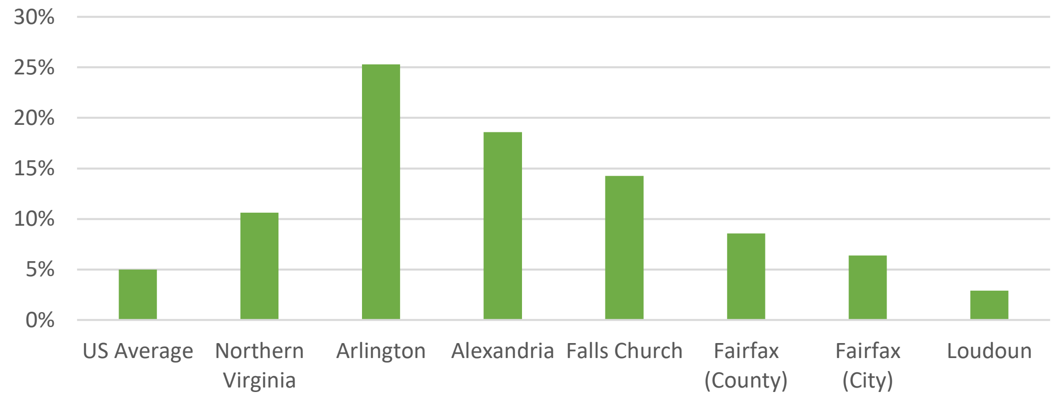

Figure 1: Commuter transit use in Northern Virginia (ACS 5-Year Estimates 2016-2020)

The purpose of this report is to attempt to evaluate and better understand pandemic transit trends in Northern Virginia. Although previous work has looked at transit in other regions[4], and transit more generally[5], no other work has focused only on Northern Virginia. There are four primary goals for this report:

A. Provide an overview of major transit trends in Northern Virginia for the past three years
B. Explore how Northern Virginia travel patterns or habits have changed
C. Explore how Northern Virginia transit services have changed
D. Summarize the analysis and findings to provide transit takeaways for the region

The following sections will focus on each of these goals, telling the story of Northern Virginia transit over the last three years.

---

[1] https://journals.sagepub.com/doi/full/10.1177/03611981211029926
[2] https://www.oecd.org/coronavirus/policy-responses/teleworking-in-the-covid-19-pandemic-trends-and-prospects-72a416b6/
[3] https://www.bts.gov/browse-statistical-products-and-data/covid-related/changes-mobility-state-0
[4] https://transitcenter.org/how-much-service-did-the-largest-transit-agencies-run-in-2021/
[5] https://www.apta.com/wp-content/uploads/APTA-COVID-19-Funding-Impact-2021-01-27.pdf

2.0 Pandemic Transit Trends

The COVID-19 pandemic has had a devastating impact on transit in the U.S. with transit in Northern Virginia providing no exception. Before diving into understanding how travel trends and service patterns might have changed as a result, a better understanding of some of these overall trends is required. This section of the report focuses on changes to the total amount of ridership and transit in Northern Virginia. While these data are broken down by transit mode and operator, the overall trends are the focus of the evaluation. The data used in these evaluations is described in **Appendix A**.

2.1 Ridership

Ridership trends were primarily evaluated using a trendline analysis. A trendline analysis evaluates trend or patterns in the same variable over many time periods. In this case, transit ridership by month. The methodology is described in **Appendix B**. The ridership trendline for all transit services in Northern Virginia is given in Figure 2.

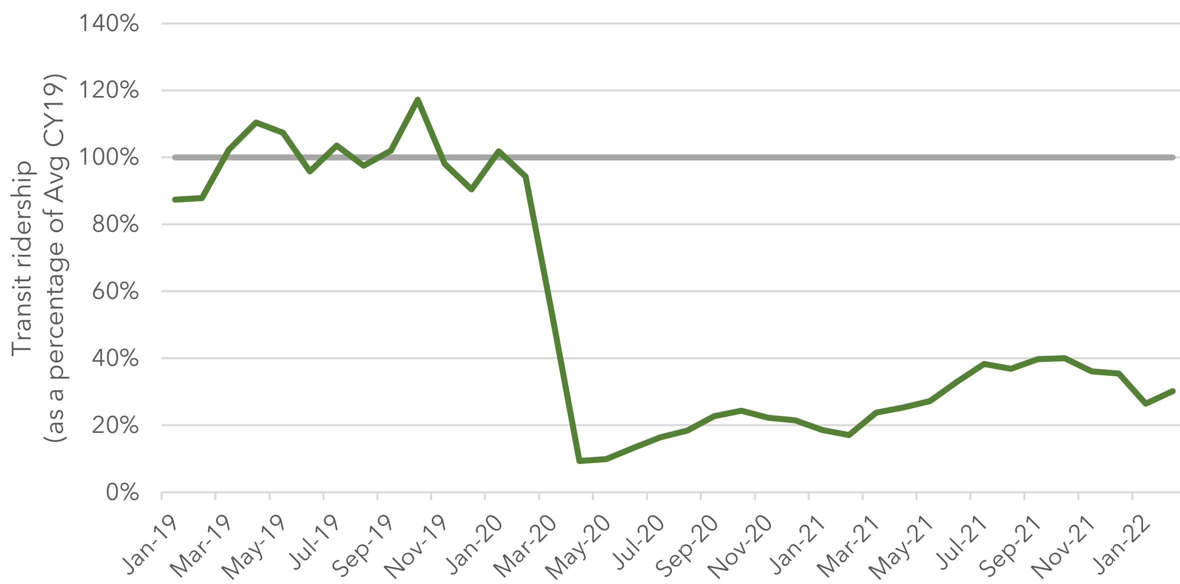

Figure 2: Northern Virginia indexed transit ridership (DRPT OLGA data)

As Figure 2 shows, there is considerable variance around the 100% index point before ridership fell in February 2020. This is expected as ridership experiences seasonal variation. Post the sharp decrease in February/March 2020, where transit ridership dropped 90%, there was a gradual increase in ridership until approximately September 2020 when the trend changed again. Transit appears to decrease until February 2021 before steadily increasing until July 2021. Finally, ridership stayed roughly consistent at approximately 40% pre-pandemic levels until December 2021 when ridership started decreasing again.

Some of these trends can be explained, at least partially, by changes in the pandemic. For example, the decrease in ridership from September 2020 to February 2021 might be partly explained by some of the increasing COVID positivity rates as people traveled for the

November-December holidays[6]. Vaccines started becoming available in January 2021[7] so the increase of vaccination rates might play a role in the ridership recovery starting in early 2021. However, while this is likely a factor, it is not clear why ridership didn't start increasing until March or why the increases plateaued in July. Finally, the drop in ridership following December 2021 might be associated with the emergence of the more infectious omicron variant[8].

However, while there are general regional transit trends, these trends differ by the type of transit service being operated. In Northern Virginia four types of transit ridership are recorded:

- **Bus**: Includes local fixed-route bus, deviated fixed-route bus (e.g., OmniRide), and commuter bus
- **Paratransit**: A demand-response service that complements fixed-route service that provides specialized services for people with disabilities
- **Commuter Rail**: A peak-period, peak-direction commuter-oriented rail service that connects suburban residents with urban jobs and activities (e.g., Virginia Railway Express (VRE))
- **Heavy Rail**: High-speed, high-capacity transit that operates in devoted right-of-way (e.g., the Washington Metropolitan Area Transit Authority's (Metro) rail system)

Figure 3 shows how the ridership of these four types of transit has changed over the last three years. As the figure shows, all transit services had significant ridership losses in March 2020. However, the rail services, both commuter and heavy, dropped more than the bus and paratransit services. While bus and paratransit experienced about an 80% decrease in ridership, rail ridership, including both heavy and commuter rail, decreased 95%. The ridership recoveries between the modes have also varied. Bus and paratransit have almost reached 60% of pre-pandemic levels while rail, especially commuter rail, have been slower to recover. These modal differences might reflect which transit populations have more access to alternative travel options, like telework or cars, and who rely more on transit. People who use rail often have higher incomes than people who use bus[9].

Although there are differences across modes, there are also ridership differences across operators. Northern Virginia has the distinction of having seven different bus operators. Figure 4 shows how ridership has changes across Northern Virginia's different bus operators. As the figure shows, there are large differences between ridership recoveries even between bus operators. City of Fairfax's City-University-Energysaver (CUE), for example, has generally seen the best recovery with some monthly ridership increasing to pre-pandemic levels. Conversely, systems with heavy commuter bus operations, including Loudoun County Transit and OmniRide, have struggled to return to pre-pandemic ridership.

---

[6]https://www.npr.org/sections/health-shots/2020/12/21/948809129/epidemiologists-urge-a-cautious-christmas-after-thanksgiving-surge-in-some-state

[7]https://www.wbaltv.com/article/the-first-covid-19-vaccine-was-administered-in-the-us-1-year-ago/38448446

[8] https://www.nytimes.com/2022/01/22/us/omicron-cases-us-deaths.html

[9] https://trid.trb.org/view/1326943

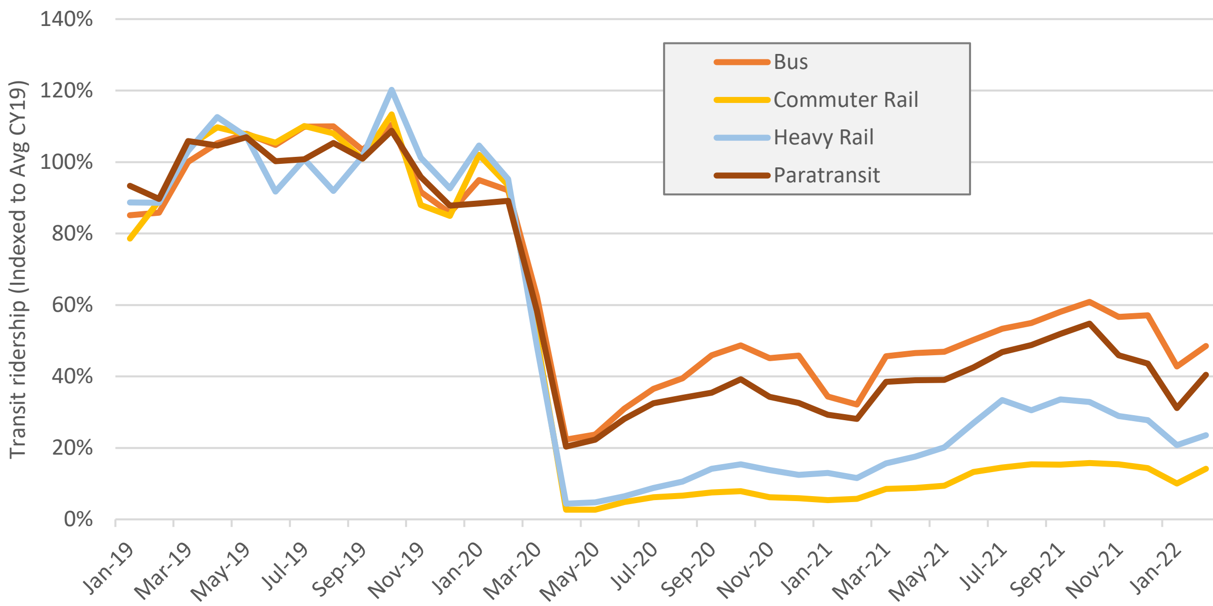

Figure 3: Northern Virginia indexed transit ridership by mode (DRPT OLGA data)

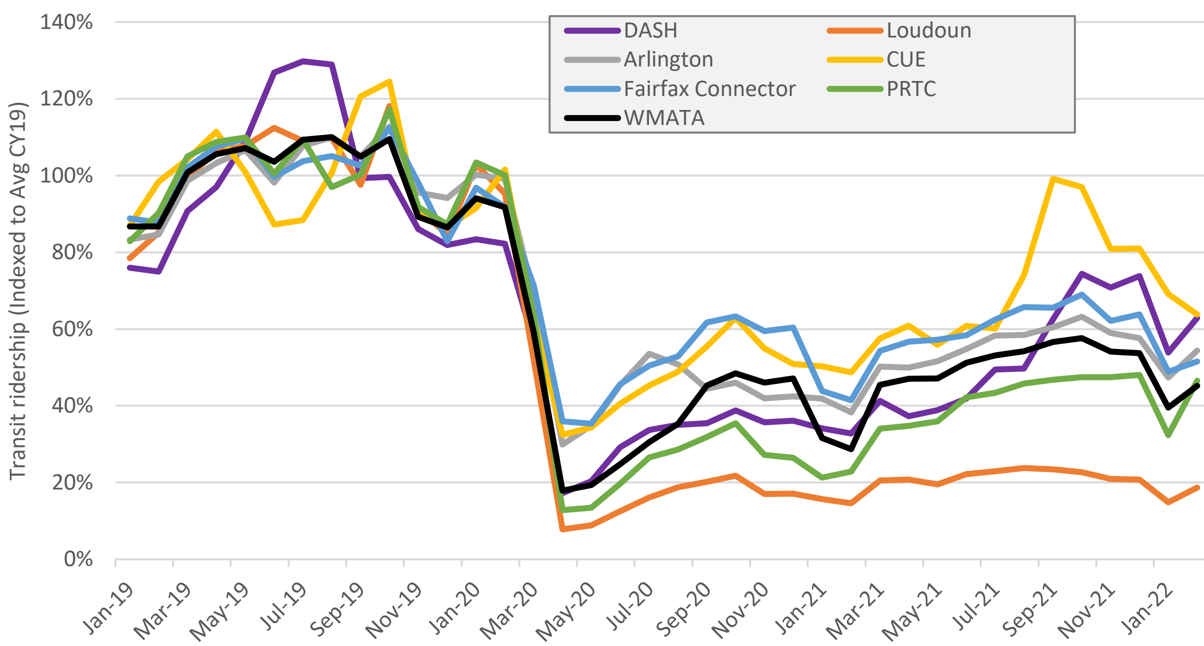

Figure 4: Northern Virginia indexed bus ridership by operator (DRPT OLGA data)

Overall, while there are regional trends in transit ridership, the evaluation of different transit modes and operators demonstrates that transit ridership recovery varies significantly between transit modes and operators; the type of transit service matters when it comes to recovery.

2.2 Transit Service

While not as dramatic as ridership, transit services also fluctuated through the pandemic. Transit operators adapted to changes in federal and state mandates, mitigated crowding, protected operators and managed systems with operator outages and shortfalls. As with ridership, trendline analysis was used to evaluate trends in fixed transit services over the past three years[10]. The trends are shown by operator in Figure 5.

As Figure 5 shows, there is little consistency among the different transit operators in Northern Virginia. While nearly all operators reduced services in April/May of 2020, CUE maintained its service levels throughout the pandemic. Of those that changed their service levels, the region saw a range in service reduction. While VRE and Loudoun County Transit saw the largest changes in service hours, with half or more of their average pre-pandemic service levels cut, OmniRide cut less than a third of service hours while Fairfax Connector cut less than a quarter. There appears to be no general patterns around why different levels of service were cut but there may be explained due to differences in jurisdictional policies, transit operation contracts, labor union agreements, and agency leadership.

Service level recovery also varied. While OmniRide recovered the fastest, returning to pre-pandemic service levels within three months, Loudoun is still operating with almost 50% fewer transit service hours compared to its pre-pandemic average. Returning to pre-pandemic service has been one of the strategies regional transit agencies have used to increase ridership. For example, in VRE's April 2021 operations board meeting, the board heard a public comment asking for more service so people could start riding trains again. Rider feedback like this helped support the decision by VRE to return to full service, announced at the June 2021 operations board meeting. Ridership followed this change. While April to May saw a 7% increase in ridership, May to June saw a 40% increase in ridership. Although VRE ridership is still below pre-pandemic levels, the additional service has likely helped with the recovery.

Another way to evaluate service data is by looking at the average bus speeds which can be approximated as service miles per service hour. Figure 6 shows these data plotted over the past three years for the different bus operators. **Appendix B** explains the calculation used.

As the figure shows, there is a large difference among operators. Bus speeds are affected by the type of service and where the service operates. Local bus service in denser areas, like Arlington and Alexandria, which have smaller stop spacing and interact with more traffic, travel the slowest. Commuter bus services travel the most distance in a revenue hour as they make longer trips with fewer stops. Local bus services in suburban areas fall somewhere in the middle. Considering these patterns, the data in Figure 6 helps to explain how services have changed.

[10] Metro vehicle hour or vehicle mile data was not provided for Virginia during the evaluation time period

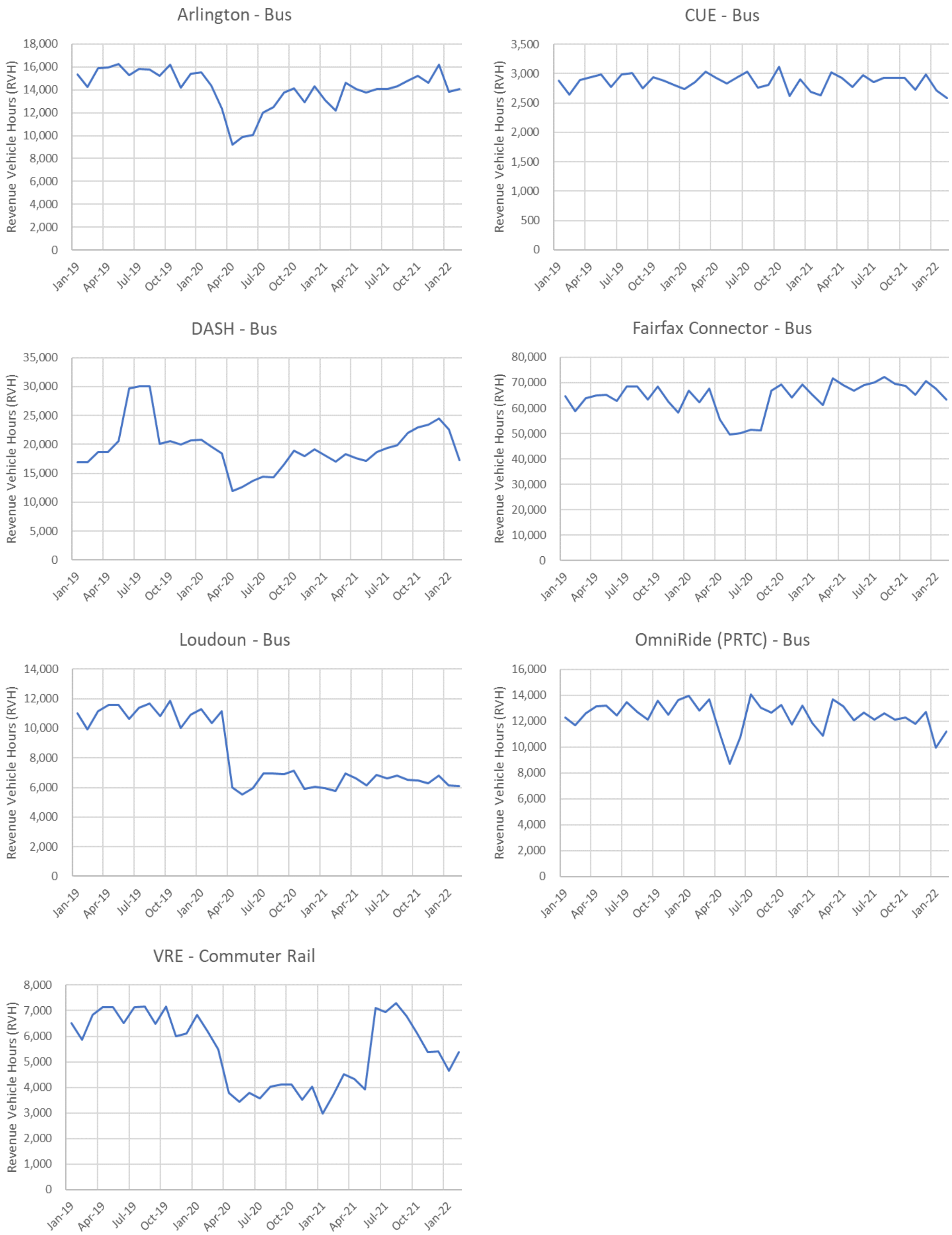

Figure 5: Changes to transit service (DRPT OLGA data)

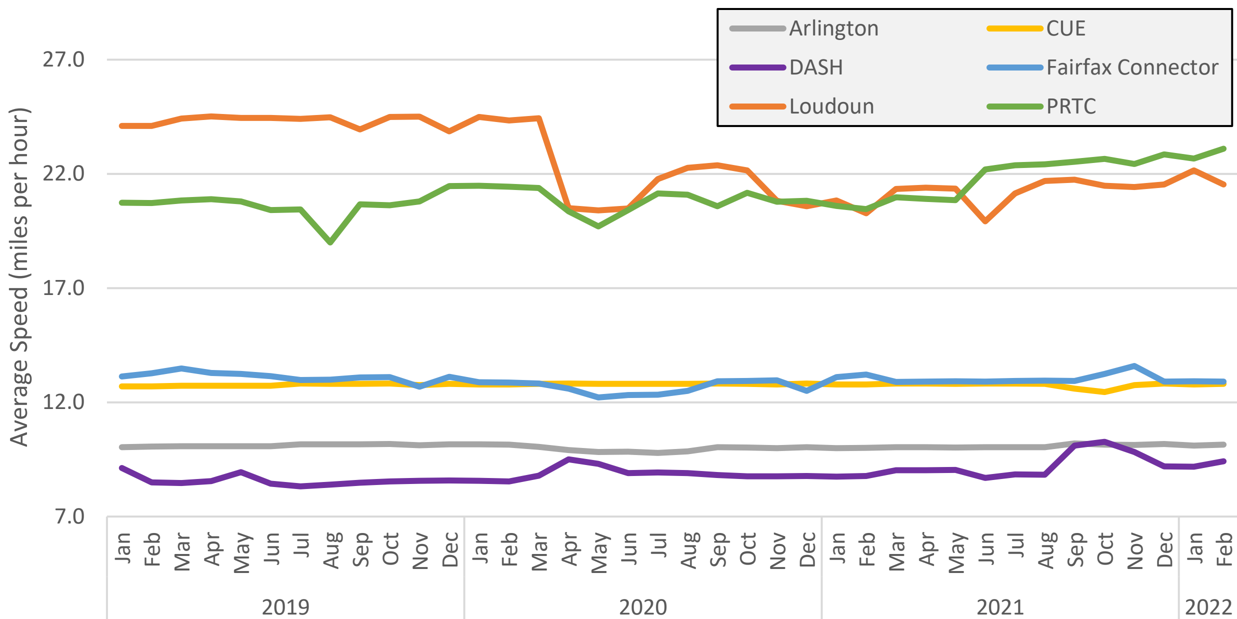

Figure 6: Northern Virginia average bus speeds

For CUE, Fairfax Connector, and Arlington Transit (ART), average bus speeds did not significantly change. This might indicate service plans did not adjust much as traffic conditions and passenger volumes changed. Average transit speeds did increase slightly for DASH. The increase coincides with the implementation of the network redesign where improving speed and reliability were project's goals[11]. Notably, Loudoun County Transit saw a significant average decrease in bus speeds that correlate with the reduction in service shown in Figure 5. As Loudoun operates both commuter and local bus service, this result likely indicates that there has been more of a reduction in commuter service than in local service. Finally, OmniRide had a noticeable increase in average transit speeds. This is likely because in June 2021 OmniRide retimed commuter bus schedules to take advantage of lower traffic volumes in both the I-66 and I-95 corridor, decreasing travel times.

Overall, the changes to the amount of service provided varies a lot in the region. However, there are regional trends. First, transit agencies offering commuter-focused services have generally seen the biggest and longest changes to their services. Second, most transit in Northern Virginia has returned to pre-pandemic levels. Finally, there appears to be a relationship between service recovery and ridership recovery. This will be explored further in section 5.0.

3.0 Travel Trends and Patterns

In section 2.0 this report demonstrated that there have been significant changes in both transit ridership and service. Although we don't have ridership survey data available, meaning we don't have riders explicitly stating how their behaviors have changed, we can use more granular ridership data to estimate how behavior might have changed. This section takes a

[11] https://media.alexandriava.gov/docs-archives/tes/alexandria-transit-vision-final-report-=2020-02-24.pdf

deeper dive into how people may have changed the way they take transit. Travel patterns were evaluated based on mode, day of travel, and geography, where possible. The following sections describe each of these analyses.

3.1 Changes in Transit Mode

The modal trends in Figure 3 give some indication how transit travel has changed. Bus and paratransit ridership retained more ridership than rail and has consistently maintained a higher proportion of pre-pandemic ridership. This suggests that, while transit was hit hard, the impact differed based on mode. People who used the bus were more likely to continue using transit than people who used rail. Figure 7 looks at this trend in more detail.

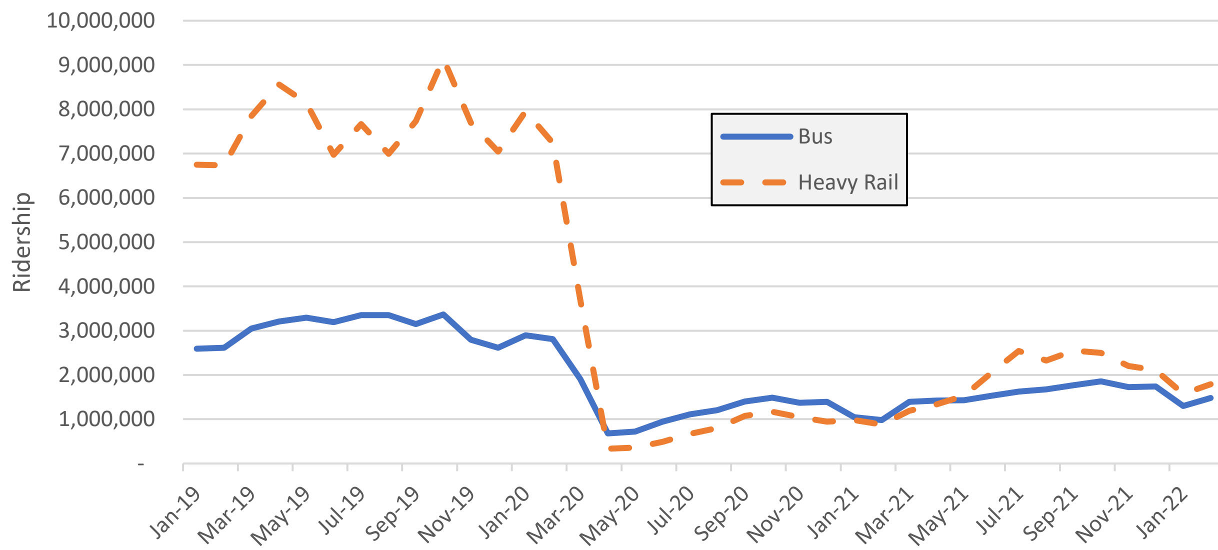

Figure 7: Changes in bus and heavy rail ridership (DRPT OLGA data)

This figure shows the trendlines for heavy rail (Metrorail) against the sum of all bus ridership in Northern Virginia. As the graph shows, pre-pandemic, heavy rail carried significantly more people than all the bus systems in Northern Virginia combined. However, because heavy rail lost so much ridership, the Northern Virginia bus systems carried more people than heavy rail for almost a year. Although rail ridership has somewhat recovered, it doesn't dominate transit ridership like it once did.

3.2 Changes in Travel by Weekday

As noted in **Appendix A**, Virginia Department of Rail and Public Transportation (DRPT) data is the most comprehensive dataset in terms of time and number of agencies but is aggregated at the monthly level. This makes it difficult to estimate weekday and weekend ridership trends. However, if the amount of Saturday or Sunday transit ridership as a proportion of weekday ridership is known, the monthly data can be disaggregated into an estimate of weekend and weekday ridership. **Appendix B** describes this in more detail. The calculation process depends on the assumption that the weekend ridership as a proportion of weekday ridership doesn't change. As already noted, the pandemic has significantly impacted work trends including the availability of telework. Consequently, the previously used assumptions for estimating weekly and weekend ridership might have changed. To test this, trendlines for weekend ridership as a proportion of weekday ridership were plotted, as shown in Figure 8.

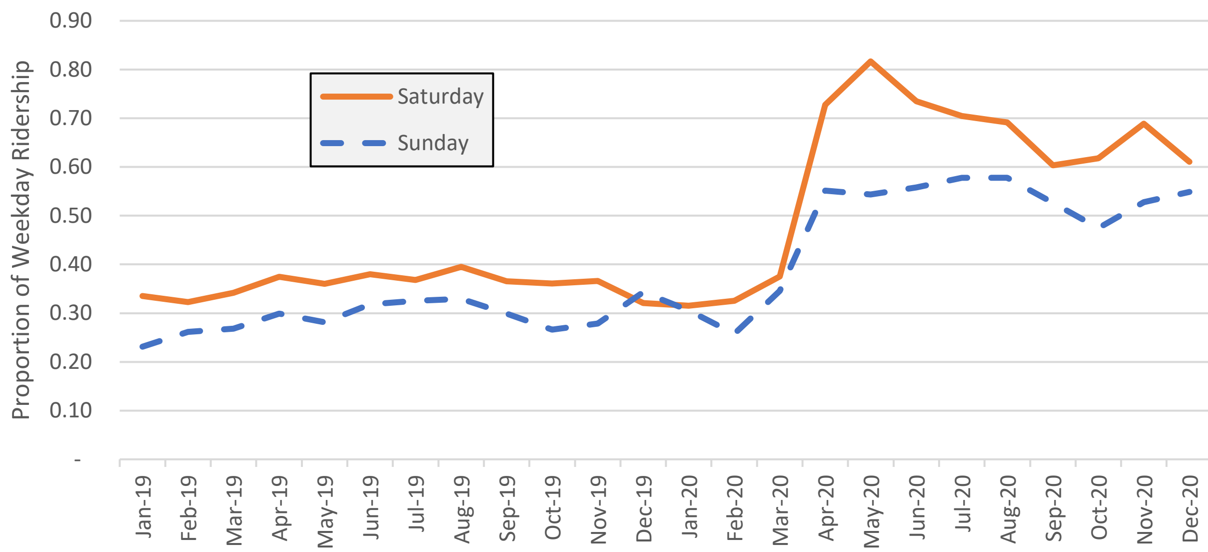

Figure 8: Weekend ridership as a proportion of weekday ridership (Northern Virginia Bus Operator data)

As Figure 8 shows, pre-pandemic Saturday ridership averaged 35% of a typical weekday while Sunday ridership averaged almost 30% of a typical weekday. While these proportions were relatively consistent before March 2020, they changed abruptly when the pandemic hit. Both Saturday and Sunday ridership increased relative to weekday ridership. These trends indicate that not all types of transit trips were impacted the same way. Weekday transit trips, which include more commute trips, were reduced more than Saturday or Sunday trips, which tend to serve more recreational trips or commute trips for jobs that were considered "essential" during the pandemic, like food service. There are three key implications from these changes. First, it means previous methods for estimating ridership by day of week are less useful. Second, travel behavior hasn't changed consistently; some types of trips have been reduced more than others. This directly connects to the third, and possibly most significant, point: transit services designed to accommodate peak commute demands might not be as effective at serving people if weekday and weekend service demand looks more similar.

3.3 Geographic Changes in Rail Ridership

Due to data limitations, it is not possible to ascertain how transit ridership has changed in different areas of Northern Virginia. However, Metrorail data is available at the station-level, meaning it is possible to see how ridership has changed for different stations. Overall ridership changes don't tell us much more than what was already shown in Figures 3 and 7. However, by estimating the underlying populations that have access to a Metro station, we can get a sense of ridership trends and patterns[12]. The demographics and characteristics of likely transit riders

[12] Transit ridership doesn't completely match census demographics because ridership often depends on more than just access; however, it can serve as an approximation when ridership demographic data is unavailable

with access to Metro stations can be estimated using Metro's general transit feed specification (GTFS) data and census data. **Appendix A** provides an overview of these data with the estimation method described in **Appendix B**. A similar analysis using the largest rail transit systems in the US was previously completed by the Urban Institute[13]. The results of the Northern Virginia analysis are given in Figure 9. In the figure a low population is defined as less than the 10th percentile while a high population is greater than the 90th percentile.

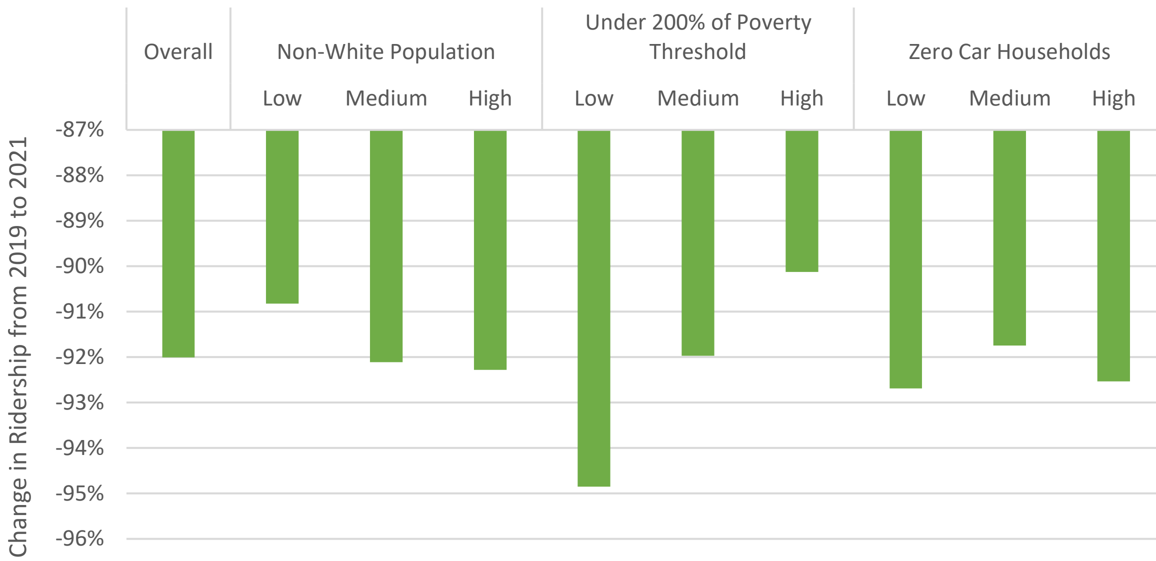

Figure 9: Change in Metrorail ridership in Virginia between 2019 and 2021 (Metrorail ridership, GTFS data, and ACS 5-Year Estimates 2016-2020)

As Figure 9 shows, changes in heavy rail ridership were not uniform across demographics. Metro stations located in areas with fewer people in poverty (defined as below 200% of the federal poverty line) saw the greatest decreases in ridership. This is consistent with the previous work by the Urban Institute. However, the Urban Institute also found rail stations with a larger white population were more likely to have a greater decrease in ridership. This is the opposite to the results in Figure 9, which instead show a higher white population had a smaller decrease in rail ridership. Finally, the figure shows no clear pattern or trend for zero car households.

Overall, a more nuanced evaluation of ridership trends has highlighted the fact that the way people use transit, and who uses transit, in Northern Virginia is different now compared to before the pandemic. Transit riders are more likely to use the bus than before, transit travel patterns look more consistent between weekdays and weekends and Virginia heavy rail ridership is likely whiter and lower income than pre-pandemic rail ridership. However, while there are differences in who uses transit and how they use it, it is difficult to ascertain whether how long-term these trends may last.

[13]https://www.urban.org/urban-wire/transit-ridership-dropped-heavy-rail-stations-during-covid-19-pandemic-ridership-change-depended-neighborhood-characteristics

4.0 Service Trends and Patterns

Previous studies, like work by the policy think tank TransitCenter, have looked at how the total amount of service has changed[14], much like the analysis in section 2.2. However, more work needs to be done to evaluate not just the change in overall service but also what transit service looks like. A transit system could offer the same amount of total service compared to pre-pandemic levels but cover different areas or change frequencies on different routes. Thus, the tends and patterns described in section 2.2 don't give the whole story. To better understand how Northern Virginia transit services changed, transit services were analyzed in three different ways[15]: access to service, amount of service, and service patterns. Each of these evaluations is described in the sections below.

4.1 Access to Bus Service

Flexibility is one of the major advantages to bus transit. Bus services can be changed and adapted to changing conditions in a way that rail can't. As section 2.0 emphasized, the region saw significant change in both ridership and service conditions. As bus services adapted to these changes, there is the potential that some people who used to have access to bus services may not still have access to bus services. GTFS data can be used with census data to better understand how bus service coverage may have changed and how any potential changes impacted the region. **Appendix B** explains the methodology in more detail.

The analysis focused on three types of populations: total population, households and commuters. Within each of these populations sub-groups were identified for further evaluation. These groups were identified because they disproportionately use or rely on transit. The results of the evaluation are given in Figures 10 through 14. Transit stops were combined for all providers operating within a jurisdiction to give the most comprehensive evaluation of access. For example, the evaluation of Fairfax County includes both stops from the Fairfax Connector as well as Metro. Consequently, even if routes changed operators, as some routes did in Fairfax[16], there is no impact to access if the route still serves the same stops.

As the figures show, between 2019 and 2022, bus access reduced among almost all jurisdictions in Northern Virginia. Only the City of Fairfax had more bus access in 2022 than 2019. The extent of the reduction in bus service was not consistent across the region. While only about 0.5% of Arlington residents saw less access to bus services, the City of Falls Church saw almost a 9% reduction. The degree of change was also not consistent across population sub-groups. Arlington, City of Falls Church and Fairfax County saw smaller reductions in access for non-white and low-income populations than the general population. Conversely, in Alexandria, non-white and low-income populations saw more of a reduction in access than the general population. Access for zero car households, on the other hand, was not reduced more than all households in any jurisdiction. Finally, areas with higher concentrations of public transport commuters were also generally not worse off in any jurisdiction except for the City of

[14] https://transitcenter.org/how-much-service-did-the-largest-transit-agencies-run-in-2021/
[15] OmniRide and Loudoun County Transit services were not included in the analysis due to the lack of 2019 data
[16] https://www.fairfaxcounty.gov/connector/news/c15_21

Falls Church, where about 11% of public transportation commuters had less access to bus services.

4.2 Change to the Amount of Bus Service

Access to bus service is only half of the transit story, the other half of the story is the service frequency. These two transit service factors can be combined to estimate the amount of bus service available to people who live, work and play in Northern Virginia. Specifically, this analysis uses a specific measure of the amount of bus service called the transit supply index (TSI). More about the calculation process used to calculate this measure is included in **Appendix B**. TSI was calculated at the census block group level for Northern Virginia for both 2019 transit and 2022 transit. All regional bus operators were included in the analysis except OmniRide and Loudoun County Transit[17]. We then found the percent change in TSI between these two years and mapped the results, as shown in Figure 16.

As Figure 16 shows, each jurisdiction in the region saw mixes of changes to transit service. Although some areas of west Arlington County and central Fairfax County lost more than 50% of service, these areas had relatively small levels of service to begin with (less than 0.5% of all service is in these areas). Consequently, even a small change in service could have a large percentage change in service. The areas with the biggest increase in service have a similar pattern. Many of these areas had small amounts of service to begin with (less than 1% of all service is in the areas with the biggest increases of service).

Figure 15 breaks down the changes of service by population to better understand the impacts of these changes to service. As the figure shows, between 2019 and 2022, more people saw increases to transit service than decreases. When broken down by sub-groups, it is evident that low-income populations, non-white populations, and zero car households were more likely to experience increases in service, and less likely to see decreases in service, compared to the total population. However, it is worth noting that these changes are generally small (the increase in service for low-income populations and zero car households being an exception).

These results contrast with the results from the access to bus service analysis described in section 4.1. While the previous section showed general decreases in access, and in some cases disproportionate reductions in access for population sub-groups, the change in the total service shows opposite trends. This may suggest that some of the changes to service between 2019 and 2022 focused on more bus frequency and less coverage.

[17] Like with access to bus service, OmniRide and Loudoun County Transit services were not included in the analysis due to the lack of 2019 data

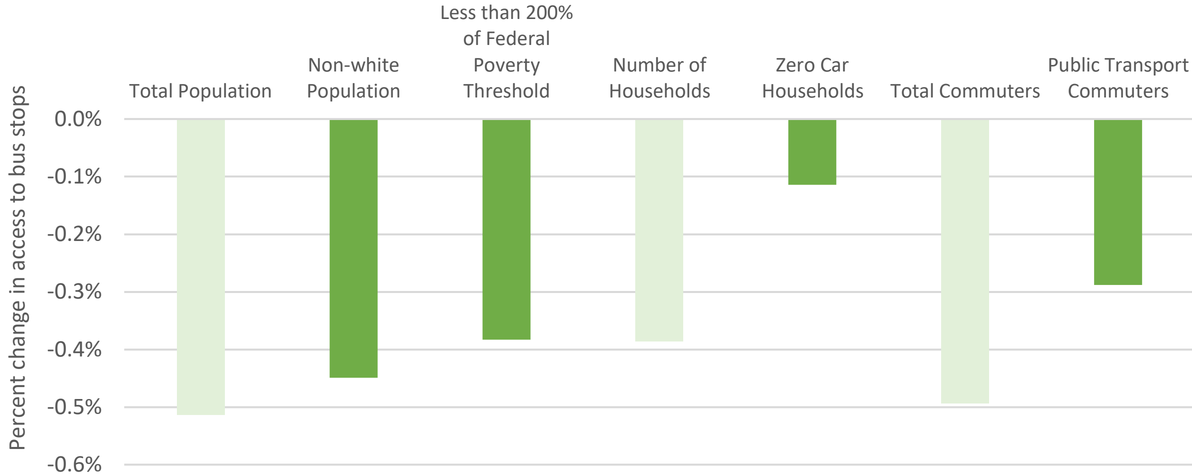

Figure 10: Change in access to bus in Arlington, 2019-2022 (GTFS data and ACS 5-Year Estimates 2016-2020)

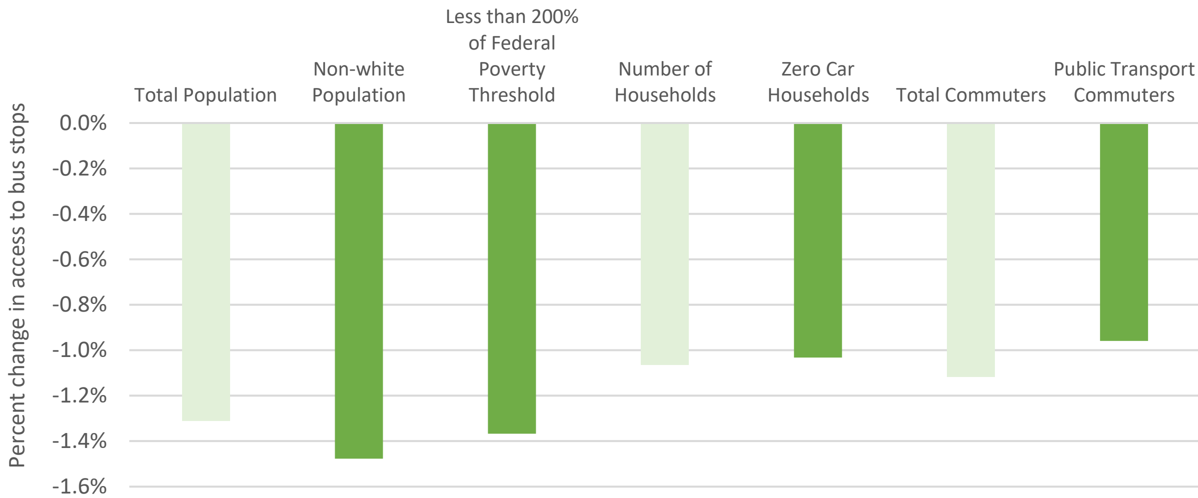

Figure 11: Change in access to bus in Alexandria, 2019-2022 (GTFS data and ACS 5-Year Estimates 2016-2020)

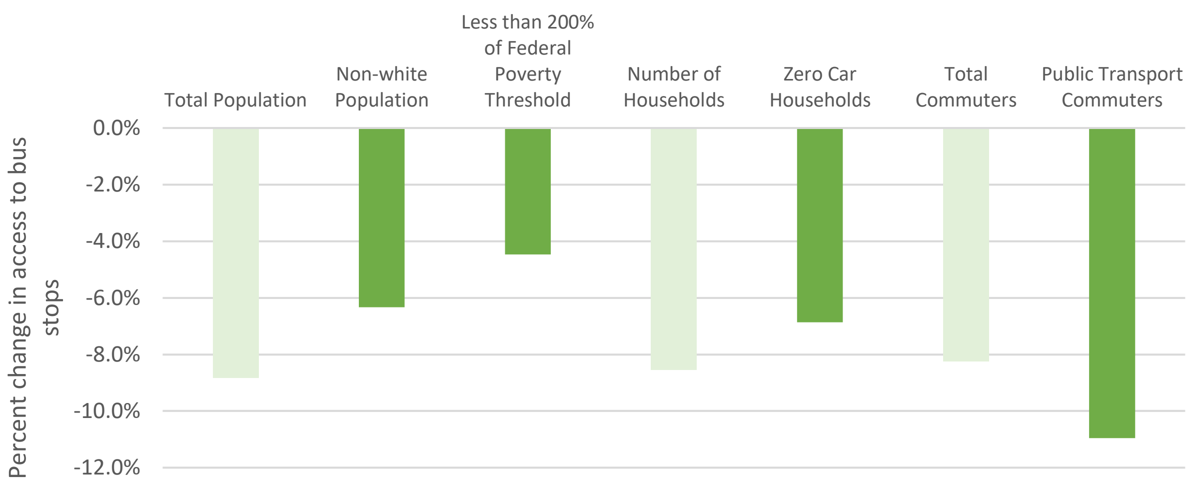

Figure 12: Change in access to bus in Falls Church, 2019-2022 (GTFS data and ACS 5-Year Estimates 2016-2020)

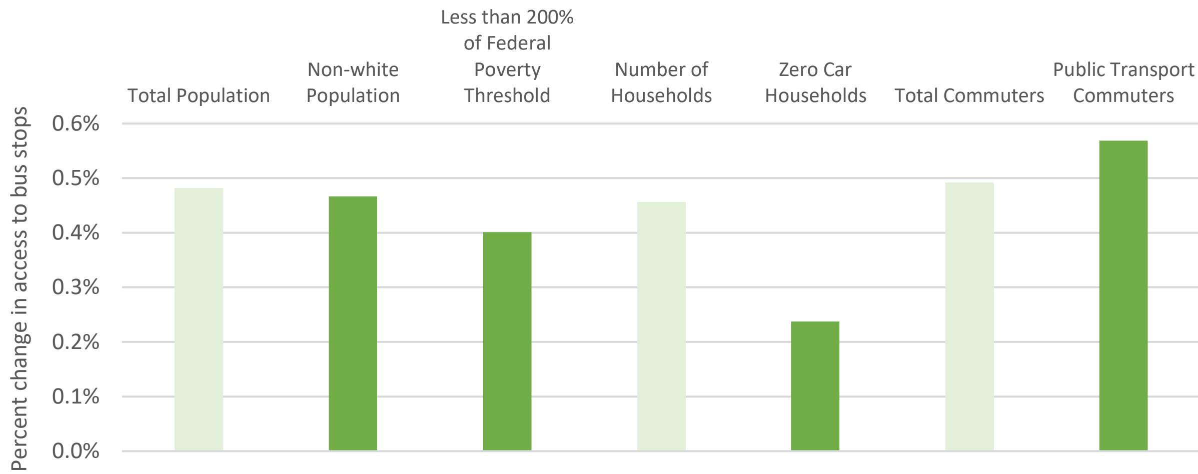

Figure 13: Change in access to bus in City of Fairfax, 2019-2022 (GTFS data and ACS 5-Year Estimates 2016-2020)

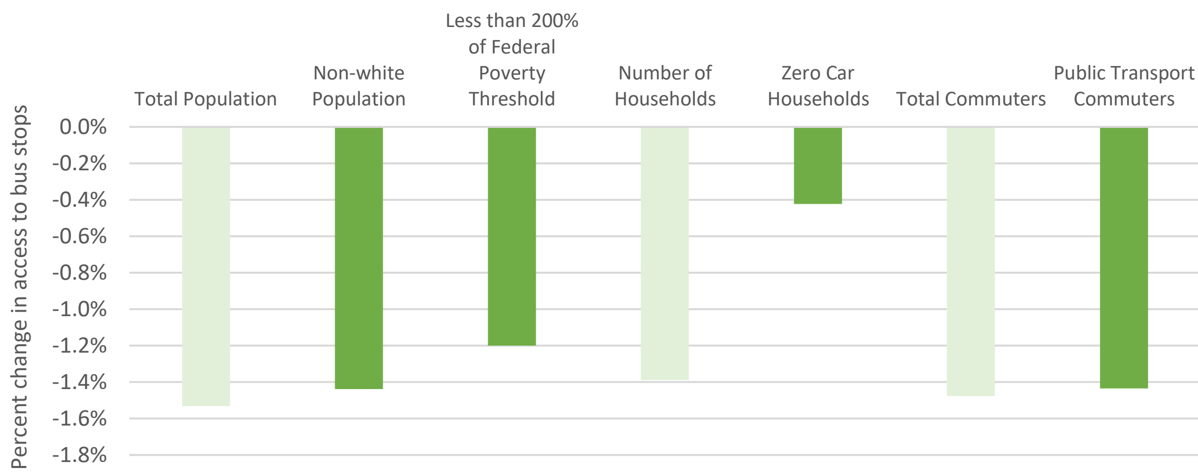

Figure 14: Change in access to bus in Fairfax County, 2019-2022 (GTFS data and ACS 5-Year Estimates 2016-2020)

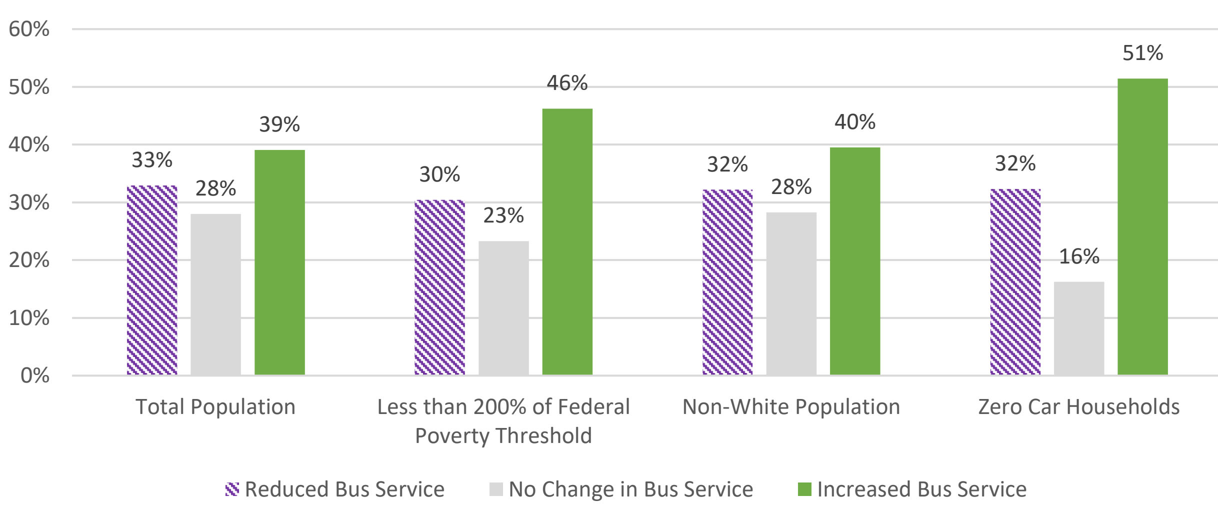

Figure 15: Changes in TSI by population group

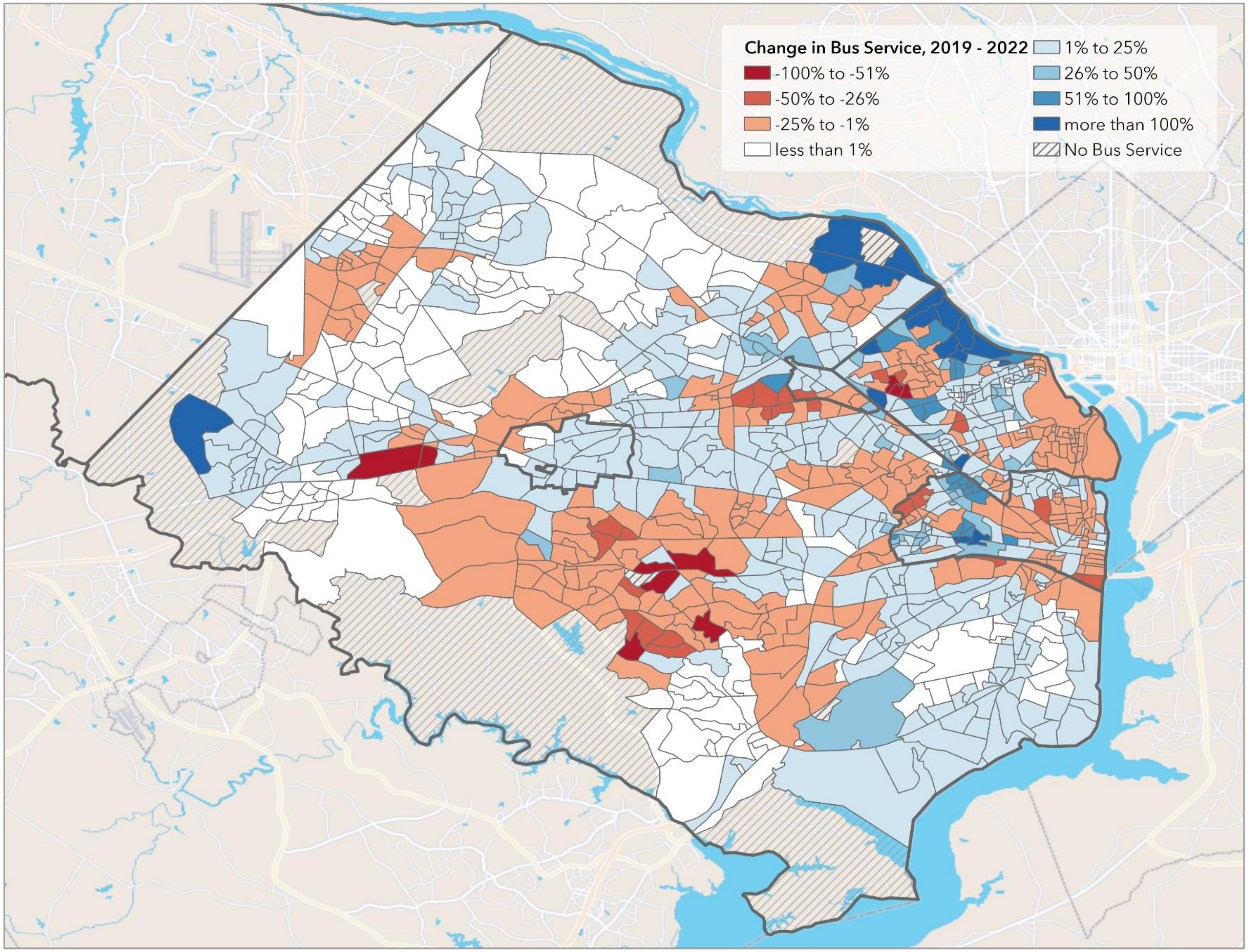

Figure 16: Map of Change in Amount of Bus Service, 2019-2022 (GTFS data and ACS 5-Year Estimates 2016-2020)

4.3 Change to Bus Service Patterns

As observed in section 2.0, travel patterns have shifted during the pandemic. While this report has demonstrated access and amount of service have changed, service patterns may have also changed. To evaluate service patterns, average weekday trips (Wednesday was chosen for consistency) were plotted over a 24-hour period. Trips were summed from GTFS data and plotted in Figure 17, 18, and 19 for Arlington, DASH and Fairfax, respectively. These three agencies were chosen for analysis due to data availability and because all three had changes in amounts of service during the pandemic (see Figure 5). As the figures show, each transit agency has a slightly different story to tell. First, all three agencies have distinct peaking characteristics for their scheduled data. All three agencies have a peak from about 6 a.m. to 9 p.m. and then again from approximately 4 p.m. to 7 p.m. Arlington Transit's weekday service patterns look almost identical between 2019 and 2022, even as the agency shifted and adjusted service, as demonstrated earlier. Conversely, DASH, which recently went through a network redesign, flattened the peak periods a little and added more all-day service. Finally, Fairfax Connector midday service was largely unchanged between 2019 and 2022 but additional trips were added during the peak periods. This likely reflects Fairfax's acquisition of peak-period heavy Metro routes in July 2021[18]. While each agency has a slightly different story to tell, the overall trend is still a peak-period heavy narrative.

In section 3.2, Figure 8 indicated ridership patterns also shifted between weekday and weekend; the proportion of weekend riders relative to weekday riders is higher. Consequently, trip count was calculated by day of week to compare how the proportion of weekend trips changed relative to weekday trips. Like with Figures 17, 18, and 19, Wednesday was used as an average weekday. The results are given in Figure 20. As the figure shows, in pre-pandemic times the proportion of weekend trips to weekday trips was consistent. Across the agencies, an average Saturday had approximately 47% of scheduled weekday service while an average Sunday had approximately 34% of scheduled weekday service. In 2022, Arlington showed no change while Fairfax Connector saw slight decreases in the proportion of weekend trips. DASH, coming out of its redesign, saw the largest change. The agency saw significant increases in weekend trips relative to weekday trips.

The evaluation of transit services in the region has demonstrated that there has been some change in service patterns over the last three years; however, the pattern of change has varied significantly between different transit agencies and geographies. Unsurprisingly, DASH has seen the most change. All transit agencies included in the analysis have shifted where people can access transit services. However, how the amount of service offered in different time periods has not changed as much. Overall, the evaluation has demonstrated that, although there has been much change, outside of DASH, the change has been incremental. Northern Virginia transit services still largely reflect the same type of service patterns seen before the pandemic emphasizing weekday and especially peak hour periods[19].

[18] https://www.fairfaxcounty.gov/connector/news/c15_21
[19] Grant funding for peak services may have also played a role in explaining these patterns

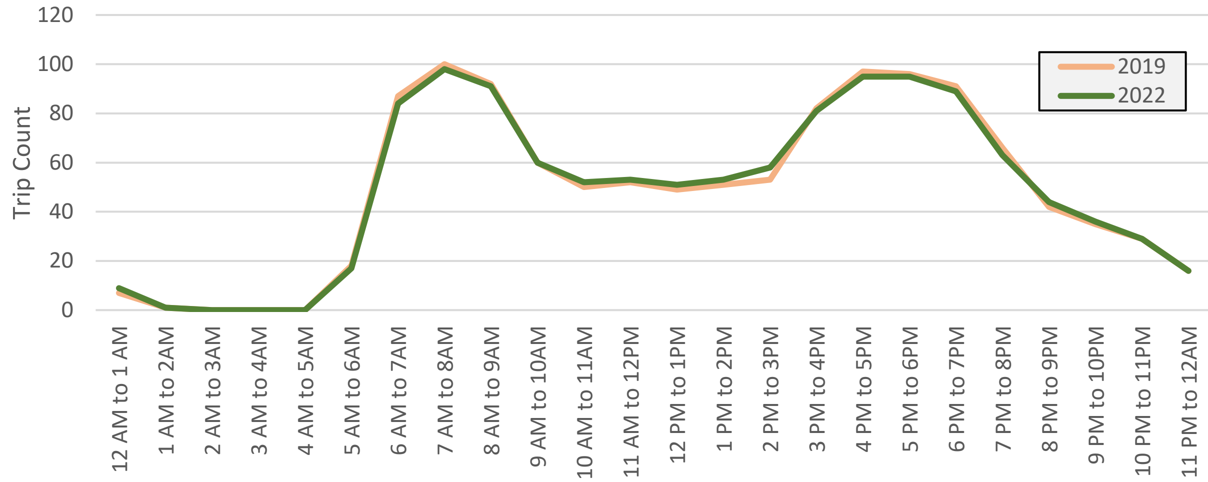

Figure 17: Arlington Transit Wednesday transit trip start times (GTFS data)

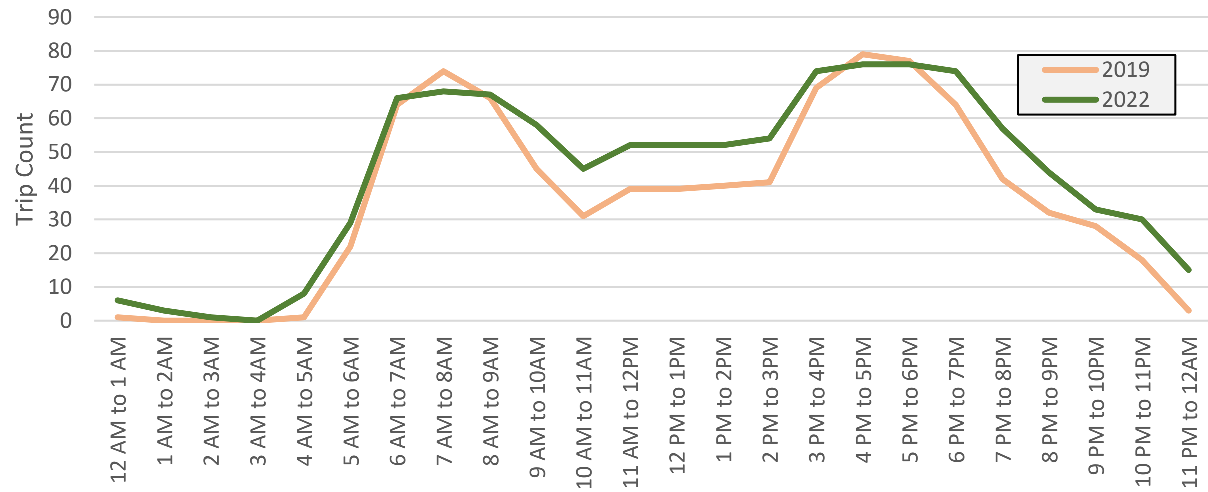

Figure 18: DASH Wednesday transit trip start times (GTFS data)

Figure 19: Fairfax Connector Wednesday transit trip start times (GTFS data)

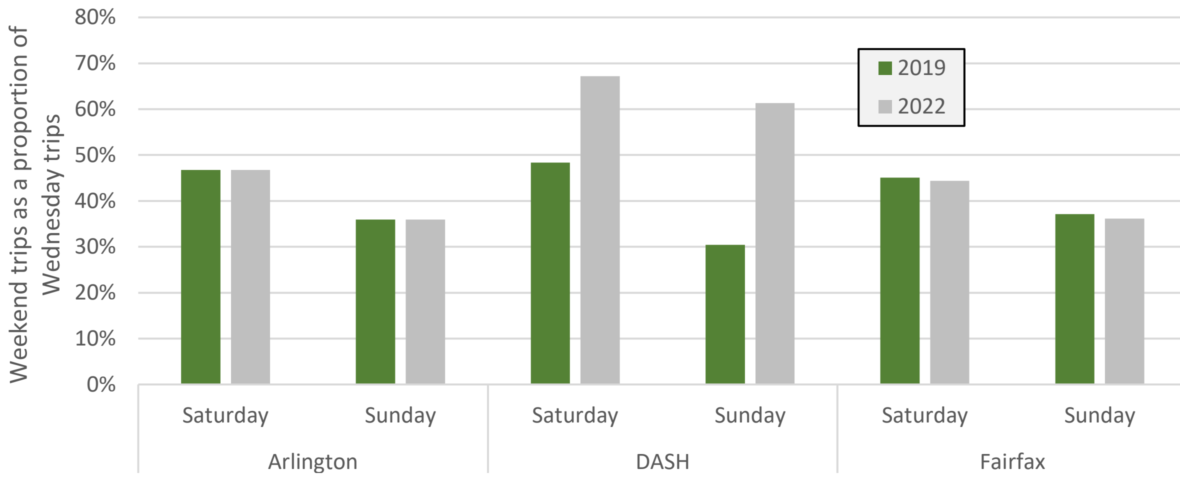

Figure 20: Weekend transit trips as a proportion of an average weekday's transit trips (GTFS data)

5.0 What does this all mean?

This report has so far provided extensive analysis and evaluations of Northern Virginia transit service and ridership over the past three years. A lot has changed. The story of transit ridership has shown that each transit agency has its own tale. Simultaneously, the evaluation of transit services has been telling its own story. How do these narratives intersect? This final section of the report connects these two stories. Section 5.1 connects ridership to transit service, explaining the implications of the changes and patterns that have been observed. Sections 5.2 and 5.3 then provide a summary of the overall observations before explaining what opportunities there may be to advance Northern Virginia transit.

5.1 The Relationship between Transit Service and Ridership

Ridership and transit service are intimately entwined. To demonstrate this, Figure 21 plots bus ridership against revenue service hours for pre-pandemic Northern Virginia transit service[20]. The dotted line is a trendline that minimizes the distance between all the data points. The equation on the chart is the relationship between revenue service hours and ridership. In this case, an increase of one service hour (x) is correlated with an increase in 10 additional transit riders. R^2 is a measure of goodness-of-fit; it shows how well the trendline explains the variation in ridership. In this case, the R^2 indicates that the trendline explains 96% of the variation in ridership. This indicates the relationship between ridership and transit service is very strong.

Figure 22 plots the same type of data during the pandemic[21]. Although the R^2 is still strong, showing the trend line explains approximately 95% of the variance in the data, the relationship between ridership and service hours have changed. While previously an increase of one service hour (x) is correlated with an increase in 10 additional transit riders, the data during the pandemic shows this one service hour (x) is now correlated with an increase in 6.4 additional

[20] Rail was not included because of how different rail service is to bus service

[21] Graph begins in June as March through June saw significant, atypical fluctuations as both transit agencies and transit ridership adjusted to the pandemic

transit riders, a 36% reduction. These different numbers suggest a change in the relationship between transit service and ridership.

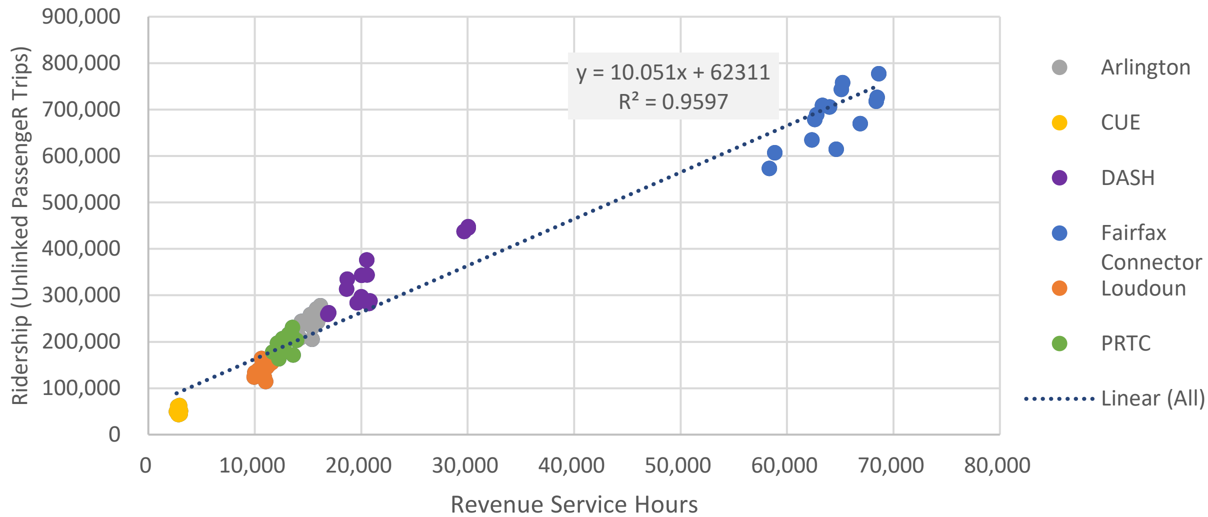

Figure 21: Pre-pandemic bus service and bus ridership (Jan 2019 – Feb 2020) (DRPT OLGA data)

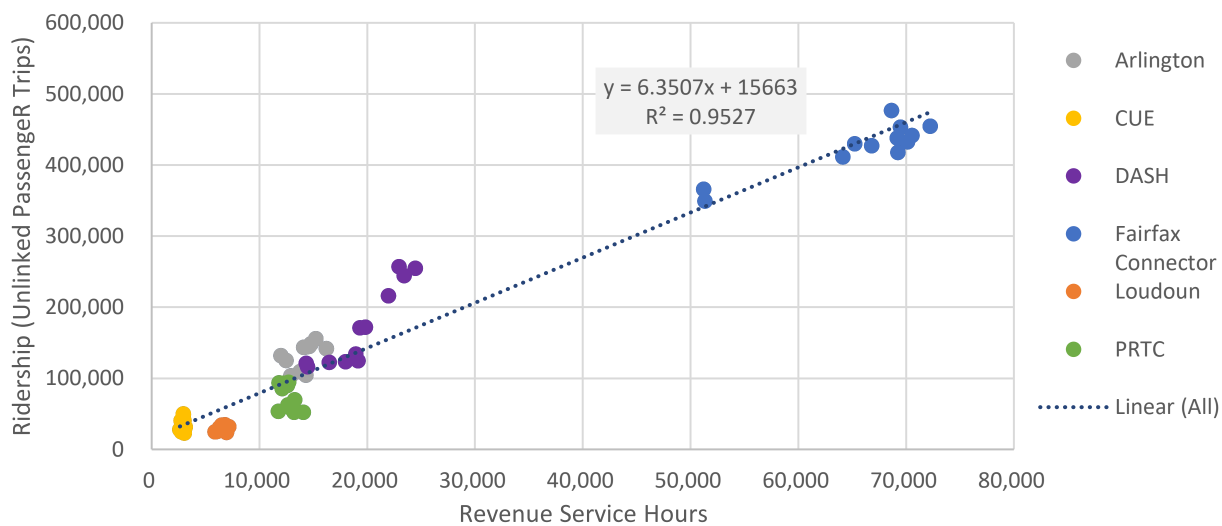

Figure 22: Pandemic bus service and bus ridership (Jul 2020 – Feb 2022) (DRPT OLGA data)

As sections 3.0 demonstrated, there is more nuance in transit service than just total amount of service hours. Service and ridership can and do vary by time of day and day of week. So, while Figure 21 shows a steeper relationship between ridership and revenue service, this is likely because the transit service, at least to an extent, matches the travel patterns and behavior of the region's transit users. But what happens if travel patterns and behavior change, like section 3.0 suggested? If transit behavior changes, but service patterns don't, the relationship between revenue service hours and ridership would change. Figure 22 shows a hint of this with DASH. The purple points moving away from the trendline show how DASH ridership and service hours changed after their network redesign took effect. It is evident that DASH adjusting the type of service to meet changes in demand resulted in a better relationship between the amount of service and ridership. The relationship between transit service and ridership can be further evaluated using a measure of transit productivity.

Transit productivity is a measure of transit efficiency. It can indicate how well transit service is serving transit users. More detail about the calculation is given in **Appendix B**. In Figure 23 a measure of transit productivity, passengers per vehicle revenue hour, is plotted for Northern Virginia bus operators for the past three years. As the figure shows, transit productivity dropped at the beginning of the pandemic. This is not unexpected as section 2.0 shows significant changes to ridership and service levels. However, as Figure 5 showed, transit service was mostly back to pre-pandemic levels within four months. Even though most bus service returned, transit productivity didn't fully recover. Some of this may be because of teleworking. However, this likely doesn't explain the whole story because, as mentioned in section 3.0, bus was likely less affected by telework than rail. As we also saw in section 3, transit started being used differently after the pandemic arrived. Weekend ridership became relatively larger and different demographic groups changed their transit use in different ways. Nevertheless, as section 4.0 highlighted, the region's transit looks functionally similar to 2019, DASH and its redesign being an exception. Thus, changing rider behavior with relatively unchanged transit could help explain the drop in transit productivity.

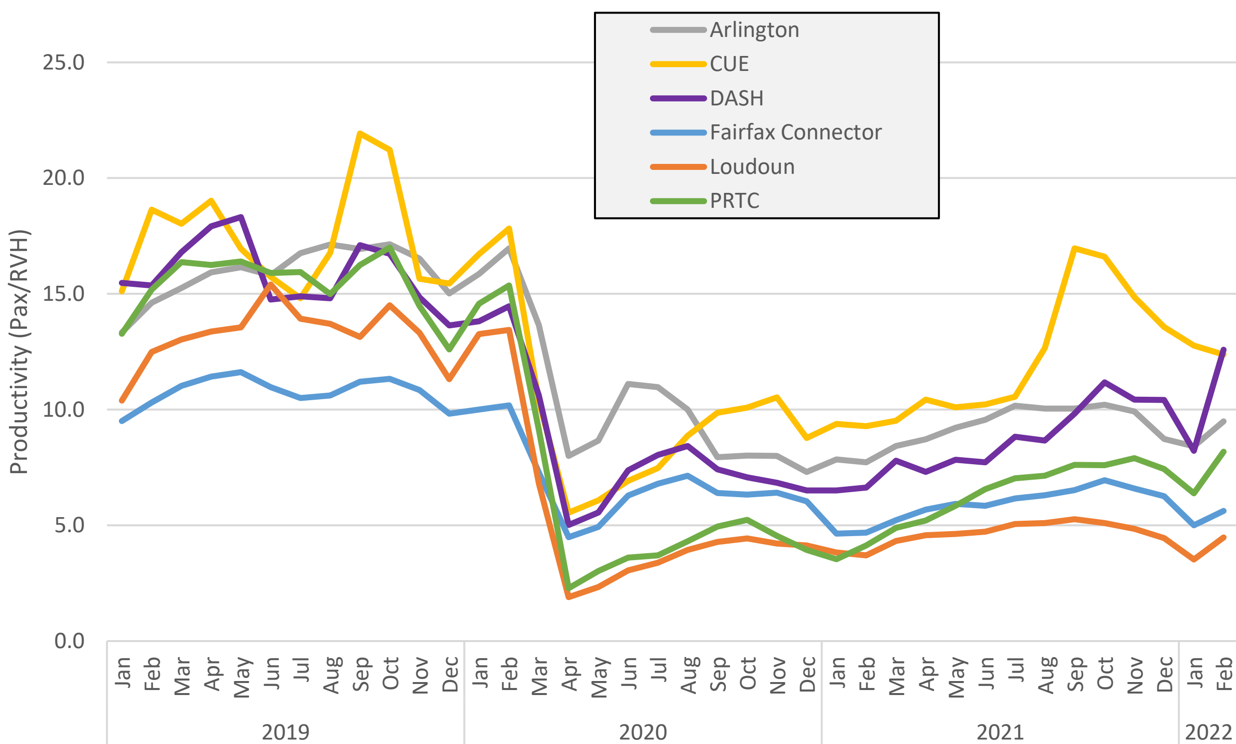

Figure 23: Transit productivity for bus operators (DRPT OLGA data)

5.2 Observations

Transit service and transit ridership are linked. Considering this relationship, there are four key observations from this report:

- **Returning transit services was correlated with ridership recovery**

Although the previous section discussed a change to the relationship between transit service and ridership, Figure 22 showed there is still a strong correlation between service recovery and ridership recovery. While the analysis contained in this report has demonstrated increases to service do not correspond with the same increase in ridership they once did, there is still a relationship between increasing service and increasing ridership.

- **One size doesn't fit all for pandemic impacts to transit**

As James Walkinshaw, a member of the Fairfax County Board of Supervisors and an NVTC Commissioner, mentioned at an NVTC Legislative and Policy Committee meeting[22], not all transit modes are going to recover in the same way. This report has empirically supported Mr. Walkinshaw's comments, demonstrating that while all transit agencies that operate in Northern Virginia have been hit hard by the pandemic, the degree to which ridership has suffered depends on the mode of transit service and the type of riders the system was serving. Consequently, what might help one transit agency recover ridership may not help another agency recover in the same way. This supports the need for a wider policy toolkit for helping transit systems recover.

- **The region should re-evaluate how transit riders are using transit today**

Before the pandemic, there was a strong correlation between the amount of transit service and ridership. This suggested transit agencies had a good idea how people were using transit and why. However, as section 3.0 demonstrated, the way people use transit has changed. Although the available data can show this in some ways, more work needs to be done to understand both how transit ridership has changed in Northern Virginia and how long-term these changes may be.

- **The region needs to design transit services for how people use transit today, not how they used transit before the COVID pandemic**

Section 3.0 has demonstrated some changes to transit behavior while transit services look functionally similar. Once transit ridership is re-evaluated, transit services must go through a similar re-evaluation process. Service patterns might need to change. The reduced commuter emphasis may mean more emphasis on trips between jurisdictions, not into Washington, DC. As sections 2.1 and 3.1 emphasized, there especially needs to be an increased emphasis on bus transit.

[22] May 25, 2022, https://www.youtube.com/watch?v=ZgJWmzv0KL4

5.3 Opportunities

Considering the trends, patterns and observations found in this report, the final question to ask is what can be done in response.

First, although rail has been hit the hardest by the pandemic, due to its fixed locations, it has the least ability to react to changing conditions. Thus, rail recovery is somewhat dependent on the recovery of some of the previous commuting patterns. A reduction in federal workforce teleworking, for example, will go a long way to helping rail's recovery. Marketing and communication strategies coinciding with large employers returning to the office might also help. NVTC's summer 2021 and 2022 transit campaigns are an example of this kind of strategy. Ensuring service is ready for when people do return, as described with VRE in section 2.2, is another opportunity to help with ridership recovery.

While opportunities for rail are limited, bus transit, has more options. The flexibility of bus makes it much easier for the mode to adapt and change to new conditions. Some of the transit providers in the region are already adjusting their bus services accordingly. DASH finished their network redesign in 2021, Fairfax County is currently in the process of revaluating their bus network and Metro is about to kick-off a systemwide bus redesign.

In addition to bus network redesigns, there is an opportunity to think about the types of trips being offered. With a reduced emphasis on commuting and more emphasis on non-commute trips like shopping, getting to medical appointments and accessing entertainment, there may be more need for cross-jurisdictional transit trips. Consequently, as the region re-evaluates what transit should look like now, part of this evaluation could consider more cross-jurisdictional transit, especially trips that could help facilitate non-commute travel purposes. These types of trips are currently not as prioritized in the region's current transit network but could become a more important part of the transit fabric. Further to this, the evaluation of transit ridership and subsequent transit service may highlight existing or new gaps in transit services. Where is there a need for transit service that is not currently being served? Section 4.1 and 4.2 demonstrated there are shifts in transit access already. More work needs to be done to identify mismatches between transit need and transit service. Both cross-jurisdictional transit and a regional gap analysis could be addressed in the planned NVTC regional bus plan[23].

To conclude, the region's transit has been in a state of flux. As we come to terms with what the "new normal" looks like, we need to look at the region's transit anew. Where can the borders between agencies be blurred? What new routes or services can we imagine that we have not considered before? How can the Northern Virginia transit experience be improved? While this has been a challenging period for transit, looking forward, there are many opportunities to learn from and improve on our transit systems to make a more useful, resilient system for Northern Virginia's residents, workers, and visitors.

[23] Procurement expected to begin Fall 2022

Appendix A – Data

Monthly Ridership Data – DRPT

The most comprehensive transit ridership data, in terms of number of operators and time extent, includes data from all transit services that operate in Northern Virginia, including City of Alexandria, DASH, Loudoun County Transit, OmniRide, the Virginia Railway Express (VRE), Arlington Transit, Fairfax Connector, City of Fairfax's City-University-Energysaver (CUE), and Metro (WMATA). Transit services include local bus (e.g., DASH), commuter bus (E.g., OmniRide), paratransit (e.g., City of Alexandria), heavy rail (e.g., Metrorail), and commuter rail (e.g., VRE).

The transit ridership data is aggregated to months as this is the required reporting format for the Virginia Department of Rail and Public Transportation (DRPT). Thus, the data used in this analysis is monthly ridership for all transit agencies for all transit modes in Northern Virginia. The data used in this analysis, provided by DRPT, ranges from January 2019 to February 2022. This range includes a year of pre-pandemic data up until the most recent data available.

Day of Week Ridership Data – Northern Virginia Bus Operators

For some Northern Virginia transit operators data was available by route by day of week. These data were available for Arlington Transit, CUE, DASH, Fairfax Connector, Loudoun County Transit, and OmniRide. Day of week data were available between January 2019 and December 2020.

Metrorail Ridership Data

Metrorail data is the most granular data available at the time of this report. Data are provided at the station level by day of week and approximate time of day (morning, midday, afternoon, and evening).

Census Data

Census data were obtained from American Community Survey (ACS) estimates. For the analyses in this report ACS 2016-2020 5-year estimates were used. These data were obtained at the census block group level.

Transit Service Data – GTFS (General Transit Feed Specification)

Originally developed by Google, GTFS[24] is a standard data format for transit schedules. Transit agencies use GTFS to feed scheduled data into applications like Google Maps, Apple Maps and transit apps. The data include everything that is needed to know when and where transit will be available, including: the specific location of transit stops, the timing and sequence of transit trips, the number of trips for each transit route and the days of the week each transit route operates.

[24] https://developers.google.com/transit/gtfs

Appendix B – Methodology

Trendline Analyses and Indexation of Transit Ridership

A trendline analysis evaluates trend or patterns in the same variable over many time periods. For example, number of transit revenue vehicle hours month-over-month. A trendline can be descriptively evaluated to identify potential trends or patterns.

Indexation of Transit Ridership

Transit ridership is given as an index to calendar year 2019 (CY 19). This is calculated as follows:

1. Average total transit ridership from January 2019 through December 2019
2. Divide monthly ridership by the averaged number from step 1
3. Multiply the values from step 2 by 100 to get a percentage

Indexing to CY 19, a full year of pre-pandemic transit ridership, allows us to better see how well ridership is recovering compared to pre-pandemic ridership levels. For example, the calculation for September 2021 is 40%, meaning that ridership for that month is 40% of the pre-pandemic average. Achieving 100% means ridership has fully recovered.

Average Bus Speeds

Speed is a measure of distance over time (E.g., miles per hour). Available transit service data includes both vehicle revenue miles (VRM) and vehicle revenue hours (VRH). Consequently, we can estimate average transit speed using the following:

$$Average\ Speed_i = \frac{\sum VRM_i}{\sum VRH_i}$$

Where *i* is an individual transit agency. This calculation repeated over time can be evaluated using a trendline analysis to observe changes to service planning.

Estimating Day of Week Ridership from Monthly Data

Day of week ridership can be estimated from aggregated monthly ridership if the proportion of Saturday to weekday ridership and Sunday to weekday ridership is known. The equation for estimating the ridership with these values is given below:

$$M_{ij} = A_j X + B_j XP + C_j XQ$$

Where:

M is monthly ridership;

A is the number of weekdays for month *j;*

B is the number of Saturdays for month *j;*

C is the number of Sundays for month *j;*

X is the estimated weekday ridership;

P is the proportion of Saturday ridership to weekday ridership estimated as ridership for an average Saturday divided by ridership for an average weekday;

Q is the proportion of Sunday ridership to weekday ridership estimated as ridership for an average Sunday divided by ridership for an average weekday;

i is an individual transit agency;

j is a month.

NVTC has historically assumed Saturday ridership is 50% of weekday ridership (*P*) and Sunday ridership is 30% of weekday ridership (*Q*). Thus, for example, if monthly ridership for a transit agency was 10,000 for May 2022 (which has 22 weekdays, 4 Saturdays, and 5 Sundays), we would have the following:

$$10{,}000 = 22X + (4)(0.5)X + (5)(0.3)X = 22X + 2X + 1.5X = 25.5X$$

$$X = 392$$

Putting *X* back into the equation gives us the following:

Day	**Average Daily Ridership**	**Monthly Ridership**
Weekday	392	8,627
Saturday	196	784
Sunday	118	588
Total		10,000*

**±1 with rounding*

Estimating Populations with Access to Transit

Census and GTFS data can be used to estimate the number of people and households that have access[25] to transit. By using different census variables, demographics and characteristics of populations with access to transit can be estimated. The step-by-step process for doing this is described below:

1. Plot transit stops/stations as points
2. Create a buffer around the stops/stations
    a. ¼ mile for bus stops
    b. ½ mile for higher-frequency transit like BRT or rail
3. Join buffers together if:
    a. Estimating populations at a transit system level
    b. Estimating populations at a route level
4. Plot census data
5. Use spatially weighted areal interpolation to estimate the number of people from the census data who might fall within the transit buffers

[25] Standard practice assumes transit is accessible within ¼ mile of transit stops for lower frequency services, like local bus, and ½ mile of transit stops for higher frequency services, like rail.

Estimating the Amount of Transit Service

The amount of transit service available in a census geographic unit was estimated using a method described by Bertolaccini and Lownes (2013)[26]. The authors used GTFS data to calculate a transit supply index (TSI) calculated using the equation below:

$$TSI_{GU} = \sum_{R} \left(\frac{coverage\ area_{R,GU}}{total\ area_{GU}} * f_{R,GU} \right)$$

Where:

$f_{R,GU}$ is the mean weekly vehicle arrivals for a stop

R is a specific route

GU is a geographic unit (e.g., census block group)

Bertolaccini and Lownes give the following steps to calculate TSI:

1. Generate 0.25 mi and 0.50 mi buffers around bus and rail stations, respectively, and dissolve by route and weekly frequency.
2. Perform a union between the buffer layer and the areal unit (block group–census tract) layer. Dissolve by route and areal unit and find the mean weekly frequency for each route through a particular areal unit.
3. Find the percentage of each areal unit covered by a route's dissolved buffer and multiply by the mean weekly frequency. This calculation provides the supply score of one route through an areal unit.
4. Sum all supply scores within an areal unit to find the total TSI of each block group–census tract.

Example

A sample block group is shown in Figure 1. Two bus routes (A and B) and one rail line serve this block group. Figure 1 includes buffers generated in Step 1 of the procedure. Steps 2 and 3 of the outlined procedure will give the results shown in Figure 2. To find the total TSI of the block group, sum the supply scores found for each of the routes. This block group has a TSI of 82.25.

[26] Bertolaccini, K. and Lownes, N.E., 2013. Effects of scale and boundary selection in assessing equity of transit supply distribution. *Transportation Research Record*, 2350(1), pp.58-64. https://doi.org/10.3141%2F2350-07

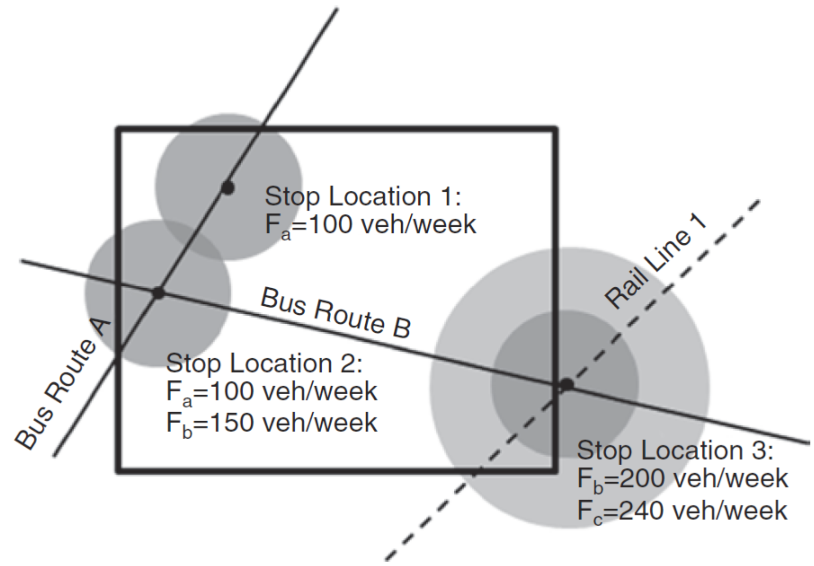

FIGURE 1 Sample block group (F_a = frequency of Bus Route A; F_b = frequency of Bus Route B; F_c = frequency of Rail Line 1; veh = vehicle).

Transit Productivity

Transit productivity can demonstrate the efficiency of transit services. Two common ways to do this are passengers per revenue hour (Pax/VRH) and passengers per revenue mile (Pax/VRM). The calculations for these two measures are given in equations 1 and 2, respectively, below.

$$Passengers\ per\ revenue\ vehicle\ hour = \frac{\sum UPT}{\sum VRH} \quad (1)$$

$$Passengers\ per\ revenue\ vehicle\ mile = \frac{\sum UPT}{\sum VRM} \quad (2)$$

Where UPT is unlinked passenger trips (ridership), VRH is vehicle revenue hours and VRM is vehicle revenue miles.