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TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP RESEARCH REPORT 209

Analysis of Recent Public Transit Ridership Trends

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2020

TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, adapt appropriate new technologies from other industries, and introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

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FOREWORD

By Dianne S. Schwager
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TCRP Research Report 209 presents the results of a quick-study analysis of recent transit ridership trends. Transit ridership across the United States has declined for six straight years. Bus ridership, which has declined more than other transit services, is now at the lowest point since at least 1973. Rail ridership, with the exception of commuter rail, has also declined, and commuter rail ridership has recently leveled off. The audience for this report includes transit agencies; local, state, and federal governments; and others interested in transit ridership trends.

The objectives of TCRP Project J-11/Task 28 were to (1) produce a current assessment of public transit ridership trends in the United States on bus and rail services in urban and suburban areas, focusing on what has changed in the past several years, and (2) explore and present strategies that transit agencies are considering and using for all transit modes in response to changes in ridership. The Georgia Tech Research Corporation conducted this quick-study project through a literature review, transit ridership analysis, and case studies that focused on strategies being used to mitigate transit ridership losses.

Changes in transit ridership are presented in this report at regional levels separately for mixed traffic modes (typically bus-based services) and dedicated right-of-way modes (typically rail-based service). A snapshot analysis using 2012 data was conducted, followed by a trend analysis for the period 2012 to 2016. The report examines the relationship between transit ridership and the following three major factors that are purported to influence transit ridership: population, transit-dependent population (i.e., zero-vehicle households), and transit service levels (i.e., transit vehicle revenue miles).

This research identified strategies for mitigating ridership losses through a review of the literature and news articles, followed by 10 case studies. Strategies transit agencies are undertaking include increasing transit service levels, adding new mobility options, and improving technology and customer amenities.

TCRP has initiated a larger research project (TCRP A-43, "Recent Decline in Public Transportation Ridership: Analysis, Causes, Responses," https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4524) to further examine transit ridership and strategies for improvements. This project, which is also being conducted by the Georgia Tech Research Corporation, will examine ridership in more detail at the route and station levels to better understand the factors affecting transit ridership. The objectives of this research are to (1) help public transportation agencies better understand changes in ridership under specific operating circumstances, (2) identify and compare strategies to increase ridership or mitigate declines in specific service areas or corridors, and (3) develop clear guidance on how public transportation agencies can apply these research findings.

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SUMMARY

Analysis of Recent Public Transit Ridership Trends

Transit ridership across the United States has declined for six straight years. Bus ridership, which has declined more than other transit services, is now at the lowest point since at least 1973. Rail ridership, with the exception of commuter rail, has also declined, and commuter rail ridership has recently leveled off.

Research Objective and Approach

The objectives of this research were to (1) produce a current snapshot of public transit (bus and rail) ridership trends in urban and suburban areas in the U.S., focusing on what has changed in the past several years, and (2) explore and present strategies that transit agencies are considering and using for all transit modes in response to changes in ridership. The research approach included a literature review, transit ridership analysis, and case studies.

Ridership Analysis by Cluster

The research on systemwide changes in transit ridership presented in this report was organized around two sets of clusters that grouped transit agencies according to similar operating environments and service characteristics. As shown in Table 1, one cluster analysis was for regions with transit services in mixed traffic (typically bus-based services), and the other cluster analysis was of regions with transit services in a dedicated right-of-way (ROW) (typically rail-based service).

In the analysis produced for this report, we have used the clustered regions to produce a current snapshot of public transit ridership trends. For each cluster, a trend analysis was performed to examine the relationship between transit ridership and the three major factors influencing transit ridership: population, transit-dependent population (i.e., zero-vehicle households), and transit service levels (i.e., transit vehicle revenue miles). Historically, transit ridership has increased with increases in each of these factors.

In each case, the relationship between transit ridership and each of these three factors is first evaluated using only 2012 data to understand the steady-state effects each factor has on transit ridership after decades of interaction. Then, the percentage change in transit ridership is compared to the percentage change in each of the three factors between 2012 and 2016 to understand their relationship in the recent past. The results are shown in Table 2. Additional key points from the transit ridership change analysis include the following:

- Although not uniformly true, in most regions, population has increased; thus transit ridership per capita has been falling at an even faster rate than total transit ridership.

Table 1. Transit agency clusters.

Mixed Traffic Clusters		Dedicated Right-of-Way (ROW) Clusters	
Cluster 1	Mid-sized, transit-oriented	Cluster A	Los Angeles
Cluster 2	Mid-sized, auto-oriented	Cluster B	Dense metropolis
Cluster 3	Sprawling small towns	Cluster C	Mid-sized, dense
Cluster 4	Sprawling metropolis	Cluster D	Mid-sized, dense, auto-oriented
Cluster 5	Dense metropolis	Cluster E	Sprawling metropolis

Table 2. Analysis of factors impacting transit ridership and change in transit ridership.

	Population	Transit-Dependent Population	Transit Service Levels
Mixed Traffic ROW (Intra-city bus, commuter bus, bus rapid transit, and streetcar service)	**2012**		
	Strong relationship for population and ridership in every cluster except sprawling metros (Cluster 4).	**Very little** relationship between zero-vehicle households and transit ridership.	**Strong** relationship between transit ridership and transit service levels, especially in mid-sized MSAs.
	Change from 2012 to 2016		
	No relationship linking cities that had population gains to increases in transit ridership.	Change in transit ridership and change in zero-vehicle households are **only** linked in the largest metros.	Change in service also more strongly linked to change in ridership in mid-sized MSAs, but **nonexistent** in larger metros.
Dedicated ROW (Heavy rail, light rail, monorail, and hybrid rail)	**2012**		
	Moderate relationship for population and transit ridership.	**Minimal** relationship between zero-vehicle households and transit ridership.	**Strong** relationship between transit ridership and transit service levels.
	Change from 2012 to 2016		
	Also, **moderate** relationship for change in population and change in transit ridership.	**No** relationship between change in zero-vehicle households and change in ridership.	**Moderate** relationship between change in transit service and change in transit ridership.

Population has historically been a strong predictor for bus ridership, but **mixed traffic (generally bus) ridership change seems unaffected by the increases in population**. Population is a more moderate predictor for dedicated ROW (mostly rail) ridership historically, and population change explains some of the recent rail ridership changes.
- **Transit-dependent population** is not a good predictor of ridership or ridership change.
- The amount of transit service provided is an important lever available for transit agencies to affect transit ridership. **The relationship between transit ridership and transit service levels is strong.** Especially in mid-sized metropolitan statistical areas (MSAs), transit service levels explain almost all of the variation in transit ridership. However, in looking at recent changes in transit service in the larger metro areas, **more bus service does not equal more bus riders.** The change in transit ridership is much more closely associated with recent change in transit service levels for dedicated ROW modes than for mixed traffic modes.
- Each marginal vehicle revenue mile is associated with twice the transit ridership in mid-sized transit-oriented regions, such as those in the Rust Belt than in similar midsize car-oriented regions in the Sun Belt. Similarly, the relationship between transit ridership and transit service levels is three times greater for transit-oriented metro areas than for car-oriented metro areas. In other words, **increasing transit service in denser transit-oriented regions** (both midsize and large metros) **will increase transit ridership much more than car-oriented regions**.
- **Small to mid-sized regions that did not increase transit service levels between 2012 and 2016 should expect 8–10% loss in transit ridership.** The y-axis intercept of the trend lines in transit service change versus transit ridership change figure is the amount of ridership change that should be expected if transit service levels had not changed ($x = 0$). Although there is a definite relationship between the change in transit ridership and the change in transit service levels, there is some other effect at play that is driving transit ridership down across clusters. Only if transit service was substantially increased would transit ridership go up. If service levels remained the same, in most regions, transit ridership would have decreased.

Strategies to Improve Transit Ridership

Transit agencies throughout the U.S. have initiated or are developing strategies to improve customer service and increase transit ridership. This research project identified many of these strategies through the literature and news article review. Strategies transit agencies are undertaking include

- **Increasing transit service levels** by restructuring bus networks and service expansion through adding new modes, such as light or heavy rail. Transit agencies are also adding dedicated ROW by increasing the use of bus rapid transit.
- **Adding new mobility options**. An emerging area includes partnerships with transportation network companies (TNCs) and bike, scooter, and car sharing companies, either to subsidize trips or through data partnerships. Similarly, some transit agencies are adding demand response and flex routes that function like the TNC services but are provided by the transit agency in the form of microtransit pilots.
- **Improving technology and customer amenities**. Technology improvements, including new fare media and better fare media integration as well as real-time information are improving customer service.

Many of these strategies, those increasing in adoption, have not been widely studied as to their impacts on transit ridership. Although some anecdotal evidence was provided by the case studies, far more research is needed to understand the impacts of these strategies on transit ridership.

Case Studies

Ten case studies were undertaken to better understand individual strategies transit agencies are using to mitigate ridership losses and increase ridership overall. Transit agencies were asked about their strategies, ridership over the past several years, and speed and reliability metrics. The strategies used by the case study transit agencies and the resulting ridership changes are summarized in Table 3. Some key results from the case studies include the following:

- **Nearly every transit agency investigated in the case studies had ridership increases through 2015 followed by steady decreases in ridership.** The exceptions to this are Houston, TX; Portland, ME; and Seattle, WA, which all saw steady or increasing ridership but also increased service substantially. In all other cases, among the transit agencies where ridership declined, the amount of service provided has remained relatively similar over this time or has only slightly increased.
- **In every transit agency reviewed, average speeds have decreased or have remained the same, indicating that more vehicles are frequently needed to offer the same or degraded service.** Some transit agencies have fought hard to keep average speeds up using strategic improvements such as signal priority or improvements to boarding.
- **Generally, on-time performance has been improving, although it is not causing transit ridership to increase.** If anything, the trend appears that on-time performance is easier to maintain as ridership has decreased.
- **Rail ridership declines have occurred later than bus ridership declines, but a similar pattern exists.** Only with substantial increases in transit service have there been substantial increases in ridership. Commuter rail seems to be faring better. Whatever is impacting bus transit ridership across the country does not have the same impact on the dedicated ROW longer-distance commuter rail services.

Table 3. Case study results.

Agency	Strategies	Results
Connect Transit Bloomington–Normal, IL	• Network redesign • Increased frequency • Real-time information	Ridership up until 2015, then down through 2017, slowly increasing again.
Greater Portland Metro Portland, ME	• Speed and reliability improvements • High school and university partnerships • Real-time information • Express routes	Ridership up until 2017 and then steady. Average speed also increasing.
IndyGo Indianapolis, IN	• Expanded frequency and hours • Downtown Transit Center	Ridership down since 2015. Average speeds down, but on-time performance has improved.

Table 3. (Continued).

Agency	Strategies	Results
King County Metro Seattle, WA	• Bus Rapid Transit • Improved fare payment • New streetcar	Bus ridership up until 2017 and then steady. Average speeds down. Rail ridership up steadily since 2016 with new service.
Maryland Transit Administration Baltimore, MD	• Network redesign	Bus ridership up until 2015 and then down since then. Light and heavy rail ridership down since 2013. Commuter rail ridership up until 2015, then steady.
Massachusetts Bay Transportation Authority Boston, MA	• Added service • Bus Rapid Transit • Speed and reliability improvements	Bus ridership up until 2015 and down since then, but recently steady. Heavy and light rail ridership steady until 2017, then down. Commuter rail ridership down in 2015, then steady.
Metro Transit Minneapolis, MN	• Bus Rapid Transit • New light rail line • New commuter rail station	Bus ridership down since 2015. Light rail ridership and service hours up after new line in 2014, but steady since 2016. Commuter rail ridership up in 2014, then back down and steady, until up in 2018.
Metro Transit Authority of Harris County Houston, TX	• Network redesign • Real-time information • Improved fare payment	Bus ridership unchanged. Light rail ridership and service hours up after new lines in 2013 and 2015, but steady since 2016.
Pinellas Suncoast Transit Authority Pinellas County, FL	• TNC partnership	Bus ridership down since 2016. Demand response ridership (TNC trips) up.
Spokane Transit Authority Spokane, WA	• Real-time information • Increased service and frequency	Ridership up until 2015, then down through 2017, slowly increasing again with increased frequency.

CHAPTER 1

Background

The last quarter of 2018 APTA Ridership Report shows a concerning trend in transit ridership continues. Overall, unlinked passenger trips are down 2.0% from the previous year with light rail down as much as 3.0%. These declines continue across all modes except commuter rail and demand response. Although bus ridership is down the most in the midsize cities (2.2% in regions with populations between 200,000 and 500,000), bus ridership is declining in all population groups. As shown in Figure 1, in 2018, following six years of consecutive decline, bus ridership attained its lowest point since 1990. Earlier APTA reports show that this is actually the lowest bus ridership since at least 1973. Even rail transit ridership declined following an upward trend since 2009. The only fixed schedule mode that seems to have escaped this trend is commuter rail, as shown in Figure 2, although transit ridership gains on commuter rail have also leveled off in the most recent years.

These ridership declines have caught the attention of many in the industry. The recent decline in transit ridership is particularly worrisome because traditional factors of ridership do not seem to be involved. In particular, as shown in Figure 3, both bus and rail vehicle revenue miles have increased steadily since 2013.

The primary objectives of this research are to

1. Produce a current snapshot of public transit ridership trends in the U.S. on rail and bus services with a focus on changes in the past few years, and
2. Explore and present strategies that transit agencies are considering and using in response.

Literature Overview

In order to understand recent ridership trends in context, the study began with a review of a variety of academic and industry sources surrounding transit ridership both overall and within the past several years. Included in this literature review are studies investigating historical transit ridership effects, studies exploring specific policy changes and associated ridership effects, and studies comparing various regions and transit agencies.

Our approach was to first look to national studies on transit ridership both recently and in the past. These studies tend to look at ten or more metropolitan areas in North America to highlight the trends associated with transit ridership overall. We then looked closer, at studies on specific factors such as density or presence of TNCs. These studies tended to focus on case studies or surveys sent to transit riders to summarize the impacts of a specific aspect or set of aspects that affects transit ridership. Finally, to get a sense of the efforts of transit agencies to bring back riders in recent years, we read news articles and transit agency reports on specific efforts, their public perception, and early results. This method allowed us to get a holistic view of transit ridership,

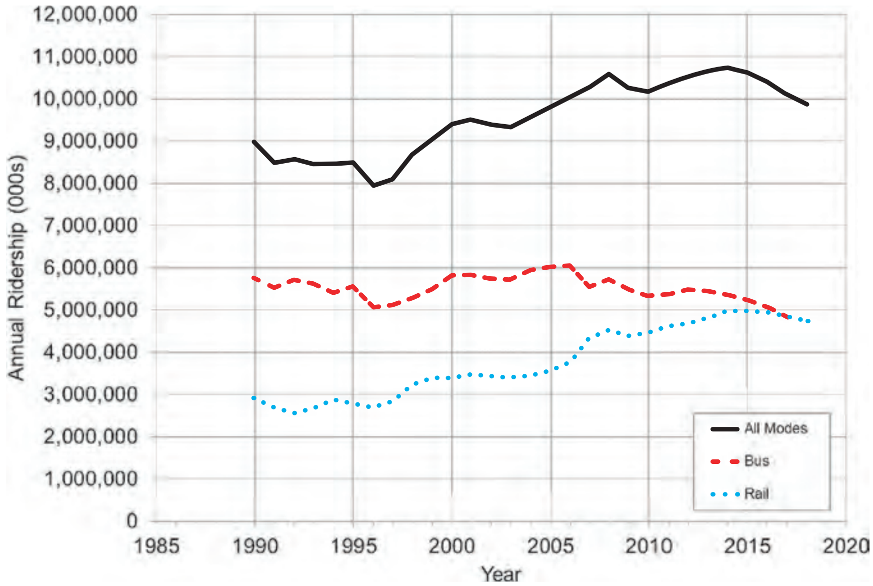

Figure 1. Change in annual ridership by year for bus, rail, and all modes.

recent trends, and what is being done to combat them. Appendix A summarizes the 66 sources reviewed.

Based on a review of the literature identified above, several overarching trends have been identified:

- **In nationwide studies, the most vital factor affecting transit ridership is the amount of service provided.** Historically, ridership and service (such as vehicle revenue miles or hours) are highly correlated at every level of transit service. Transit agencies that increase service tend to see corresponding ridership increases. This service may be in the form of a new area served by transit or simply more frequent service to existing areas.

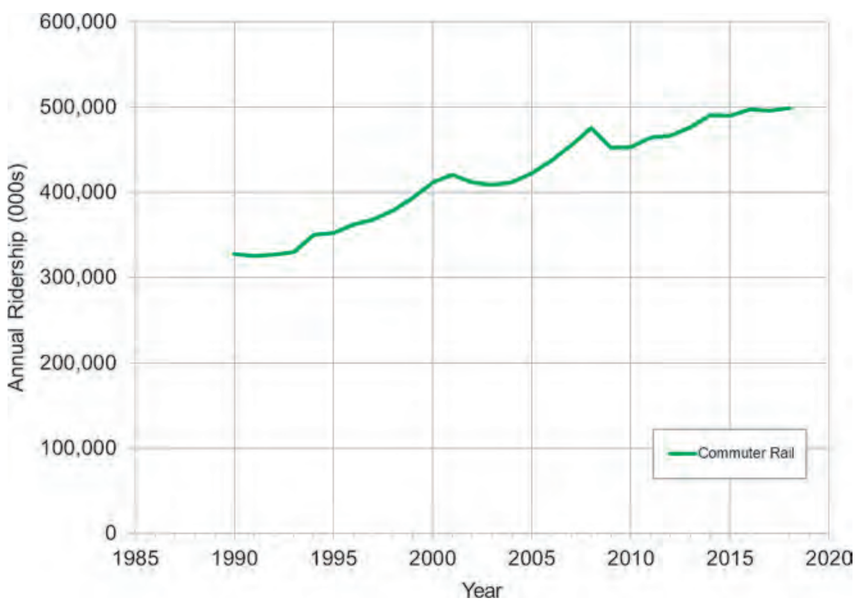

Figure 2. Change in annual ridership by year for commuter rail.

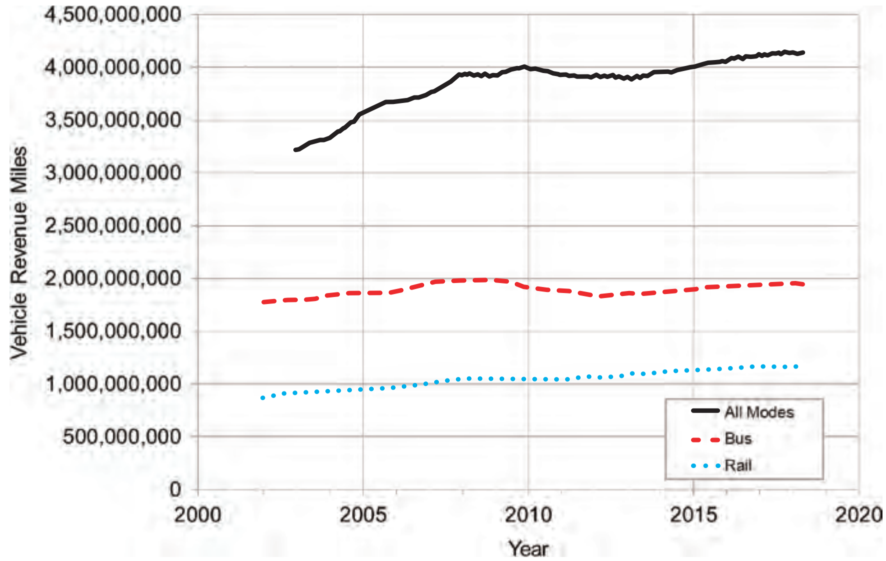

Figure 3. Change in annual vehicle revenue miles by year for bus, rail, and all modes.

- **However, in the past few years, many transit agencies have increased service without associated ridership increases.** Contrary to historic trends, transit agencies have not seen the ridership gains from service improvements that they had seen prior to 2008.
- **Transit ridership is tied to economic factors.** Unemployment and to a lesser extent gas prices affect transit ridership nationwide, and while low unemployment creates more trips, it also increases vehicle miles and purchases. Since about 2012, the economy has improved, likely playing a role in ridership declines.
- **Transit ridership is also tied to built environment factors.** Higher housing and employment density correlate to higher transit ridership, and higher availability of parking at workplaces has been shown to decrease transit ridership nationwide.
- **Shifts in housing and demographics are not favoring transit access.** Despite a brief trend in the other direction, suburbs are outpacing urban cores in growth nationwide. These fast-growing suburbs are generally not as accessible by transit as urban cores. Additionally, gentrification in urban cores has displaced transit-dependent populations to the suburbs, and wealthier groups who are less likely to take transit have been taking their place. Although some suburbanites may use transit, their usage patterns will differ.
- **There are a growing number of resources that replace the need to make trips.** Telecommuting and working from home are trends that have grown considerably in recent years, driving down the need for monthly transit passes. Delivery services such as Amazon or GrubHub make trips to stores and restaurants less necessary and frequent, and are particularly prevalent in urban areas well served by transit.
- **Shared mobility services are growing in popularity and likely have mixed effects on ridership.** Bike and car sharing services make auto ownership less necessary, but there is evidence that they may be replacing transit trips. Some transit agencies and city officials are skeptical of integration with these services, as they see them as competitors.
- **There is evidence that TNCs replace transit trips, particularly outside of peak hours.** TNCs, like Uber and Lyft, are used for both recreational purposes and commuting, although mostly for off-peak and airport trips. However, many users report that these services replaced their transit trips. Overall, TNCs may add auto trips to the road and raise vehicle miles traveled.

- **There is also evidence that TNCs complement transit, particularly for rail systems.** TNCs have the potential to serve as last-mile connections to rail and bus rapid transit (BRT) systems and may help enable a transit lifestyle. Many cities have begun supplementing their demand-responsive service with TNC services to bridge system gaps.
- **Transit agencies have been upgrading technology in an attempt to win back riders.** Improvements in real-time information has been shown to boost transit ridership slightly. Fare technology that improves simplicity and speeds up buses is being implemented in several cities, with limited results on the ridership effects of these changes.
- **Bus networks are being restructured to provide more concentrated service and attract riders.** This trend consolidates low-frequency meandering services into high-frequency direct services, bringing more residents closer to high-frequency bus lines. Bus ridership effects have been slightly positive but with limited results at this point.
- **Overall, there is little consensus as to the full picture describing recent transit ridership declines.** There are a multitude of candidate factors, from competing services like TNCs to societal factors like gentrification. More research is needed to understand the impact of multiple factors, especially new trends in transportation, on transit ridership.

CHAPTER 2

Research Approach

Transit agencies in the United States operate in a wide variety of environments, from small towns to mega regions, where decades of urban development have shaped the way people travel. This context affects not only the contributors to changing transit ridership, but also which strategies may be effective at offsetting ridership declines. While the overall ridership trend is pointing downward, it is important to identify sub-trends in order to grasp the full implications. Identifying the characteristics associated with transit ridership decline is also necessary to effectively target its root causes.

Discerning the sub-trends is particularly relevant because the largest transit agencies account for a disproportionate share of ridership; the New York MTA alone contributed 33% of 2015 unlinked transit passenger trips in the U.S. The ridership decline could be attributed to a few large transit agencies, for example due to extended rail closure; or it could be attributed to many small ones, for example due to urban migration; or it could be attributed to both. Furthermore, any analysis of averages would skew towards the largest regions and overlook ridership trends in smaller ones. Organizing transit agencies into groups of peers is necessary to compare the evolution of transit ridership over time.

With this knowledge, the research presented in this report was organized around two sets of clusters that group transit agencies according to similar operating environments and service characteristics. Using the clusters, national ridership trends were identified and graphed along with changes in population, transit vehicle revenue miles, and zero-vehicle households. Then, ten case study transit agencies were selected across the clusters to look at route-level ridership change within the transit agency.

Clustering

The first step of this analysis of ridership trends is to classify transit agencies with similar operating environments and service characteristics. A full description of the methodology used is described in a *Transportation Research Record* paper titled "Comparing Transit Agency Peer Groups Using Cluster Analysis" (Ederer et al., 2019). Transit regions were clustered into groups of peers on the basis of metropolitan area population, percentage of population living in a dense area, percentage of zero-vehicle households, and transit operating expenses.

Two cluster analyses were performed: one for transit services in mixed traffic and one for services in a dedicated ROW. The mixed traffic and dedicated ROW mode categories were separated based on National Transit Database data.

- Mixed traffic regions included all metro areas operating intra-city bus, commuter bus, BRT, and streetcar service.

- Dedicated ROW modes included heavy rail, light rail, monorail, and hybrid rail. Dedicated ROW services only included systems with 1 million or more unlinked passenger trips per year.

Transit agencies that operate mixed and dedicated ROW service were included in both clusters. Metrics attributed to different modes were split according to mode for each clustering. This method captures the differences in operation and funding logistics that may be present for different modes within the same transit agency and region.

With the understanding that many transit agencies operate in the same city, and that riders have little discretion for the specific transit agency operating a service, we found it useful to group *regions* rather than transit agencies. Transit providers within a region often compete for the same riders or connect groups of riders together, so pooling all of the transit service in a region provides a much more useful glimpse into particular ridership trends in a city than an agency-by-agency analysis. We clustered regions based on their core-based statistical area, often known as metropolitan or micropolitan statistical areas. This core-based statistical area was chosen as it has the most data availability for any regional metric from the U.S. Census. American Community Survey (ACS) 5-year estimates were used for the years 2012 and 2016, as well as transit data from the National Transit Database supplemented with data from the American Public Transportation Association (APTA). The availability of timely data was a limitation of the study, as 2016 data was the most recent available at the time of analysis. Downward trends in transit ridership have continued into 2017 and 2018 with some cases being even more substantial than what is shown in this report.

Clusters—Mixed Traffic Modes

The resulting clusters are described below. Figure 4 shows a map of mixed traffic regions color-coded by cluster. In all cluster solutions, the New York City metropolitan area was an outlier. It was not included in this analysis.

- **Cluster 1: Mid-sized, transit-oriented.** This features older industrial cities that are typically in the Northeast and Midwest that have declined in population in the past several decades. These areas have a relatively high number of zero-vehicle households and are typically small to midsize metro areas. Cities include Albany, Baltimore, Pittsburgh, and Cleveland.
- **Cluster 2: Mid-sized, auto-oriented.** This features primarily smaller, recently developed cities in the Midwest and South with low percentages of people living in zero-vehicle households. Cities include Indianapolis, Kansas City, Charlotte, and Nashville.
- **Cluster 3: Sprawling small towns.** This consists of the smallest cities operating fixed-route transit service and includes a disproportionate number of "college towns." The metro areas in this cluster are the least dense, least populated, and spend the least on transit of the transit agencies included in this analysis. Cities include Lansing, Burlington, Blacksburg, and Knoxville.
- **Cluster 4: Sprawling metropolis.** The cities in this cluster are sprawling, large cities that have a low percentage of zero-vehicle households. Operating expenditures in this cluster reflect the large population of these areas. Cities include Atlanta, Houston, Denver, and Phoenix.
- **Cluster 5: Dense metropolis**. This consists of the largest metro areas in the United States. Metro areas in this cluster are very dense and spend substantially more on bus operations than regions in other clusters. Example cities include Boston, Philadelphia, Chicago, Seattle, and Miami.

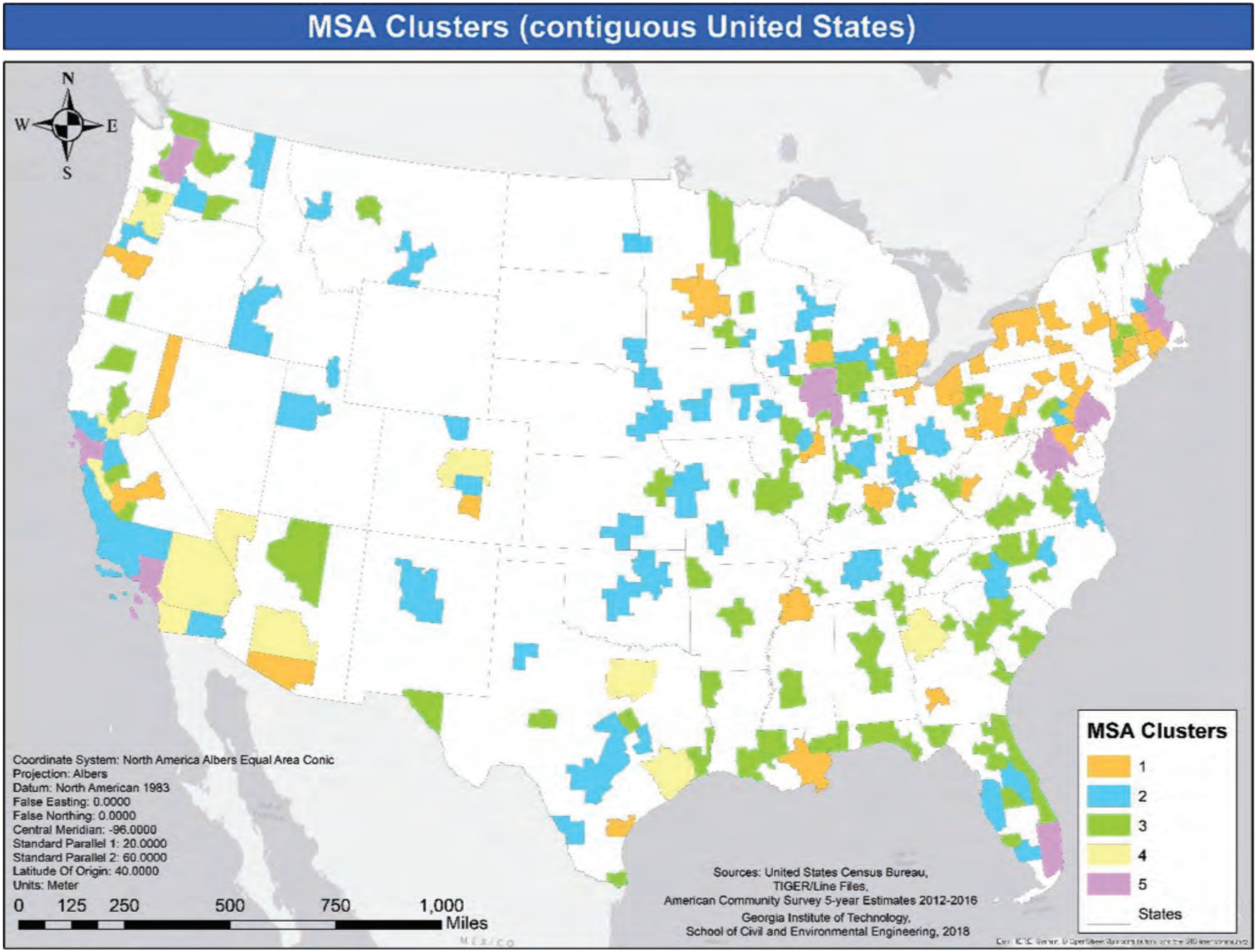

Figure 4. Map of mixed traffic transit regions by cluster.

Clusters—Dedicated Right-of-Way Modes

The resulting dedicated ROW clusters are described below. Figure 5 delineates the clusters for metropolitan areas operating dedicated ROW services with at least 1 million trips per year.

- **Cluster A: Los Angeles.** The Los Angeles metropolitan area is an outlier in this grouping. It is unusually large with a higher percentage of people in dense areas but with very low investment in dedicated ROW service.
- **Cluster B: Dense metropolis.** This includes Chicago, Boston, Philadelphia, San Francisco, and Washington D.C. These are large metro areas with extensive transit systems and large commuter rail networks.
- **Cluster C: Mid-sized, dense.** This consists of cities that are relatively small, compact, and with a high number of zero-vehicle households. This includes former industrial hubs in Baltimore, Buffalo, Cleveland, and Pittsburgh.
- **Cluster D: Mid-sized, dense, auto-oriented.** This consists of medium-sized metro areas that are mainly in the western areas of the country, such as San Jose, Portland, Seattle, Phoenix, Sacramento, Denver, and San Diego as well as Miami. These cities have low percentages of zero-vehicle households but a high proportion of population living in dense census tracts.
- **Cluster E: Sprawling metropolis.** This consists of sprawling large metro areas with relatively few dense census tracts, many of which are located in the southern (Atlanta, Dallas, Houston, Charlotte) and western (Salt Lake City, Minneapolis, St. Louis) regions of the U.S.

Figure 5 presents the clusters in the form of a dendogram, in which the regions most closely related are shown as connected by a line. Cluster A (Los Angeles) is therefore more closely related to Cluster B (dense metropolis) than to the other clusters. Similarly, Cluster D (mid-sized auto-oriented) and Cluster E (sprawling metropolis) are more closely related to each other than the other clusters, and so on.

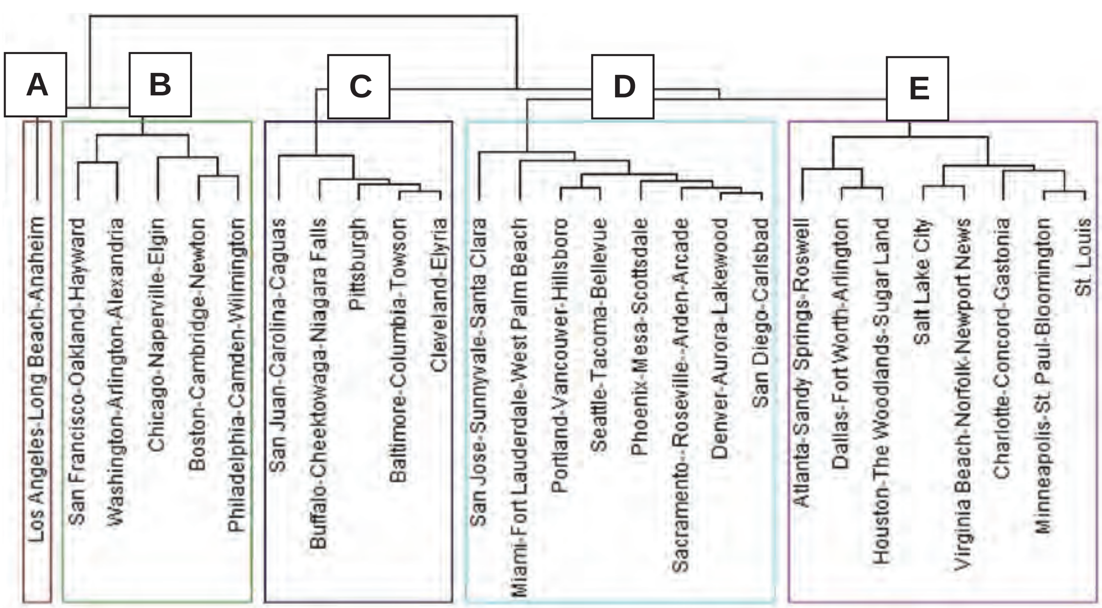

Figure 5. Dendogram of dedicated ROW clusters.

Table 4. Case study transit agencies.

Transit Agency	City	Mixed Traffic Cluster	Dedicated ROW Cluster
Connect Transit	Bloomington–Normal, IL	2	N/A
IndyGo	Indianapolis, IN	2	N/A
Pinellas Suncoast Transit Authority	St. Petersburg, FL	2	N/A
Spokane Transit Authority	Spokane, WA	2	N/A
Greater Portland Transit District	Portland, ME	3	N/A
Maryland Transit Administration	Baltimore, MD	1	C
Metro Transit	Minneapolis–St. Paul, MN	1	E
Metropolitan Transit Authority of Harris County	Houston, TX	4	E
Massachusetts Bay Transportation Authority	Boston, MA	5	B
King County Metro	Seattle, WA	5	D

Ridership Trends

It is important to understand how ridership is changing according to changes in service levels, population, and transit-dependent population, as these are the major factors traditionally influencing transit ridership. Therefore, for each mixed traffic and dedicated ROW cluster, a trend analysis was performed to examine the relationship between transit ridership and these three factors. In all cases, transit ridership was defined by unlinked passenger trips. Service levels are represented by transit vehicle revenue miles, although multiple similar measures were tested. Population is represented by one-year ACS estimates. Transit-dependent population is represented by zero-vehicle households from the ACS. Additional factors were considered, but due to data limitations, these three were the most reliable across multiple regions. Appendix B clarifies the data limitations the study team faced in the analysis. With regard to transit vehicle revenue miles, other service level variables were considered, but all service level variables were very closely linked, leading the study team to conclude that only one was necessary for further analysis.

Transit Agency Strategies and Case Study Selection

There is little existing peer-reviewed research on strategies that transit agencies have taken to combat the declines in transit ridership. Therefore, news articles and transit agency reports were examined to get a picture of strategies being undertaken and the degree to which they have been successful.

Taking into account the transit ridership trends, the factors influencing those trends, and the strategies transit agencies are using to combat ridership change, ten transit agencies were selected to conduct case studies. Table 4 lists the ten transit agencies and their associated clusters for mixed traffic modes and dedicated ROW modes. Five of the transit agencies have both dedicated ROW and mixed traffic modes, all five mixed traffic mode clusters are represented, and all dedicated ROW clusters except Los Angeles are represented.

CHAPTER 3

National Ridership Trends

Based on the literature and industry knowledge, the major factors traditionally influencing transit ridership are changes in service levels, population, and transit-dependent population. For each mixed traffic and dedicated ROW cluster, a trend analysis was performed to examine the relationship between transit ridership and these three factors. In all cases, transit ridership was defined by unlinked passenger trips. Service levels are represented by transit vehicle revenue miles. Population is represented by one-year ACS estimates. Transit-dependent population is represented by zero-vehicle households from the ACS.

Population, zero-vehicle households, and transit service levels were plotted against transit ridership to determine whether they were similar in magnitude and direction. In each case, the relationship between transit ridership and its determinants is first evaluated using only 2012 data. This point-in-time analysis helps explain the steady-state effects each factor has on transit ridership after decades of interaction. Of course, the causal relationship goes both ways as transit ridership could directly or indirectly affect population size, share of zero-vehicle households, and transit service levels. In the second part of the analysis, the percentage change in transit ridership is compared to the percentage change in each explanatory factor between 2012 and 2016. This analysis helps explain their relationship in the short term. Exploring how factors change together within a four-year period can provide important insights on the potential causal relationships that have been driving ridership down. In all of the figures, regions are abbreviated with three letter codes, shown in Appendix C.

Ridership Trends Analysis for Mixed Traffic Modes

Using the Clusters 1 through 5 as explained in Chapter 2, trends in transit ridership are graphed in comparison to trends in population, zero-vehicle households, and service levels at a point in time. In addition, trends in change in transit ridership as compared with changes in these factors are described in the following section for the mixed traffic modes. For more information about which regions are in each cluster, see Appendix C.

Population—Mixed Traffic Modes

While transit ridership is declining nationally, the population of urban areas overall is at its highest point in history. Although suburbs have been growing at a faster pace in recent years, urban cores have increased in population every year since 2006 (Frey 2018). These trends make the recent decline in transit ridership even more alarming because they indicate that ridership per capita has been falling at an even faster rate than ridership as a general total.

One potential explanation for the transit ridership decline is that population growth has been concentrated in sprawling metropolitan areas, particularly in the Sun Belt, while denser cities, particularly in the Rust Belt, have lost population. According to a study by Driscoll et al. (2018), urban migration away from cities with strong transit markets may be a leading cause of the ridership decline.

The relationship between population and transit ridership in each cluster is first evaluated for 2012, as shown in Figure 6. In Clusters 1 and 5, which contain transit supportive regions, population explains a large part of the variation in ridership among regions. In Cluster 1, which contains mid-sized MSAs, only San Juan; Detroit, MI; and Honolulu, HI, deviate from the linear relationship between population and ridership. In Cluster 5, which contains large MSAs, the relationship is also clear, although heavily influenced by Los Angeles and Chicago.

Clusters 2, 3, and 4, which are all car-oriented MSAs, have diverging trends. While Cluster 2, which contains mid-sized MSAs, shows a clear positive relationship between population and ridership, Cluster 4, which contains larger MSAs, does not. Cluster 3 (small towns) seems to be showing a trend, but it is more difficult to identify because a large subset of the cluster is

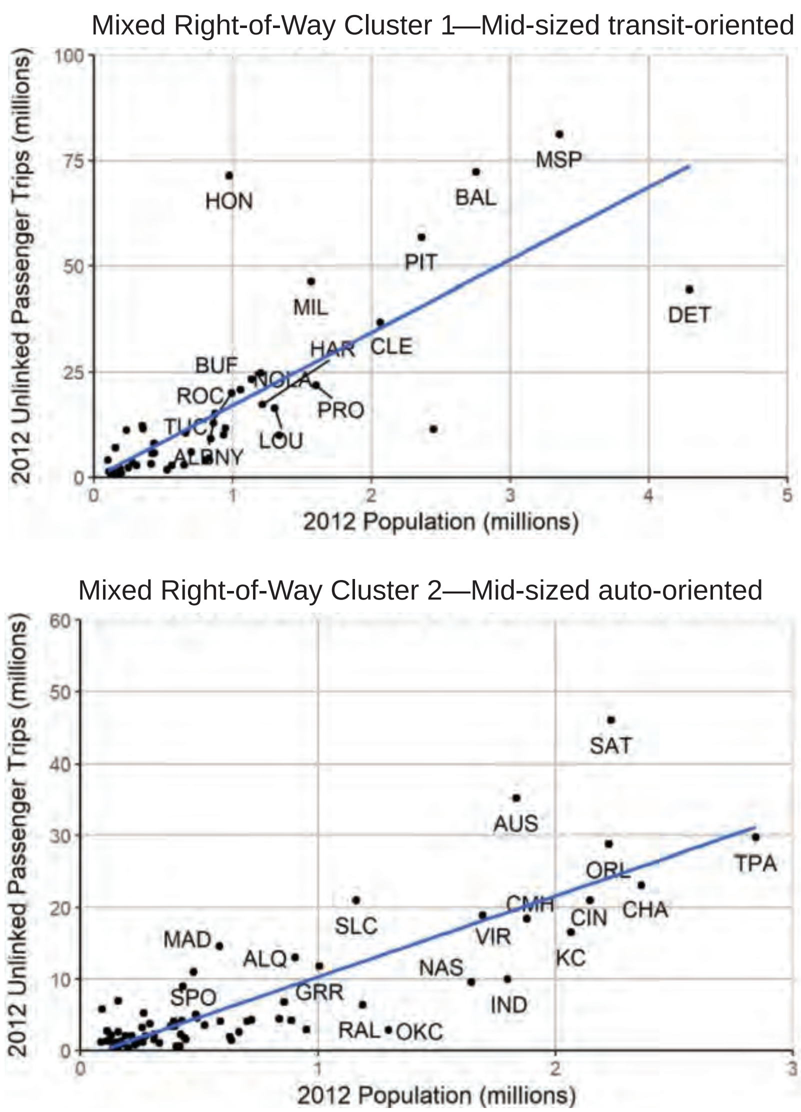

Figure 6. Transit ridership vs. population for mixed traffic modes, 2012.

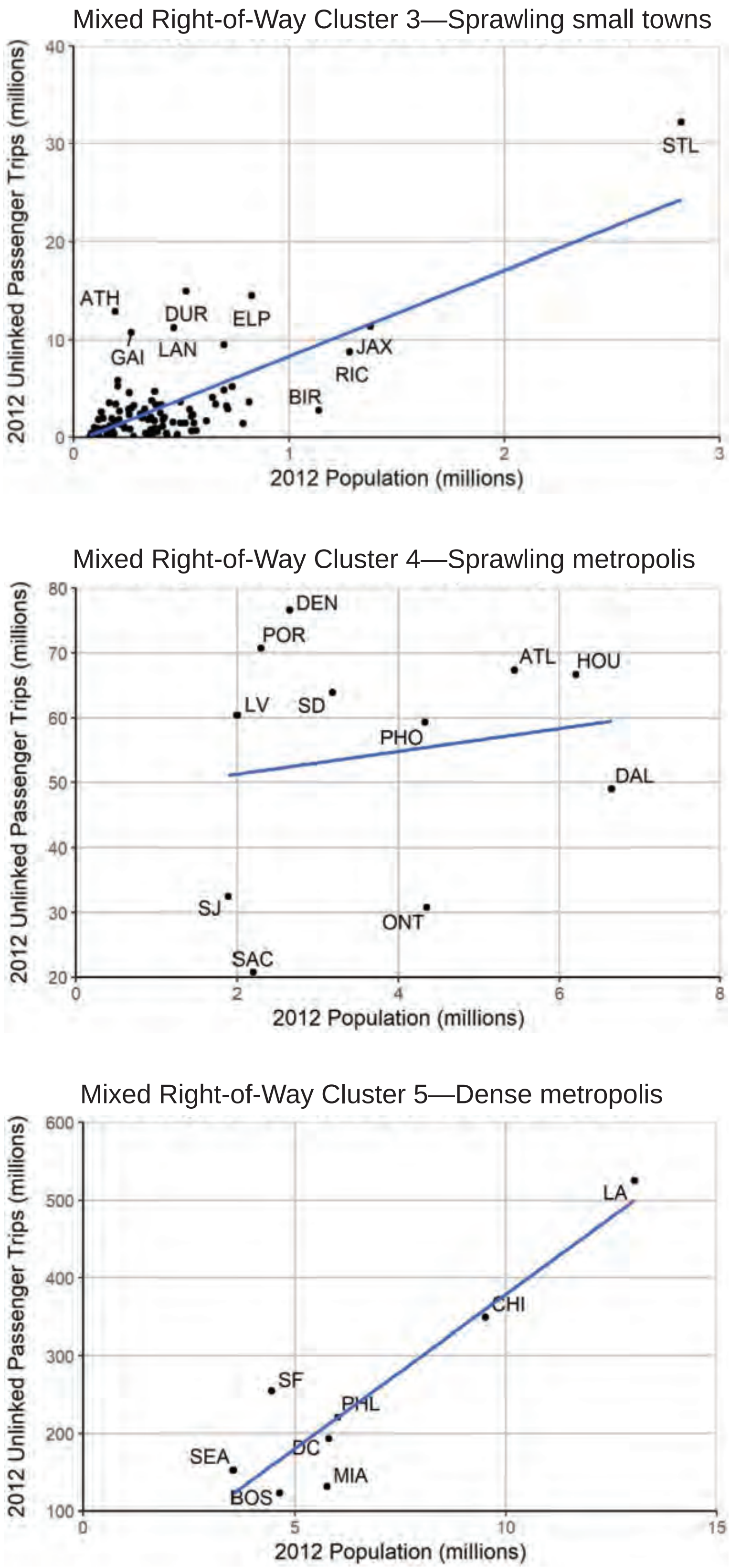

Figure 6. (Continued).

highly homogeneous. The 62% of regions that have less than a million in population and less than 5 million unlinked transit passenger trips seem to be uniformly distributed. However, the ridership of satellite regions orbiting around this core group tends to increase with population. Overall, the trend between population and transit ridership is quite strong in every cluster except for Cluster 4, sprawling metropolises.

Population Change—Mixed Traffic Modes

In order to understand how the change in ridership between 2012 and 2016 relates to population, Figure 7 shows ridership change against population change in percentage.

Despite the strong trends in Figure 6, the short term trends in Figure 7 are mixed. In some cases, metro regions with dense urban cores lost the most ridership and gained the least population. Areas in Cluster 1 (mid-sized transit-oriented) lost the most population with 20 out of 47 metro regions experiencing a net population loss. Metro regions in Cluster 5 (dense metro)

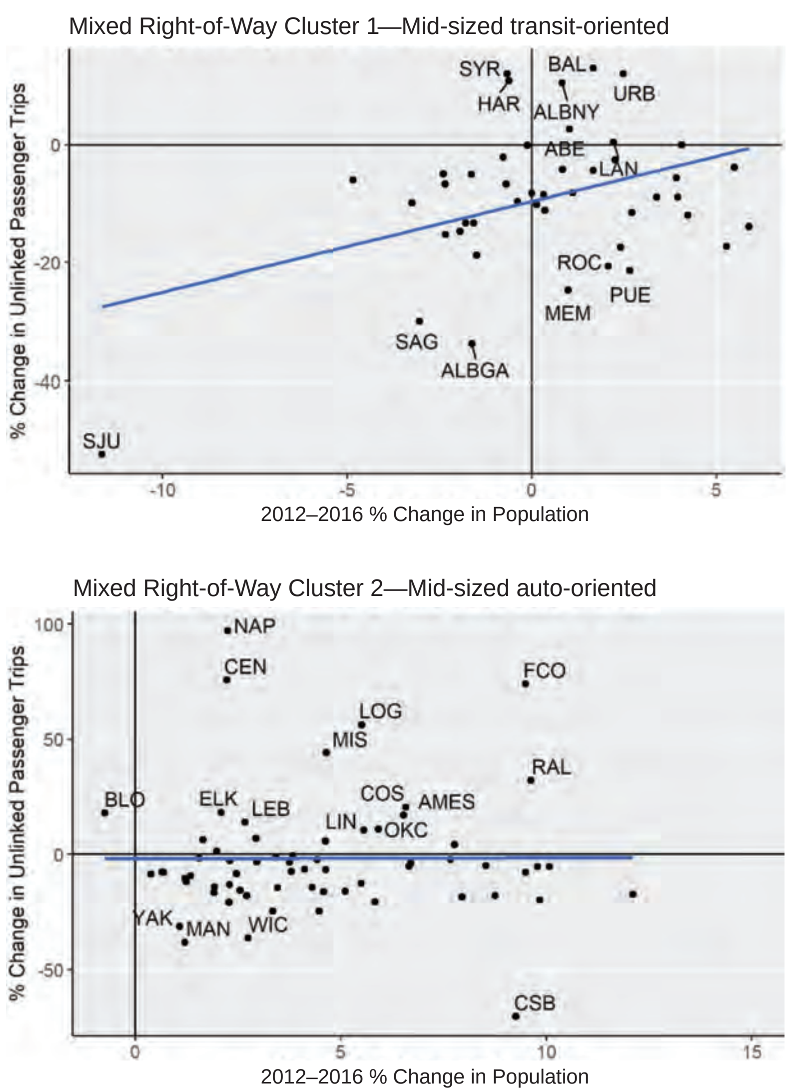

Figure 7. Change in transit ridership vs. change in population for mixed traffic modes.

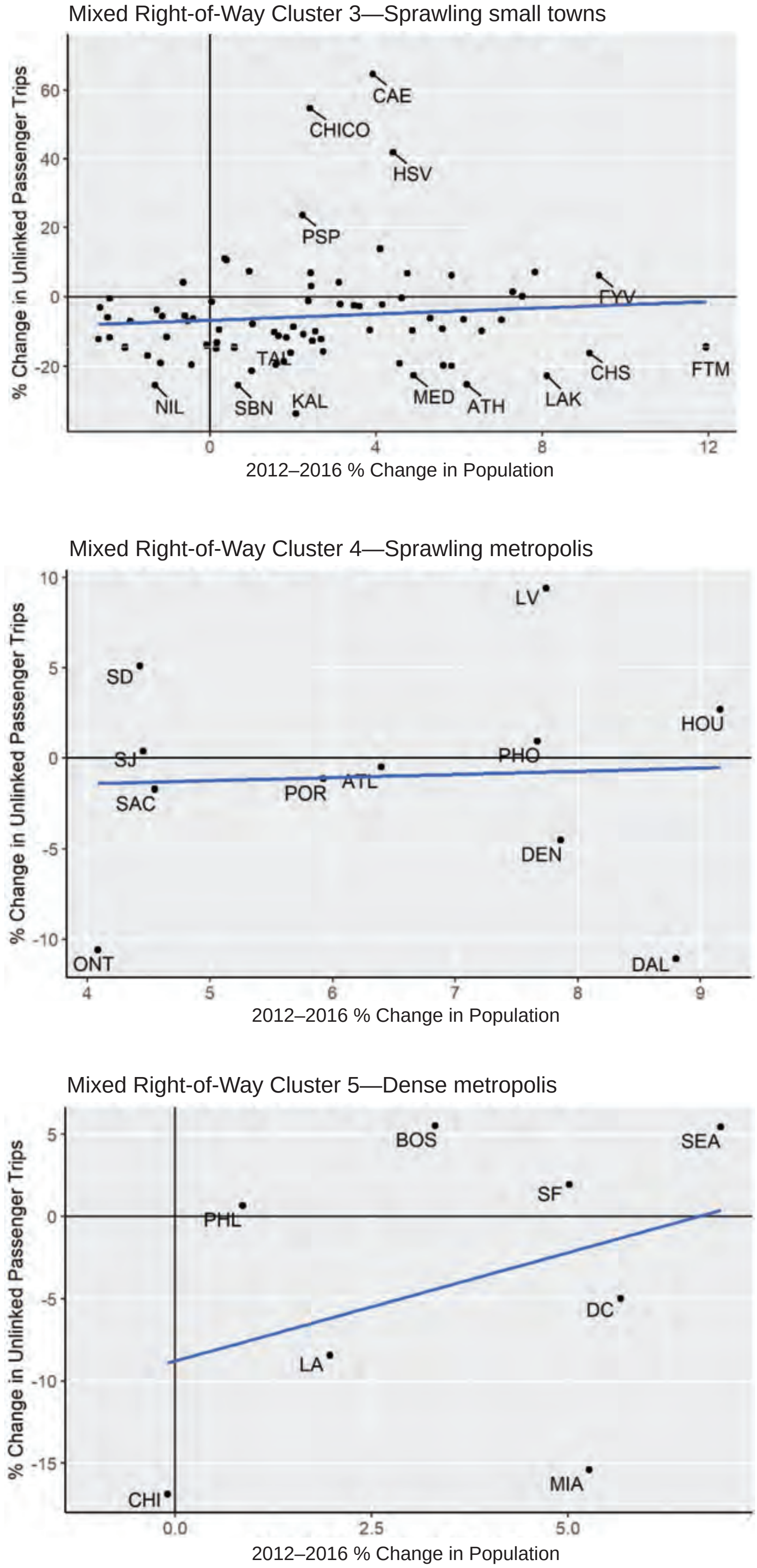

Figure 7. (Continued).

all grew by less than 7%. In both clusters, however, transit ridership change seems unaffected by the decline in population. Clusters 2 and 3 (mid-sized auto-oriented and sprawling small towns) have no clear trend either. Metro regions are scattered around a negative change in ridership that is not affected by changes in population. In both clusters, the trend line is flat, which indicates that the change in transit ridership is uncorrelated with change in population. Despite population growing by more than 4% for every MSA in Cluster 4 (sprawling metro), there is also no relationship.

Overall, there is a strong relationship between transit ridership and population but almost none between ridership change and population change. In every cluster except for Cluster 4, population explains a large portion of the variation in ridership. It is interesting to note that Clusters 2, 3, and 4 have gained the most population perhaps at the expense of Clusters 1 and 5. However, if population change was a significant factor of transit ridership for mixed traffic modes, then these trends would be reflected within each cluster in Figure 7, particularly Clusters 1 and 5. We therefore conclude that although population is an indication of transit ridership, other factors than recent population changes are having an overwhelming effect on transit ridership change. It may be that changes within a population, such as demographics, are having a larger impact than overall population change.

Zero-Vehicle Households—Mixed Traffic Modes

The proportion of households with zero vehicles is an important indicator of transit ridership because it reflects the medium- to long-term propensity of individuals to ride public transportation. Zero-vehicle households can be delineated into two groups:

- car-free households, where residents choose to live without a car, and
- carless households, where residents lack access to a vehicle for physical or financial reasons.

A recent study based on the 2012 California Household Travel Survey found that 79% of zero-vehicle households are carless (Brown, 2017). In general, the total lack of cars in a household is more closely associated with constraint than choice. These households, therefore, constitute a population sometimes referred to as captive transit riders because they have no other accessible means of transportation. Larger households can also be one-vehicle households, thus necessitating travel by other means for most members of the household; however, readily available data to quantify these households in every region is more difficult to obtain. Zero-vehicle households are therefore used as a surrogate for those without automobile access.

The proportion of zero-car households should also be understood in the context of density. Density determines whether people can live without a car and still have access to alternative transportation options. While Clusters 1 and 2 have the same proportion of population living in transit-supportive density, the proportion of households without cars is almost twice as great in Cluster 2 as in Cluster 1. The same can be said about Clusters 4 and 5, which have similar densities but very different proportions of zero-car households. These numbers suggest that regions in Clusters 1 and 5 have large proportions of transit-dependent households.

Figure 8 shows the percentage of zero-vehicle households against unlinked passenger trips in each cluster. In Clusters 1, 2, and 3 (lower population MSAs), the regions with the greatest transit ridership have medium—and in some cases low—proportions of zero-vehicle households. These regions include Honolulu, HI, and Baltimore, MD, in Cluster 1; Orlando, FL, and Austin, TX, in Cluster 2; and St. Louis, MO, and Durham, NC, in Cluster 3, which all have far greater levels of ridership than the average in their cluster, yet have relatively low zero-vehicle households compared to other cities.

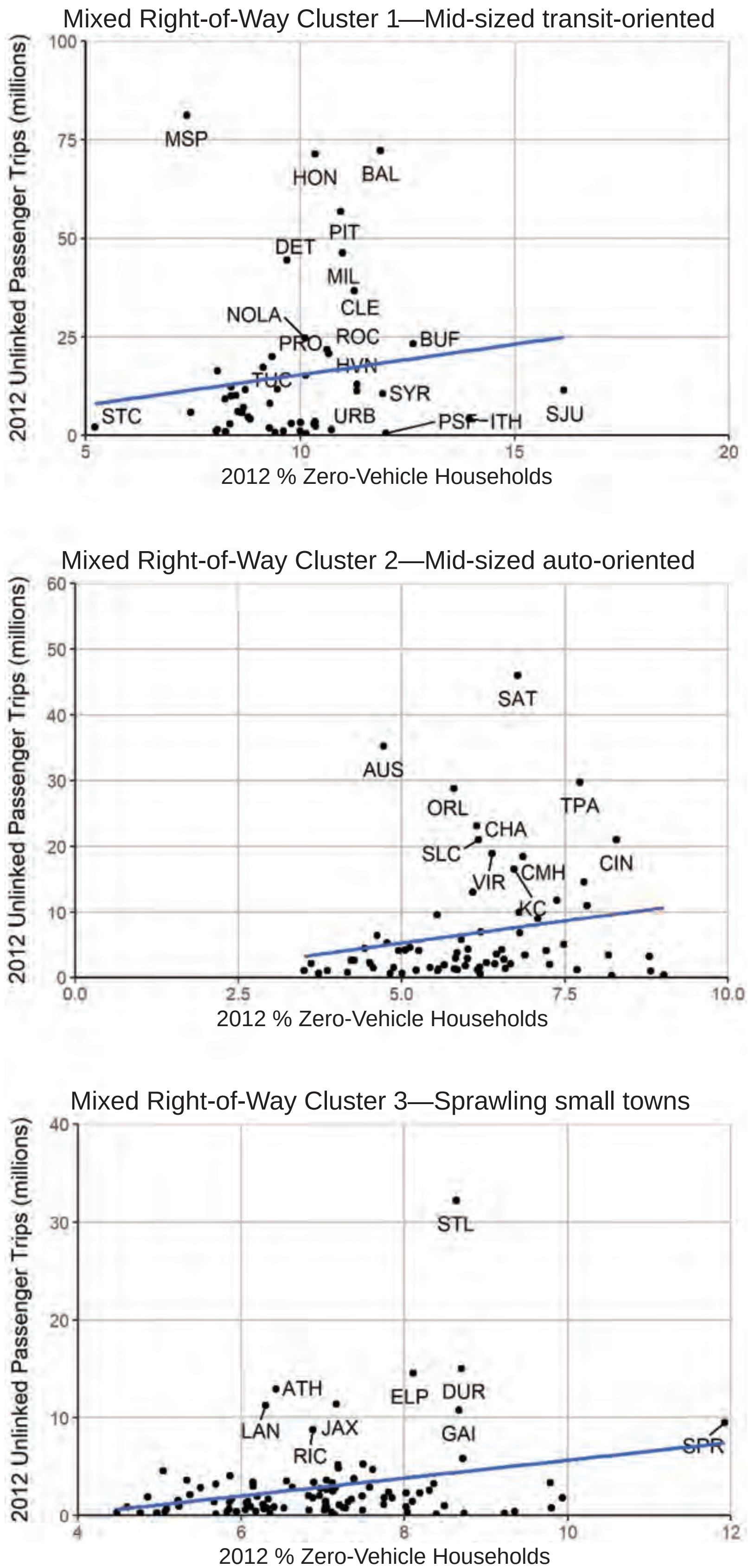

Figure 8. Transit ridership vs. percentage of zero-vehicle households, 2012.

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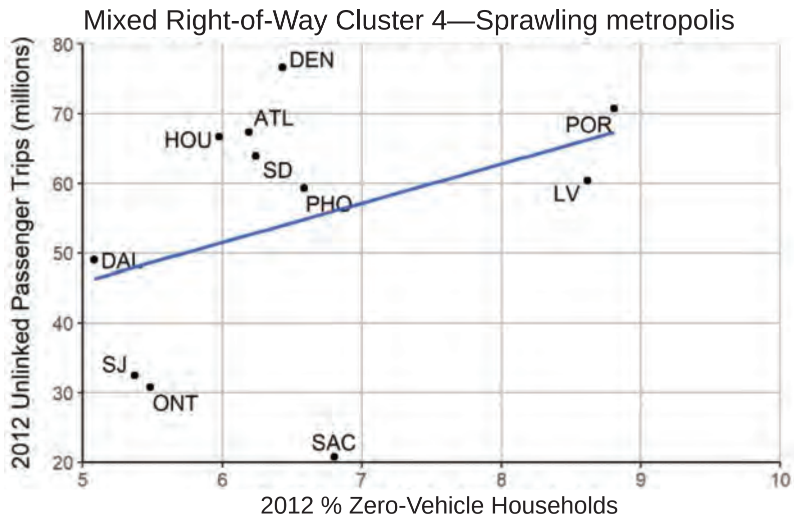

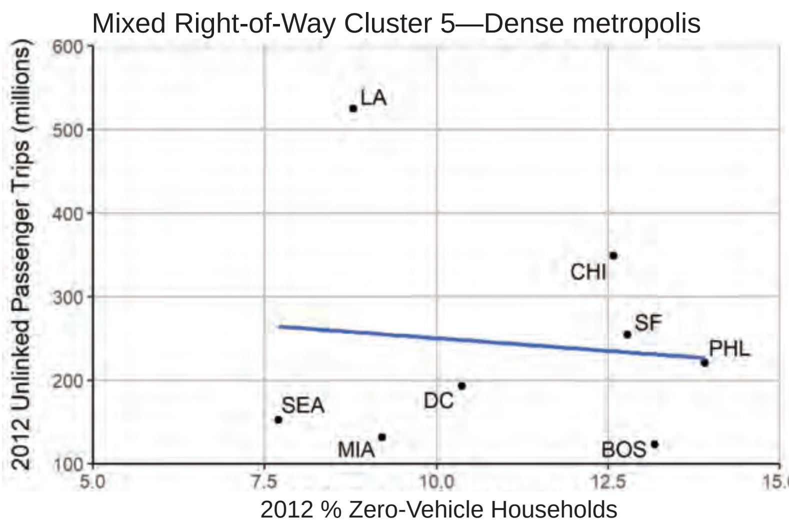

Figure 8. (Continued).

Besides these outliers, there is a slight positive trend in all three clusters. However, it is apparent that the proportion of zero-vehicle households accounts for a small share of variation in transit ridership. There is also not a strong relationship between transit ridership and the proportion of zero-vehicle households in Clusters 4 and 5 (higher population MSAs), although the more car-oriented large metropolitan areas in Cluster 4 have a slightly stronger relationship than the more transit-oriented large metropolitan areas in Cluster 5.

Change in Zero-Vehicle Households—Mixed Traffic Modes

While the proportion of zero-vehicle households at a point in time reflects the steady-state of economic, land-use, and transportation forces, the increase in car ownership has been identified as a major cause of transit ridership decline. A study from the Southern California Association of Governments suggested that the decrease in zero-vehicle households was the primary cause of transit ridership decline in the greater Los Angeles area (Manville et al., 2018). To evaluate this trend at the national level, Figure 9 shows the change in transit ridership against the absolute change in percentage of households with zero vehicles between 2012 and 2016.

Unlike the 2012 analysis, there is a relationship between the change in transit ridership and the change in zero-vehicle households in Cluster 4 (sprawling metros) and Cluster 5 (dense metros), but not in Clusters 1, 2, and 3 (lower population MSAs). The relationship between the change in transit ridership and zero-vehicle households is rather flat in Clusters 1, 2, and 3, with regions spread widely and almost symmetrically around.

In the large metro areas—Clusters 4 and 5—however, the change in zero-vehicle households is associated with change in transit ridership. In Cluster 4, only Las Vegas, NV, increased in proportion of zero-vehicle households, and in Cluster 5, Seattle, WA, was the only region not to decline in zero-vehicle households except for Boston, MA, which did not substantially change. Overall, the decline in transit ridership is therefore connected with the decline in proportion of zero-vehicle households in large metro areas (Clusters 4 and 5) but not in smaller ones (Clusters 1 to 3).

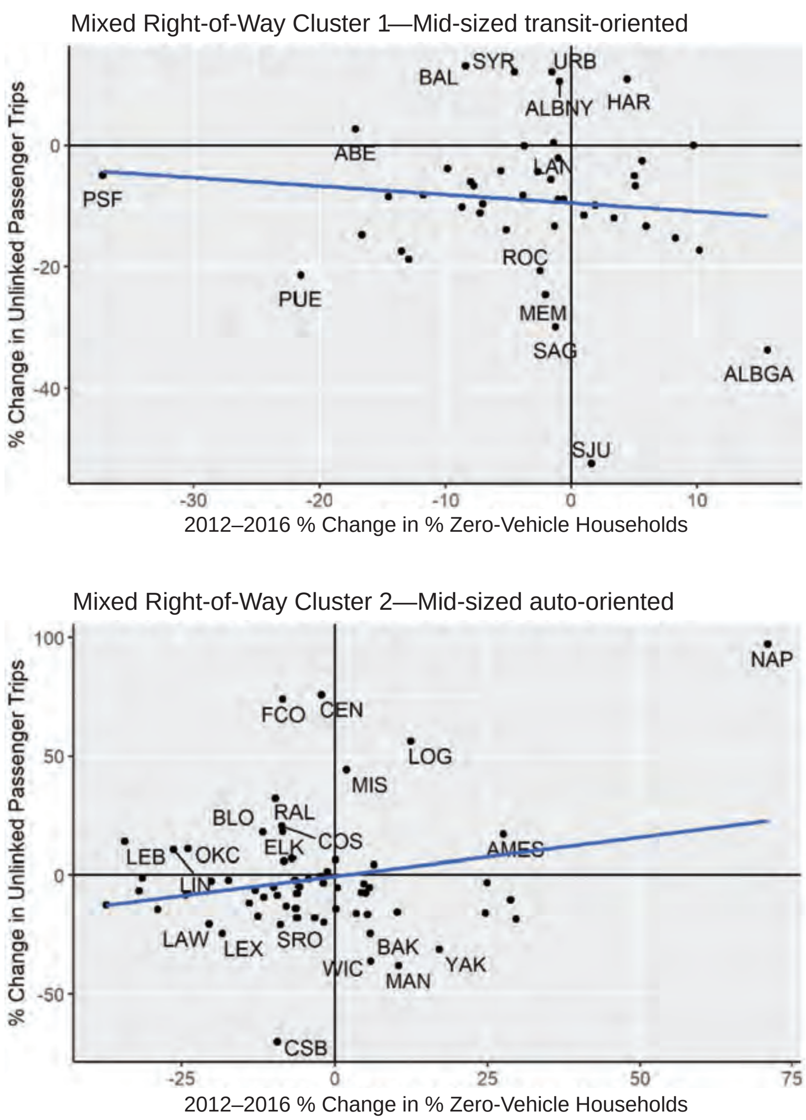

Figure 9. Change in transit ridership vs. change in zero-vehicle households for mixed traffic modes.

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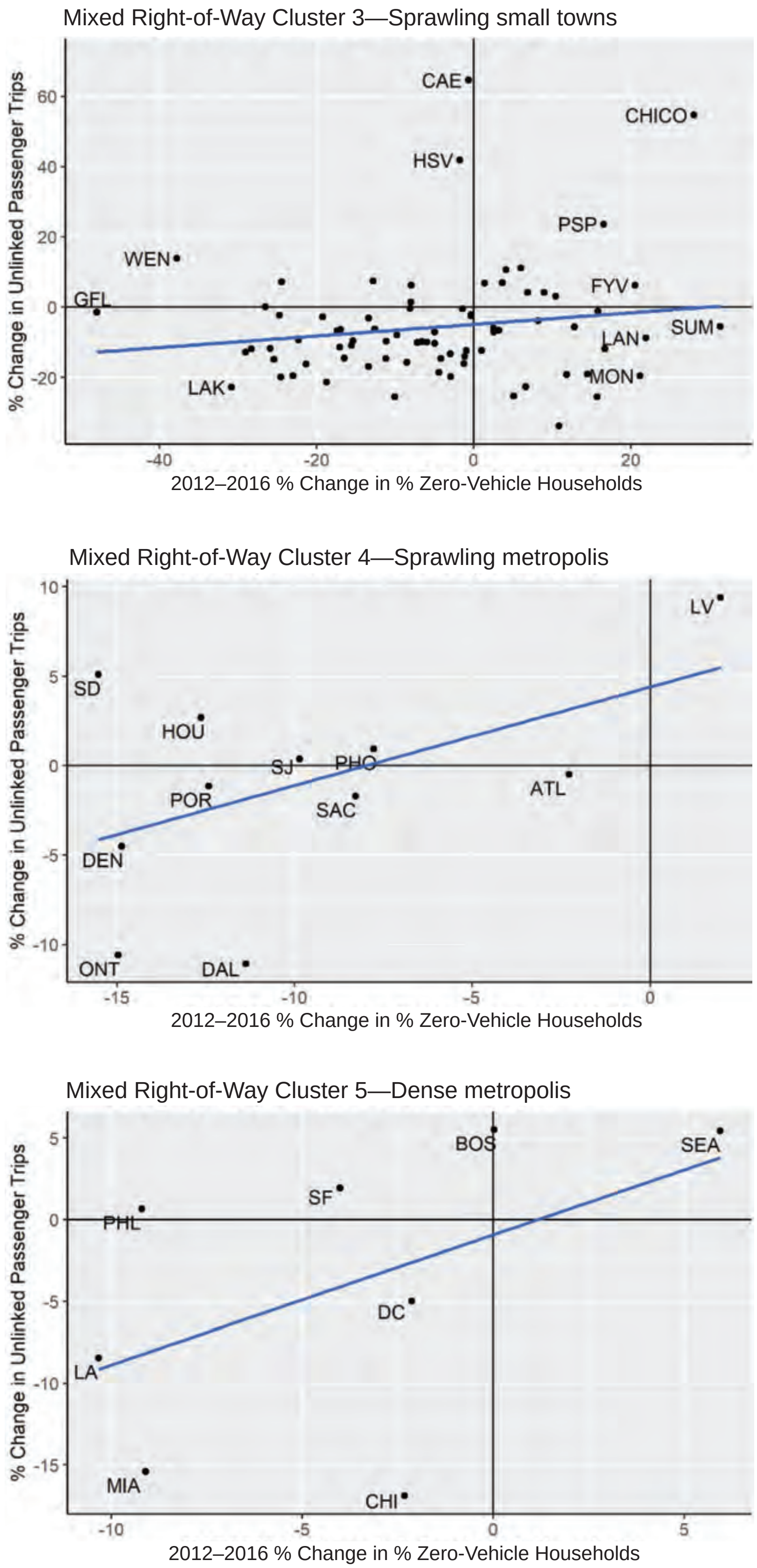


Figure 9. (Continued).

Transit Service—Mixed Traffic Modes

The amount of service provided is one of the few levers available for transit agencies to affect ridership. It is therefore important to evaluate the relationship between ridership and service levels both at a point in time and as a change over time. In order to better understand the base-case relationship between transit ridership and service levels, Figure 10 shows 2012 transit ridership against 2012 transit service levels (determined by vehicle revenue miles) in each cluster.

In every cluster, the relationship between transit ridership and transit service levels is both clear and strong. In Clusters 1 and 2, transit service levels explain almost all of the variation in transit ridership. In both clusters, transit service levels span a wide spectrum with the largest regions having 50 times more transit service than the smallest ones.

The relationship between transit ridership and transit service levels holds true at all levels of transit service. It is interesting to note that the trend line has slope equal to 3 in Cluster 1 and slope equal to 2 in Cluster 2. These results suggest that each marginal vehicle revenue mile is associated with more transit ridership in mid-sized transit-oriented Rust Belt regions than in car-oriented—and for the most part Sun Belt—regions of similar sizes and densities.

In Cluster 3, the trend is also clear, but there is not as much spread in transit service levels as in Clusters 1 and 2. There are nine regions with much more transit vehicle revenue miles and transit ridership than the rest of the cluster. These are the same regions that had overwhelming transit ridership for their proportion of zero-vehicle households in the last analysis. All other regions within the cluster are compact between zero and three million transit vehicle revenue miles. The group of compact regions shows a relationship between transit ridership and transit service levels, which extends to outlying regions with far greater transit service levels, thereby confirming the trend.

Although there is also a clear relationship between transit ridership and transit service levels in Clusters 4 and 5, it does not explain as much of the variation in transit ridership. This is especially true in Cluster 4 with Las Vegas, NV, and Dallas, TX, for which transit service levels do not explain transit ridership well.

Besides Boston, MA, all regions in Cluster 5 provided more transit service in 2012 than even the largest region in Cluster 4, which was Houston. It is also worth noting that the slope of the relationship between transit ridership and transit service levels is three times greater for Cluster 5 than for Cluster 4. These results indicate that transit service levels contribute far more ridership in the large transit-oriented metropolitan areas of Cluster 5 than in more car-oriented Sun Belt regions of Cluster 4.

Figure 10 shows that there is a strong relationship between transit ridership and service levels at a point in time. These results suggest that transit service levels may be a strong influencer of transit ridership, but it is important to also evaluate the influence of changes in transit service levels in the next section to explain the ridership decline since 2012.

Change in Transit Service Levels—Mixed Traffic Modes

As shown in Figure 11, there is a definite relationship between change in transit ridership and change in transit service levels in Clusters 1 and 2, and to a lesser extent, Cluster 3.

- In Cluster 1, the spread around the trend line is wide, but consistent. Every region where ridership has grown has increased transit service levels.
- In Cluster 2, the relationship explains a large part of the variation in transit ridership. Regions with the greatest ridership growth have increased transit service levels the most, and regions with the greatest fall in ridership have reduced transit service levels the most.
- In Cluster 3, several regions where both transit ridership and transit service levels increased dramatically between 2012 and 2016 drive the relationship.

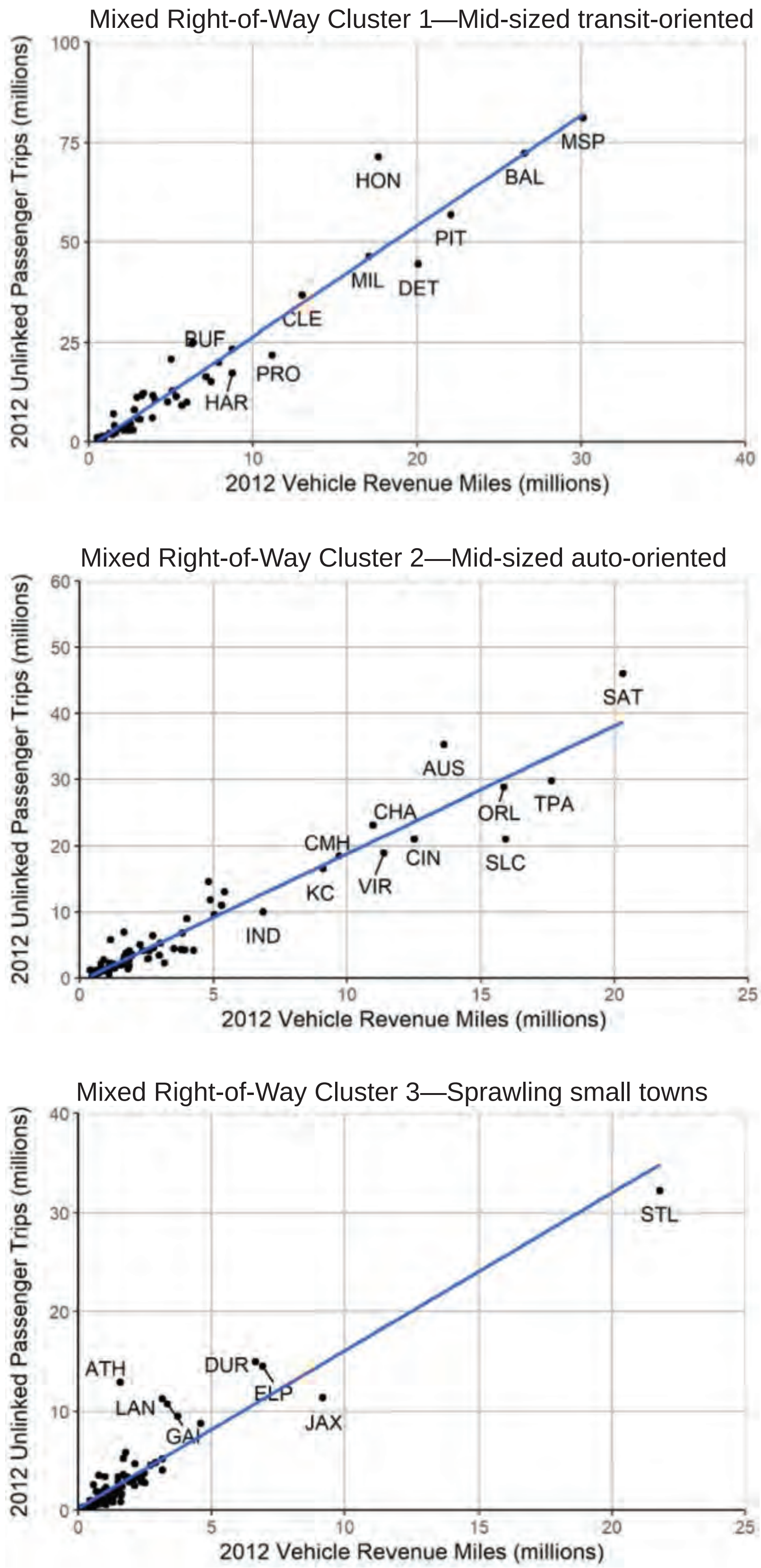
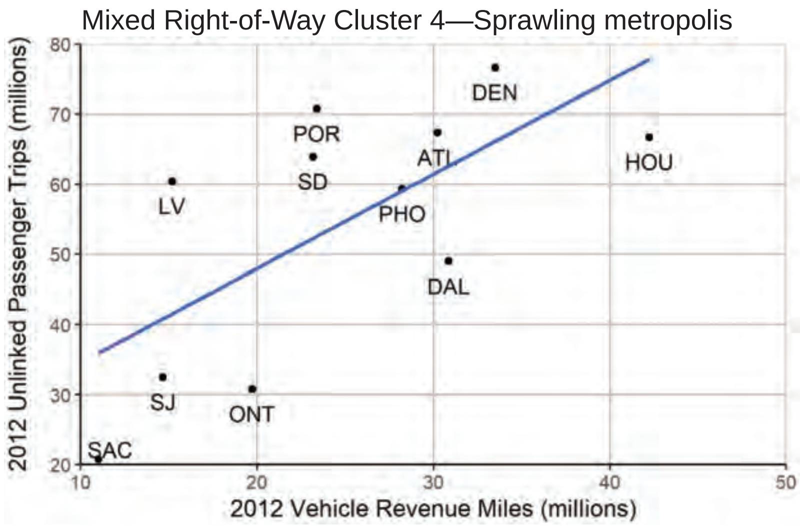


Figure 10. Transit ridership vs. transit service levels for mixed traffic modes, 2012.



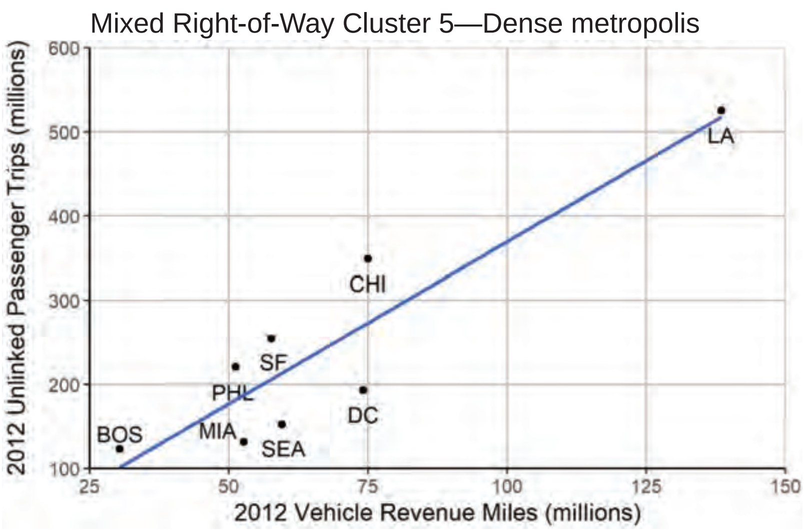


Figure 10. (Continued).

There are, however, outliers such as Chico, CA; Huntsville, AL; and Elizabethtown, KY, where ridership increased despite slight reductions in transit service levels and regions such as Fayetteville, MO; Baton Rouge, LA; and Port St. Lucie, FL, where vehicle revenue miles increased by more than 75% but transit ridership did not substantially increase.

Besides the strength of the relationship, the intercepts are also interesting. The intercept of the trend lines is the amount of ridership change that should be expected if transit service levels had not changed. The intercept is −11% for Cluster 1, −9% for Cluster 2, and −8% in Cluster 3. These results indicate that small to mid-sized regions that did not change transit service levels between 2012 and 2016 should expect 8–10% loss in ridership. Although there is a definite relationship between the change in transit ridership and the change in transit service levels, there is also a systematic effect driving transit ridership down in transit agencies across clusters irrespective of service levels.

In Clusters 4 and 5, there is no discernable relationship between the change in transit ridership and the change in transit service levels. If anything, the trend in Cluster 4 is pointing

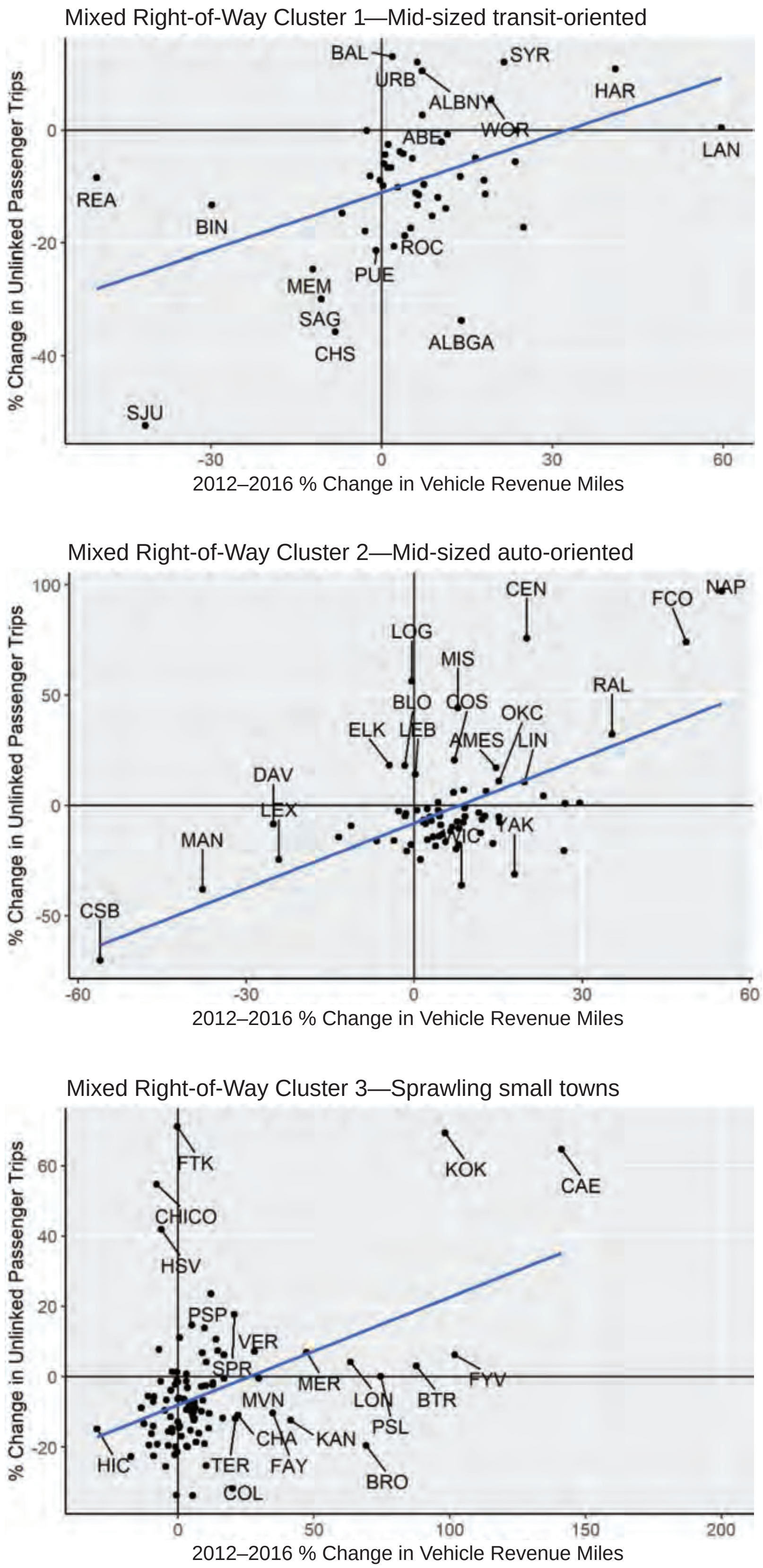


Figure 11. Change in transit ridership vs. change in transit service levels for mixed traffic modes.

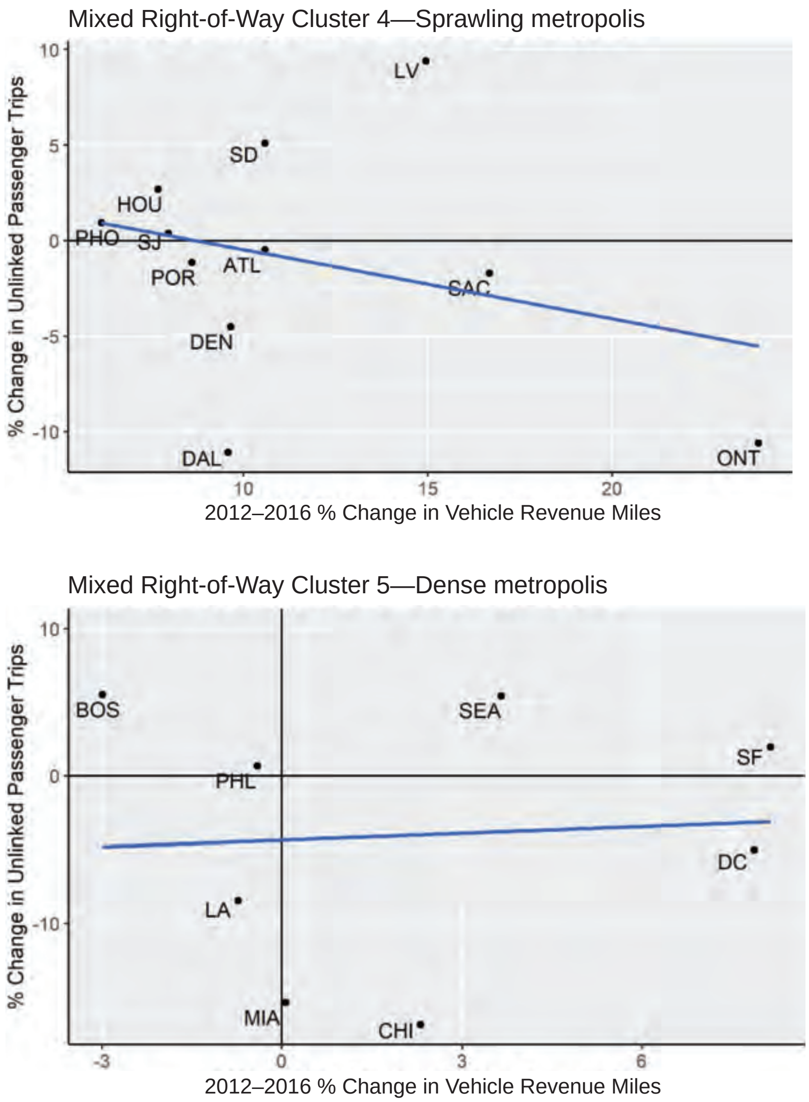


Figure 11. (Continued).

downward with San Bernardino, CA, which increased vehicle revenue miles by 28%, still losing 11% of ridership. Regions in Cluster 5 exhibit no relationship between change in transit ridership and transit service levels. Boston cut service by 3% and increased ridership by 5.5%, while Washington D.C. increased service by 7.9% and lost 5% of ridership. As for small and medium-sized regions, large metro areas lost transit ridership systematically with an average drop of 1% in Cluster 4 and 4% in Cluster 5. However, unlike small and mid-sized regions, the change in transit service levels was not a significant factor of transit ridership change between 2012 and 2016 in large metro areas.

Overall, Figure 11 shows that transit service levels were not responsible for the decline in ridership in mixed traffic modes between 2012 and 2016. In every cluster, an overwhelming majority of regions both increased transit service and lost ridership. The relationship between transit ridership and transit service levels for small transit agencies means that small transit agencies were able to minimize the decline in ridership and in some cases even yield modest increases, but at the cost of increases in transit service. In larger regions, changes in transit ridership seem completely uncorrelated with increasing transit service levels.

Ridership Trends Analysis for Dedicated Right-of-Way Modes

In this section, the analysis of population, zero-vehicle households, and service levels in 2012 and the changes in each from 2012 to 2016 is repeated for dedicated ROW transit modes. A critical difference with mixed traffic modes is that regions operating transit in its own lane are typically much larger and there are a limited number of regions operating dedicated ROW. Due to the limited number of regions, these graphics are presented as one for all clusters, although clusters are shown using the symbols:

- Cluster A: Blue Rhombus
- Cluster B: Purple Triangles and Green Crosses
- Cluster C: Red Triangles
- Cluster D: Blue Crosses
- Cluster E: Black Circles

Population—Dedicated Right-of-Way Modes

Figure 12 shows 2012 transit ridership against 2012 population. The point in time scatter plot of transit ridership and population has only a moderately strong relationship overall. Cluster C (midsize dense), Cluster D (midsize auto-oriented) and Cluster E (sprawling metro) are compact in the lower left quadrant of the graph. There would be a slight upward trend if not for the three most populated MSAs—Miami, FL; Houston, TX; and Dallas, TX—having only modest transit ridership and, in Houston's case, below average ridership. Regions in Cluster B (dense metro) have much greater ridership for their population, although there, too, no clear relationship can be established. Los Angeles, the lone region in Cluster A, has the most population by far but lower transit ridership than any metro region in Cluster B (dense metro).

Figure 13 shows the percentage change in transit ridership against the percentage change in population between 2012 and 2016. The relationship between the change in transit

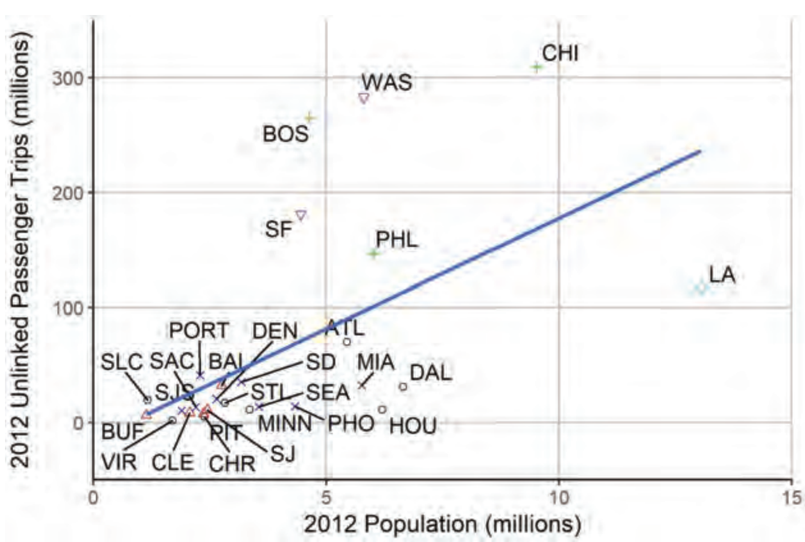


Figure 12. Transit ridership vs. population for dedicated ROW modes, 2012.

ridership and change in population is also moderately strong. Except for Minneapolis, MN; Seattle, WA; and Houston, TX—which have expanded their rail systems—ridership and population change seems to have a linear and positive relationship across clusters. Cluster C (midsize dense) regions, which are all Rust Belt regions with the exception of San Juan, Puerto Rico, have lost the most population overall and experienced the greatest transit ridership decline. Cluster D (midsize auto-oriented) regions gained the most population overall and experienced gains in ridership except for Sacramento, CA, and Portland, OR. Cluster A (Los Angeles), Cluster B (dense metro), and Cluster E (sprawling metro) are spread out along and around the trend line. As for mixed traffic modes, but to a lesser extent, the trend line intercept is clearly negative, meaning for a region with no population growth, ridership would be down.

Zero-Vehicle Households—Dedicated Right-of-Way Modes

Figure 14 shows 2012 transit ridership against 2012 percentage of zero-vehicle households and Figure 15 shows the percentage change in transit ridership against the percentage share of zero-vehicle households between 2012 and 2016. Cluster D (midsize auto-oriented) and Cluster E (sprawling metro) are compact in the lower left quadrant of Figure 14 with low levels of zero-vehicle households and low ridership. Cluster C (midsize dense) regions have much higher shares of zero-vehicle households, from Pittsburgh, PA, at 11% and San Juan, Puerto Rico, at 16%, but transit ridership is within the ranges of Cluster D (midsize auto-oriented) and Cluster E (sprawling metro). Cluster B (dense metro) also has high shares of zero-vehicle households, between Washington D.C. at 10% and Philadelphia, PA, at 13%. All the transit agencies with the greatest ridership are from Cluster B (dense metro). Los Angeles is in between with 8% zero-vehicle households and transit ridership between Cluster B and all the others. As shown in Figure 15, there also is no clear relationship between transit ridership change and zero-vehicle households change between 2012 and 2016.

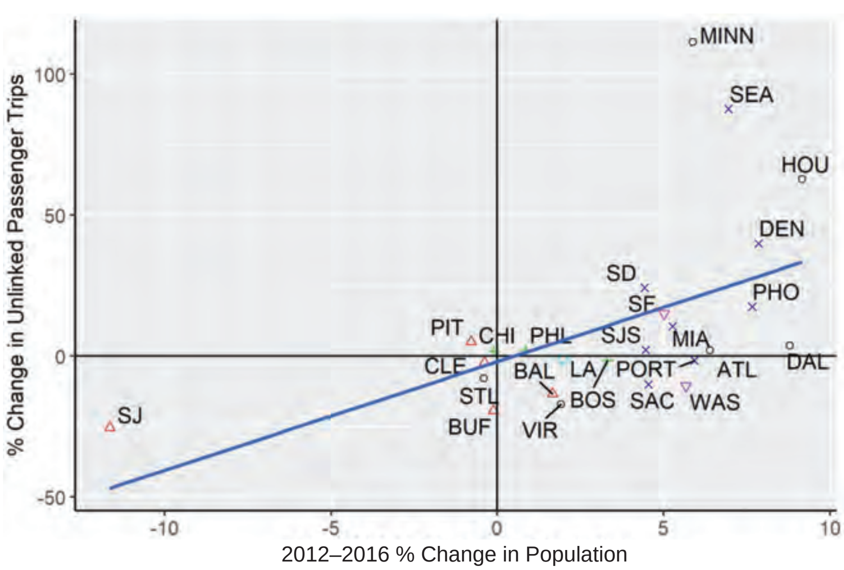


Figure 13. Percentage change in ridership vs. percentage change in population between 2012 and 2016 for dedicated ROW modes.

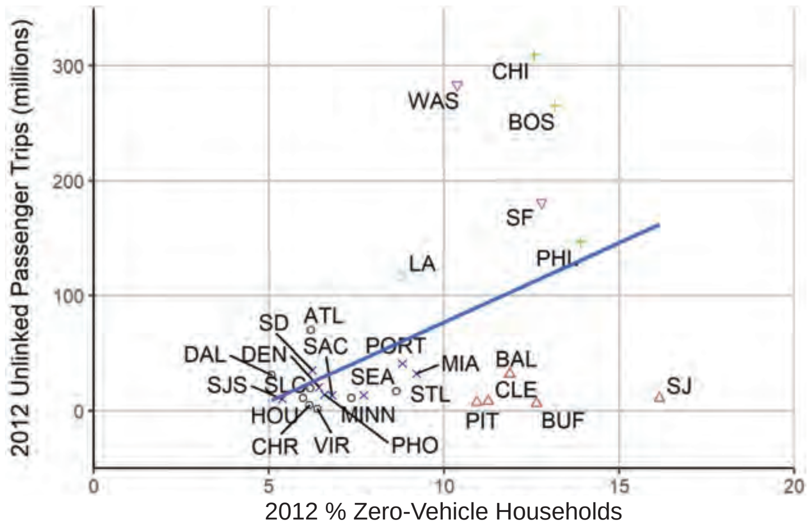


Figure 14. Transit ridership vs. percent zero-vehicle households for dedicated ROW modes, 2012.

Vehicle Revenue Miles—Dedicated Right-Of-Way Modes

Transit agencies have relied on dedicated ROW modes in recent years to increase transit ridership. Between 2012 and 2016, total transit vehicle revenue miles in the United States have increased by 7.5% for dedicated ROW modes. As shown in Boisjoly et al. (2018), the increase in rail service has often come at the expense of bus service. The effort to prioritize rail has allowed dedicated ROW modes to keep increasing in ridership between 2012 and 2015, when bus ridership was declining. However, rail ridership has dropped in 2016 and again in 2017. It is therefore important to evaluate the relationship between transit ridership and service levels. Figure 16 shows 2012 transit ridership against 2012 transit service levels, and Figures 17*a* and 17*b* show the percentage change in transit ridership against the percentage in transit service levels between 2012 and 2016 for dedicated ROW modes.

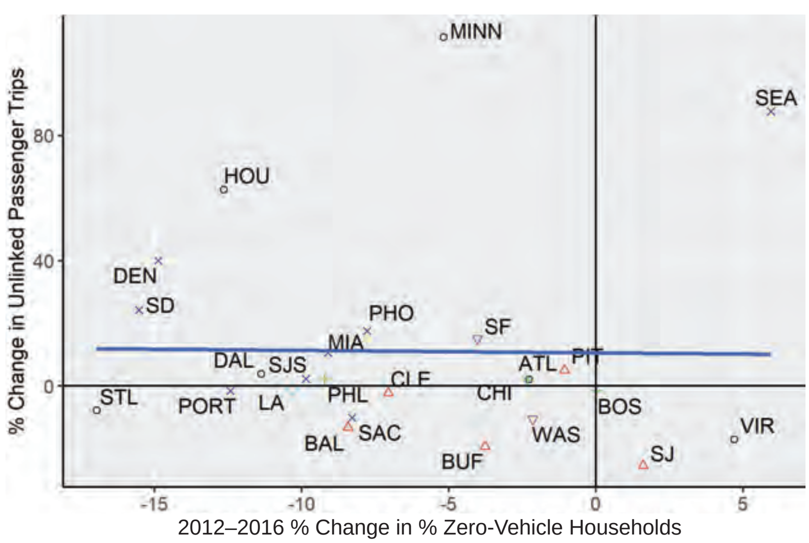


Figure 15. Percent change in transit ridership vs. percent change in share of zero-vehicle households between 2012 and 2016 for dedicated ROW modes.

Figure 16. Transit ridership vs. transit service levels for dedicated ROW modes, 2012.

Figure 16 shows there is a clear relationship between the two variables at a point in time, which holds true across the spectrum of service levels. The vast majority of regions are grouped in the lower left corner of the figure. These regions are distributed closely around the trend line. Note that while the labels are spread out, the actual points follow the line closely. Ridership in regions with greater dedicated ROW transit service is distributed along the same line. The only outliers are Boston, MA—which has slightly more transit ridership than would be expected for its service level—and San Francisco, CA—which has slightly less transit ridership than would be expected for its service level. This trend is consistent with mixed traffic modes, where transit ridership is also closely related to transit service levels.

Figure 17*a* would show a strong relationship if it were not for a few outliers such as Houston, TX. While Houston, TX, did increase ridership by 62%, these gains are modest in comparison

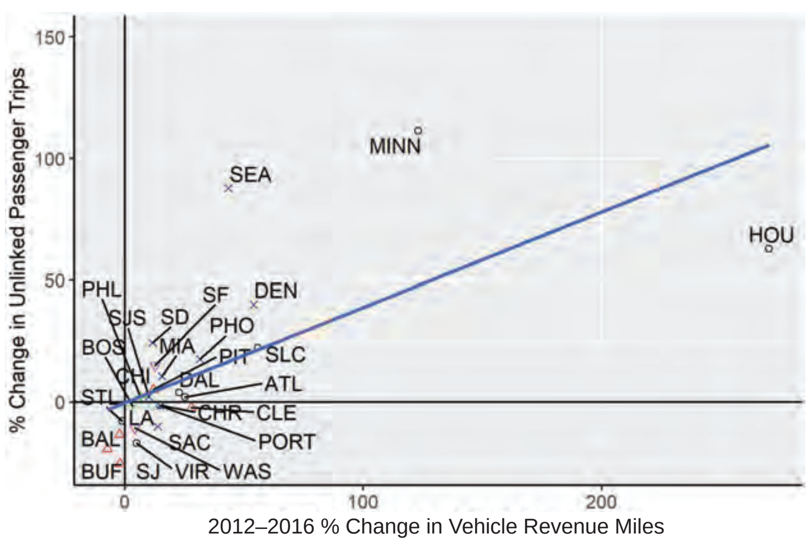


Figure 17a. Percentage change in transit ridership vs. percentage change in transit service between 2012 and 2016 for dedicated ROW modes.

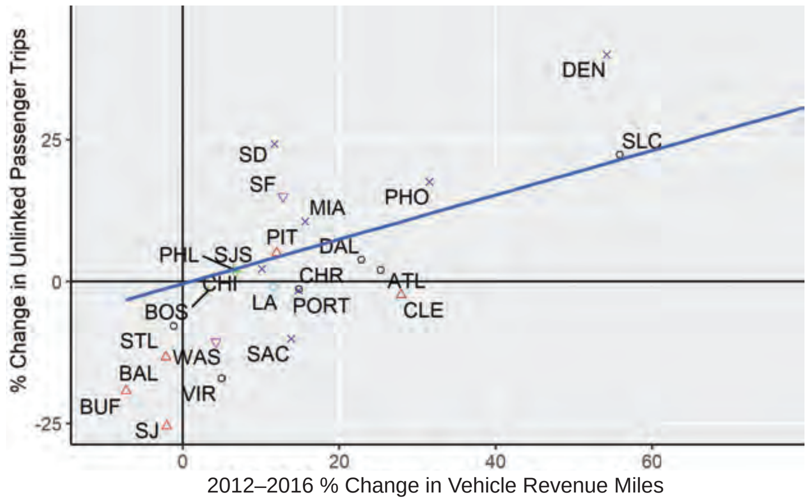


Figure 17b. Zoomed-in version of percentage change in transit ridership vs. percentage change in transit service between 2012 and 2016 for dedicated ROW modes.

to the 265% increase in transit service. Seattle, WA, and Minneapolis, MN, had much greater gains in ridership for more modest increases in service. By zooming in without these three cities in Figure 17*b*, the relationship between change in transit ridership and change in transit service levels is easier to see as far stronger for dedicated ROW modes than for mixed traffic modes.

Summary

Through this analysis of trends, we were able to evaluate the relationship between transit ridership and three of its main determinants, both at a point in time and as a change over time (2012 to 2016). Our analysis confirmed that population and service levels, which are typically associated with transit ridership, explain a large portion of the variation in transit ridership among peer transit agencies. We found a close relationship between the change in the factors and the change in transit ridership for dedicated ROW modes. However, this correlation does not hold for all factors for mixed traffic modes.

We found differing trends for population and ridership for dedicated versus mixed traffic modes. There is a clear relationship between 2012 ridership and population for mixed traffic modes, but it is more moderate for dedicated ROW modes. Conversely, there is a clearer relationship between transit ridership change and population change between 2012 and 2016 for dedicated ROW modes but not for mixed traffic modes. While both dedicated and mixed traffic modes had a strong relationship between ridership and service levels in 2012, the change in transit ridership was much more closely associated with change in transit service levels for dedicated ROW than for mixed traffic modes, especially in larger metropolitan areas.

Population affects transit ridership both directly and through the quantity of transit service available, both in terms of operations and infrastructure. Our results suggest that the direct effect (population on ridership) is stronger on dedicated ROW modes and that the indirect effect (service levels on ridership) is stronger on mixed traffic modes. The point-in-time transit ridership is more sensitive to population for mixed traffic modes because these modes can be expanded incrementally. Dedicated ROW modes, however, are the product of deliberate, often regional, policy decisions that require long-term planning and therefore may not necessarily follow population linearly. Conversely, the change in transit ridership has a stronger relationship with the change in population for dedicated ROW modes because these modes provide a fast and reliable service, which is more competitive with private vehicles in congested cities.

While there is a clear relationship between transit ridership and transit service levels at a point in time for both mixed traffic and dedicated ROW modes, the change in ridership is much more closely associated with change in service levels for dedicated ROW modes than for mixed traffic modes. With superior travel speed and reliability, dedicated ROW modes can attract patrons who also have access to private vehicles. Therefore, ridership on these modes may be more sensitive to service levels.

A significant departure from previous findings in the literature is that neither population nor transit service levels explain the change in transit ridership between 2012 and 2016 for mixed traffic modes. Transit regions overall gained both population and service levels while still losing transit ridership. Clearly, new factors are at work influencing transit ridership beyond the traditional factors of population, zero-vehicle households, and service levels.

CHAPTER 4

Transit Agency Strategies

A national trend of falling transit ridership has had many wondering what can be done. Many transit agencies across the country have undertaken campaigns to win back riders. From simple boosts in service to complex partnerships, these transit agencies and the cities they serve are hoping to avoid the national trend. No one solution can work as a catch-all because operating conditions between transit agencies can vary widely and ridership has many complexities. However, lessons learned from the various strategies attempted can be important for other transit agencies to understand how and if to implement a strategy in their area.

Service Levels

Transit agencies have long known that ridership is sensitive to the levels of service, reliability, and fares. Recently, levels of transit service have been identified as the main reason for the national decline in ridership both in the literature and in the news. Many experts have pointed to transit agencies that have increased service and gained the most ridership as examples.

Seattle stands out with a 1.3% increase in bus ridership and a 74% increase in light rail ridership between 2014 and 2016 based on an analysis of National Transit Database (NTD) data. Service additions likely played a considerable role in this growth, with bus and light rail vehicle revenue hours increasing 9% and 42% over the same period, respectively. However, the Seattle region's ridership growth cannot be entirely attributed to added service. According to Curbed, Seattle saw a nearly 9% drop in single-occupancy vehicle commuting from 2005 to 2015, the highest drop among major U.S. cities (Keeley, 2016). A dedicated transit mall, strategic small projects to speed up buses, and quick political maneuvering to come up with funding before shortfalls have all helped Seattle stay on top of ridership changes (Small, 2017).

As shown in Chapter 3, change in transit service levels, in terms of vehicle revenue miles, only explains a portion of the changes in transit ridership levels and the portion it explains is dependent on mixed traffic versus dedicated ROW and the size and density of the region. While transit service levels explain some of the decline in mixed traffic transit ridership in smaller regions (Clusters 1, 2, and 3), they are not correlated with ridership change in larger regions (Clusters 4 and 5). These trends indicate that the decline in transit ridership, especially in large transit agencies, is caused by some other factors that are occurring at a more disaggregate level. It is therefore important to analyze the other factors and strategies that may be affecting the ridership impact of service provided by transit agencies. The remainder of this chapter describes the initiatives by transit agencies to increase ridership independently of service levels.

Bus Network Restructuring

Recent efforts to increase transit ridership have consisted in restructuring bus networks to prioritize service concentration over coverage. Bus network redesigns in locations such as Houston, TX, have prioritized frequency of service in core corridors over long and circuitous routes with lower frequencies. The theory behind these efforts is that there is an inherent trade-off between service coverage and frequency of service (Walker, 2012). Therefore these network redesigns reflect a shift in policy goals from spreading service to reach the few and concentrating it to attract the many.

In August 2015, Houston's Metropolitan Transit Authority (MTA) of Harris County redesigned their bus network, increasing high-frequency bus routes, while cutting lower-frequency routes. The system was redesigned for the first time since the 1980s, with some routes unchanged since the 1920s (Lewis, 2015). Figure 18 shows the bus network before and after the redesign. The MTA's goal was to simplify bus routes and improve frequency to reach a higher proportion of residents. However, the Houston press reported that low-income neighborhoods lost 12 routes whereas non-low-income neighborhoods gained three (Flynn, 2015).

Called the "hottest trend in transit" by Governing Mag at the end of 2017, bus network restructuring is being considered by transit agencies across the nation. The Los Angeles Metro announced in May 2017 the start of a three-year process to restructure the bus network in response to a 20% drop in ridership over three years (Hymon, 2017). The Dallas Area Rapid Transit (Schmitt, 2017), the Southeastern Pennsylvania Transportation Authority (Laughlin, 2017), and the Washington Metro Area Transit Authority (Powers, 2017) are exploring similar bus network redesigns. Omaha Metro Area Transit, Austin's Capital Metro, and Columbus's Central Ohio Transit Authority (COTA) have followed suit with their own network redesigns. Seattle's King County Metro went through a similar process, albeit over the course of several years. Metropolitan Atlanta Rapid Transit Authority (MARTA) commissioned a Comprehensive Operations Analysis study, which also recommended concentrating bus service on core corridors (Parsons Brinckerhoff, 2016). In reducing their coverage, however, MARTA has faced stiff resistance from residents who rely on bus service as their only mode of transportation (Abubey, 2017).

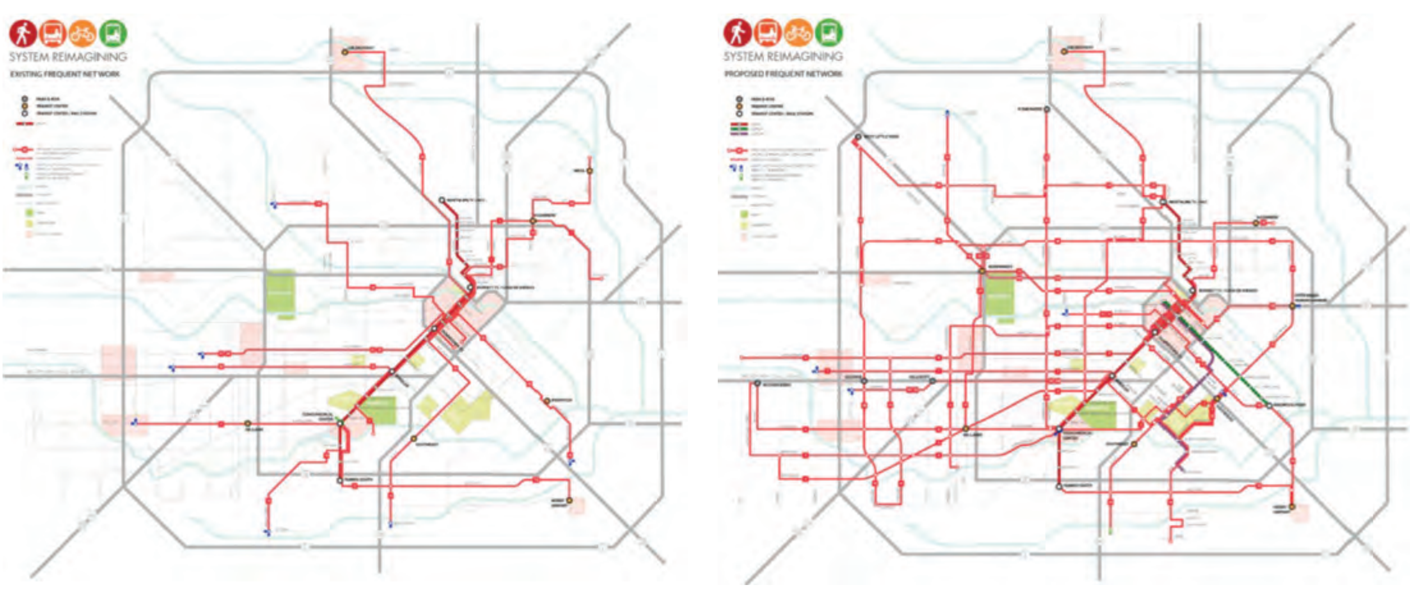


Figure 18. Houston Metro before and after frequent network redesign map.

One potential contributing factor not yet addressed in the literature or in the press is that these bus network redesigns were accompanied by net increases in bus operating budgets, likely to add substantial service. There is a need for research to parse the contributing factors of transit ridership and evaluate the singular impact of prioritizing concentration over coverage.

Mode Integration

In recent years, transit agencies have started changing their bus networks to improve the connectivity among modes. This trend is analogous to network redesigns described above but distinct because they do not necessarily prioritize service concentration over coverage. Mode integration is the reorienting of transit service to improve links among modes of transit, such as rail and bus. It is usually done in preparation for service expansion of new high-capacity transit lines. In Minneapolis–St. Paul, MN, and in Baltimore, MD, where new light rail and BRT lines were added, the bus networks were readjusted accordingly. The objective was to facilitate connections among modes.

In Minneapolis, parts of the bus network were restructured to serve a new light rail line. In preparation for the opening of the Metro Green Line in June 2014, surrounding bus routes were routed and timed to transfer seamlessly (Metro Transit, 2012). Metro's predictions were that around 40% of Green Line riders would connect to the bus system, and the network needed realignment to best facilitate these connections. The process took around two years to plan and implement. In addition, a new rapid bus service was planned and opened in 2016 with a direct connection to the Green Line (Shieferdecker, 2017). Green Line ridership in 2015 was 37,400, nearing Metro's goal of 41,000 yearly rides by 2030. Central Corridor ridership, including Green Line and surrounding bus routes, nearly doubled between 2013 and 2015 (Metro Transit, 2016). Overall, light rail ridership has increased 126% while vehicle revenue hours have increased 162% between 2013 and 2016. Bus ridership over the same period has fallen by 16% despite a 2% increase in vehicle revenue hours based on an analysis of NTD data.

Similar efforts took place between 2015 and 2017 by the Maryland Transit Administration (MTA) in Baltimore, as several routes were rebranded and the system reworked to provide BRT-ready color-coded lines with 24-hour service and high frequencies radiating from the city center. Additionally, connecting local buses were planned to form rings around the city to bridge gaps in service, and peak-period express buses would create fast links to downtown. The MTA's stated goals were to provide better and more frequent service city-wide and to strengthen connections between bus and rail (Maryland Transit Administration, 2017). The system went into effect in June of 2017 to much fanfare and high expectations (Dovak, 2017). In an analysis of NTD data, despite a 7% increase in bus vehicle revenue hours between 2016 and 2017, bus ridership fell by nearly 9%.

Dedicated Right-of-Way and Bus Rapid Transit

Increased congestion in growing cities, due in part to increased single-occupancy vehicle and TNC trips, has slowed bus speeds in cities (Schaller, 2018). As these services both slow down transit and potentially pull riders away, many transit agencies and their cities are giving transit dedicated lanes to move vehicles faster through congested streets. Dedicated lanes also allow for tighter headways and keep buses from frequent bunching. These partnerships between transit agencies and local jurisdictions display a dedication to improving transit experiences and ridership. Although the negotiations are often considerable, they can often be completed at little capital cost compared to the resulting benefits to transit riders.

Two cities' pilots proved wildly successful at both speeding up vehicles and attracting riders at little cost. In Toronto, the city's busiest streetcar route on King Street was plagued with delays and inconsistent service as the vehicles sat in traffic with cars. In November 2017, a one-year pilot was announced to help speed up the streetcars by restricting private cars' access to the street. One hundred eighty parking spots were removed to make way and private vehicles were forbidden to drive more than one block without turning right or left (Spurr, 2018). Deliveries, local access, and emergency access were not affected, and car travel times throughout the city experienced little change. The streetcar, however, saw increases in on-time performance to 85% on time, as vehicles were more consistently arriving within four minutes of their scheduled time. The pilot has also seen small decreases in travel time and increases in transit ridership of 13% all day and up to 19% for the afternoon peak between October 2017 and March 2018 (City of Toronto, 2018).

In Boston, the city's transportation department tested pilot bus lanes as part of their 2030 plan (City of Boston, May 2018). Bus ridership for the Massachusetts Bay Transportation Authority (MBTA) has fallen over 9% since 2012, corresponding to an 8% reduction in vehicle revenue hours based on NTD data. In a partnership between the city and the MBTA, a temporary bus lane was created in the Roslindale neighborhood along Washington St., one of the city's busiest routes. The temporary lane was originally set with orange cones blocking off a single inbound lane to cars between 5–9 A.M. on weekdays. The results were a decrease in travel time by 20–25% during rush periods. In response to overwhelming support from bike and transit riders, the city made the bus lane permanent after the end of the four-week implementation period. Similarly, a peak-hour bus lane that replaced a mile of on-street parking along Broadway in Everett has cut trip times by 20–30% (City of Boston, June 2018).

Transportation Network Companies and Bike, Scooter, and Car Sharing Partnerships

There is currently much discussion on the role of transportation network companies (TNCs), such as Uber and Lyft, in recent transit ridership declines. Though a thorough analysis has yet to be completed, there is evidence that these services may be helping to increase ridership in some cases and decrease ridership in others (Hall et al., 2018). Regardless, TNCs have the potential to decrease auto ownership, and many transit agencies have partnered with these services to allow connectivity to areas near stops and stations that encourages transit use for a portion of each trip.

A prime example is the Pinellas Suncoast Transit Authority (PSTA), whose pilot partnership with Uber was the first of its kind, who recently expanded and added a Lyft partnership (PSTA, 2016). PSTA provides subsidies to Uber, Lyft, and taxi rides to designated bus stops, expanding their service area outside of walking distance from bus lines. NTD data shows that demand response ridership increased over 5% between 2015 and 2017, with reported vehicle revenue hour increases of 91%. Bus ridership, however, fell nearly 20% over the same period, while bus vehicle revenue hours fell 3%.

Since PSTA's pilot, 13 other transit agencies, including some of the country's largest, have begun exploring subsidized rides in their service areas (APTA, 2018a). These programs range from paratransit-specific trips to full service area TNC subsidies. A potential benefit to some of these programs is the elimination of select inefficient and underutilized bus routes so as to send more resources to routes that need them. Ridership effects are still unknown, and a variety of factors including wait time, fares, accessibility, and service area are at play.

Additional partnerships between transit agencies and shared mobility services such as bike-share and scooters have the potential to allow more car-free trips. These technologies allow first-and-last-mile connectivity from transit stops and stations without transit or private vehicles. The FTA sandbox program, detailed in the next section and primarily focused on demand response, has provided funding for a bike sharing partnership in Chicago that looks to include bike sharing in its trip planning and fare payment app (Spielman, 2017).

A 2015 survey of over 80 transit agencies and transportation stakeholders by Iacobucci et al. (2017) found that only transit agencies in Boston and Seattle had data sharing partnerships with TNCs and that many officials were skeptical of partnerships with TNC and car sharing companies. Others were concerned with their transit agencies' and local jurisdictions' ability to keep up with rapidly changing technology but insisted that access to data is key for the future success of these partnerships. Since the study, transit agencies such as Miami-Dade Transit (Zipcar, 2017) and the Maryland Transit Administration (Zipcar, 2018) have added dedicated car sharing spaces at rail stations as an added form of flexibility for transit riders to complete trips and run errands.

Demand Response and Flex Routes

To provide greater transit access in low-density neighborhoods, a re-emerging strategy consists in using demand-responsive transit. Research using simulation has shown that in low-density areas, demand-responsive transit can service short trips faster (Qiu et al., 2015) and at a lower cost than fixed routes (Edwards and Watkins, 2013). Several transit agencies have implemented demand-responsive service either to reach the first-and-last-mile or to connect origins and destinations directly.

There are two main approaches used in practice to provide demand-responsive transit. The first approach consists in using third-party software to dispatch transit agency operators. The Denver Regional Transportation District has been providing dynamic rides with their own vehicles and operators since 2000 (Becker et al., 2013). Kansas City (Kansas and Missouri), the Bay Area in California, and Austin, Texas, all experimented with demand-responsive programs operated by their own staff, with varying degrees of success, detailed below. Chicago's suburban Pace recently announced a microtransit pilot to supplement its fixed-route network and provide more streamlined service (DemandTrans, 2018).

The second approach consists of employing independent drivers who use their own vehicles to pick up customers at their door, similar to the TNC partnerships described above. The Los Angeles Metro is planning a similar program in partnership with the technology company, Via. The advantage of going through independent drivers is that the transit agency can take advantage of economies of scale from existing networks of ride-hailing drivers. There still lacks, however, quantitative research to assess the service and ridership implications of the programs.

One primary source of funding and inspiration for recent demand response programs comes from the Federal Transit Administration's Mobility on Demand Sandbox Program. The $8 million program, announced in October 2016, is interested in assisting transit agencies and departments of transportation in introducing mobility tools like demand response and vanpool programs. A total of 11 transit agencies were involved in the program for fiscal year 2016, with some pilot programs extending to bike sharing partnerships and advanced trip planner technology in addition to demand response and paratransit pilots (FTA, 2017).

Outside of these Sandbox programs, transit agencies in Kansas City, the Bay Area, and Austin have been experimenting with unique approaches to demand response microtransit.

- In 2016, the **Kansas City Area Transportation Authority** (KCATA) announced a one-year microtransit pilot with Ford and microtransit provider Bridj. The goal of the project was to extend KCATA's reach to new communities by placing 10 roving vans throughout the service area, and when riders would enter their origin and destination from a set of specific pickup and dropoff points, rides would be paired and chained together with Bridj's algorithm (Marshall, 2016). During the pilot, a series of surveys were conducted on those participating, with over half indicating they chose to use the service because it was cheaper than alternatives. While 25% of respondents indicated that they drove less often because of the service, a similar number indicated using the bus less often (Shaheen et al., 2016). Despite promising technology and survey results, a pilot attracted only 1,480 rides. Bridj later went out of business. Officials in Kansas City saw the pilot as a learning process, and they were optimistic that with better marketing and more data, a similar type of service could be successful in the U.S.

- The Bay Area's **Santa Clara Valley Transportation Authority** (VTA) experimented with a similar microtransit pilot for six months in 2016. Called "FLEX," the service launched in January 2016 to test the viability of an on-demand service and its associated software in the region. Within a six square mile service area, riders could use an app to request a shared ride between 5:30 A.M. and 8:30 P.M. (VTA, 2016). The high costs and lack of ridership of the pilot caused it to be severed after six months. A Curbed article argues that its primary issues were a restrictive service area, lack of connection to existing transit options like light rail, and lack of utility to most potential users (Sisson, 2018).
- Despite the lack of ridership in other cities, **Austin's** microtransit pilot saw much greater success. In June of 2017, **Capital Metro** partnered with Via to provide free on-demand rides for a year within a specified service zone. The service was available through an app, and a vehicle was guaranteed to arrive within 15 minutes (Capital Metro, 2017). Within two months, the service reached its six-month ridership goals, and after a year, the vehicles had served more than 20,000 rides (Bliss, 2017). Austin's pilot may have been unique due to lack of fares and the city's uneasy history with TNC providers. In May 2016, Uber and Lyft were effectively forced out of Austin by a referendum requiring drivers to be held to similar scrutiny as taxi drivers. After a year, the services were allowed to resume normal service (Liptak, 2017).

Fare Media and Integration

Fares are a vital component in transit policy, as it is a delicate balance between transit ridership and revenue. Transit fare media and fare policies can determine the ridership experience and ultimately affect transit ridership. Outdated fare technology can slow down vehicles and damage a transit agency's perception as being outdated or left behind, and new fare technology can help modernize and speed up service. A 2015 study in Los Angeles showed a 2 second decrease in dwell time per passenger using a smart card over a traditional ticket (Shockley et al., 2015).

Transit agencies have recently implemented account-based and open-loop fare payment systems to reduce the time and effort required to purchase a transit fare. Account-based systems integrate these modes into a single user account, which can then be anonymously tied to trips for better origin-destination data. Slow and inefficient payment systems serve to keep buses and trains waiting longer for passengers to board. Open-loop payments allow riders to use their own bank accounts and smartphones to pay without purchasing passes or tickets from the transit agency. Several transit agencies have undertaken these technologies to simplify methods of payment and combine services into a single platform.

- In **Portland, OR, TriMet** recently began a transition to a comprehensive, permanent pass. The transit agency currently relies on paper tickets to collect and validate fares, often resulting in slow boarding processes (TriMet, 2018). TriMet's new Hop Fastpass allows seamless connection between bus, rail, streetcar, and commuter rail modes with built-in transfers.

TriMet also accepts phone payments via mobile wallets and NFC readers (Altstadt, 2018). An added feature of the Hop Fastpass is its fare-capping capabilities. Riders taking multiple trips will never be charged more than the cost of a day pass in a single day, nor will they be charged more than a monthly pass in a single month, regardless of how many trips they take (Hop Fastpass, 2018). This policy can provide peace of mind to riders concerned with paying multiple fares and may encourage extra trips.

- In **Chicago, IL,** a magnetic-swipe system was slowing down buses and costing the **CTA** close to $5 million per year in handling expenses (O'Neil, 2013). Chicago's Ventra system, set up in July 2014, was one of the first smart card technologies of its size in the U.S., combining bus and rail swipe into a faster tap system. Later, Metra commuter rail, Pace suburban bus, and real-time tracking were combined with CTA services into one app that allows purchasing and using fares without a physical card. This system allows any Chicago transit rider to use a single account and payment system, simplifying transit use across the region (Ventra, 2018).

Additional Strategies

In addition to the methods detailed above, there are a variety of efforts that cities and transit agencies have gradually adopted that may be helping to boost ridership. The availability of real-time information in transit service has grown substantially over the past several decades. These generally app-based services have allowed transit riders to have confidence in the arrival of their next bus or train and potentially decrease wait time at stops and stations. A 2015 study by Brakewood et al. demonstrated that the arrival of real-time information to buses in New York City brought with it a 2–3% increase in ridership.

The arrival of alternatives to auto ownership in recent years may also help transit agencies sustain or grow ridership. A 2018 study of 25 North American regions by Boisjoly et al. showed that the presence of a bike sharing service and Uber both correlated with higher ridership than in regions without. However, timely data on the impacts of such services on ridership are just emerging and more research is needed.

Similarly, many agencies are turning to customer experience issues as part of an effort to improve ridership. Through surveys, agencies such as LA Metro have found that security concerns, homelessness, and unavailable or unreliable transit information have caused former riders to stop using transit. Overall, incremental improvements such as real-time information, partnerships with other mobility services, and improvement to customer service have the potential to retain riders and help curb auto-dependency within regions.

Summary

Transit agencies across the country have adopted a wide variety of tactics to combat recent ridership declines. While research must still be done on the effectiveness of the implementation of all of the pilots and programs above, there are some key takeaways to be had from projects over the last several years. While transit service levels remain a key determinant of transit ridership, transit agencies have implemented new strategies to maximize the effectiveness of scarce operating funds. One of the most significant trends of the last several years has been network restructuring and integration. Transit agencies have also implemented partnerships with ride-hailing companies and piloted microtransit programs. Dedicated bus ROW has shown the potential for drastic improvements in operational efficiency, which could translate into increased transit ridership.

CHAPTER 5

Case Studies

To further explore strategies transit agencies are using along with the relationships between ridership and operations, ten case studies were chosen for further analysis. The ten case studies conducted represent a variety of conditions in terms of ridership change, other performance trends, and strategies attempted to encourage transit ridership and combat potential declines. The ten transit agencies include the following:

- Connect Transit in Bloomington–Normal, IL
- Greater Portland Transit District in Portland, ME
- IndyGo in Indianapolis, IN
- King County Metro in Seattle, WA
- Maryland Transit Administration in Baltimore, MD
- Massachusetts Bay Transportation Authority in Boston, MA
- Metro Transit in Minneapolis–St. Paul, MN
- Metropolitan Transit Authority of Harris County in Houston, TX
- Pinellas Suncoast Transit Authority in St. Petersburg, FL
- Spokane Transit Authority in Spokane, WA

For each transit agency, an interview was conducted to obtain background information on ridership trends and strategies from the transit agency's perspective. Data on unlinked passenger trips, vehicle revenue miles, vehicle speeds, and in some cases on-time performance were obtained from each transit agency and trends in each of these operating characteristics were graphed along with their relationship to transit ridership.

Case Study 1—Connect Transit, Bloomington–Normal, IL

Background

Connect Transit operates fixed-route bus service in the Bloomington–Normal, IL, metro area, providing around 8,600 trips per weekday. Connect Transit operates 15 fixed routes that converge on two transit centers. Illinois State University represents a sizable portion of both the region's population and the transit agency's ridership. The typical Connect Transit passenger is transit dependent and between 18 and 24 years old.

Bloomington–Normal Public Transit System was established as a joint effort between the City of Bloomington and the Town of Normal in 1972. After rebranding as Connect Transit in 2012 and refocusing efforts on customer service, employee development, and technology, the fixed-route bus system saw significant growth in transit ridership in 2012, 2013, and 2014. In 2015, Connect Transit received the American Public Transportation Association (APTA) Award for Outstanding Public Transportation System for transit agencies in North America providing fewer than 4 million passenger trips annually. In 2015, the transit agency switched from a flag system, where passengers could flag down a bus at any safe street corner, to a fixed system, where passengers can only be picked up and dropped off at predetermined bus stop locations and transfer centers. The Connect Transit fixed-network was comprehensively redesigned in 2016 with long and circuitous routes replaced with new route alignments on major corridors. The network redesign consisted of increasing frequency, adding Sunday service to the system, and providing customers with a real-time mobile app. Since the redesign, minor adjustments to the transit system were made, included cutting a route in 2017 and extending service hours for select routes in 2018.

Key Performance Trends

Key trends for bus service from 2012 to 2018 are shown in Figure 19, which displays a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, and average speed. Bus ridership since 2012 has followed a remarkable trend, peaking in 2015 at over 35% above 2012 levels, and recently settling near 15% above. This all came with almost no change in service levels and recently declining average speeds. The increasing ridership happened at the same time new technologies were rolled out under the new General Manager who joined the transit agency in 2011. A redesigned website, mobile bus tracking, a rebranding to Connect Transit, and better customer service all took place in the last several years. The increase in ridership may be partially due to a change in the method for estimating ridership, from manual counts to automated passenger counts (APC). However, new technology could also account for improvements in passenger information, which may also partially explain the ridership increase.

Although the network was redesigned in 2016 to increase fixed-route ridership, the number of passenger trips and average speed continued to drop until mid-2017, as seen in Figure 19. This initial decrease of riders may be due to the public confusion of the new routes with reused names. The decrease in average speed may be explained by new route alignments on major corridors with congestion. After an initial adjustment period post-launch of the restructured system, fixed-route ridership began to increase. An extra hour of service on four of Connect Transit's main routes was added in late 2018.

Ridership data for Figure 20 and Figure 21 were calculated as monthly average weekday boardings averaged over the fall period (September, October, November, and December) of 2013 and 2017. Both passenger counts and route frequencies were provided from the transit agency. While the route alignments and schedules changed between 2013 and 2017, their

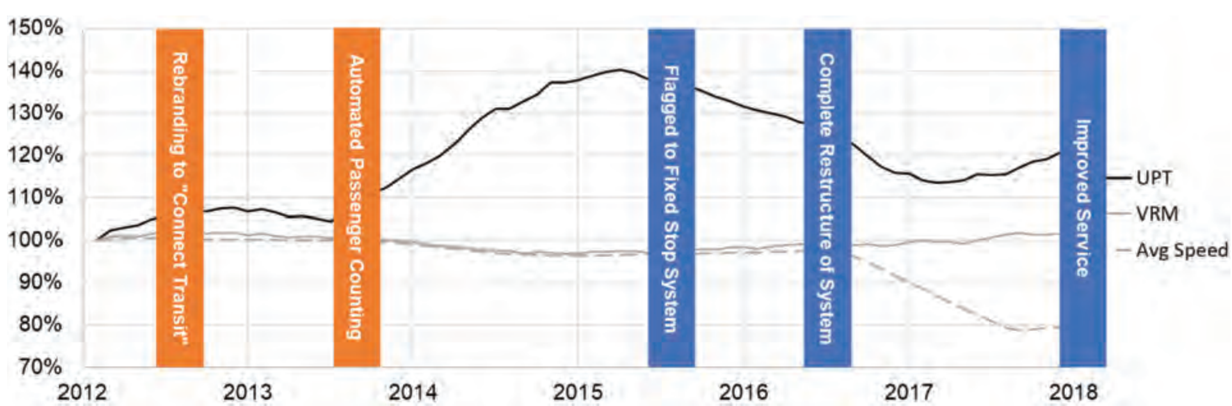


Figure 19. Connect Transit bus systemwide trends (UPT = unlinked passenger trips; VRM = vehicle revenue miles).

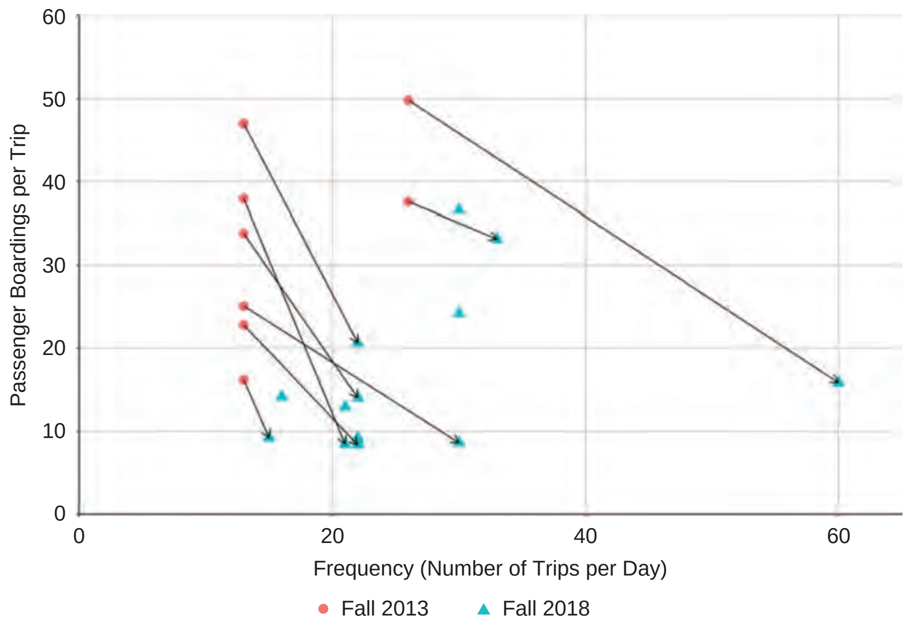


Figure 20. Connect Transit frequency and ridership trends in 2013 and 2018.

comparison provides insights on the effect of the network redesign. From 2013 to 2017, all bus routes increased frequency but did not increase in passenger boardings per trip as seen in Figure 20. Connect Transit saw a peak in ridership in 2015 and overall average weekday ridership has decreased between the end of 2013 and the end of 2018.

On-time performance increased overall from 2013 to 2018 after the introduction of fixed routes and a restructured system, as seen in Figure 21. Following the system restructure in 2016, overall on-time performance improved. This may be due to the new alignment on major

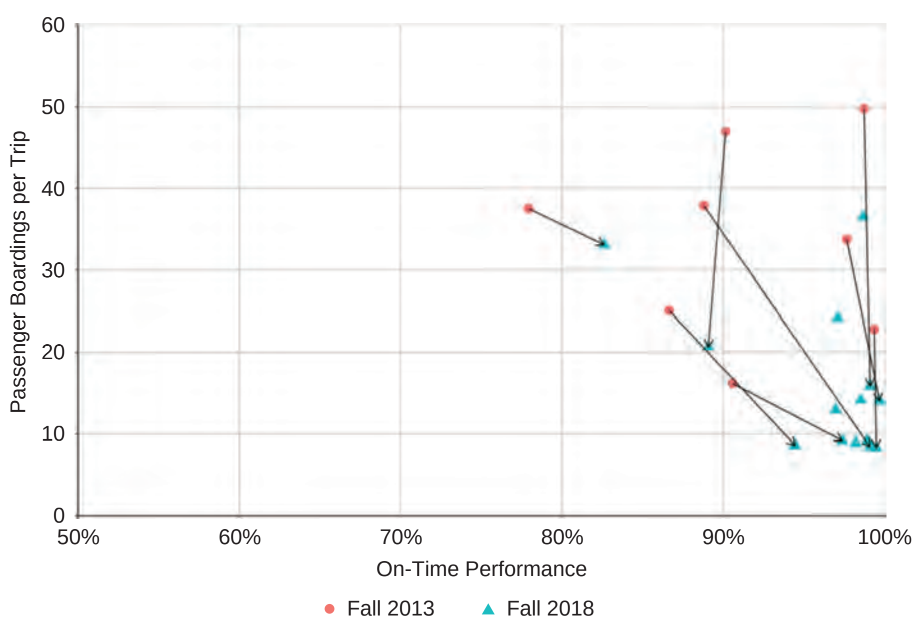


Figure 21. Connect Transit on-time performance and ridership trends in 2013 and 2018.

corridors, which allowed buses to operate shorter routes on better-maintained streets. Dwell times were also added in 2016 to the schedule on all routes to allow room for error or delay.

Future Plans to Encourage Ridership

Connect Transit was recently awarded a grant for battery–electric replacement buses. Connect Transit hopes the new-technology buses will allow improvements in on-time performance while decreasing operating expenses. There is additional discussion of improving bus stop infrastructure, increasing fares, and the discontinuation of low-performing routes.

Case Study 2—Greater Portland METRO, Portland, ME

Background

The Greater Portland Transit District (Greater Portland METRO) is Maine's largest public transit agency and provides more than 1.8 million boardings per year. METRO operates 11 fixed-route bus services in southern Maine, including Brunswick, Falmouth, Freeport, Gorham, Portland, South Portland, Westbrook, and Yarmouth. In the past half-decade, METRO bus ridership has increased after implementing high school student transit passes and a commuter service.

Founded in 1966, METRO went through several decades of declines in bus service area and ridership. In 2004, the transit agency began expanding again, and improvements have come quickly since then. After a 2013 bus priority study of recommended improvements to a street to increase speed of buses, two signals were modified to accommodate transit, and an in-line bus stop was added by 2017. In 2015, free rides for high school students began, and Sunday service was increased. An express bus service, METRO Breez, was added in 2016 and expanded in 2017. A university program with University of Southern Maine (USM) started providing free transit for students, staff, and faculty in 2018. The Husky Line, a distinctively-branded bus route featuring more frequent connections for students and professionals, was introduced in 2018 as well.

Key Performance Trends

Key trends for bus service from 2012 to 2018 are shown in Figure 22 which displays a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue

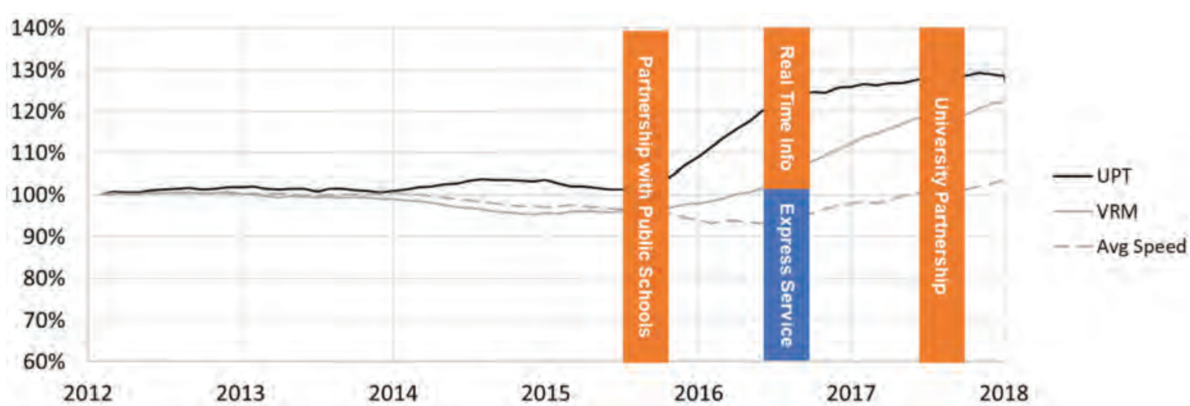


Figure 22. METRO bus systemwide trends.

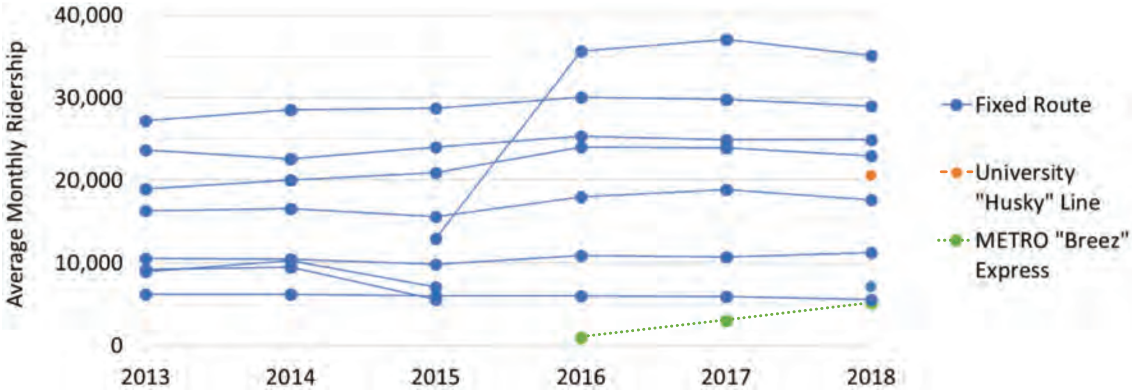


Figure 23. METRO bus ridership trends by route.

miles, and average speed. Bus ridership since mid-2015 shows a remarkable trend of nearly 30% growth. A sizable portion of this ridership may be attributed to incoming high schoolers following the elimination of yellow bus service in 2015, indicated on Figure 22. Fixed-route ridership continued to grow from 2016 to 2018, and service levels and average speed have steadily grown as well. METRO Breez express bus service began operating in August 2016, connecting the downtowns of Portland, Freeport, and—in mid-2017—Brunswick.

Ridership data for Figure 23 was calculated on each route as average monthly ridership over a year from 2013 to 2018. Historic route frequencies were not available. METRO bus ridership has remained steady or increased on all routes.

Unfortunately, on-time performance data before February 2018 was not available. METRO defines a bus to be "on-time" if it is operating less than six minutes late at a timepoint. On-time data is calculated and tracked through an automatic vehicle location (AVL) system. Available on-time performance data, February 2018 to February 2019, is displayed in Figure 24. Low on-time performance on express bus may be due to the longer route.

Future Plans to Encourage Ridership

Looking towards the future, transit officials of greater Portland have begun a study of the region's bus, rail, and ferry services to guide transportation planning for the next three decades.

METRO will deploy a new fare structure and payment system in 2019 to modernize the system. Although mobile app and plastic card technology will be introduced, a cash box will

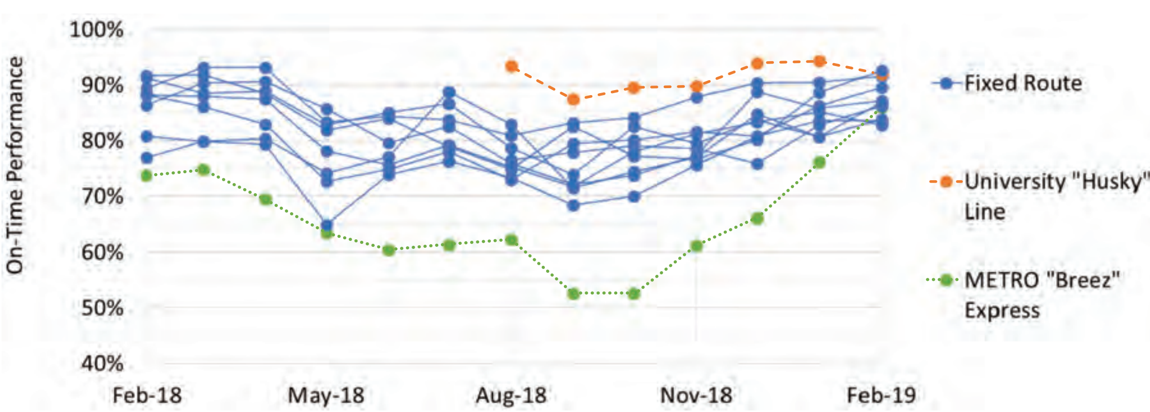


Figure 24. METRO bus on-time performance trends by route.

remain. A fare increase has been proposed, from $1.50 to $2.00, and the current reduced fare for riders older than 65 will extend to riders between 6 and 18. METRO is planning to add zero-emissions vehicles to its fleet in 2020. The city of Portland is also undergoing a series of progressive enhancements, such as changes to zoning code that allows developers to pay a fee in lieu of meeting minimum parking requirements.

Case Study 3—IndyGo, Indianapolis, IN

Background

The Indianapolis Public Transportation Corporation, branded as IndyGo, is the largest public transportation operator in Indiana. IndyGo provides and operates bus and paratransit services around the Indianapolis region with 31 fixed bus routes, providing nearly 10 million passenger trips a year. IndyGo is improving resources and operations over the next five years to expand service frequency and hours of operation for its fixed-route local network. The transit agency is also constructing three new rapid transit lines and changing the orientation of their network from a hub-and-spoke network to a grid system.

Fixed-route transit ridership generally declined since the public agency took over operations in 1975. IndyGo has recently undertaken a series of active steps to reverse the trend. Free circulator routes and university-focused routes became popular in the mid-2000s, with transit ridership peaking in 2003 at more than 10.9 million unlinked annual passenger trips. These routes fell out of use and were discontinued in 2009 with system transit ridership falling to 8 million annual riders. On-board surveys conducted by IndyGo in 2009 and 2016 indicate that the typical rider profile—a low-income adult traveling between home and work—has not changed significantly over the years. A similar distribution of activities is seen between 2016 and 2009 responses, but there are slightly fewer passenger activities per vehicle trip in 2016. Today, the typical IndyGo passenger is transit dependent and frequently uses services to a wide variety of destinations.

Key Performance Trends

Key performance trends of IndyGo from 2012 to 2018 are shown in Figure 25, which displays a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, and average speed. The system saw a leap in transit ridership between 2012 and 2015, followed by steady ridership declines despite a new downtown transit center opening in

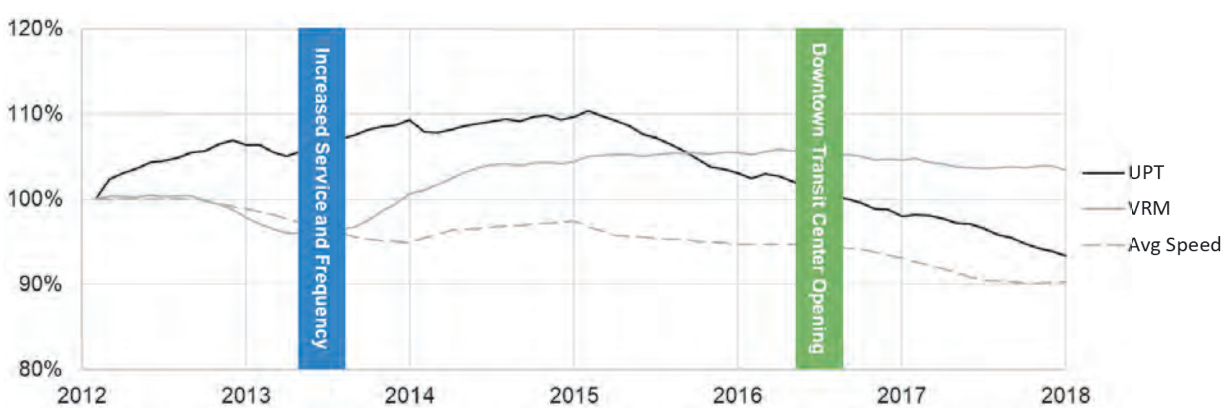


Figure 25. IndyGo bus systemwide trends from 2012 to 2018.

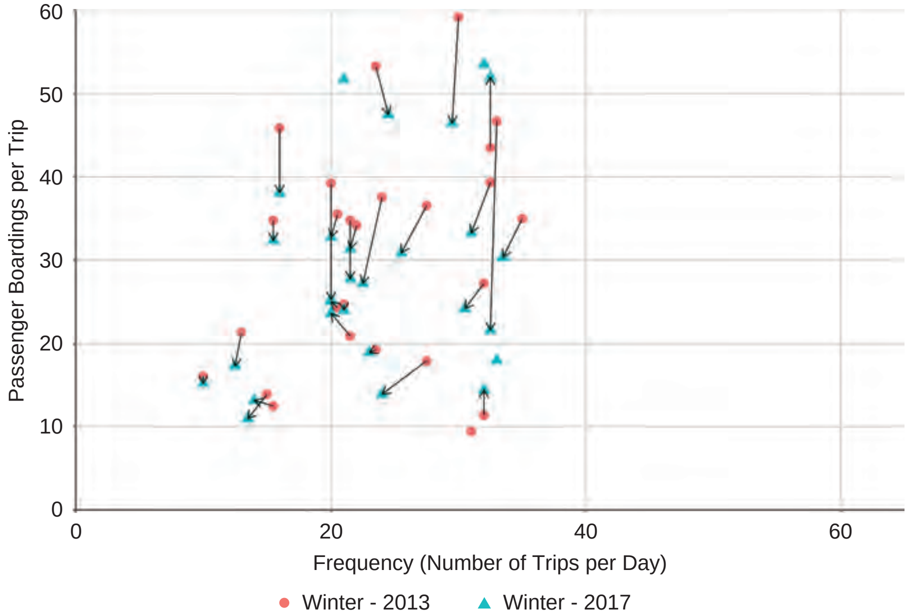


Figure 26. IndyGo frequency and ridership trends in 2013 and 2017.

2016. Improved frequency, extended hours, and additional stop amenities were implemented on existing fixed routes in mid-2013. Fixed-route-level frequency has not dramatically changed since mid-2013, and route-level transit ridership has decreased from late 2013 to late 2017, as seen in Figure 26. From 2013 to 2017, routes with typically high ridership lost the most ridership proportionally. Transit ridership data for Figure 26 and Figure 27 is from monthly farebox data averaged over the period, and stop and frequency data is from the transit agency's General Transit Feed Specification (GTFS).

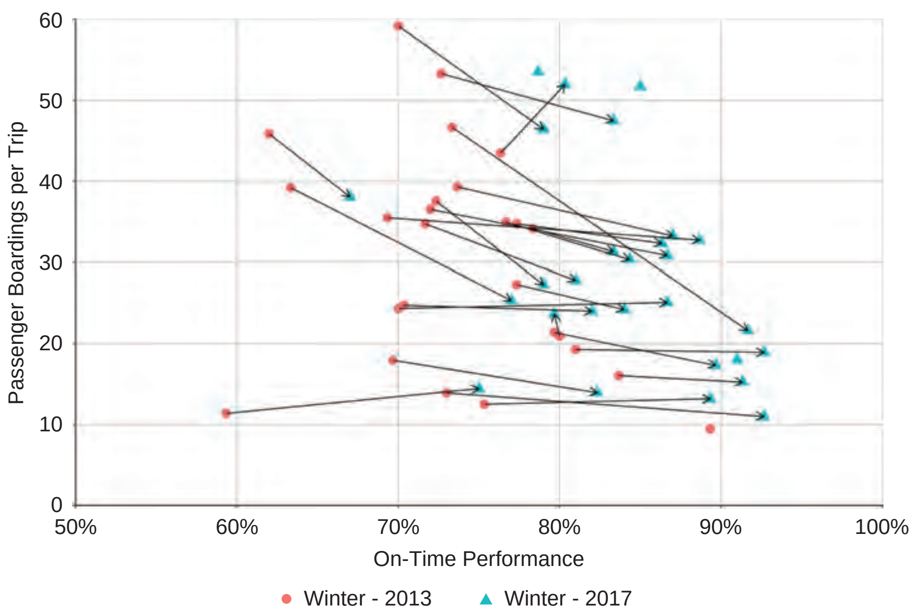


Figure 27. IndyGo on-time performance and ridership trends in 2013 and 2017.

IndyGo has defined on-time performance as one minute early to five minutes late from scheduled arrival since 2009. IndyGo measures on-time performance with on-board AVL systems and is in the process of transitioning to a new platform. IndyGo tracks every professional coach operator's on-time performance each month and frequently recognizes drivers who meet or exceed the goal of a 90% on-time monthly average.

Although the average speed has dropped nearly 10% since 2012, the on-time performance for each route has improved on all routes between 2013 and 2017, as seen in Figure 27. Improving on-time performance during this period has not resulted in ridership increase. On-time performance data for the winter periods in Figure 27 is calculated by averaging IndyGo's self-reported data averaged over the months of November, December, and January. Winter storms in 2013 may partially account for low on-time performance. However, the long-term trend of improved reliability is shown in Figure 28.

Future Plans to Encourage Ridership

To prepare for upcoming capital improvements, the strategic planning division at IndyGo has performed exploratory analysis of ridership trends. Changes in IndyGo ridership have generally mirrored national changes with a slight lag. At the local level, the IndyGo team has examined geospatial transit ridership trends as seen in Figure 29. While examining area stop-level boardings, they found a decrease of boardings on specific streets that were affected by street closures and resulting delay.

Past efforts to improve on-time performance and frequency have not resulted in ridership improvements. Looking to the future, IndyGo is hoping to combat decreasing ridership by

- Adding BRT lines,
- Utilizing geospatial analysis tools,
- Updating rolling stock,
- Converting one-way streets to two-ways for more accessibility, and
- Improving transit shelters downtown.

Three bus rapid transit (BRT) lines will replace some of IndyGo's most popular routes and include improved station infrastructure, dedicated lanes, transit-signal priority, level boarding, and off-board fare collection infrastructure starting in 2019 through 2022. Downtown transit shelters will be converted to "Super Stops," which include near-level boarding, real-time arrival information, and upgraded lighting and covered seating.

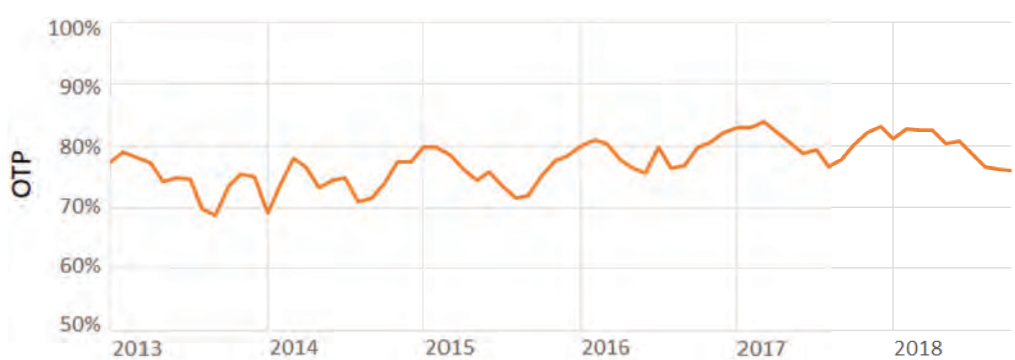


Figure 28. IndyGo systemwide on-time performance (OTP).

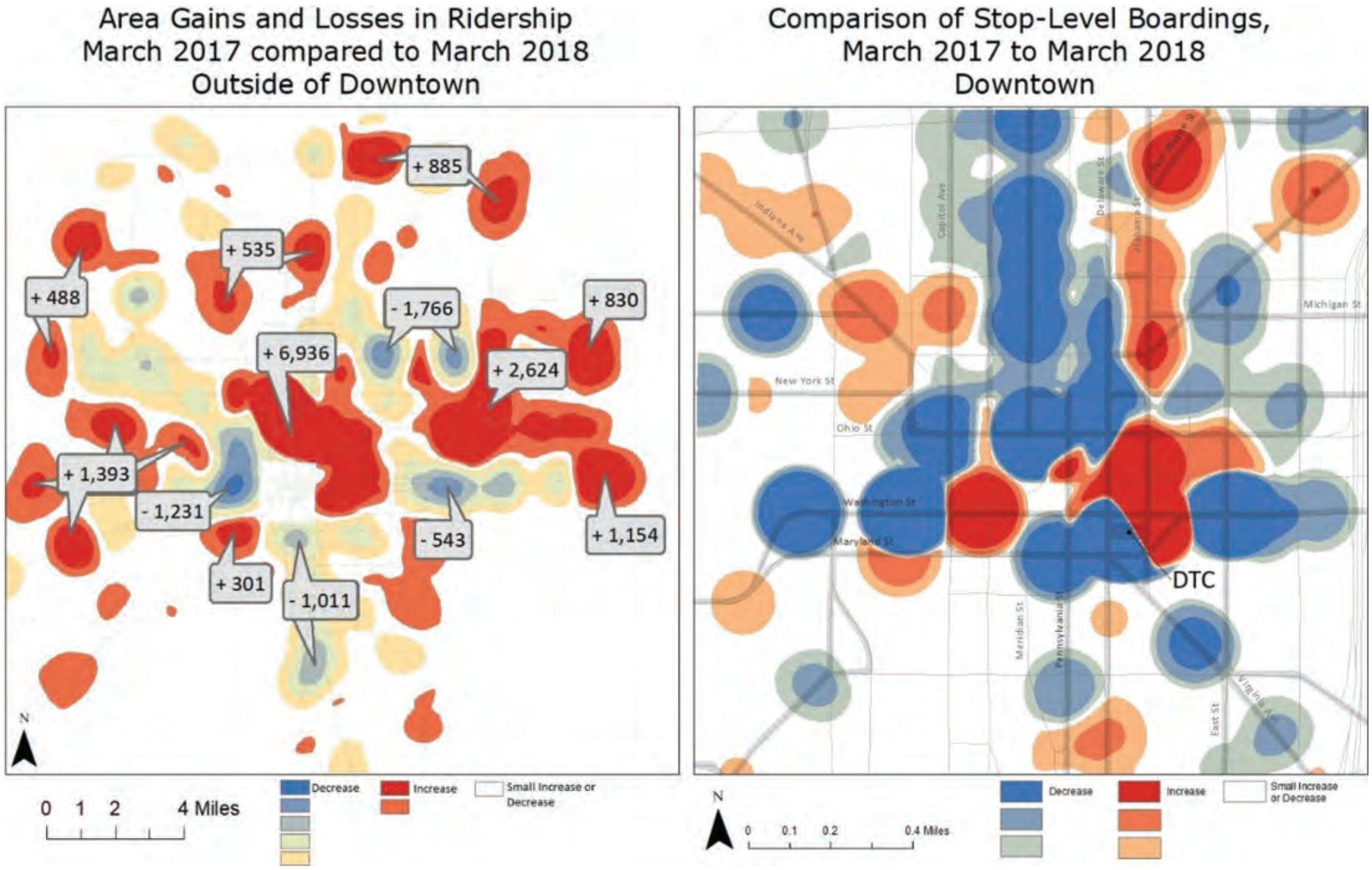


Figure 29. IndyGo area year over year ridership gains (losses).

Case Study 4—King County Metro, Seattle, WA

Background

King County Metro is the primary operator of bus service, vanpools, paratransit services, and community shuttles in the Seattle region. The transit agency also operates two streetcar lines, Seattle's light rail and commuter rail services. As the eighth-largest bus agency in the U.S., King County Metro operates 237 fixed-route bus services and provides over 120 million passenger trips each year. Seattle has recently been featured in the press for its dramatic shift from driving to transit. Light rail openings have boosted these effects, but King County Metro has also managed to continually increase bus ridership over the past several years.

Founded in 1973, King County Metro has played an increasingly important role in reducing congestion, protecting the environment, and getting people where they need to go in the Seattle area. King County Metro operated in the downtown Seattle fare-free zone for almost 40 years until the ride free area was eliminated in 2012. A network of high-frequency limited-stop bus routes, known as RapidRide, was introduced in 2010 and expanded in 2011, 2012, and 2014. RapidRide operates on six corridors and accounted for approximately 17% of bus ridership in 2017. After briefly reducing service in 2014, fixed-route bus service has restructured and expanded fixed-route bus hours and frequency service in 2015, 2016, 2017, and 2018. Over the past three years, King County Metro has significantly increased ridership, launched a reduced-fare program

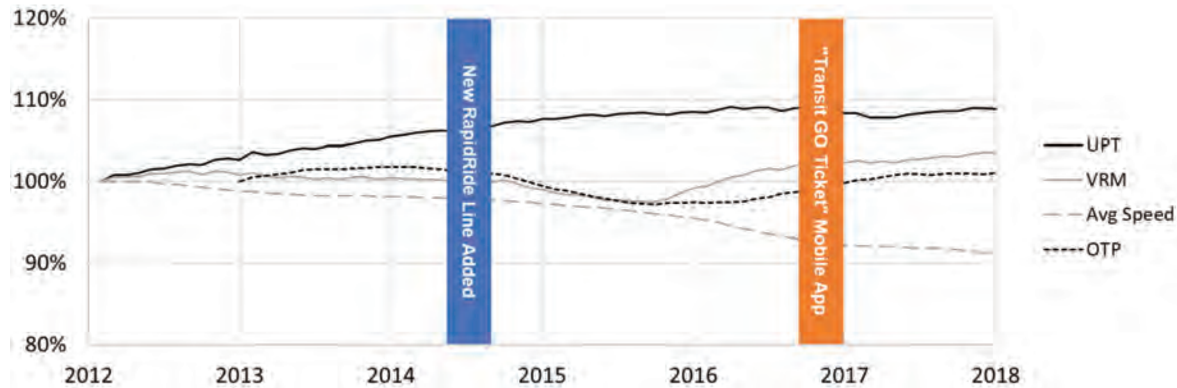


Figure 30. King County bus systemwide trends from 2012 to 2018.

for lower-income passengers, improved passenger and operator safety, and transitioned towards zero-emission bus fleets. "Transit GO Ticket" mobile app was launched at the end of 2016 and allows riders to buy and redeem transit tickets for King County Metro buses, King County Water Taxi, Seattle Streetcar, Sound Transit's Link light rail, and Sounder trains on their mobile devices. Future large technology projects include bus lanes, signal priority, and re-timing, often on a corridor level, to help improve bus route performance. King County Metro also implements constant small spot improvements like adding parking restrictions to help buses access stops.

Key Performance Trends

Key performance trends for fixed-route bus and streetcar service are shown in Figure 30 and Figure 31, respectively, which display a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, average speed, and on-time performance. As seen in Figure 30, despite a consistent decrease in average speed, fixed-route bus ridership has followed an upward trend since 2012 and has remained roughly constant since mid-2016. The decrease in bus average speed may be due to an increase in traffic within Seattle causing average bus speed to gradually slow. Increased ridership may also explain a portion of the decrease in average speed; increased ridership is associated with higher dwell times. King County Metro officials indicated during interviews that service frequency was increased in an attempt to address this passenger crowding. A decrease in average fixed-route bus speed may explain decreased on-time performance on certain routes, as seen in Figure 30.

Streetcar ridership trends, placed on a different scale due to dramatic increases following the opening of the First Hill Line, are seen in Figure 31. The First Hill Line nearly tripled the system's length in 2016.

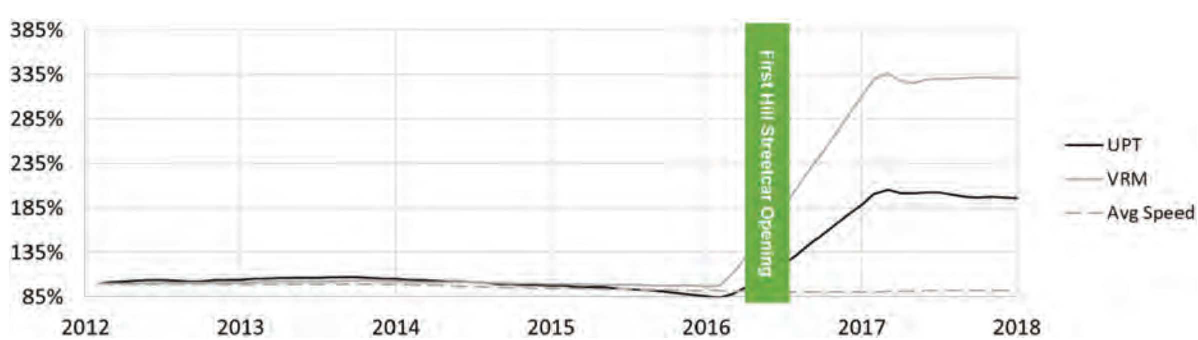


Figure 31. King County streetcar systemwide trends from 2012 to 2018.

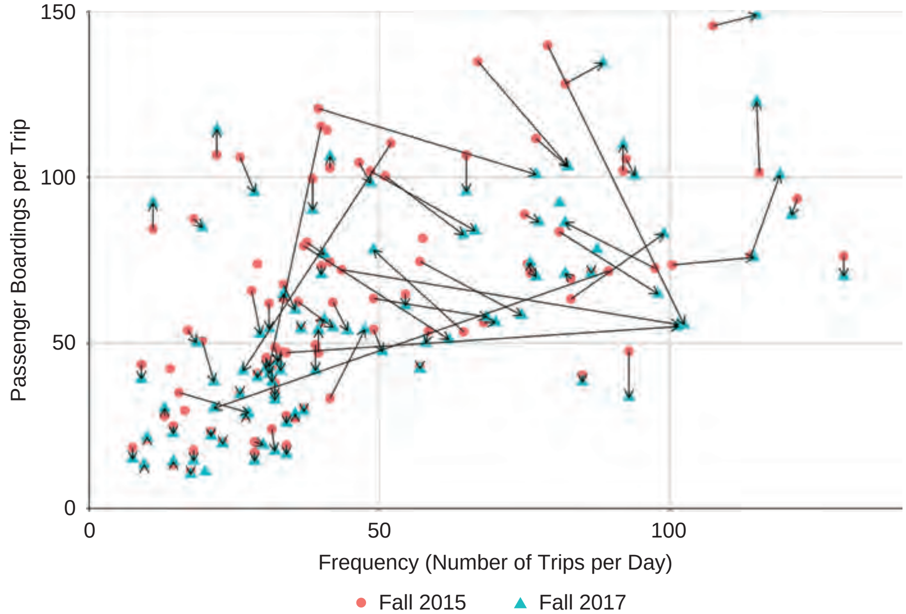


Figure 32. King County bus frequency and ridership trends in 2015 and 2017.

Fixed-route bus ridership data for Figure 32 and Figure 33 is from adjusted average weekday automated passenger counter (APC) data averaged monthly over the fall period (September, October, November, December, January, February, and March). The fall 2015 service period extends from September 2015 to March 2016 and the fall 2017 service period extends from September 2017 to March 2018. Frequency data is provided from the transit agency. Express bus service and "One-Way Peak-Only" routes are not displayed in Figure 32 and Figure 33. Service frequencies have generally increased between 2015 and 2017, but ridership trends have not increased on every route.

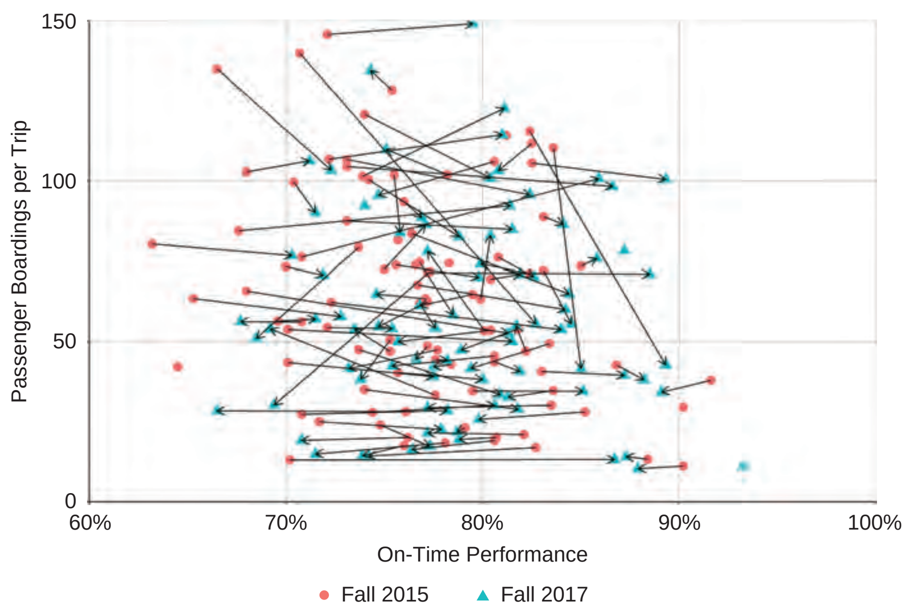


Figure 33. King County bus on-time performance and ridership trends in 2015 and 2017.

King County Metro defines on-time performance as an arrival time between 1.5 minutes ahead of to 5.5 minutes behind the posted schedule. The on-time performance metric for each route is calculated as the number of on-time arrivals divided by the total number of arrivals at time stops. The average weekday on-time performance metric during the fall service period is displayed per route in Figure 33.

Future Plans to Encourage Ridership

King County Metro continues to monitor ridership and system performance and analyze crowding and reliability; they allocate a large budget each year to address crowding, reliability, and service expansion needs to encourage ridership. Recent and future key projects include the following:

- Third Avenue is largely considered the key transit spine in Seattle. Beneath it lies the transit tunnel, which serves light rail and bus vehicles in dedicated lanes. On the avenue itself, transit priority has been added for additional downtown capacity, and recent improvements include restricting left turns and extending transit priority hours, both taking place throughout 2018.
- State Highway 99 is a downtown freeway in Seattle, which the group mentions receiving transit upgrades around 2016. The highway is also the focus of a major construction project, and due to anticipated traffic impacts, King County Metro has provided additional service along parallel routes to provide alternative transportation options. These projects are both ongoing and therefore do not show up in the figures. Additionally, as planners mentioned, their goal is primarily to make incremental improvements along small segments of routes across several years.
- Four new RapidRide lines will be added by 2024 to create a grid of frequent bus lines connecting the major population centers in King County. There are additional plans to add seven new RapidRide lines between 2025 and 2040.
- After the successful test of three battery–electric buses and an in-depth feasibility analysis, King County Metro will purchase only zero-emission buses starting in 2020.

Case Study 5—Maryland Transit Administration, Baltimore, MD

Background

The Maryland Transit Administration (MTA) provides bus, light rail, heavy rail, and commuter rail service in the Baltimore, MD, region. Commuter trains also serve the Washington, D.C., region. MTA operates 80 fixed-route bus lines, three light rail lines, three commuter rail lines, and one heavy rail line, providing around 300,000 trips per weekday. The MTA took over bus operations from the private Baltimore Transit Company in 1970. The fixed-route bus network prior to BaltimoreLink had many routes that served outdated job locations and were too long to manage reliably; buses that served downtown Baltimore frequently compounded congestion.

In June 2017, the fixed-route bus network was redesigned. The transit agency spread out the routes within the downtown core and created a grid of high-frequency routes with the goal of a more efficient and reliable bus network. BaltimoreLink is a complete overhaul and rebranding of the system, reworked to provide bus rapid transit (BRT)-ready color-coded lines with 24-hour service and high frequencies radiating from the city center. Additionally, connecting local buses were planned to form rings around the city to bridge gaps in service, and peak-period express buses would create fast links to downtown. In the future, MTA is pursuing the addition of a new rail line and a new northbound corridor with BRT treatments.

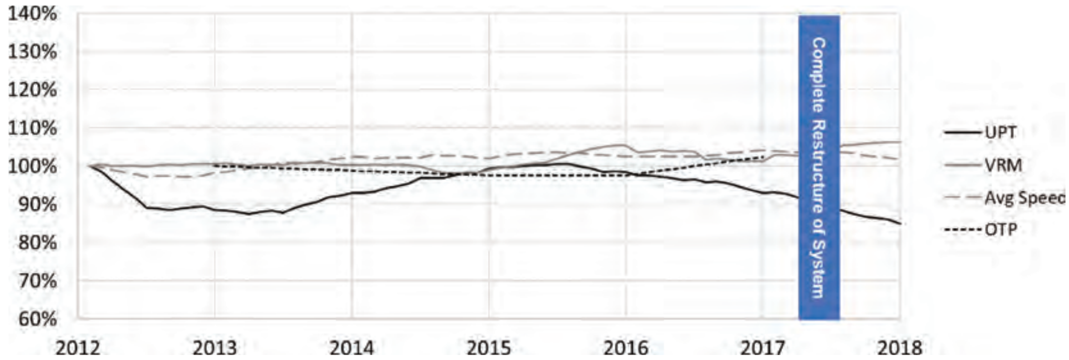


Figure 34. MTA bus systemwide trends from 2012 to 2018.

The Metro Subway heavy rail line opened in 1983, serving northwest suburbs and downtown Baltimore. The commuter rail, known as Maryland Area Regional Commuter (MARC), began operation in 1984 between Baltimore and Washington, D.C. An unconnected light rail line opened in 1992, serving north suburbs, downtown, and the Baltimore airport. Most of MTA's light rail operates on a dedicated ROW, and, as of 2007, the mixed-traffic downtown portion of the route operates with a transit-signal priority system.

Key Performance Trends

Key performance trends for fixed-route bus, light and heavy rail, and commuter rail service are shown in Figure 34, Figure 35, and Figure 36, respectively, which display a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, average speed, and on-time performance. MTA's fixed-route bus ridership trend grew from 2013 to 2015, as seen in Figure 34. However, ridership has begun to plummet, falling nearly 15% from its peak in 2015. Vehicle revenue miles, average speed, and on-time performance have all remained steady or improved over the same period for both bus and rail modes. Unfortunately, on-time performance data is available only on a fiscal year basis, and only reliably until 2016. Rail ridership followed a similar downward trend following 2015 as seen in Figure 35. Commuter rail, MARC, ridership has increased from 2012 to 2014 and since remained fairly constant as seen in Figure 36.

Fixed-route bus ridership data for Figure 37 is from adjusted average weekday APC data averaged monthly over the fall period (September to December). Frequency data is provided

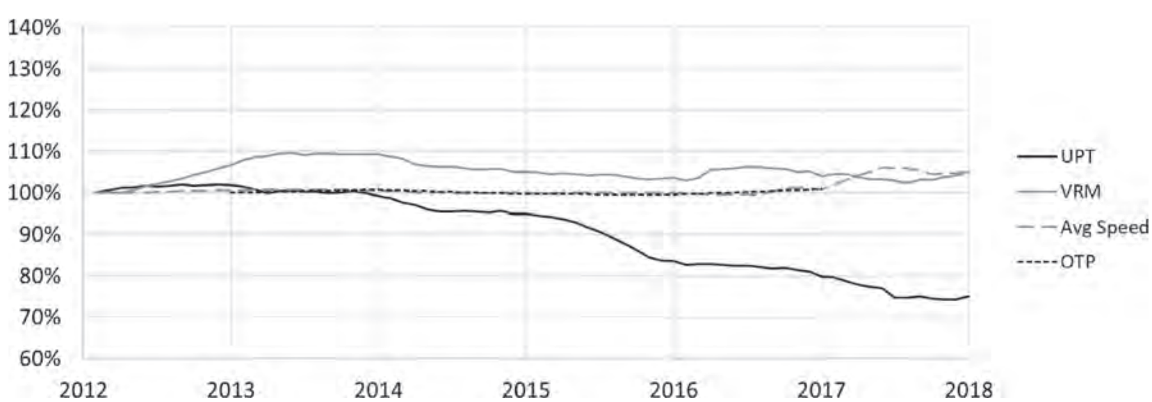


Figure 35. MTA light rail and heavy rail systemwide trends from 2012 to 2018.

56 Analysis of Recent Public Transit Ridership Trends

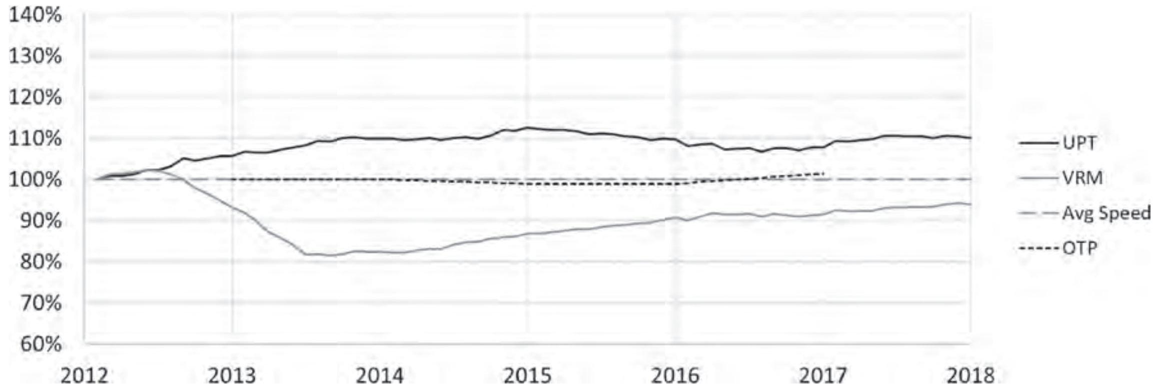


Figure 36. MTA commuter rail systemwide trends from 2012 to 2018.

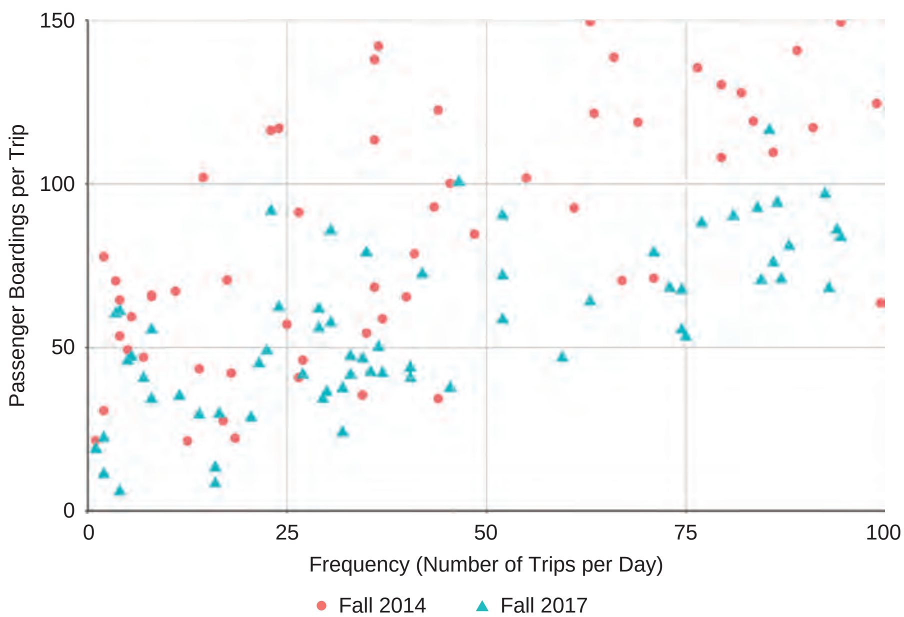


Figure 37. MTA frequency and ridership trends in 2014 and 2017.

from GTFS (General Transit Feed Specification) archives. Because of the network redesign and complete overhaul of the fixed bus system, 2014 and 2017 data are not connected in the figure. It is not possible to relate 2014 routes to 2017 routes due to the substantial changes in the network. The new BaltimoreLink network includes new route alignments, frequencies, and spans on most routes. Route-level on-time performance data is not available because of a recent shift from using Automatic Vehicle Location (AVL) to an APC system. MTA's fixed bus routes have seen a decrease in passenger boardings per trip, as seen in Figure 37. Service frequencies have generally increased between 2014 and 2017, but ridership trends have not increased on every route.

Future Plans to Encourage Ridership

Although MTA's fixed bus ridership did not increase after the launch of BaltimoreLink, the network redesign process has left MTA in a better position for future transit improvements:

- The Purple Line will be a 16-mile light rail line in suburban Washington, D.C., that will extend from Bethesda, MD, to New Carrollton, MD. It will provide a direct connection to the Metrorail Red, Green, and Orange Lines, as well as MARC Train, Amtrak, and local bus services. The line will mainly operate in dedicated lanes with 21 planned stations. Purple Line service is anticipated to begin in 2022.

- MTA is in the process of designing dedicated bus lanes, transit-signal priority, Light RailLink and Metro SubwayLink station enhancements, bus stop improvements, streetscaping, and roadway repaving on a five-mile stretch of North Avenue in Baltimore, with completion by the end of 2021.

Case Study 6—Massachusetts Bay Transportation Authority, Boston, MA

Background

The Massachusetts Bay Transportation Authority (MBTA) operates bus, light rail, heavy rail, and commuter rail in the Boston metro area. The MBTA operates some of the oldest rail lines in the country, including the first subway in the U.S. The MBTA system revolves around three heavy rail lines and one branched light rail main line that meet in downtown Boston. There are 177 bus routes, five bus rapid transit (BRT) routes, and 13 commuter rail routes filling out the rest of the system. A history of strong transit ridership in the Boston metro area is the result of a connected and comprehensive system. To address existing service issues—including unreliable and slow service and overcrowding—MBTA is working on modernizing their fixed-route bus system with the Better Bus Project.

The MBTA was formed in 1964 as a replacement for Metropolitan Transit Authority. Cuts in service and track mileage occurred in the latter half of the 20th century, as routes lost ridership and were abandoned. The Silver Line BRT was opened in 2002, followed by a series of extensions and expansions of that system until the present day. Recent projects to improve fixed-route bus ridership primarily focus on speeding up buses on select routes. In a partnership between the city and the MBTA, a temporary bus lane was created in the Roslindale neighborhood along Washington St., one of the city's busiest routes, in May 2018. The temporary lane was originally set with orange cones blocking off a single inbound lane to cars between 5 and 9 A.M. on weekdays, allowing only buses and bikes to travel in the lane. The results were a decrease in travel time by 20–25% during rush periods. In response to overwhelming support from bike and transit riders, the city made the bus lane permanent after the end of the four-week implementation period.

Key Performance Trends

Key performance trends for fixed-route bus, heavy rail and light rail, and commuter rail are shown in Figure 38, Figure 39, and Figure 40, respectively, which display a 12-month rolling average of unlinked passenger trips, vehicle revenue miles, and average speed normalized to January 2012. Prior to 2014, passenger trip counts were collected and processed from farebox data. APC were implemented in most buses after 2014, but possible counting software errors made ridership data unreliable in 2015. The MBTA reports highly detailed on-time performance data, aggregated by individual day and mode. Daily on-time performance data became public in 2016. Bus on-time performance data only goes back to 2015; rail on-time performance data only became available in March 2016 and is therefore excluded from the figures. Bus data includes the Silver Line BRT.

Trends in fixed bus ridership include increased bus ridership in mid-2015, followed by steady declines, as seen in Figure 38. The increases may be due to inconsistencies in passenger trip reporting; starting in 2014, MBTA switched from farebox data to APC data for ridership data.

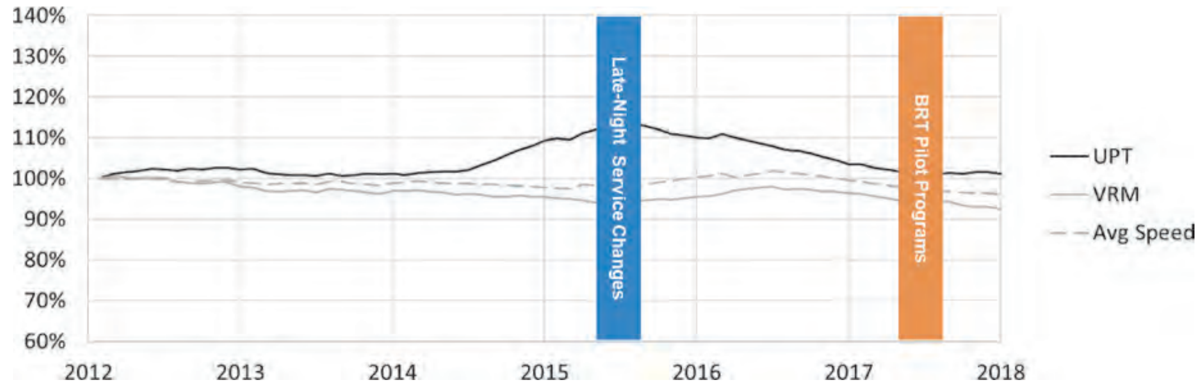


Figure 38. MBTA bus systemwide trends.

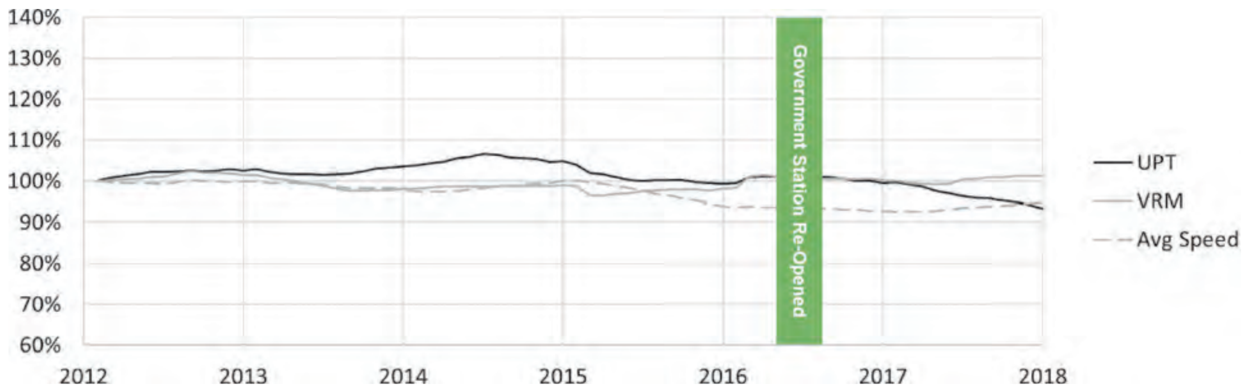


Figure 39. MBTA heavy rail and light rail systemwide trends.

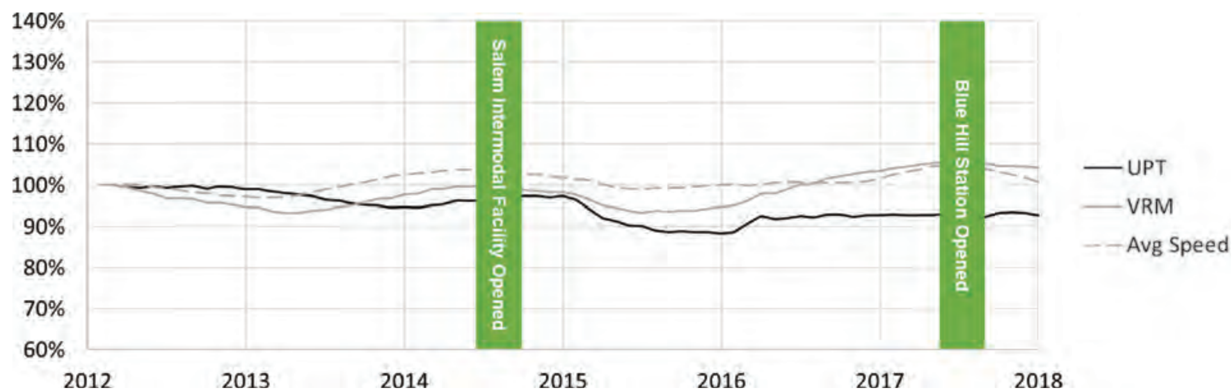


Figure 40. MBTA commuter rail systemwide trends.

An increase in bus ridership may also be due to a steady increase in bus use as more people are moving to bus accessible areas. MBTA fixed-route buses did not experience the national trend of ridership declines until about 2015—possibly a benefit of a larger, more robust system. Vehicle revenue miles and speed remained somewhat constant over the period for both bus and rail, indicating that any route-level bus lane or reliability pilots may be holding off general declines in systemwide ridership seen with other transit agencies. Heavy rail and light rail ridership has remained fairly constant from 2012 to 2018, as seen in Figure 39. The temporary closing of Government Center Station from March 2014 to June 2016 may explain a drop in light rail ridership. Commuter rail ridership has decreased since 2015 despite the opening of two new stations, as seen in Figure 40. MBTA believes the drop in commuter rail ridership is due to service interruptions in winter of 2015.

Fixed-route bus ridership data for Figure 41 and Figure 42 is weekday APC data averaged monthly over the fall period (September, October, November, and December) provided by the transit agency. Frequency data were obtained from archived GTFS (General Transit Feed Specification). MBTA defined 15 key bus routes with high ridership, service frequency, and span of service hours. These key bus routes are displayed in Figure 41 and Figure 42. Key routes with increases in service frequencies between 2014 and 2017 did not see increases in ridership, as seen in Figure 41.

MBTA defines on-time performance for frequent bus service as a departure between 0 minutes before and 3 minutes after its scheduled departure. Infrequent bus service is defined as on-time if it arrives 1 minute ahead to 6 minutes behind the posted schedule. The on-time performance metric for each route is calculated as a percentage of the number of on-time arrivals divided by the total number of arrivals at time stops. The on-time performance metric averages weekday peak and off-peak service during the fall period and is displayed per route in Figure 42. On-time performance has increased on all key bus fixed routes.

Regarding impacts from the bus lanes, in MBTA's own analysis, the Washington Street A.M. peak bus lane in the Roslindale neighborhood has seen an increase of 4% in boardings along the corridor comparing Fall 2017–18 to Fall 2018–19. However, this analysis does not address that some riders may be coming from other routes rather than being new to MBTA service,

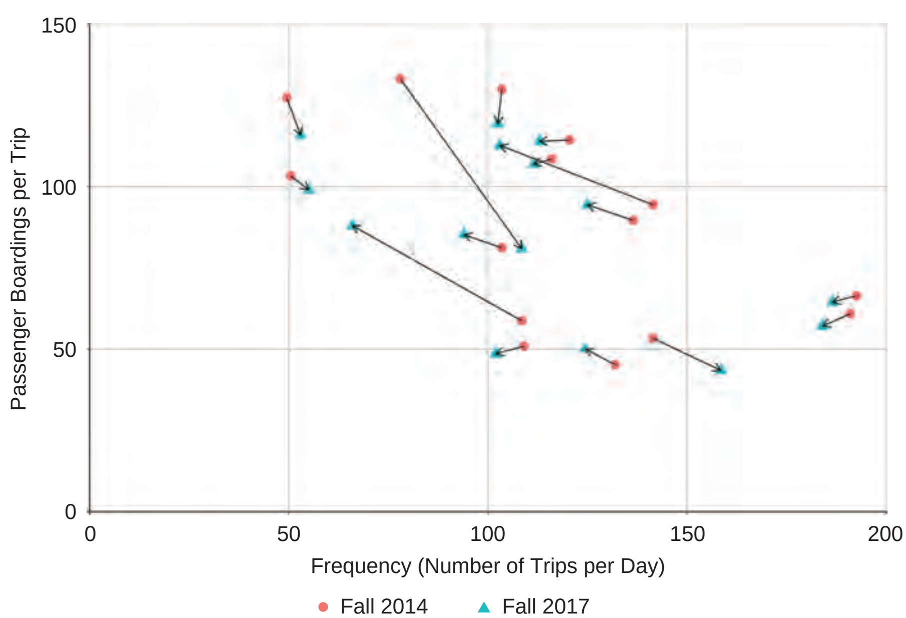


Figure 41. MBTA bus frequency and ridership trends in 2014 and 2017.

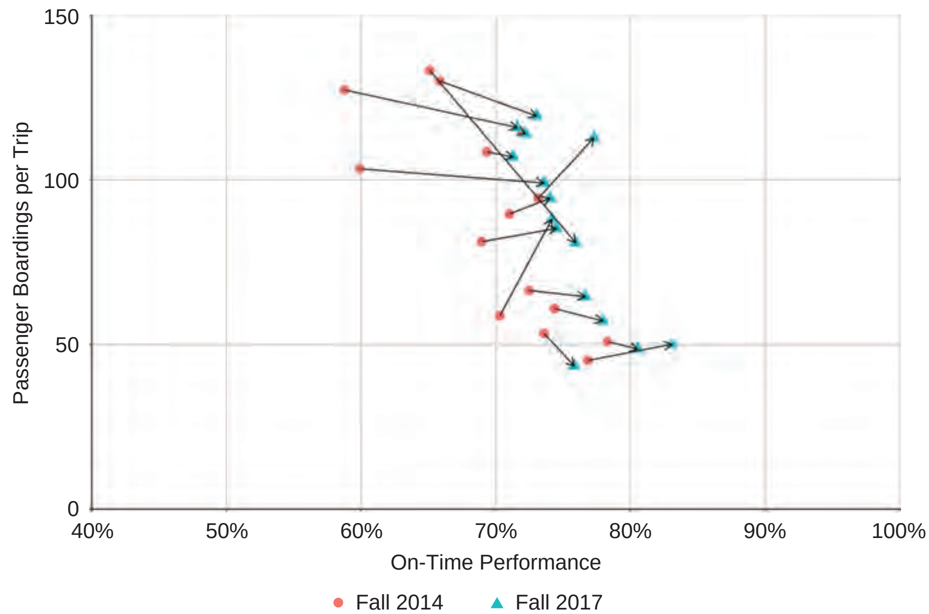


Figure 42. On-time performance and ridership trends in 2014 and 2017.

and some may be due to growth in the neighborhood population rather than the bus lane specifically. MBTA continues to conduct analysis of their ridership impacts from these projects and across their system.

Future Plans to Encourage Ridership

MBTA continues to monitor ridership and system performance to encourage transit ridership. Utilizing metrics and analysis, MBTA is planning a number of projects, including renovating stations, modernizing fare collection systems, and upgrading services across all modes. Current and future projects include the following:

- The Better Bus Project will improve MBTA bus service by reinventing the bus network to reflect changing demographics and replacing the fare collection system. Improvements will be completed with a continuous change focus that includes the implementation of pilot projects and the continuing practice of making regular, quarterly updates to scheduled service to better align schedules with rider demand. After the 2018 analysis period, the program has proposed consolidating duplicate routes, improving the space available at bus stops, and eliminating obsolete variants of some bus routes in 2019.
- MBTA plans to replace subway fleets and upgrade tracks, signals, and switches. New subway cars will be added over the next five years to improve frequency of trains along the Orange and Red Lines by 2022.
- Green Line Extension (GLX) will extend the northern end of the Green Line light rail system by 2021 with seven new T stations.

Case Study 7—Metro Transit, Minneapolis, MN

Background

Metro Transit operates bus, light rail, and commuter rail services in the Minneapolis–St. Paul metro area. As the largest transit operator in Minnesota, the transit agency provides service to over 250,000 daily riders and operates 127 fixed bus routes, two light rail lines, two BRT lines,

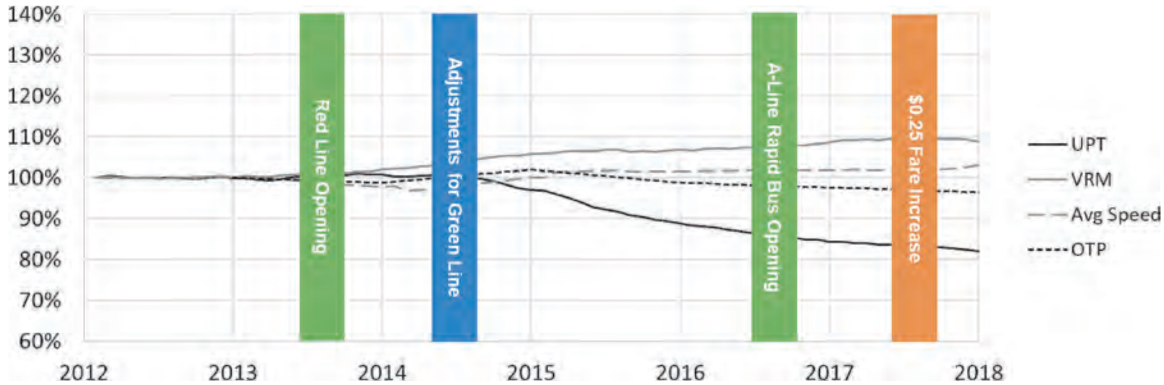


Figure 43. Metro Transit bus systemwide trends from 2012 to 2018.

and one commuter rail line. Metro Transit recently opened a BRT line—the Red Line—in 2013, a light rail line—the Green Line—in 2014, and a rapid bus line—the A Line—in 2016. Looking towards the future, Metro Transit will continue to construct a number of rapid bus projects to improve mobility.

Founded in 1967, Metro Transit originally provided bus service to the Minneapolis–St. Paul metro area. The growing Twin Cities region began studying light rail in 1972, but a line would not be implemented until 2004 with the opening of the Metro Blue Line. In 2009, a commuter rail line opened to the north suburbs. A BRT service began in 2013, and 2014 saw the opening of Metro's current busiest light rail line, the Metro Green Line. In preparation for the opening of the Metro Green Line in June 2014, surrounding bus routes were routed and timed to facilitate bus and rail transfers. The process took around two years to plan and implement. In addition, a new rapid bus service with transit-signal priority and near-level boarding, the A Line, was planned and opened in 2016 with a direct connection to the Green Line.

Key Performance Trends

Key performance trends for fixed-route bus, light rail, and commuter rail service are shown in Figure 43, Figure 44, and Figure 45, respectively, which display a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, average speed, and on-time performance. Since Metro indicates on-time performance only in annual reports, on-time performance numbers represent an entire year of service. As seen in Figure 43, fixed-route bus service ridership has decreased despite the addition of the rapid A Line. Bus service

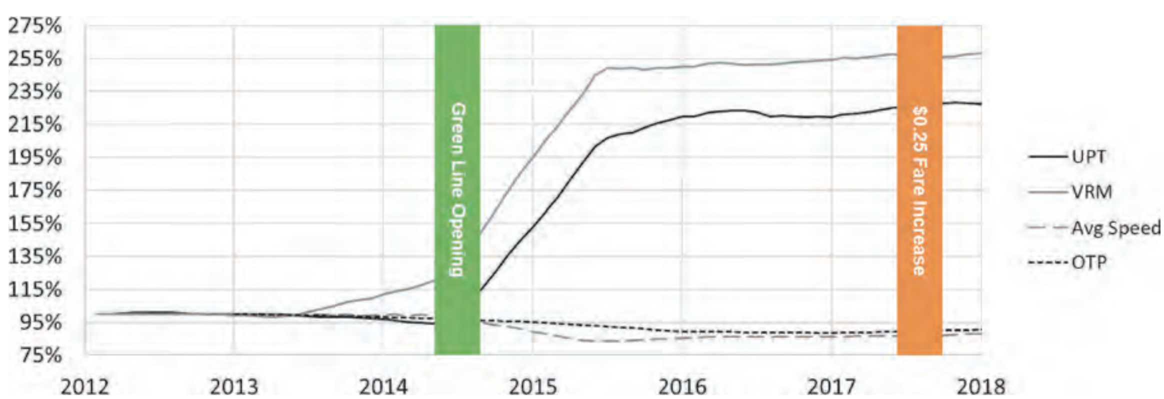


Figure 44. Metro Transit light rail systemwide trends from 2012 to 2018.

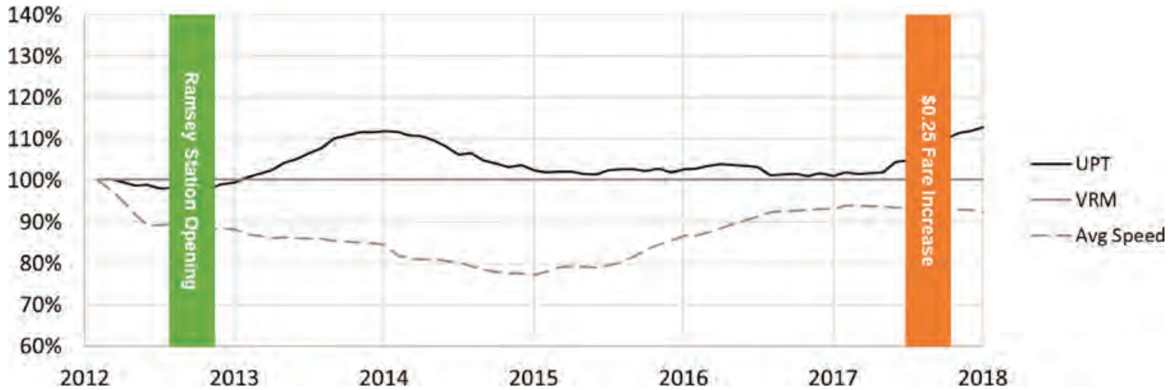


Figure 45. Metro Transit commuter rail systemwide trends from 2012 to 2018.

has risen systemwide, average speed has been relatively constant, and on-time performance has decreased. Light rail service has increased dramatically between 2012 and 2018. Figure 44 has a different scale than the others to show large passenger increases after the Green Line opening. Light rail average speed and on-time performance have remained generally constant, though the Green Line opening has brought both down for rail service slightly. Light rail service increases were followed closely by ridership increases, as seen in Figure 44. After the opening of a new commuter rail station in 2012, commuter rail service has stayed relatively constant over the past five years, as seen in Figure 45. Ridership trends associated with the recent fare increase in November 2018 have not been examined.

Interviews with planners at Metro Transit provided additional insight into some strategies being undertaken to combat ridership decline. As seen in Figure 43 and Figure 44, bus ridership decreases correspond to rail ridership increases, as corridors previously served by buses were phased out and replaced with rail service. Metro Transit also observed bus ridership continued to drop after rail service was established and stable. In June 2016, the introduction of a new rapid bus line immediately boosted corridor ridership by 30% simply by speeding up bus. Fixed-route bus ridership data for Figure 46 are from adjusted average weekday APC data averaged monthly

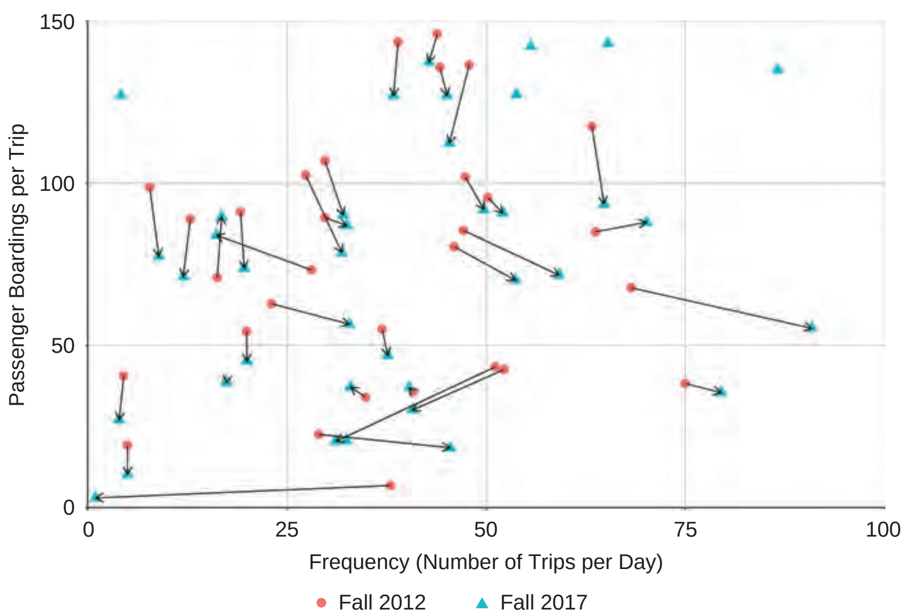


Figure 46. Metro Transit bus frequency and ridership trends in 2012 and 2017.

over the 2012 and 2015 fall period (September to November). Frequency data is provided from the transit agency. Express bus service routes are not displayed in Figure 46. Service frequencies have generally increased between 2012 and 2015, but ridership trends have not increased on every route.

Future Plans to Encourage Ridership

Metro Transit continues to invest in transit projects and technology to encourage ridership. In early 2019, Metro Transit implemented NexTrip real-time bus departure information. Construction of two BRT projects—the C Line and METRO Orange Line—is currently underway, and four additional BRT lines are in the planning process.

Case Study 8—Metropolitan Transit Authority of Harris County, Houston, TX

Background

The Metropolitan Transit Authority of Harris County (known as METRO) runs bus, commuter bus, and light rail service in the Houston metropolitan area. METRO is the Houston region's largest public transit provider, operating 83 local bus routes, 31 commuter bus routes, 3 light rail lines, and 1 community connector, totaling almost 85 million passenger trips per year. METRO has an expansive fixed transit bus system and the most transit ridership in Texas. After a large bus system redesign and addition of two light rail lines in 2015, overall transit system ridership grew about 0.8% from 2016 to 2017.

Houston METRO was founded in 1979 with a one-cent sales tax to replace a smaller system, HouTran. The transit agency expanded fixed-route bus service with park & ride and high occupancy vehicle (HOV) lanes to become one of the largest all-bus fleets in the United States in the 1990s. The transit agency's first light rail line opened in 2004, ending a 14-year period during which Houston was the largest city in the country without a rail system. The most recent rail extension occurred in 2015, although METRO remains primarily a bus system.

In August 2015, METRO redesigned its bus network, increasing the number of high-frequency bus routes while reducing lower-frequency routes. The system was redesigned for the first time since the 1980s. Houston's sprawling nature made downtown-oriented routes only useful for some trips while high-frequency gridded routes allow for faster travel, even if it requires a transfer. The transit agency's goal was to simplify bus routes and improve access to frequent service while still maintaining coverage service in low-density areas. As part of the redesign, METRO set a goal for METRO's system network of 80% high-frequency routes and 20% coverage routes. The plan included upgrading bus stop signage and route maps with clearer information and adding trip planning apps and text-in next bus information. "Q Mobile Ticketing," a smartphone app with the ability to purchase, store, and validate transit passes, was also introduced in August 2015. During the launch event, the call center doubled in size, and buses with free fares roamed to pick up unknowing would-be passengers. A key aspect of the redesign was increased weekend service, with nearly all routes running the same baseline service all seven days. Reliability was a heavy motivator behind the redesign but no study has been completed on on-time performance since the implementation.

Key Performance Trends

Key performance trends of Houston METRO bus and light rail from 2012 to 2018 are shown in Figure 47 and Figure 48, respectively, which display a 12-month rolling average normalized

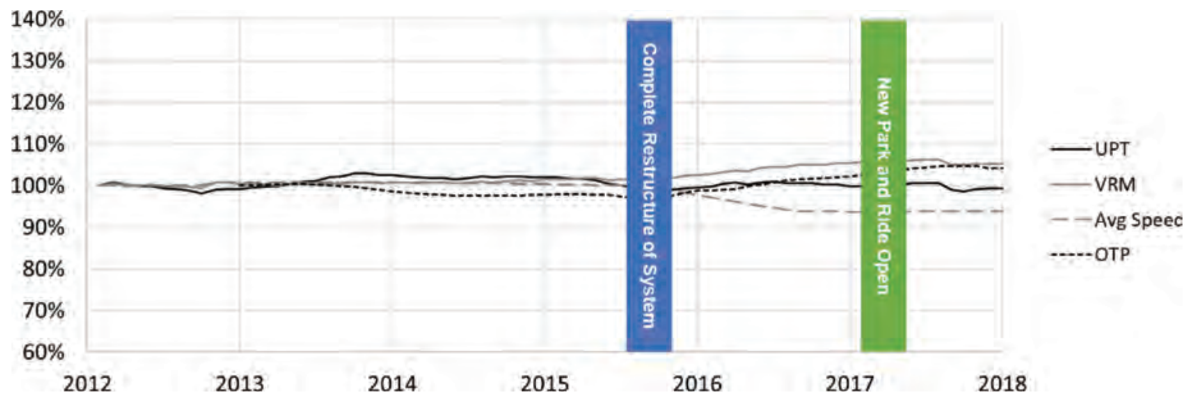


Figure 47. Houston METRO bus systemwide trends from 2012 to 2018.

to January 2012 of the unlinked passenger trips, vehicle revenue miles, on-time performance, and average speed. Houston METRO fixed-route bus ridership has remained unchanged since a systemwide overnight redesign, the opening of which is indicated on Figure 47. Steady increases in transit service levels following the redesign appear to have little effect on ridership. Additionally, decline in average speed is most likely a product of routes being transitioned to serve denser, more congested areas of the city.

Rail ridership trends are overwhelmed by the openings of two light rail lines in 2015, indicated on Figure 48 with an expanded scale to show the dramatic effects of rail openings. These new lines have steadied out at nearly 300% more service than was provided in 2012, however ridership sits only 70% above the 2012 level.

While the route alignments and schedules changed between 2013 and 2017, their comparison provides insights on the effect of the network redesign as seen in Figure 49. Only a few of the routes remained similar enough to be able to relate 2013 and 2017 route data with an arrow in the figure. Ridership is calculated as average weekday boardings during the fall period in September, October, November, December, January, and February of 2013 and 2017. Both passenger counts and route frequencies were provided from the transit agency. From 2013 to 2017, bus routes with increased frequency did not increase in passenger boardings per trip.

On-time performance transit data was not available for analysis. METRO defines fixed-route bus on-time performance as leaving within the five-minute window after the scheduled departure time. On-time performance data is calculated based on automatic vehicle location (AVL) software.

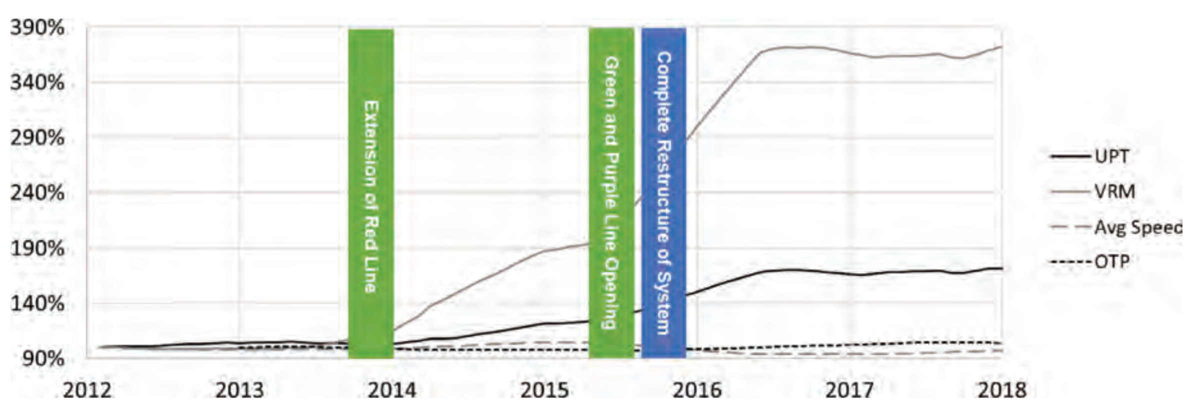


Figure 48. Houston METRO light rail systemwide trends from 2012 to 2018.

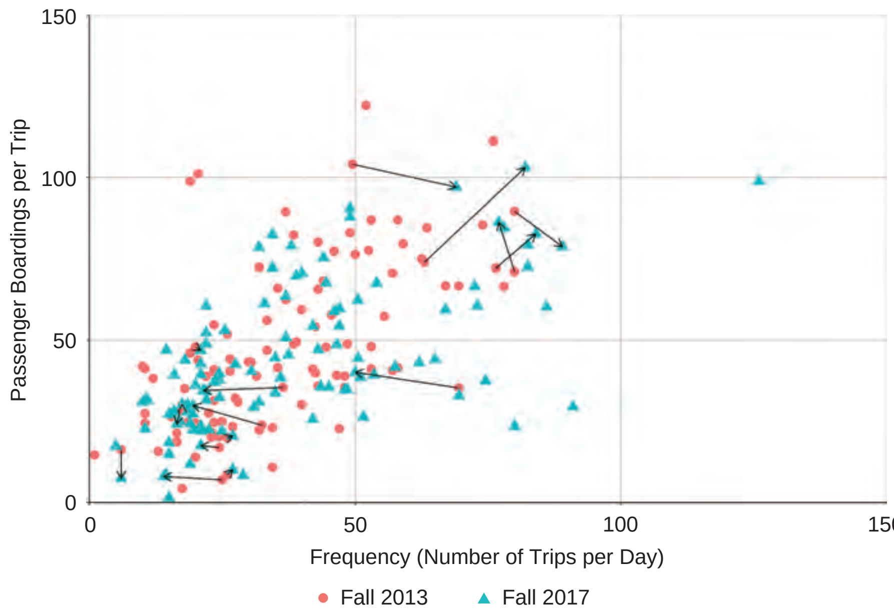


Figure 49. Houston METRO frequency and ridership trends in 2013 and 2017.

Future Plans to Encourage Ridership

As Houston's population grows, Houston METRO plans to meet the region's transportation needs by expanding its transit network. In January 2017, METRO began developing a new plan, METRONext, for transit services in the Houston/Harris County region with a focus on providing more transportation choices to more people. The goals of METRONext are to improve mobility, enhance connectivity, support vibrant communities, and ensure a return on investment. METRONext will develop a Regional Transit Plan, the Vision Plan, and a Moving Forward Plan. The Vision Plan will identify major capital investments and other improvements needed for METRO to meet the mobility challenges of the next 20 years. The Moving Forward Plan is the first step in implementation and includes major investments such as increased regional express service, extended light rail lines, a new BRT system, and many improvements to the existing bus network including new Park & Rides, Community Connectors, an increase in bus service, and enhanced bus stops to address Universal Accessibility. Future bus rapid transit systems include the Uptown BRT project with frequent transit service from Westpark to the Northwest Transit Center in 2020 and the connecting Inner-Katy BRT project to downtown.

Case Study 9—Pinellas Suncoast Transit Authority (PSTA), Pinellas County, FL

Background

The Pinellas Suncoast Transit Authority (PSTA) is the operator of bus, commuter bus, and demand response services in the St. Petersburg, FL, area. PSTA now operates 34 fixed routes providing 12.4 million passenger trips a year. PSTA was one of the first operators to provide subsidies to TNCs for connecting service to select bus stops in 2016 with their Direct Connect program. After implementing all phases of Direct Connect in 2018, PSTA is looking to evaluate every bus route in the system, redesign their fixed-route system, and implement an express BRT corridor.

Formed in 1984 in the merger of two area transit agencies, the PSTA operates in the greater Tampa-St. Petersburg area. While PSTA serves St. Petersburg and some surrounding areas, a separate transit agency called Hillsborough Area Regional Transit (HART) serves Tampa and points east, despite the downtown areas of Tampa and St. Petersburg being no more than 15 miles apart. The two systems began honoring each other's fares and allowing free transfers in 2004. The transit agency recently made headlines as the first operator to provide subsidies to TNCs for connecting service to select bus stops. This partnership, which began in 2016, covers the first $5 of an Uber ride to designated bus stops, expanding their service area outside of walking distance. Lyft was added soon after, and in 2018, the number of designated stops doubled to 24. This program, called Direct Connect, was the first to integrate TNCs into a local bus system. The program was implemented in three phases from early 2016 to early 2018 with increasing operational coverage across the greater Tampa-St. Petersburg area.

Key Performance Trends

Key trends for bus service from 2012 to 2018 are shown in Figure 50, which displays a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, average speed, and on-time performance. Phases 1 and 2 of the TNC partnership start date are indicated on the figure. Phase 3 was fully implemented in April 2018. Bus ridership dropped throughout 2016 and 2017, while service, speed, and on-time performance remained roughly the same. Demand response ridership, which PSTA uses to categorize these TNC trips, is up nearly 10% since late 2016. In addition, the trend of speed dropping rapidly while vehicle revenue miles increase at a similar rate seems to indicate quite a large increase in vehicle revenue hours. This likely corresponds to an increase in the number of demand response vehicles on the road at any given time. It appears that while the pilot has grown demand response ridership, buses are not seeing positive results of the pilot. This is perhaps due to the phenomenon of a preference for a one-seat ride. In other words, once passengers are already in the TNC vehicle, they would prefer to take it all the way to their destination than transfer to a bus along the way.

While focusing on implementing the Direct Connect Program, frequency of PSTA fixed routes has not dramatically shifted between 2015 and 2018, as seen in Figure 51, which shows fixed-route ridership and frequencies before and after Direct Connect's full implementation. Ridership data for Figure 51 and Figure 52 are from average daily APC data averaged monthly over the fall period (October, November, December, January, and February), and frequency data is provided from the transit agency. Average daily ridership has decreased on all but four routes since fall 2015.

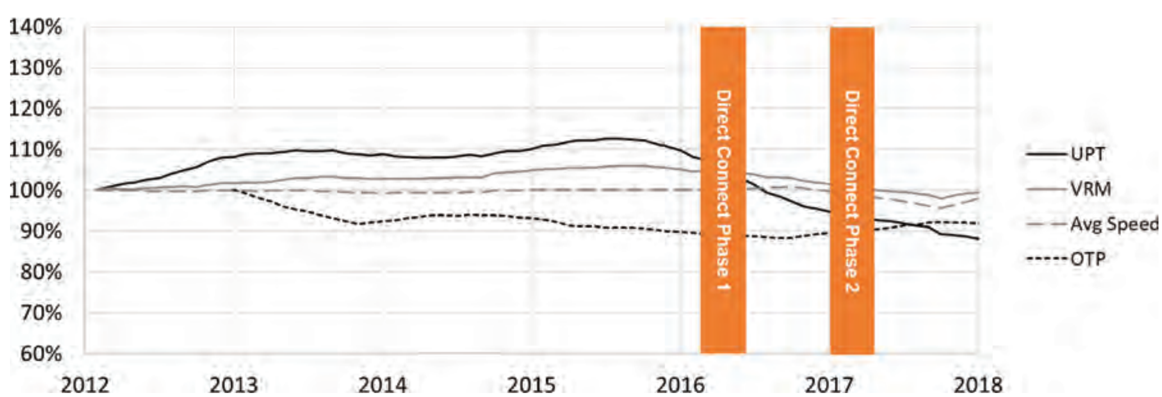


Figure 50. PSTA bus systemwide trends from 2012 to 2018.

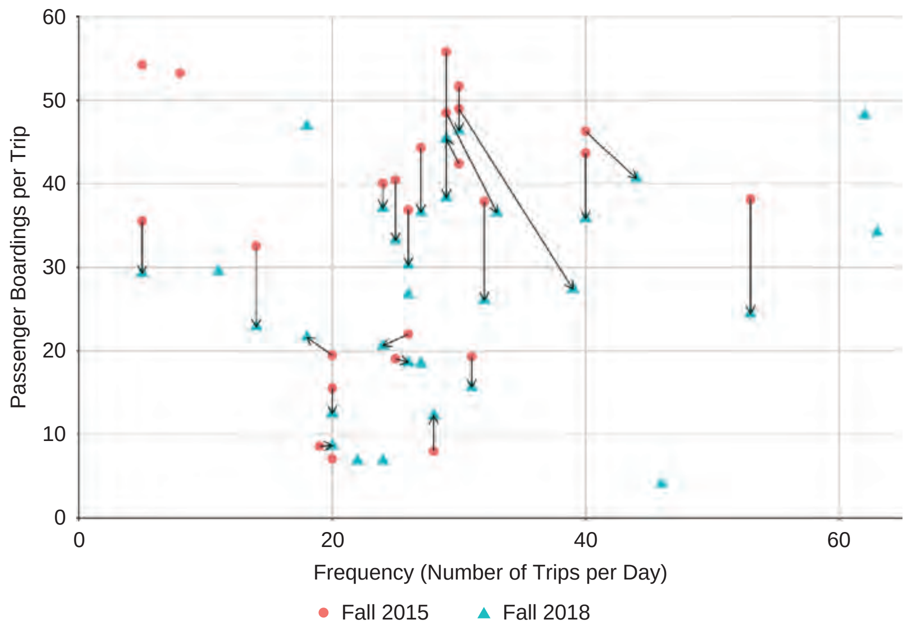


Figure 51. PSTA frequency and ridership trends in 2015 and 2018.

PSTA defines on-time performance as 0 minutes early to 4.59 minutes late. This definition was modeled after the American Bus Benchmarking Group (ABBG) standard. On-time performance is collected using HASTUS transit scheduling software and recorded as monthly average on-time performance, as seen in Figure 52. On-time performance increased on every bus route between fall 2015 and 2018, but this trend was not associated with an increase in ridership.

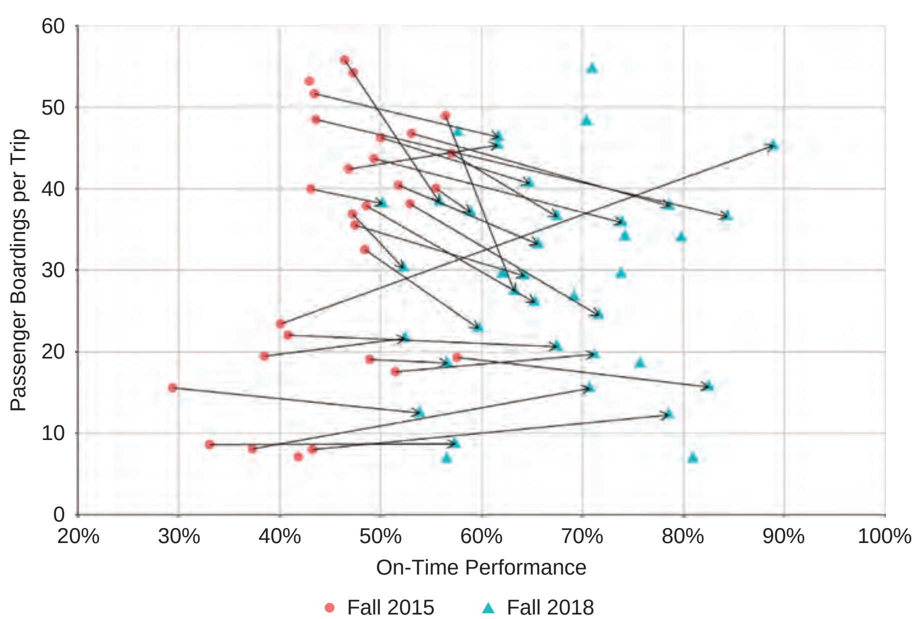


Figure 52. PSTA on-time performance and ridership trends in 2015 and 2018.

Future Plans to Encourage Ridership

PSTA is working towards increasing transit ridership, making transit more competitive with driving, and building financial stability. Current projects towards their goal of "safely connecting people and places" include

- Circulator Study in Downtown St. Petersburg,
- Bus Rapid Transit,
- Advantage Pinellas Transit Planning Effort, and
- New mobile ticketing app and smartcard system.

PSTA is currently conducting an analysis of transit circulation within downtown St. Petersburg to identify options for a modified or new network of circulator services. Express Bus Rapid Transit (BRT) service will be piloted in St. Petersburg's Central Avenue corridor from downtown St. Petersburg to the Gulf beaches and will open in 2021. Advantage Pinellas is a planning effort to evaluate every bus route in the system. On-board rider surveys and public outreach will result in recommendations for route and mobility service changes. PSTA and HART are currently beta testing "Flamingo Fares," a regional mobile ticketing app and smartcard system.

Case Study 10—Spokane Transit Authority, Spokane, WA

Background

The Spokane Transit Authority (STA) is the sole provider of bus and demand response service in Spokane County, WA. Public takeover of Spokane's bus routes took place in 1968 after years of declining revenues. A public transportation benefit area was established in 1980 to devote sales taxes to transit, and STA was created alongside it. STA serves the cities of Spokane, Spokane Valley, Cheney, Liberty Lake, Airway Heights, Medical Lake, the Town of Millwood, and part of Eastern Washington University. Today, the transit agency operates 36 fixed routes, most of which run through a downtown transit center. Five routes provide frequent, 15-minute or less service all day. In addition to the fixed-route bus service, STA provides commuter express routes, paratransit, and vanpool services.

During the early 2000s, fixed-route bus service was expanded, and the region experienced ridership growth as a result. Due to the recession, revenue from sales tax was lost, and STA was forced to cut and restructure fixed-route service frequency to concentrate on key routes. Productivity (as defined as riders per revenue mile) and ridership increased, following this consolidation and the implementation of a university pass program, until 2015. By partnering with universities and local community colleges, the typical rider has shifted to a slightly younger demographic.

Key Performance Trends

Key performance trends of STA from 2012 to 2018 are shown in Figure 53, which displays a 12-month rolling average normalized to January 2012 of the unlinked passenger trips, vehicle revenue miles, on-time performance, and average speed. Despite some growth early in the decade, transit ridership in Spokane dropped by nearly 10% between 2015 and 2017 because of the movement of business and construction delays. During this period, Spokane introduced real-time information and university bus pass programs. On-time performance tracks, similar to ridership, gradually decreasing beginning in mid-2015. Vehicle revenue miles and average speed have remained fairly constant until the end of 2017, when ridership trends appear to be pointing upward, perhaps due to the transit agency's most recent strategic plan to increase service and

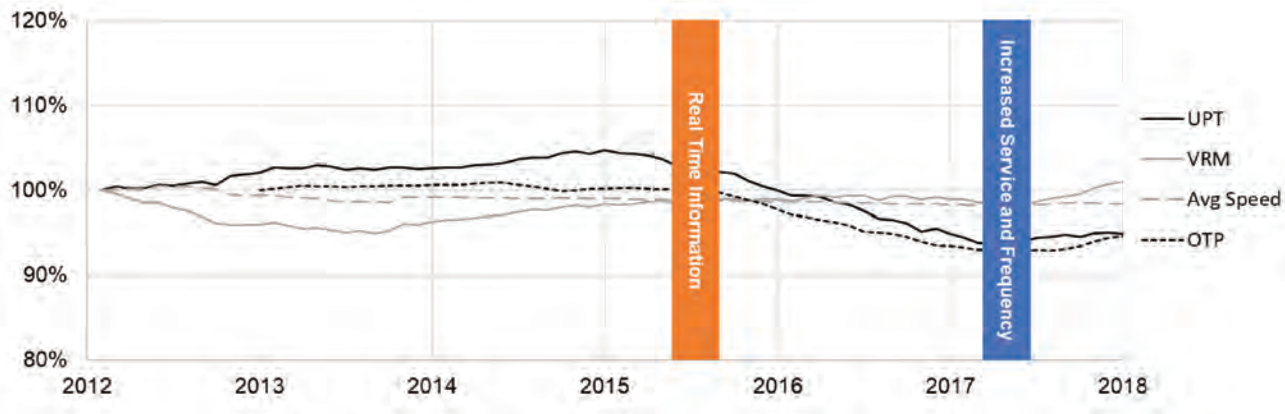


Figure 53. STA bus systemwide trends from 2012 to 2018.

ridership. Ballot measures increasing sales tax—passed in 2016 and 2018—have resulted in more funding and a focus on high performance transit.

Service changes implemented in 2017 included extending Saturday night service, increasing weekend service, providing new routes, and improving bus stop facilities. The new routes and increased frequencies on some routes can be seen in Figure 54 and Figure 55, which compare transit ridership data with frequency and with on-time performance, respectively, in 2016 before implementation and 2018 after implementation. Ridership data is the average weekday fare-box data during the fall period in September, October, November, and December of 2016 and 2018. Stop and frequency data is from the transit agency's General Transit Feed Specification (GTFS). On-time performance data has been collected with a CAD/AVL system since 2014. The fixed-route service frequency and ridership trends associated with the 2017 shift in service are displayed in Figure 54. Although the increased frequency has resulted in more riders, transit ridership per trip has decreased, so route productivities have declined.

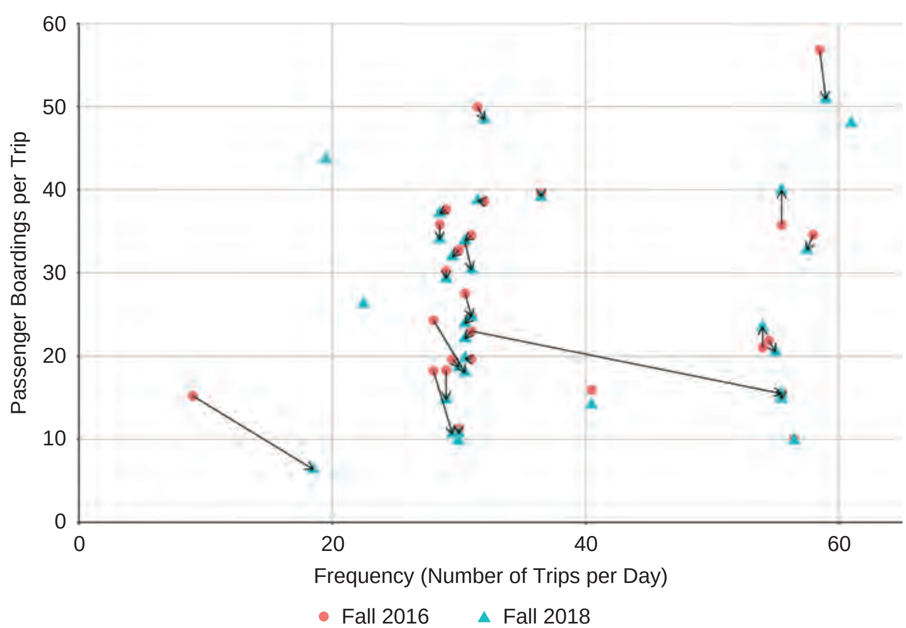


Figure 54. STA frequency and ridership trends in 2016 and 2018.

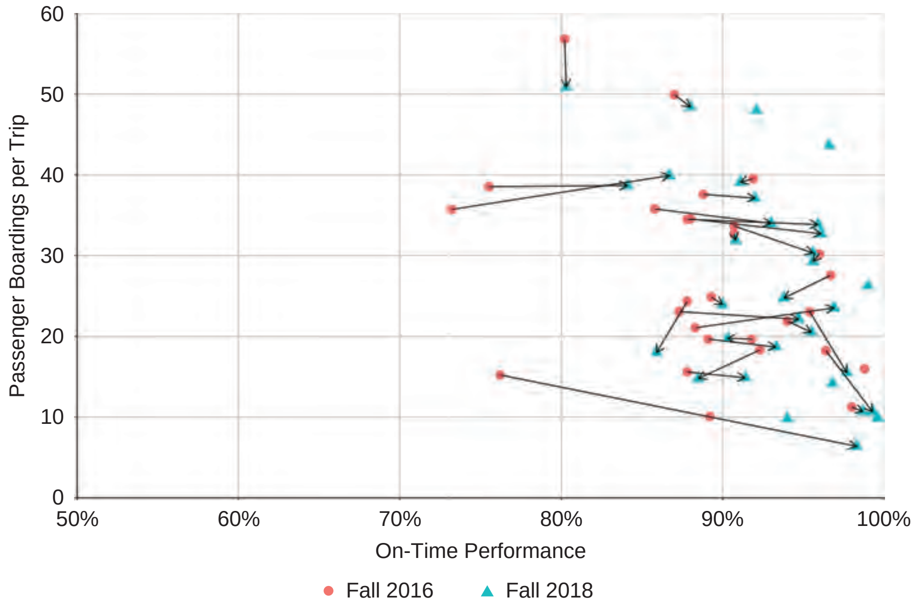


Figure 55. STA on-time performance and ridership trends in 2016 and 2018.

On-time performance and transit ridership trends during the 2016 and 2018 period are also displayed in Figure 55. STA is committed to on-time performance and maintains a very high systemwide standard. The 2017 service change included stop improvements associated with lower dwell times and higher on-time performance. Although on-time performance is highly valued by customers, there was no clear trend between on-time performance and ridership.

Future Plans to Encourage Ridership

The local community has recently invested in transit by voting to increase sales tax funding in 2016 and 2018, developing college bus pass programs, and providing bus passes to everyone who works or lives in a new urban neighborhood development. Future key projects include the addition of a six-mile BRT route, Central City Line, that will connect Spokane's downtown and colleges and improve service, speed, and reliability in 2021 with near-level platforms, off-board ticketing, and transit-signal priority. There are also plans to extend the transit service area of STA to the nearby Coeur d'Alene metropolitan area in 2025.

Summary

Nearly every transit agency investigated in the case studies had ridership increases through 2015 followed by steady decreases in ridership. The exceptions to this are Houston, TX; Portland, ME; and Seattle, WA.

- In Houston, transit ridership has remained relatively constant without the declines seen by most transit agencies, but this is among substantial increases in service that came with the network redesign.
- In Portland, transit service has been increased, especially on routes that serve schools and universities, and these strategic improvements have paid off as ridership has increased greater than the service.

- In Seattle, transit service has also increased, but ridership has increased even more. Ridership on both bus and streetcar have increased steadily over time with substantial investments in dedicated ROW and rapid transit services as well as a focus on speed and reliability.

In all other cases, among the transit agencies where ridership declined, the amount of service provided has remained relatively similar over this time or has only been slightly increased.

In every transit agency reviewed, average speeds have decreased or have remained the same, indicating that more vehicles are frequently needed to offer the same or degraded service. Some transit agencies have fought hard to keep average speeds up using strategic improvements such as signal priority or improvements to boarding. Generally, on-time performance has been improving, although it is clearly not causing transit ridership to increase. If anything, the trend appears that on-time performance is easier to maintain as ridership has decreased.

With regard to rail ridership, the results are more mixed. In some transit agencies, such as the Maryland Transit Administrations's light rail, ridership decreased, and in others, such as Boston's heavy rail, ridership remained steady. Minneapolis and Houston had substantial increases in ridership on light rail, but only with even greater increases in service, including the opening of new lines. Commuter rail seems to be faring better across the country, and the transit agencies among the case studies are no different. Whatever is impacting bus transit ridership across the country does not have the same impact on the dedicated ROW longer-distance commuter rail services.

However, all of the transit agencies interviewed are working hard to retain their riders. Transit agencies such as Houston and Baltimore are restructuring their bus service in some way including network redesigns and simplification of routes and information. Oftentimes, such as in Boston, this is paired with substantial analysis, making use of new data and analytics tools. Pinellas County has implemented a substantial partnership with the TNCs. Multiple transit agencies are updating their rolling stock, especially to obtain lower emitting and faster boarding vehicles. Newer technology in fare media and real-time information is being considered or has been adopted by many of the transit agencies. Transit agencies such as Portland and Spokane are doing substantial work to attract high school and college students as well as strategic partnership with new developments. Finally, there is a concerted effort to use dedicated ROW such as BRT and bus lanes as well as strategic speed and reliability improvements to maintain higher levels of service and better customer service for riders.

CHAPTER 6

Conclusions and Next Steps

In the United States, transit ridership overall has declined for six straight years. Bus ridership is at the lowest point since at least 1973, and rail ridership has decreased over the past few years, as well. There are many possible factors for this decline in ridership. A recent APTA report summed up many of the factors in four main areas: erosion of time competitiveness, reduced affinity, erosion of cost competitiveness, and external factors (APTA, 2018b).

- Erosion of time competitiveness relates to increased congestion in cities from densification, delivery services, and TNCs, causing decreasing speed on shared ROW transit services such as traditional bus. Due to these decreasing speeds, additional service hours are needed just to maintain existing headways.
- Reduced customer affinity and loyalty stems from changing populations that are less apt to purchase a monthly pass because they telework or use multiple modes.
- Cost competitiveness relates to the lower cost of auto ownership and inexpensive TNC fares.
- External factors include parking availability and movement of major generators outside of dense areas.

The recent decline in transit ridership is particularly worrisome because traditional factors of effecting transit ridership do not seem to be involved. According to data from the National Transit Database, transit agencies have increased bus service (vehicle revenue miles) by 5% between 2012 and 2016. Although our analysis found that amount of service provided was a strong predictor of both bus and rail transit ridership using 2012 data, the change in service levels was only a predictor of change in ridership in smaller cities or for dedicated ROW. In fact, we found that transit agencies had to increase service by 8–10% from 2012 to 2016 to expect unlinked passenger trips to remain unchanged.

Meanwhile, urban population in the United States is at its highest point in recorded history (Ratcliffe, 2012), and urban core areas have grown in population every year since 2006 (Frey, 2018). Although population is still a strong predictor of the level of transit ridership, especially for bus ridership in denser cities, our analysis found that population change and ridership change were entirely uncorrelated for bus and only somewhat correlated for rail. The health of the economy should also be encouraging people to make more transit trips. In 2017, unemployment levels in the United States were at their lowest level since the recession in 2009.

A potential contributing factor to the decreasing transit ridership is the economic displacement of low-income earners from dense urban-centers to the suburbs (Florida, 2017). While cities are becoming denser, their populations have higher-incomes and more cars. Studies in Portland, OR, and Southern California have verified that low-income migration may be impacting transit ridership. In our analysis, the 2012 proportion of zero-vehicle households and transit ridership are not strongly linked, but the 2012 to 2016 change in zero-vehicle households and transit ridership are linked in the largest cities.

The decreases in transit ridership found in the last four years were not only in the largest cities but across the board. Nearly every transit agency investigated in the case studies had ridership increases through 2015, followed by steady decreases in ridership. Giving credence to the APTA time competitiveness factor, in every case study transit agency, average speeds are down or have remained the same. Commuter rail seems to be faring better across the country, and the transit agencies among the case studies are no different. Whatever is impacting bus transit ridership across the country does not have the same impact on the dedicated ROW longer distance commuter rail services.

In an attempt to turn the declining transit ridership trend around, transit agencies have implemented new strategies. Transit agencies such as Houston and Baltimore are adding service and redesigning their networks to increase frequencies on their core routes and attract new riders. Others such as Portland, ME, and Spokane, WA, are adding service to attract certain populations. New pricing schemes and fare technologies are helping to incentivize riders and reduce the friction in transit fare purchasing. Transit agencies are implementing microtransit pilots to provide a similar experience to TNCs or are partnering with TNCs to subsidize rides. Finally, transit agencies are using improvements to speed and reliability to improve service and ridership strategically, especially through more dedicated ROW that prioritizes transit over general traffic.

Future Research

The question that remains is how much these strategies can help mitigate and reverse the declines in transit ridership and how transit agencies can most efficiently implement these changes. Although there is a growing body of research on these factors, we still lack a comprehensive understanding of the extent to which various factors impact transit ridership, and many of the strategies transit agencies are using to mitigate or reverse trends are not well understood from a ridership impact perspective. Population trends segmented by multiple factors such as age group, race and ethnicity, and income levels should be explored in greater detail to explain the impact of baby-boomer retirement, millennial transportation patterns, gentrification, and other similar migrations within a city.

Further research is needed, especially at a disaggregate level that looks not at ridership on a city by city basis but on a route by route and zone by zone basis using fare card and passenger counter data to understand where transit ridership is decreasing within a city and what external factors are impacting those decreases. Further research should assess not just ridership change on a yearly or even monthly basis, but should segment ridership into types of trips (long distance, short distance, commuter, off peak), as sometimes ridership increases in one area can temporarily mask declines in another. Assessing individual trip behavior can also be a key to understanding how ridership is changing. Additional work by TCRP is being conducted through TCRP A-43, “Recent Decline in Public Transportation Ridership: Analysis, Causes, Responses”; and TCRP H-56, “Redesigning Public Transportation Networks for a New Mobility Future.” Both of these projects will conduct deeper dives into understanding the ridership question in a new mobility future.

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APPENDIX A

Literature Review

Table A-1. Newspaper articles regarding transit system changes and ridership.

	Source Title	Author	Year	Relevant Takeaways
1	Community Outraged over MARTA Bus Changes	Abubey	2017	MARTA has faced stiff resistance from residents who rely on bus service as their only mode of transportation.
2	There's No Transit but Microtransit for This Sprawling Texas City	Bliss	2017	Austin implemented a demand-responsive program that quickly met its ridership goals and exceeded expectations.
3	VMT Hits Nominal High, Approaches per Capita Mark	Davis	2017	Total vehicle miles traveled are now at their highest point in history.
4	Metro Plans to Reimagine and Restructure Its Vast Bus System	Hymon	2017	The Los Angeles Metro announced in May 2017 the start of a three-year process to restructure the bus network in response to a 20% drop in ridership over three years.
5	SEPTA Looks to Texas for Ideas for Bus Route Redesign	Laughlin	2017	SEPTA announced a bus redesign.
6	Metro Is Mulling a Major Redesign of the Bus System. But First, Officials Need to Figure Out Why People Are Not Riding	Powers	2017	WMATA announced a bus redesign.
7	Capital Metro Takes Its Bus Network Realignment to the Riders	Pritchard	2017	In Austin, a ridership increase following a network redesign is partly attributed to night and weekend bus service expansions.
8	Dallas Council Members Say Bus Network Overhaul Can't Wait	Schmitt	2017–July	DART announced a bus redesign.
9	Transit Ridership Falling Everywhere—But Not in Cities with Redesigned Bus Networks	Schmitt	2017–February	A Streetsblog piece about bus redesigns and their general resilience against ridership declines.
10	Public Transit Should Be Uber's New Best Friend	Silver & Fischer-Baum	2015	FiveThirtyEight article which investigates Uber usage in New York City, finding that Uber usage is higher near the subway, suggesting a link between the two.
11	How Seattle Bucked a National Trend and Got More People to Ride the Bus	Small	2017	In Seattle, bus ridership increased by 0.4% between 2014 and 2016, during which King County Metro redesigned their bus network.
12	Bus Network Redesigns Are the Hottest Trend in Transit	Vock	2017	In Houston, bus ridership increased by only 1.2% in the first year, which was much lower than the 20% expected, even though the operating budget increased by 4%.

Table A-2. Transit agency and government reports regarding transit ridership.

	Source Title	Author	Year	Relevant Takeaways
1	Understanding Recent Ridership Changes: Trends and Adaptations	APTA	2018	Identifies erosion of time competitiveness, reduced affinity, erosion of cost competitiveness, and external factors as major trends in transit ridership.
2	U.S. Population Disperses to Suburbs, Exurbs, Rural Areas, and “Middle of the Country” Metros	Frey	2018	Suburbs have outpaced urban cores in growth rate.
3	State of the American Workplace	Gallup	2017	43% of Americans reported working remotely at least sometimes, a four-percentage point increase since 2012. Telecommuters also reported working remotely more often; 75% reported working from home more than once a week from 66% in 2012.
4	Accountability Center	King County Metro	2017	King County Metro’s annual performance measures, describing a bus network redesign that took place over several years.
5	Comprehensive Operations Analysis	Parsons Brinckerhoff	2016	A Comprehensive Operations Analysis Study commissioned by MARTA which recommended concentrating service on core corridors.
6	TNCs Today: A Profile of San Francisco Transportation Network Company Activity	SFCTA	2017	Found that TNC trips are concentrated during peak hours and that they contribute 6.5% of all vehicle miles traveled in San Francisco.
7	Private Mobility, Public Interest	TransitCenter	2016	A report that suggests that transit agencies and TNCs partner to share data and serve cities together.

Table A-3. Academic literature on traditional causes of ridership increases and decreases.

	Source Title	Author	Year	Relevant Takeaways
1	Predicting Transit Ridership at the Stop Level: The Role of Service and Urban Form	Dill et al.	2013	Stop-level analysis of transit ridership in three cities in Oregon. Service characteristics were most important determinants of ridership.
2	Strategies to Attract Auto Users to Public Transportation	Dueker et al.	1998	Parking availability and gas prices are important determinants of attracting riders to transit.
3	Big-City Transit Ridership, Deficits, and Politics: Avoiding Reality in Boston	Gomez-Ibanez	1996	A Boston case study, confirming that employment correlates positively with ridership overall and that service levels play a significant role.
4	A Note on Trends in Transit Commuting in the United States Relating to Employment in the Central Business District	Hendrickson	1986	An analysis of changes in transit commuting between 1960 and 1980. Transit commuting is closely tied to employment level in the central business district.
5	Secrets of Success: Assessing the Large Increases in Transit Ridership Achieved by Houston and San Diego Transit Providers	Kain & Liu	1999	Found that increases in service, reduction in fare, and growth in employment and population contributed the most to increasing ridership.
6	Factors Affecting Urban Transit Ridership	Kohn	2000	A nationwide Canadian study on transit ridership that finds that changes in fares and service levels can greatly affect ridership.
7	A Time-Series Analysis of Public Transit Ridership in Portland, Oregon, 1971–1982	Kyte et al.	1998	Compared ridership before and after service changes in Portland, OR. Found that service hours' effect on ridership varied by route, but that it was significant overall.
8	Determinants of Transit Ridership Analysis of Post WWII Trends and Evaluation of Alternative Networks	Liu	1993	Nationwide study of transit ridership post WWII. Found that greater employment is tied to both higher levels of commuting and more vehicle purchases. Found that vehicle revenue miles strongly correlate with ridership.
9	Modeling the Commute Mode Share of Transit Using Continuous Accessibility to Jobs	Owen & Levinson	2015	Predicted mode share based on accessibility measures and on demographics using data from the Minneapolis–Saint Paul Metropolitan Area at the census block-group level. They found that transit mode was negatively correlated with income and vehicle ownership, even when considering accessibility.
10	Increasing Transit Ridership: The Experience of Seven Cities	Sale	1976	Service expansions and gas prices played a large role in transit growth in the 1970s.
11	Public Transportation and Land Use Policy	Pushkarev & Zupan	1977	Seminal discussion of the population and employment densities required to support public transportation service.

	Source Title	Author	Year	Relevant Takeaways
12	The Effects of Population Density and Income on per Capita Transit Ridership in Western American Cities	Spillar & Rutherford	1998	This study links population density to higher transit ridership, though several other factors are likely at play, including income.
13	The Factors Influencing Transit Ridership: A Review and Analysis of the Ridership Literature	Taylor & Fink	2003	A review of relevant literature surrounding public transit ridership.
14	Nature and/or Nurture? Analyzing the Determinants of Transit Ridership Across U.S. Urbanized Areas	Taylor et al.	2009	National study of transit ridership against a wide variety of factors. Found that the population of recent immigrants and the percentage of carless households were positively correlated with transit ridership. The correlation between demographic characteristics and transit ridership remains strong even when taking population density and access to transit into consideration.
15	Traveler Response to Transportation System Changes Handbook	TCRP Report 95	2004	Housing and workplace density, as well as low parking availability, correlate to higher transit ridership.

Table A-4. Academic literature on impacts of new trends on transit ridership.

	Source Title	Author	Year	Relevant Takeaways
1	Taxicabs as Public Transportation in Boston, Massachusetts	Austin & Zegras	2012	Showed that heavy rail stations generated less trips than surrounding areas, but that the opposite was true for light rail and BRT services.
2	Employee Transportation Benefits in High Transit Mode Share Areas: University Case Study	Block-Schachter & Attanucci	2008	Parking and driver mileage benefits correlated with decreased transit use, while transit benefits and discounted passes correlated with higher transit use in Boston, MA.
3	Invest in the Ride: A 14 Year Longitudinal Analysis of the Determinants of Public Transport Ridership in 25 North American Cities	Boisjoly et al.	2018	A large study summarizing transit ridership effects, showing that service levels are the primary determinant of ridership. Also found that the presence of Uber in a city was not a significant factor in ridership.
4	Understanding the Effects of Transit Benefits on Employees' Travel Behavior: Evidence from the New York–New Jersey Region	Bueno et al.	2017	Parking and driver mileage benefits correlated with decreased transit use, while transit benefits and discounted passes correlated with higher transit use in New York and New Jersey.
5	Shared-Use Mobility in the United States: Current Adoption and Potential Impacts on Travel Behavior	Clewlow	2016	A survey of TNC and carsharing users, with mixed effects on transit usage.
6	Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States	Clewlow & Mishra	2017	Survey of TNC users found that overall, users decreased bus usage but increased commuter rail usage, and many made trips they would not have made without the availability of TNCs.
7	Understanding Changes in Demographics, Preferences, and Markets for Public Transportation	Coogan et al.	2018	Critical factors for predicting future transit markets are age, race, and foreign-born status. There is substantial variation in transit usage by region of the U.S., residential neighborhood type, and employment location. Attitudes and perceptions significantly affect transit usage and residential and employment location choice.
8	Promoting Sustainable Travel Modes for Commute Tours: A Comparison of the Effects of Home and Work Locations and Employer-Provided Incentives	Dong et al.	2016	Parking and driver mileage benefits correlated with decreased transit use, while transit benefits and discounted passes correlated with higher transit use in Portland, OR.
9	The Effect of Demographic Changes on Transit Ridership Trends	Driscoll et al.	2018	Modeled the impact of population age on transit ridership since 1989. Found that a contributing factor to the decline in ridership per capita was an aging population that makes less trips on average. Authors also point to slower rates of population growth in U.S. counties with abundant transit service than in counties with little transit available.

	Source Title	Author	Year	Relevant Takeaways
10	TCRP Research Report 188: Shared Mobility and the Transformation of Public Transit	Feigon & Murphy	2016	Large study on TNC usage that primarily finds that users utilize the services for recreation or social activities, and that the services have allowed users to postpone auto ownership or sell their car.
11	The New Urban Crisis: How Our Cities Are Increasing Inequality, Deepening Segregation, and Failing the Middle Class and What We Can Do About It	Florida	2017	Details gentrification effects on transit ridership. While cities are becoming denser, their populations are becoming whiter, have higher-incomes, and more cars.
12	On the Factors Influencing the Choices of Weekly Telecommuting Frequencies of Post-secondary Students in Toronto	Habib	2017	Study focused solely on post-secondary students in Toronto and found that owning a transit pass correlates negatively with high-frequency telecommuting.
13	Is Uber a Substitute or Complement for Public Transit?	Hall et al.	2018	Found that Uber presence and intensity correlated with ridership decrease in MSAs with smaller population sizes and ridership increase in MSAs with large population sizes.
14	A Framework for Understanding the Impacts of Ridesourcing on Transportation	Henao & Marshall	2017	A report explaining the complexities in understanding TNCs' effects, due to data availability and confounding trends.
15	Transit Systems and the Impacts of Shared Mobility	Iacobucci et al.	2017	Largely duplicative study to TCRP Research Report 188.
16	Falling Transit Ridership: California and Southern California	Manville et al.	2018	Increasing auto ownership especially among lower-income households was found to have a significant effect on falling transit ridership in the Southern California region. Transit ridership fell sharply in the past several years despite heavy investments in service.
17	The Impact of Carsharing on Public Transit and Non-Motorized Travel: An Exploration of North American Carsharing Survey Data	Martin & Shaheen	2011	Households that utilize carsharing use transit less than before joining carsharing.
18	In Portland, Economic Displacement May Be a Driver of Ridership Loss	Mills & Steele	2017	Compared bus stop-level changes in the real-estate values with ridership changes and found a significant overlap. This suggests that focusing service entirely on highest-density areas may not yield the maximum ridership.
19	Implications to Public Transportation of Emerging Technologies	Polzin	2016	An overarching view of how to handle TNCs' effects, suggests that agencies monitor the impact of technology on travel behavior, redefine transit's role as mobility options change, and position transit to address emerging issues.

	Source Title	Author	Year	Relevant Takeaways
20	Just a Better Taxi? A Survey-Based Comparison of Taxis, Transit, and Ridesourcing Services in San Francisco	Rayle et al.	2016	Found that 33% of rideshare users would have made the trip by transit, 39% by taxi, and only 6% would have driven their own car.
21	North American Carsharing: 10-Year Retrospective	Shaheen, Cohen, & Chung	2009	A report combining 15 studies finds that car sharing members' transit usage increased 13.5–54% after joining carsharing.
22	How Carsharing Affects the Travel Behavior of Households: A Case Study of Montréal, Canada	Sioui et al.	2012	Zero-car households that utilize carsharing use transit less than zero-car households in general.
23	Incorporating Online Shopping into Travel Demand Modeling: Challenges, Progress, and Opportunities.	Suel et al.	2018	Delivery services such as Amazon and GrubHub have made shopping and dining delivery possible. This study reviews recent literature surrounding these online providers and their potential effects on travel demand.
24	A New Market Segmentation Approach: Evidence from Two Canadian Cities	Van Lierop & El-Geneidy	2017	Develops a conceptual framework to segment the market for marketing efforts.
25	New Potential for Multimodal Connection: Exploring the Relationship Between Taxi Trips and Transit in New York City	Wang & Ross	2016	Taxi services are about equally split between competing with and complementing transit trips.
26	Modeling Taxi Trip Demand by Time of Day in New York City	Yang & Gonzales	2014	Transit access increases taxi usage in New York City even when controlling for population and employment density.
27	Comparison of Mode Cost by Time of Day for Nondriving Airport Trips to and from New York City's Pennsylvania Station	Yang et al.	2014	Cost prohibited the utility of taxi trips for all times of day except overnight, when transit service frequency dropped significantly. Transit was most valuable during peak periods, when headways were shortest and vehicular traffic was highest.

Table A-5. Academic literature on transit agency strategies.

	Source Title	Author	Year	Relevant Takeaways
1	Metropolitan Transit Agency's Experience Operating General-Public Demand-Responsive Transit	Becker et al.	2013	The Denver Regional Transit Authority has been providing dynamic rides with their own vehicles and operators since 2000.
2	The Impact of Real-Time Information on Bus Ridership in New York City	Brakewood, Macfarlane, & Watkins	2015	Found that the introduction of real-time information correlates with a 2.3% increase in bus ridership in New York City.
3	Best Practices for Transportation Agency Use of Social Media	Bregman & Watkins	2013	A book describing potential strategies for transit agencies to create an online presence.
4	Comparing Fixed-Route and Demand-Responsive Feeder Transit Systems in Real-World Settings	Edwards & Watkins	2013	In low-density areas, demand-responsive transit can service short trips at a lower cost than fixed routes.
5	Demi-Flexible Operating Policies to Promote the Performance of Public Transit in Low-Demand Areas	Qiu et al.	2015	In low-density areas, demand-responsive transit can service short trips faster.
6	UpRouted: Exploring Microtransit in the United States	Westervelt et al.	2018	The Kansas City Area Transportation Authority and Santa Clara Valley Transportation Authority both offered demand-responsive transit programs operated by their own staff, but the programs were discontinued due to insufficient ridership.

APPENDIX B

Data Limitations

Throughout our analysis, there were several significant potential ridership factors we were interested in studying but were unable to draw conclusions about due to lack of quality data. These factors appeared either in the literature as factors significantly correlated with transit ridership or in articles surrounding pilot projects with promising initial results. Despite this, they were either inconsistently measured and reported geographically or between years, or they were not measured at all. A lack of data on these factors prevents researchers from performing rigorous studies on their effects and may potentially hurt viable means of maintaining and growing ridership.

Dedicated Right-of-Way

It is generally accepted knowledge in the transit industry that dedicated right-of-way (ROW) modes, such as heavy rail, are seen as more reliable and faster than mixed traffic modes such as streetcar and bus. Separating vehicles from general travel lanes allows them to travel faster and more consistently than those that sit in traffic. This, in turn, results in higher ridership per route mile on these modes. Cities that have implemented dedicated streetcar and bus lane pilots, such as Boston and Toronto (identified in Task 3) experienced higher ridership along these routes. As part of our study of strategies to combat ridership declines, we were interested in studying on a nationwide scale the effects of dedicated ROW on ridership. This type of study may have allowed us to see correlation between ROW for particular modes and ridership trends.

However, we were unable to complete this type of analysis due to a simple lack of reliable data. While metrics involving transit way mileage are available for each year in the National Transit Database (NTD), our analysis has shown them to be unreliable. The first issue involves a change in the way NTD classified transit way mileage for non-rail modes. In 2012, non-rail "exclusive" and non-rail "controlled" ROW were reported for each mode. In 2016, categories were changed to "exclusive fixed guideway bus lane miles," "exclusive high intensity bus lane miles," and "controlled access high intensity bus lane miles." This addition of "fixed guideway" mileage led many transit agencies to include numbers unrelated to exclusive ROW. For example, each operator of trolleybus service reported their mileage of trolley wire regardless of ROW characteristics. Some transit agencies reported fixed guideway mileage for traditional bus modes rather than including these lane miles in "high intensity bus lane" mileage.

Another issue with transit way mileage data involves its general accuracy. Despite frequent campaigns to introduce bus lanes and segregate transit vehicles from other traffic, NTD data shows about as many transit agencies decreasing their dedicated ROW as increasing it. As shown in ***Figure B-1*** below, data from the NTD shows a relatively even spread of regional growth and decline in dedicated ROW mileage for otherwise mixed ROW modes, such as bus and streetcar. The declines in dedicated ROW are more likely due to inconsistencies in reporting rather than actual guideway miles being repurposed for mixed traffic. The inconsistencies in reporting dedicated ROW mileage disqualify it as a metric for analysis, despite the interesting and potentially useful conclusions that may come from such an analysis. Future studies on implementation of dedicated ROW on ridership and service efficiency are recommended, perhaps through data gathering from a large group of transit agencies themselves.

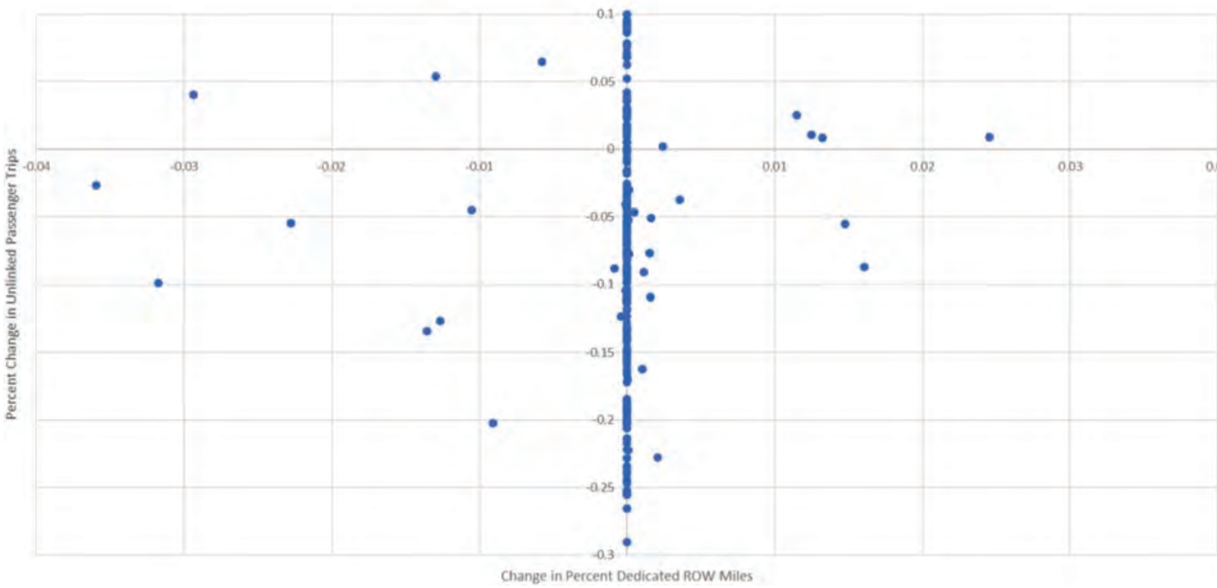

Figure B-1. Percentage change in unlinked passenger trips vs. percentage change in dedicated ROW miles between 2012 and 2016.

Reduced Reporters

While NTD reduced reporters are generally smaller transit agencies operating 30 vehicles or less, they have a different set of reporting requirements and apparent data standards than full reporters. While they are technically required to report unlinked passenger trips, vehicle revenue miles, and fare revenue, many of the holes in data we discovered were due to reduced reporters' lack of data for portions of our study period. While reporting requirements appeared not to change between 2012 and 2016, these missing data led us to remove several transit agencies from the analysis. While it is important to note that many of these transit agencies lack resources to gather and analyze their data, this analysis took into account these smaller transit agencies which are often ignored in nationwide transit studies. Having reliable data available is the best way to guarantee a thorough analysis of these trends.

Mode Change

A byproduct of the multitude of transit modes currently in service across the U.S. is their often complex categorization. Modes like BRT and Streetcar blur the lines of what bus and rail services mean, and modes like hybrid rail may not be innately understood by all transit agencies. Even within a mode like streetcar, modern versions may act more like light rail than historic ones, which may affect their ridership and service characteristics. When transit agencies are given forms to report, many seemed to have reacted slowly to the introduction of new modes. For example, BRT systems in Cleveland and Boston were fully operational by 2012, yet they reported these statistics as motor bus (MB) that year. In 2016, this data was correctly assigned to BRT. This misrepresentation of mode statistics makes parsing historical data by mode unreliable, as service that acts like BRT may not be comparable at all to service that acts like MB.

A separate issue, related to the dedicated ROW issues above, is that several transit agencies have routes that behave like different modes along the course of their route. Examples include the MBTA Green Line, which generally operates as light rail but with several segments running in mixed traffic as a streetcar, and the MBTA Silver Line, which transitions from a dedicated busway to street running mid-route. These transitions must be handled in a logical way in data collection, either by correctly denoting ROW mileage or assigning new modal categories based on combinations of other modes. This level of data would help future researchers sort through modal types to better identify ridership patterns.

Service Area

In our effort to compare transit service and passengers across hundreds of regions in the United States, the issue of regional scale became vital. Restricting comparison to municipal limits rarely makes sense as transit agencies themselves generally are not constrained to particular cities. Urbanized area (UZA), the geographic measure used by the NTD, is largely not available from sources like the U.S. Census Bureau more fine-grain than every ten years. Urbanized areas have complex geographic boundaries that extend to the far reaches of a region, often reaching into nearby cities otherwise unaffiliated with a particular region. Because of their concentration on higher-density areas, UZAs tend to skew regional density high.

In contrast, Core-Based Statistical Areas (CBSAs) used in our analysis tend to include entire counties for the sake of simplicity. This allows for much more frequent data availability, but often includes hundreds of square miles of undeveloped land and skews density down for most regions. To compare transit service across regions of various size, we had to settle on CBSAs for data availability. This was not ideal, but was deemed necessary to complete the regional analysis.

However, transit agencies do report “service areas” to the NTD, technically required to conform to a geographic buffer surrounding the routes serviced by the transit agency. This metric would be ideal for a transit service analysis and for comparing densities of regions that actually have operational transit service. However, the self-reported nature of NTD's service area left the data particularly unusable. Some transit agencies appear to simply report the square mileage of the counties they operated in without regard to service at all. Other transit agencies restricted their service area differently by mode. Both of these misrepresent what should constitute a transit agency's service area, though no methodology would be perfect. For example, commuters who drive in from outlying counties to park-and-rides generally are missed in a service area calculation. However, future studies would benefit from a specified methodology for determining a transit agency's true service area.

Tract-Level Data and CBSA Changes

In our analysis, we relied on one-year data from the American Community Survey in order to accurately measure year-to-year variation in population and zero-vehicle households. Unfortunately, this left us unable to perform an analysis on any scale smaller than the CBSAs, as Census data on the tract and urbanized area levels are only available from the decennial census or as ACS 5-year estimates, which are not usable for comparisons of point-in-time data. Tract-level data would allow for remarkably fine-tuned analyses of trends not only related to transit, but of population and demographics in general. Metropolitan areas contain immense variation between their tracts, and the ability to track changes between non-decennial years would have vast impacts on the research world. Realistically, however, reliable year-to-year data would require a significantly scaled up effort by the U.S. Census, particularly for all 74,000 census tracts at the one-year level.

Additionally, CBSAs underwent a change in 2013 where many metropolitan and micropolitan areas gained or lost counties. This caused some issues with reconciling the demographic statistics between the years of 2012 and 2016. Documentation on the changes and how they affected population statistics was largely nonexistent. Piecing together data that was available, we were able to reconstruct some CBSAs to perform an accurate comparison of their 2012 and 2016 statistics. However, many CBSAs also had to be thrown out as their geographies could not be matched. Better documentation on these changes and how demographic statistics shifted would help researchers more accurately and thoroughly compare one-year data from before and after the change.

Conclusion

Despite our confidence in our data and results, there were several data challenges that prevented this analysis from going further. Lack of nationwide reporting standards for certain metrics in the NTD restricted our analysis and many others to basic reportable metrics. Geographic data limitations caused issues with data reconciliation and prevented a thoroughly nationwide study. Transit agencies must be able to accurately collect and analyze the data they can about their service and passengers, particularly at a time when transit ridership is declining. Quality data can help transit agencies and researchers alike to find the best answers to the many questions asked of them.

APPENDIX C

Metropolitan Statistical Areas Abbreviations by Cluster

Table C-1. Abbreviations for metropolitan statistical areas in mixed traffic cluster 1.

Metropolitan Statistical Area	Abbreviation	State
Akron	AKR	OH
Albany	ALBGA	GA
Albany-Schenectady-Troy	ALBNY	NY
Allentown-Bethlehem-Easton	ABE	PA-NJ
Altoona	ALT	PA
Ann Arbor	AA	MI
Baltimore-Columbia-Towson	BAL	MD
Binghamton	BIN	NY
Bridgeport-Stamford-Norwalk	BRI	CT
Buffalo-Cheektowaga-Niagara Falls	BUF	NY
Champaign-Urbana	URB	IL
Charleston	CHS	WV
Cleveland-Elyria	CLE	OH
Corpus Christi	CC	TX
Dayton	DAY	OH
Decatur	DEC	IL
Detroit-Warren-Dearborn	DET	MI
Erie	ERIE	PA
Eugene	EUG	OR
Flint	FLINT	MI
Fresno	FRE	CA
Hartford-West Hartford-East Hartford	HAR	CT
Ithaca	ITH	NY
Johnstown	JST	PA
Lancaster	LAN	PA
Louisville/Jefferson County	LOU	KY-IN
Memphis	MEM	TN-MS-AR

Metropolitan Statistical Area	Abbreviation	State
Milwaukee-Waukesha-West Allis	MIL	WI
Minneapolis-St. Paul-Bloomington	MSP	MN-WI
New Haven-Milford	HVN	CT
New Orleans-Metairie	NOLA	LA
Pittsburgh	PIT	PA
Pittsfield	PSF	MA
Providence-Warwick	PRO	RI-MA
Pueblo	PUE	CO
Reading	REA	PA
Reno	RNO	NV
Rochester	ROC	NY
Saginaw	SAG	MI
San Juan-Carolina-Caguas	SJU	PR
Scranton--Wilkes-Barre--Hazleton	SWB	PA
St. Cloud	STC	MN
State College	SCE	PA
Syracuse	SYR	NY
Toledo	TOL	OH
Tucson	TUC	AZ
Urban Honolulu	HON	HI
Wheeling	WHE	WV-OH
Williamsport	WIL	PA
Worcester	WOR	MA-CT

Table C-2. Abbreviations for metropolitan statistical areas in mixed traffic cluster 2.

Metropolitan Statistical Area	Abbreviation	State
Albuquerque	ALQ	NM
Ames	AMES	IA
Anchorage	ANC	AK
Appleton	APP	WI
Austin-Round Rock	AUS	TX
Bakersfield	BAK	CA
Billings	BIL	MT
Bloomington	BLO	IL
Boise City	BOI	ID
Cedar Rapids	CED	IA

Metropolitan Statistical Area	Abbreviation	State
Charlotte-Concord-Gastonia	CHA	NC-SC
Cincinnati	CIN	OH-IN
College Station-Bryan	CSB	TX
Colorado Springs	COS	CO
Columbus	CMH	OH
Corvallis	COR	OR
Davenport-Moline-Rock Island	DAV	IA-IL
Des Moines-West Des Moines	DSM	IA
El Centro	CEN	CA
Elkhart-Goshen	ELK	IN
Fargo	FAR	ND-MN
Fort Collins	FCO	CO
Grand Rapids-Wyoming	GRR	MI
Green Bay	GB	WI
Indianapolis-Carmel-Anderson	IND	IN
Iowa City	IOWA	IA
Kahului-Wailuku-Lahaina	KAH	HI
Kansas City	KC	MO-KS
Killeen-Temple	KIL	TX
La Crosse-Onalaska	LAC	WI-MN
Laredo	LAR	TX
Lawrence	LAW	KS
Lebanon	LEB	PA
Lexington-Fayette	LEX	KY
Lincoln	LIN	NE
Logan	LOG	ID
Lubbock	LUB	TX
Madison	MAD	WI
Manchester-Nashua	MAN	NH
Missoula	MIS	MT
Modesto	MOD	CA
Napa	NAP	CA
Naples-Immokalee-Marco Island	NAP	FL
Nashville-Davidson--Murfreesboro--Franklin	NAS	TN
North Port-Sarasota-Bradenton	SRQ	FL
Oklahoma City	OKC	OK
Omaha-Council Bluffs	OMA	IA
Orlando-Kissimmee-Sanford	ORL	FL

Metropolitan Statistical Area	Abbreviation	State
Oshkosh-Neenah	OSH	WI
Oxnard-Thousand Oaks-Ventura	OXN	CA
Raleigh	RAL	NC
Salem	SLE	OR
Salinas	SAL	CA
Salt Lake City	SLC	UT
San Antonio-New Braunfels	SAT	TX
San Luis Obispo-Paso Robles-Arroyo Grande	SLO	CA
Santa Cruz-Watsonville	SCZ	CA
Santa Fe	SFE	NM
Santa Maria-Santa Barbara	SBB	CA
Santa Rosa	SRO	CA
Sioux City	SIC	SD
Sioux Falls	SIF	SD
Spokane-Spokane Valley	SPO	WA
Springfield	SPR	MO
Stockton-Lodi	STO	CA
Tampa-St. Petersburg-Clearwater	TPA	FL
Tulsa	TUL	OK
Vallejo-Fairfield	VAL	CA
Virginia Beach-Norfolk-Newport News	VIR	VA-NC
Wichita	WIC	KS
Yakima	YAK	WA
York-Hanover	YORK	PA

Table C-3. Abbreviations for metropolitan statistical areas in mixed traffic cluster 3.

Metropolitan Statistical Area	Abbreviation	State
Athens-Clarke County	ATH	GA
Augusta-Richmond County	AUG	GA-SC
Baton Rouge	BTR	LA
Bay City	BAY	MI
Beaumont-Port Arthur	BEA	TX
Bellingham	BEL	WA
Birmingham-Hoover	BIR	AL
Blacksburg-Christiansburg-Radford	BLA	VA
Bloomington	BLO	IN
Bremerton-Silverdale	BRM	WA
Brownsville-Harlingen	BRO	TX

Metropolitan Statistical Area	Abbreviation	State
Burlington-South Burlington	BUR	VT
Canton-Massillon	CAN	OH
Cape Coral-Fort Myers	FTM	FL
Charleston-North Charleston	CHS	SC
Chattanooga	CHA	TN-GA
Chico	CHICO	CA
Columbia	COL	MO
Columbia	CAE	SC
Crestview-Fort Walton Beach-Destin	DES	FL
Deltona-Daytona Beach-Ormond Beach	DAY	FL
Duluth	DUL	MN-WI
Durham-Chapel Hill	DUR	NC
Eau Claire	EC	WI
El Paso	ELP	TX
Elizabethtown-Fort Knox	FTK	KY
Evansville	EVA	IN-KY
Fayetteville	FAY	NC
Fayetteville-Springdale-Rogers	FYV	MO
Flagstaff	FLG	AZ
Fort Wayne	FWA	IN
Gainesville	GAI	FL
Great Falls	GFL	MT
Greensboro-High Point	GSO	NC
Greenville-Anderson-Mauldin	GSP	MS-SC
Gulfport-Biloxi-Pascagoula	GPT	LA-MS
Hanford-Corcoran	HAN	CA
Harrisburg-Carlisle	MDT	PA
Harrisonburg	HAR	VA
Hickory-Lenoir-Morganton	HIC	NC
Holland	HOL	MI
Huntington-Ashland	HUN	OH
Huntsville	HSV	AL
Jackson	JAC	MI
Jackson	JAN	MS
Jackson	JSN	TN
Jacksonville	JAX	FL
Kalamazoo-Portage	KAL	MI
Kankakee	KAN	IL
Kennewick-Richland	KEN	WA

Metropolitan Statistical Area	Abbreviation	State
Knoxville	KNO	TN
Kokomo	KOK	IN
Lafayette	LAF	LA
Lafayette-West Lafayette	LWL	IN
Lakeland-Winter Haven	LAK	FL
Lansing-East Lansing	LAN	MI
Little Rock-North Little Rock-Conway	LIT	AR
Longview	LON	WA
Lynchburg	LYN	VA
Medford	MED	OR
Merced	MER	CA
Mobile	MOB	AL
Montgomery	MON	AL
Mount Vernon-Anacortes	MVN	WA
Muncie	MUN	IN
Niles-Benton Harbor	NIL	MI
Ocala	OCA	FL
Olympia-Tumwater	OLY	WA
Palm Bay-Melbourne-Titusville	MEL	FL
Panama City	PAN	FL
Pensacola-Ferry Pass-Brent	PNS	FL
Peoria	PEO	IL
Port St. Lucie	PSL	FL
Portland-South Portland	PSP	ME
Racine	RAC	WI
Redding	RED	CA
Richmond	RIC	VA
Roanoke	ROA	VA
Rochester	RST	MN
Rockford	RCK	IL
Rome	ROM	GA
San Angelo	ANG	TX
Savannah	SAV	GA
Sebastian-Vero Beach	VER	FL
Sheboygan	SHE	WI
Shreveport-Bossier City	SHR	LA
Somerset	SOM	PA
South Bend-Mishawaka	SBN	IN-MI

Metropolitan Statistical Area	Abbreviation	State
Springfield	SPI	IL
Springfield	SPR	MA
St. Louis	STL	MO-IL
Sumter	SUM	SC
Tallahassee	TAL	FL
Terre Haute	TER	IN
Topeka	TOP	KS
Torrington	TOR	CT
Waco	WACO	TX
Wenatchee	WEN	WA
Winston-Salem	WIN	NC
Youngstown-Warren-Boardman	YNG	OH-PA
Yuba City	YUBA	CA

Table C-4. Abbreviations for metropolitan statistical areas in mixed traffic cluster 4.

Metropolitan Statistical Area	Abbreviation	State
Atlanta-Sandy Springs-Roswell	ATL	GA
Dallas-Fort Worth-Arlington	DAL	TX
Denver-Aurora-Lakewood	DEN	CO
Houston-The Woodlands-Sugar Land	HOU	TX
Las Vegas-Henderson-Paradise	LV	NV
Phoenix-Mesa-Scottsdale	PHO	AZ
Portland-Vancouver-Hillsboro	POR	OR-WA
Riverside-San Bernardino-Ontario	ONT	CA
Sacramento--Roseville--Arden-Arcade	SAC	CA
San Diego-Carlsbad	SD	CA
San Jose-Sunnyvale-Santa Clara	SJ	CA

Table C-5. Abbreviations for metropolitan statistical areas in mixed traffic cluster 5.

Metropolitan Statistical Area	Abbreviation	State
Boston-Cambridge-Newton	BOS	MA-NH
Chicago-Naperville-Elgin	CHI	IL-WI
Los Angeles-Long Beach-Anaheim	LA	CA

Metropolitan Statistical Area	Abbreviation	State
Miami-Fort Lauderdale-West Palm Beach	MIA	FL
Philadelphia-Camden-Wilmington	PHL	DE-PA-MD
San Francisco-Oakland-Hayward	SF	CA
Seattle-Tacoma-Bellevue	SEA	WA
Washington-Arlington-Alexandria	DC	DC-MD-VA-WV

Table C-6. Abbreviations for metropolitan statistical areas in dedicated ROW.

Metropolitan Statistical Area	Abbreviation	State	Cluster
Atlanta-Sandy Springs-Roswell	ATL	GA	E
Baltimore-Columbia-Towson	BAL	MD	C
Boston-Cambridge-Newton	BOS	MA-NH	B
Buffalo-Cheektowaga-Niagara Falls	BUF	NY	C
Charlotte-Concord-Gastonia	CHR	SC	E
Chicago-Naperville-Elgin	CHI	IL-WI	B
Cleveland-Elyria	CLE	OH	C
Dallas-Fort Worth-Arlington	DAL	TX	E
Denver-Aurora-Lakewood	DEN	CO	D
Houston-The Woodlands-Sugar Land	HOU	TX	E
Los Angeles-Long Beach-Anaheim	LA	CA	A
Miami-Fort Lauderdale-West Palm Beach	MIA	FL	D
Minneapolis-St. Paul-Bloomington	MINN	MN-WI	E
Philadelphia-Camden-Wilmington	PHL	DE-PA-MD	B
Phoenix-Mesa-Scottsdale	PHO	AZ	D
Pittsburgh	PIT	PA	C
Portland-Vancouver-Hillsboro	PORT	OR-WA	D
Sacramento--Roseville--Arden-Arcade	SAC	CA	D
St. Louis	STL	MO-IL	E
Salt Lake City	SLC	UT	E
San Diego-Carlsbad	SD	CA	D
San Francisco-Oakland-Hayward	SF	CA	B
San Jose-Sunnyvale-Santa Clara	SJS	CA	D
San Juan-Carolina-Caguas	SJ	PR	C
Seattle-Tacoma-Bellevue	SEA	WA	D
Virginia Beach-Norfolk-Newport News	VIR	VA-NC	E
Washington-Arlington-Alexandria	WAS	DC-MD-VA-WV	B

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S. DOT	United States Department of Transportation

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