Transit Network Analysis

Providing an Optimal Transit Network Strategy for Mid-Size Transit Systems

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Abstract

Transit network analysis is an emerging field in transportation planning. This practicum addresses the issue of declining transit ridership in many North American regions and the trend towards rethinking transit networks to improve ridership and transit modal share. While there is existing research reporting on large cities such as Houston and Seattle, the focus of this practicum is on transit agencies in mid-sized regions having a population serving area between 100,000 and 1,000,000 residents, with two case studies in Columbus and Kansas City. Redesigning a transit network requires transit planners to carefully consider current land use patterns, ridership/coverage ratio, and most importantly the political environment. The process typically will take years to accomplish. Columbus took four years to successfully roll out their redesigned network to positive results, while Kansas City is in its first full year of planning for a network redesign strategy and are encountering numerous obstacles unique to the region. In addition to examining how to redesign transit networks for better efficiency, this practicum identifies other innovative strategies transit planners are considering in improving ridership and modal share, such as microtransit, universal transit passes, and low-income transit passes. While most of the research focuses on transit agencies in Columbus and Kansas City, several elements can be applied to other transit agencies that are considering a redesign of their transit network. A questionnaire was developed that was sent to all North American transit agencies in mid-sized regions, and five planners were interviewed in Columbus and Kansas City to learn more about the process of transit network restructuring. Findings and recommendations include determining the optimal balance between providing ridership and coverage service in the transit network, realizing that transit network restructuring is a long-term process, and remembering there are other tools that can be used to attract riders such as rider incentives and microtransit. Future research opportunities can include a focus on Canadian transit agencies, winter cities, how transit agencies balance providing frequent bus service in major corridors and coverage service elsewhere, and revisiting Kansas City after they complete their transit network restructuring process.

Keywords: Transit planning, transit network, transportation, Columbus, Kansas City

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1. Introduction

Public transit across North America has experienced declines or stagnation in ridership in the past 2-3 years. Transit systems in Montreal, Ottawa, and Calgary experienced declines in ridership since 2013 (Curry, 2016). Winnipeg is no exception, as Winnipeg Transit experienced a 3.3% decline in ridership between 2014 and 2015, with minimal ridership recovery since (City of Winnipeg Transit Department, personal communication, August 23, 2019). While lower gas prices, the economic downturn, and the rise of car sharing services may have contributed to the declines in ridership, an overlooked reason could be the fact transit networks have not kept up with population and urban growth or improvements in service.

Some transit agencies have looked at redesigning their transit networks to adapt to ongoing employment and residential trends. Transit networks are usually designed using two configurations: Radial and grid, although most mid-size transit systems use a combination of the two methods. Radial networks consist of routes branching around a few hubs such as downtown or a shopping mall, while grid networks consist of parallel routes largely in main corridors, maximizing efficiency but also increasing transfers. Figure 1.1 shows how a simple radial network could minimize transfers, while Figure 1.2 shows a simple grid network that maximizes transfers. However, per Walker (2009) a grid network is more effective in optimizing frequency for routes, since less routes are needed to connect communities to various destinations, and resources can be used on a single major corridor route.

An increasing number of transit agencies are planning on restructuring their transit networks to improve efficiency and establish a frequent transit network. The refocus in transit network planning means that planners are putting less emphasis on a radial network and more on a grid network that improves service on major corridors.

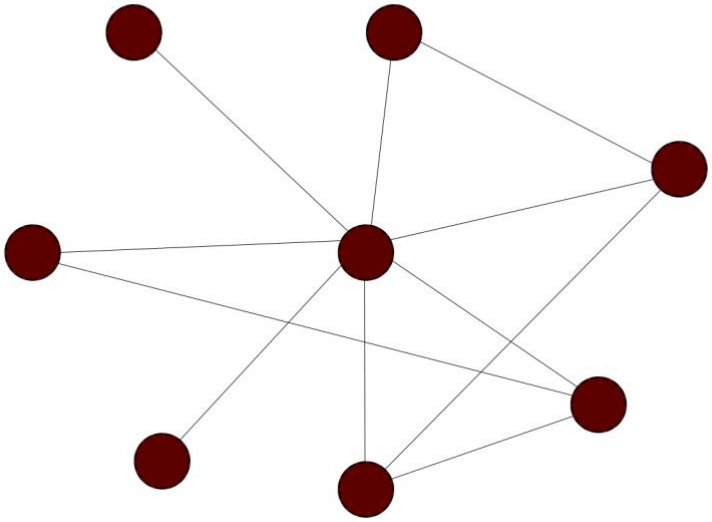

Figure 1.1: A simple radial network that connects outlying nodes with the central node.

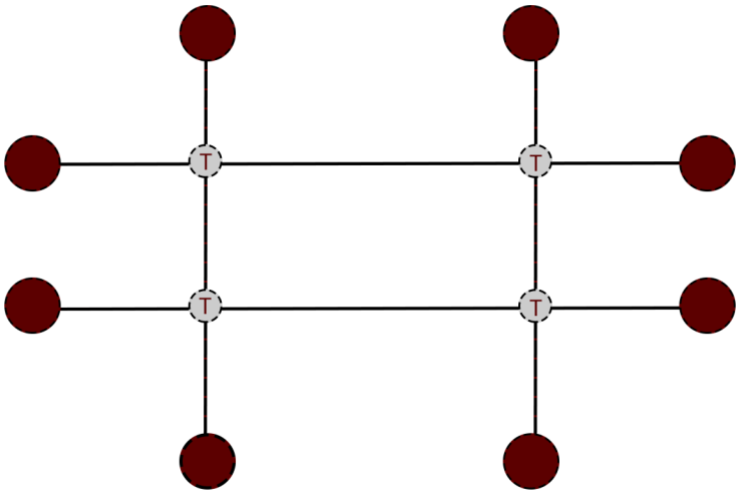

Figure 1.2: A simple grid network that highlights transfer locations to connect to different nodes.

1.1. Research Purpose

The research examines strategies that allow transit systems to optimize their networks in strengthening major corridors and providing reliable coverage in communities away from major corridors. Precedents include transit systems that have undergone or are undergoing network restructuring strategies, such as Houston, Mississauga, and Calgary. The strategies and lessons

from previous network restructuring proposals (both completed and ongoing) are used to determine what the best approach is for mid-size transit systems to optimize their network to balance ridership and coverage goals.

Many mid-size cities and regions have residents who largely drive, rather than using alternative modes of transport. To improve the environmental sustainability of these communities, there should be a modal shift towards public transportation, however alternative transport modes need to be attractive for residents to change their commuting options. This research identifies what attributes residents look for in considering transit over driving, as well as what allows transit users to continue taking public transit over driving. Given the information, strategies can be determined to allow choice riders to consider public transit over driving, and restructuring the transit network to balance frequency and coverage goals.

1.2. Key Questions

The following are research questions identified in this practicum:

Q1 What factors are considered when redesigning transit networks?

Q2 What metrics were used for transit agencies redesigning their networks to evaluate their goals?

Q3 How do transit agencies determine the optimal balance between providing high frequency on core routes and equitable coverage for other routes?

The questions are designed to answer different elements considered in transit operations planning and factors that transit planners look at in a transit network redesign. By adapting a transit network to employment and residential trends, as well as focusing more on frequent service in major corridors, transit planners hope that it would increase transit modal share in cities and regions.

1.3 System Reimagining - Houston METRO's New Bus Network

Houston, the 4th largest city in the United States, restructured their bus network in 2015 after realigning their policies on how to optimally serve their population. The core principle of their restructured network is to optimize the balance between ridership and coverage goals by

providing frequent service in major corridors while maintaining service in communities away from key corridors.

Houston METRO, like many North American transit systems, was strapped for money and was looking at strategies to improve service without costs to the public (Jaffe, 2014). While many transit systems in this situation would opt for a fare increase or a service decrease, Houston decided on an innovative approach to restructure their transit system to improve efficiency. Bliss (2016) noted the old system was too focused in serving downtown, where only 25% of Houston's jobs are located. Many routes were also not frequent enough, as the system lacked a frequent service network due to how the routes were designed. Finally, there was redundancy in many routes, with duplication of routes serving corridors leading to downtown.

The restructured bus network for Houston focused on minimizing route redundancy and creating corridors with frequent transit service. Figure 1.3 shows the difference between the two networks, both with similar operating costs. Holeywell (2015) examined the differences between the old and restructured network, and identified changes such as high-frequency routes (those operating every 15 minutes or better daily), routes serving different employment centres beyond downtown, dedicated key corridor services, less duplication of routes, and a higher focus on the light rail system.

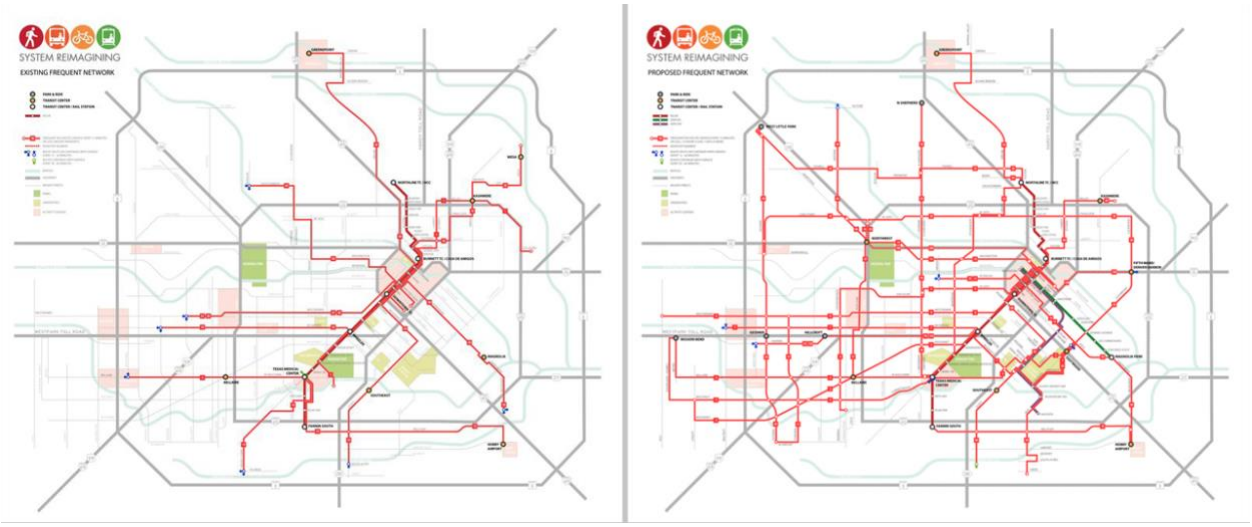

Figure 1.3: The previous frequent transit network (red coloured lines operating every 15 minutes or better daily) is shown at left, compared to the restructured network at right. Note the restructured network was accomplished with no net increase in buses. (WBUR, 2015)

The results were positive in the first year, as Binkovitz (2016) reported ridership increases for both its bus and rail network, at 1.2% and 16.6% respectively. Houston METRO's overall ridership increased by 6.8%, which was a reversal of several other transit systems that continued in stagnation or decline. Figure 1.4 shows the ridership difference for the first six-month period of 2015 and 2016.

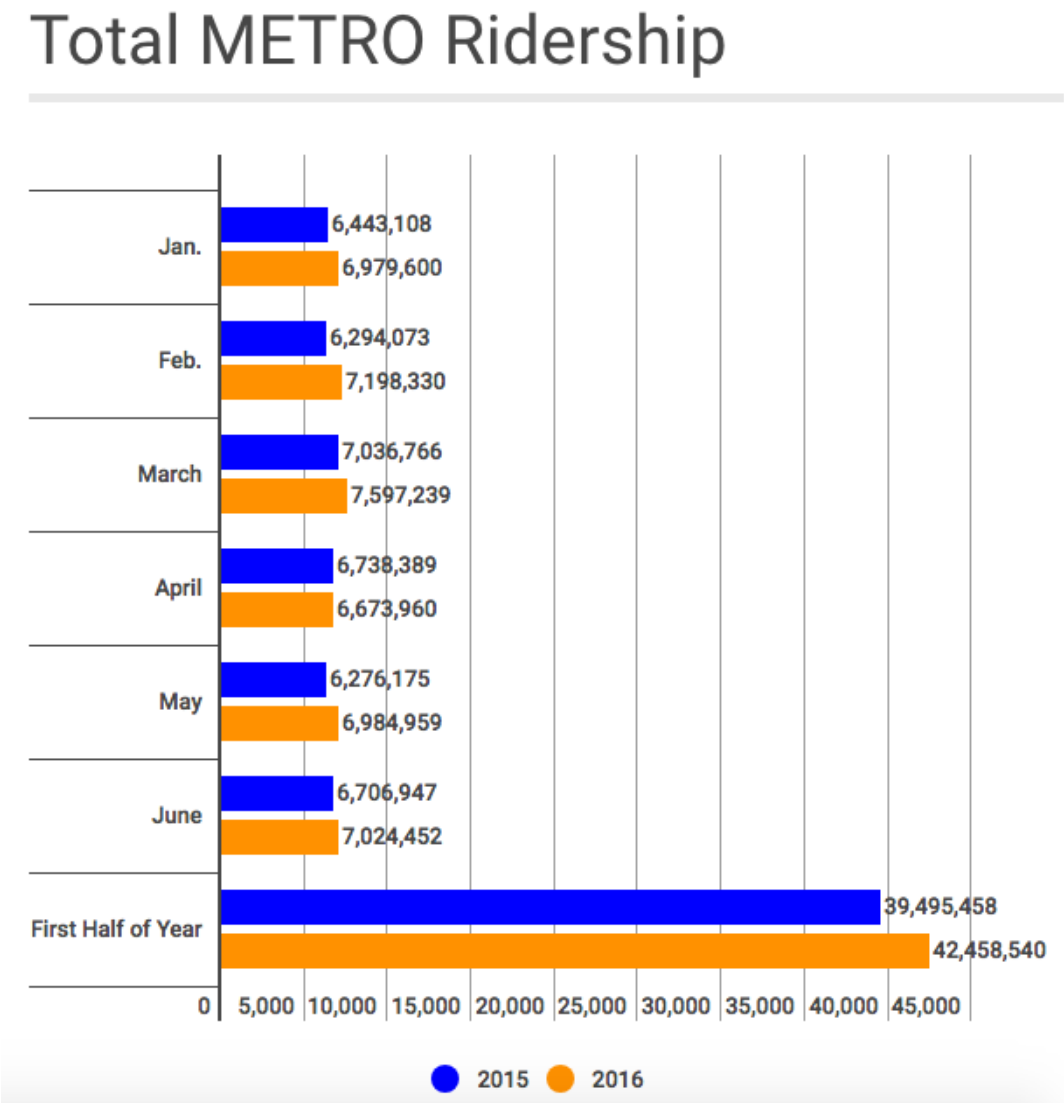

Figure 1.4: Ridership on the Houston METRO in the first half of 2016 compared to 2015. (Binkovitz, 2016)

The restructured bus network has also significantly increased access to frequent transit service for residents and employment. Figure 1.5 shows the difference in how many residents are within a half mile (800 metres) from a frequent transit route, as well as the number of jobs within a half mile from frequent transit service.

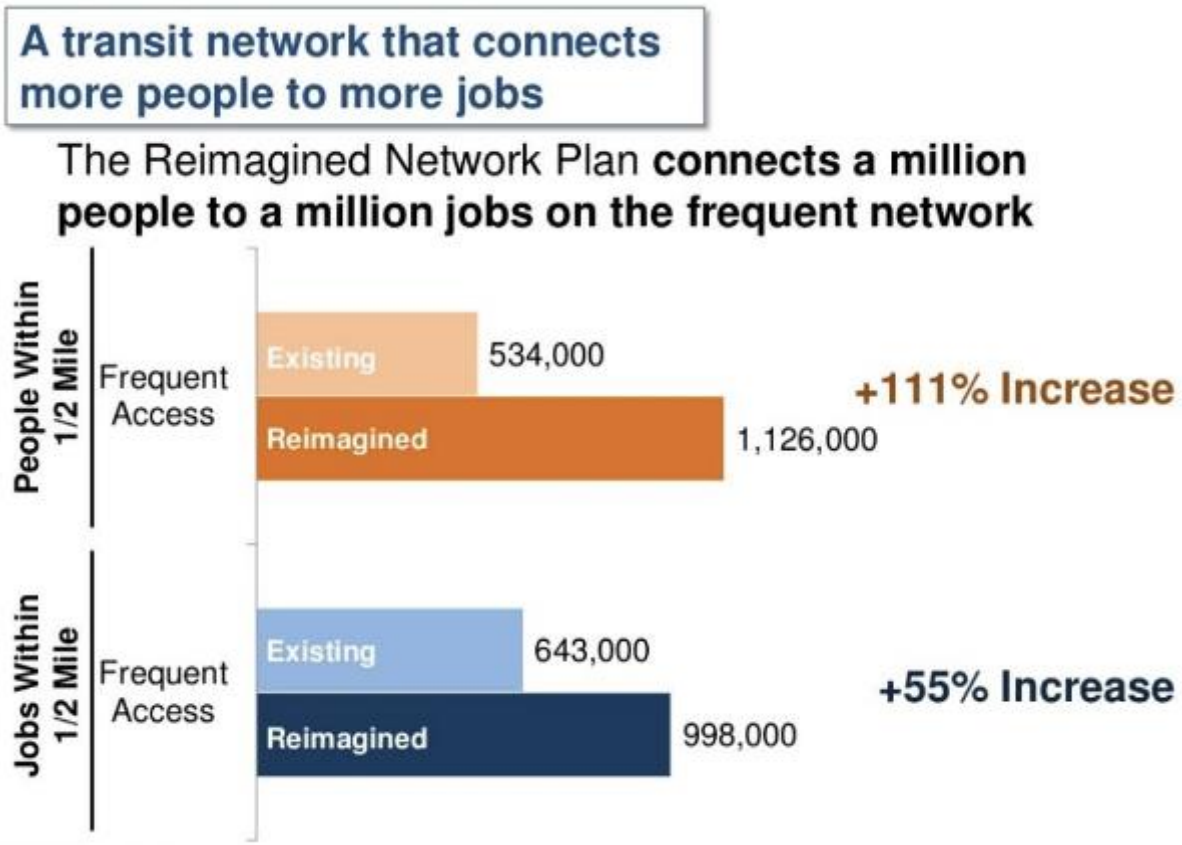

Figure 1.5: The difference in number of residents and jobs connected to a frequent transit route, pre-and post-network restructuring. The Reimagined Network Plan is the Houston's restructured transit network shown in Figure 1.3. (Jaffe, 2014)

While Houston's network restructuring has only been in effect for 2 years, the initial results have been positive, with ridership increases in the transit network and improved transit access to employment hubs for residents. Schmitt (2017) supports the Houston network restructuring figures, as total 2016 ridership showed an overall 2.3% increase compared to 2015, which was a reversal compared to other transit systems in major US cities having had ridership declines. Figure 1.6 shows transit ridership changes for major cities in the United States, where the two cities with the biggest ridership increase were the same two that underwent a bus network restructuring plan in the past two years.

UZA Name	Sum of 2015	Sum of 2016	Change
Seattle, WA	178,640,154	185,913,534	4.1%
Houston, TX	83,285,295	85,180,489	2.3%
Milwaukee, WI	40,610,851	41,476,982	2.1%
Detroit, MI	36,734,180	37,079,598	0.9%
New York-Newark, NY-NJ-CT	4,222,700,561	4,241,214,495	0.4%
San Francisco-Oakland, CA	454,952,418	454,996,256	0.0%
Boston, MA-NH-RI	403,464,723	402,554,159	-0.2%
Pittsburgh, PA	63,990,430	63,570,697	-0.7%
Denver-Aurora, CO	101,021,365	99,777,407	-1.2%
Portland, OR-WA	112,440,100	110,985,034	-1.3%
San Antonio, TX	37,983,886	37,290,201	-1.8%
Salt Lake City-West Valley City, UT	44,909,741	43,776,825	-2.5%
Minneapolis-St. Paul, MN-WI	96,636,368	93,716,857	-3.0%
Chicago, IL-IN	623,466,948	603,747,357	-3.2%
Urban Honolulu, HI	68,587,549	66,361,162	-3.2%
Las Vegas-Henderson, NV	72,044,767	69,420,973	-3.6%
Dallas-Fort Worth-Arlington, TX	75,998,371	72,137,725	-5.1%
Baltimore, MD	111,070,976	105,214,371	-5.3%
Atlanta, GA	141,154,134	132,925,293	-5.8%
Philadelphia, PA-NJ-DE-MD	369,644,085	346,276,496	-6.3%
Phoenix-Mesa, AZ	69,525,177	64,898,486	-6.7%
San Diego, CA	94,921,830	88,507,937	-6.8%
St. Louis, MO-IL	47,250,866	44,020,031	-6.8%
Cleveland, OH	46,844,074	43,507,057	-7.1%
Los Angeles-Long Beach-Anaheim, CA	619,459,557	572,589,716	-7.6%
San Jose, CA	44,718,244	40,763,554	-8.8%
Miami, FL	156,449,301	141,556,090	-9.5%
Washington, DC-VA-MD	441,222,366	396,260,838	-10.2%
Austin, TX	32,795,531	28,893,986	-11.9%
San Juan, PR	38,853,326	32,289,221	-16.9%

Figure 1.6: Transit ridership numbers and percentage change in major US cities in 2015 and 2016. The two cities at the top, Seattle and Houston, both underwent a restructuring of their bus networks in the past two years. (Schmitt, 2017)

Houston's positive results from its network restructuring has caught the attention of other North American cities that have followed suit in developing similar strategies to restructure their bus network, including Omaha (Jaffe, 2015), Columbus (Miller, 2017), Los Angeles (Jaffe, 2015), Boston (Miller, 2017), and Austin (Schmitt, 2016). While each transit agency would likely use different approaches in rethinking their network, the basic balancing approaches would still apply in developing their optimal network: Coverage vs. frequency, radial network vs. grid

network, piecemeal vs. overhauling the entire system, and having a uniform schedule that riders can understand (Formby, 2016; Miller, 2017).

The literature review in the next chapter further analyzes how transit networks are designed, how riders value transit, and research gaps in transit network planning that this practicum covers. Chapter 3 covers research methods used in this practicum. Chapter 4 summarizes findings from my research. Chapter 5 analyzes the findings from chapter 4 and relates them to the research questions shown in Section 1.2. Finally, chapter 6 concludes the research and looks at areas for further research in transit network planning.

2. Literature Review: Considerations in Transit Network Planning

This literature review considers themes important to transit network planning. These include explaining the network design problem and the value of transit, transit ridership and travel behaviour, and looking at areas of further research. There are many factors taken into consideration in transit planning, especially knowing how to balance providing frequent service in major corridors and coverage service outside major corridors. One way to determine the optimal balance is to look at the travel behaviour of riders and what factors they use to determine whether they ride transit or not.

2.1. Network Design Problem and the Value of Transit

An effective transit network should take into consideration what the transit system wants to achieve, essentially called the Network Design Problem (Caggiani et al, 2017, pg 9). Walker (2008) concludes transit systems should find the optimal balance between ridership goals and coverage goals, because the two goals counteract with one another. Each route should serve the purpose of maximizing ridership or maximizing coverage, not both. Routes designed for ridership are largely dedicated to main corridors, providing frequent service and maximizing fare revenue. Meanwhile, routes designed for coverage provide social equity for communities far from main corridors but are unable to drive. Their main goal is to connect outlying communities into the main network, where riders can transfer to a frequent transit route to access their destination.

With transit network planning, consideration should be taken in ensuring most neighbourhoods have access to some form of transit service, as it would allow choice riders to have options of whether they drive or take transit to their destination. Another important aspect is transit connectivity, to ensure different modes of transport can integrate with one another. Chowdhury et al (2014) emphasizes ride times and low waiting times as characteristics of an effective transit network, identifying Paris and London excelling in compared to Auckland, New Zealand. Arbex et al (2015) also supports the vision of connectivity, especially for larger transit systems, in which outlying corridors would be served by feeder routes with smaller buses, with mainline routes running larger buses connecting major corridors and transit hubs. Providing network connectivity would make the transit system more efficient compared to having routes radiate from a major service hub.

Several think-tanks have conducted their own research on what residents value when choosing transit over driving. For example, TransitCenter conducted a survey of 3000 people in 2016, finding riders value frequency and travel time the most when choosing how to go from point A to B. Other elements of value include reliability and real-time information, so riders would know exactly when their actual trip arrives. There is also significant diversity in transit usage demographics, in which people of all ages and economic status use public transit, depending on the city. The survey also identified that transit agencies should not take captive riders for granted, as some people would ride transit regardless if the service isn't adequate. Tyrinopoulos and Antoniou (2012) also had similar findings, where lack of frequency and lack of service reliability were big determining factors in residents not using transit. This is further analyzed by Lindstrom Olsson (2003), who highlighted a combination of strengthening the transit network and implementing car restrictions as a strategy for residents to consider transit over driving.

2.2. Transit Ridership and Travel Behaviour

There are several factors that could influence travel behaviour in riders, which in return could affect transit ridership. Factors include fares, population density, frequency, access to parking for private transport, access to freeways, or crime on transit. While the private automobile does reign supreme in most places in North America, Taylor et al (2003) discovered two markets where transit modal share has grown: travellers with limited access to vehicles and commuters to large employment centres with limited free parking.

Taylor et al (2003) also provides a framework on external and internal factors that could influence transit ridership, which is adopted for the analysis in this section. Three major external factors are identified: Socio-economic factors, spatial factors, and public finance factors. Internal factors include fare pricing, service quantity, and service quality.

A major socio-economic factor is employment and employment levels, which was greatly emphasized during the Great Depression when transit ridership dropped 25% in the United States, but private vehicle ownership increased (Taylor et al, 2003). Sanchez (2007) had a more in-depth correlation analysis between transit ridership and urban employment, stating that while improving transit access may be beneficial to improving employment, there are other decisions that come into play related to the accessibility of public transit, such as route configurations.

Other socio-economic factors include auto ownership and income levels, but their relationships are more complicated. Gomez-Ibanez (1996) compared employment growth, suburbanization, rising income, and transit usage, and found that rising income and suburbanization had a larger effect in transit ridership than employment growth. Sanchez (2007) looked at rising income levels and how it could mean people would have more money to purchase a vehicle due to employment, therefore lowering transit ridership. Furthermore, Kitamura (1989) compared car ownership, car use, and transit use in the Netherlands, and discovered that a change in car ownership affects car and transit use, but a change in transit users has minimal effect on car use and ownership, meaning despite high vehicular usage, planners should not be hesitant on improving transit in metropolitan areas.

Spatial factors include the relationship between transportation, land use, and travel behaviour. Politicians tend to have more control of spatial factors, however the best strategies to improve transit modal share tend to be politically unpopular, such as parking fees (Taylor et al, 2003). Several studies have identified parking as a major spatial factor in influencing transit ridership (Morral and Bloger, 1996; Litman, 2004), and charging a tax on parking would positively influence transit ridership. Litman (2004) suggested a 20-60% shift when implementing driving disincentives such as parking fees.

Public finance factors include transit subsidies and public/private operation of transit systems (Taylor et al, 2003). However, recent articles discovered minimal changes in ridership per capita despite increased subsidies since 1970 (Taylor et al, 2009) or the duration of the public transit tax credit in Canada (Rivers et al, 2016). Smerk (1986) highlighted potential areas of private sector opportunity in the transit industry including handi-transit, express bus services, certain regular fixed routes, support activities, transit properties, or shared facilities. Karlaftis et al (1999) looked at the privatization of Indianapolis's transit system, where the agency experienced a 2.5% decrease in operating costs, however Leland et al (2009) challenged the concept of privately owned and managed transit systems, stating it's no more efficient and effective than publicly owned transit systems due to a lack of competition and higher transaction costs. Overall, the existing literature argues both ways on public/private operation of transit systems, and further research can be conducted on recent findings in public/private transit operations.

Fare integration is also a method of improving transit ridership, and Sharaby et al (2012) found an 18.6% ridership growth after a transit system in Israel switched from a fare per boarding policy to a zone-based policy, where free transfers between bus routes was introduced.

Both service quantity and quality are important factors in determining transit ridership and travel behaviour. Taylor et al (2003) differentiated the two by saying that service quantity covers the transit network and its frequency and coverage balance, while service quality includes intrinsic aspects such as customer service and safety. While many transit agencies try to design routes that serve as many destinations as possible, recent literature has shown that it may not be the best approach in providing good service quantity. Badia et al (2017)'s analysis of the Nova Xarxa in Barcelona showed that riders are willing to transfer if the network is well-designed for transfers, which allows for higher frequency along major road corridors. However, as mentioned earlier, fare integration is important when designing a transit network based on transfers, and this was something Nova Xarxa considered when restructuring their network. Kim et al (2007) looked at service quality in St. Louis's light rail line, noting lower pick-up/drop off, walking, and transit usage for those light rail stations that are associated with higher reported crimes, and that safety was a primary concern for many female riders.

Ultimately, there are many factors that need to be considered when modelling travel behaviour. Van Wee et al (2008) lists pertinent elements including trip choice, route choice, departure time choice, and mode choice, which would all run in a model that simulates travel mode demand. Location choice, car ownership, and technology choice are other factors that should also influence the design of transport networks, including public transit. With so many factors in play, it is not surprising that implementing congestion and road pricing measures can be complicated.

2.3 Conclusions and Areas for Further Research

Transit ridership can be influenced in different ways, with different strategies that can help improve ridership and modal share in cities and regions. The literature placed a large emphasis on ensuring each transit route serves its own purpose in attracting riders, whether it's providing maximum frequency in major corridors or ensuring coverage in outlying areas. It also addresses the question on what residents value in choosing transit over driving, and factors influencing travel behaviour for residents.

There is a gap in the literature on what tools transit planners can use to balance the counteracting goals of frequency and coverage in transit networks, and to what extent would residents either be willing to walk to the nearest transit stop, or transfer from one route to another if needed. For instance, climate may be an important factor in how transit networks are designed in some regions, especially if it's a winter city. A region's road or land use design may affect the ability to design an optimal transit network. Some transit agencies may consider a piecemeal approach in restructuring their networks to minimize confusion from residents on restructured transit routes. This practicum evaluates different tools that mid-size transit agencies use to restructure their transit networks, and provides a framework on how other regions can design their transit network to improve ridership and modal share.

3. Research Methods

Research methods include questionnaires, semi-structured interviews, and an informative case study of Columbus and Kansas City. The questionnaires are used to answer the research question on factors in redesigning transit networks, while the semi-structured interviews and case study answer questions on metrics in evaluating goals for transit agencies and providing an optimal balance between ridership and coverage services.

3.1 Questionnaires to Transit Agencies in Mid-Sized Cities

To identify more information on mid-sized transit agencies in North America, I designed a questionnaire and used data from the Canadian Urban Transit Association and the American Public Transportation Association to select the transit agencies that received the questionnaire.

I conducted questionnaires to planners in transit agencies for 93 North American regions with population serving sizes between 100,000 and 1,000,000 residents. The questionnaires asked what stage of their transit network restructuring strategy each transit agency is in, such as "haven't considered", "under consideration", "in the planning process", "recently completed", or "completed several years ago". A copy of the questionnaire is attached in Appendix A. The questionnaires were designed to be completed online and sent to senior transit planners via email. I identified the transit planners by searching the city, region, or transit agency's online documents, and introduced myself as a graduate student at the University of Manitoba doing practicum research on transit network analysis. I expected a response rate of 60% and to be completed in two weeks. Fincham (2008) agrees that a 60% response rate is achievable using a multimode approach such as mailing and e-mailing surveys. Given sufficient responses, it was expected that the analysis of the responses would provide data to answer Q1: *What are factors considered when redesigning transit networks?*

In the end, there were 21 responses to the questionnaires after giving each transit agency 10 business days to respond to the questionnaire. The biggest obstacle in acquiring more questionnaire responses was a lack of replies despite sending an initial and follow-up email. However, each response I received was informative in explaining their transit agency's planning process and if they have a network restructuring plan in place. Despite the lower than expected response rate, I believe this was the best method to gather information from a variety of transit agencies in a short time span.

3.2 Semi-Structured Interviews

Semi-structured interviews were conducted based on the findings from the questionnaire. I interviewed five planners from transit agencies in two mid-sized cities, in Columbus that has undergone a transit network restructuring strategy and in Kansas City, where the agency is in the planning stages of such strategy. I asked questions related to the reasons, factors involved, the process, expected vs actual results, and lessons learned from the transit agency's network restructuring plan. I expected the interviews to provide different perspectives on topics outlined above, and to would allow transit planners to further explain what they think residents value in public transit and, assuming they were successful, what mid-sized cities can do to restructure their network in attracting more riders. The semi-structured interview questions (included in Appendix B) were intended to provide context to the last two research questions:

Q2: *What metrics were used for transit agencies redesigning their networks to evaluate their goals?*

Q3: *How do transit agencies determine the optimal balance between providing high frequency on core routes and equitable coverage for other routes?*

I analyzed interview data using content analysis and separated the transcript data into research themes and subthemes by coding. After, I tallied via a separate table, how often the themes came up, and those receiving the highest frequency would likely be areas deemed to be most important when considering a transit network restructuring plan.

3.3 Case Study Research

An in-depth case study of a mid-size city having undergone a transit network restructuring strategy and implementation is provided in this practicum. The case study aligned with the semi-structured interviews and questionnaires above, and I included case data from interviews with planners and secondary sources.

Yin (1989) defined a case study as an empirical inquiry on a contemporary issue, which is normally complex and where the context is not evident. The case study usually helps answer "how" and "why" research questions of a topic, is used when the researcher cannot control the

events of their research field. Case studies can be used to confirm a theory or consider alternative approaches to such theory.

There are two types of case study designs: Single case design and multiple-case designs. Yin (1989) identifies advantages and disadvantages of a multiple-case design, such as having a more compelling evidence in supporting a claim, yet requiring extensive resources and time beyond the means of a single student. Case studies can be quantitative or qualitative. A quantitative case study relies on statistical approaches in studying the issue, while a qualitative case study looks at approaches that do not involve numerical data (Yin, 1981). They can both be useful in case study research, and the contrast between qualitative and quantitative research does not distinguish the various research strategies (Yin, 1989).

This practicum presented an appropriate opportunity to conduct case study research, as the topic is complex and many factors may be in play. There are many ways a city or region can conduct a transit network restructuring plan, and different cities and regions may have different reasons to conduct such approach. The results of the case study could incorporate elements from all three research questions.

For this practicum, I used the multiple-case design approach. While multiple-case designs would require more resources compared to a single case design, this is a topic where different cases may have different causes and results, such as reasons behind restructuring the transit network, objectives of the network restructuring process, and the eventual results. While I acknowledge that resources may be limited to conduct multiple cases, I tried to keep the cases very brief and selective in description and focus, as that would allow a direct comparison in reasons, strategies, and outcomes to each transit agency's network restructuring plan.

4. Findings

Chapter 4 expands on transit network planning theory and the essentials of designing an effective transit network for its riders. Throughout the questionnaires and interviews, I uncovered many findings beyond those addressed in current literature.

4.1 Questionnaires to Transit Agencies in Mid-Sized Cities

In total, there were 21 responses to the questionnaires from eleven states and one province (see Figure 4.1). Respondents were given two weeks to respond and were asked if they consent to an interview if they were selected. The smallest transit agency that responded had a service area population of under 190,000, while the largest transit agency that responded had a service area population of just over 1,080,000.

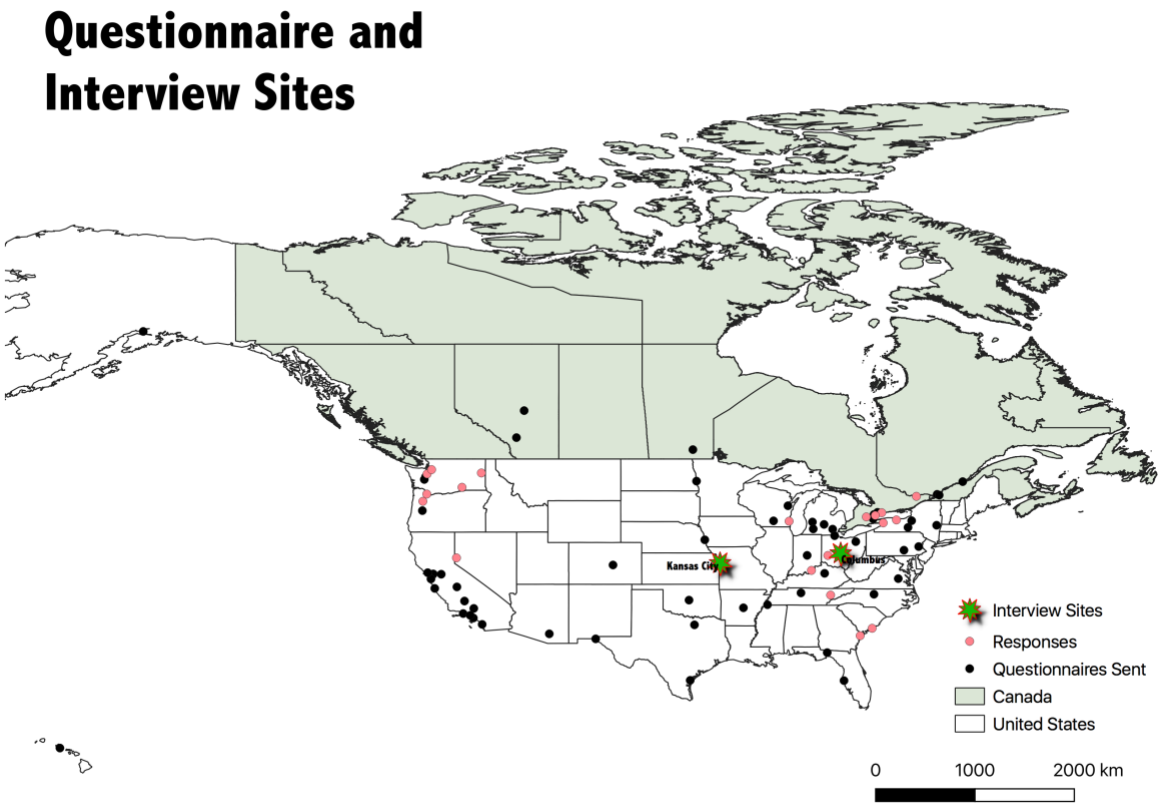

Figure 4.1: Map showing location of each transit agency where questionnaires were sent, those that responded, and where interviews were conducted for this research.

4.1.1 Transit Ridership Trends

There were noticeable differences in the responses between Canadian and US transit agencies. The Canadian transit agencies that responded, Waterloo Region, Durham Region, Mississauga, and Ottawa, all reported stable or increasing transit ridership in the past five years, while most American transit agencies reported decreasing ridership, despite stable or increasing service area population. Common cited reasons for ridership trends included employment trends, gas price fluctuations, and the economic downturn.

The findings were consistent with 2018 ridership data from the American Public Transportation Association, which reported a 2% overall ridership decrease in American transit agencies and a 6% ridership increase in reported Canadian transit agencies (American Public Transportation Association, 2018). Data from the Canadian Urban Transit Association reported similar findings for Canadian transit agencies, with most transit agencies reporting between 0 and 15% ridership growth.

4.1.2 Reasons for Network Restructuring

From the 21 responses to the questionnaires, 20 mentioned their transit agency has either completed or are in progress of a network restructuring plan. However, the reasons for restructuring differed between Canadian and American transit agencies.

Canadian transit agencies focused more on improving frequencies, providing an alternative mode of transportation to driving, and service integration with rapid transit corridors or neighbouring transit agencies. American transit agencies are using network restructuring to curb decreasing ridership trends, reduce costs, fix outdated routings, and adapt to the decentralization of regions across the United States. However, some American transit agencies also cited the introduction of rapid transit as a factor in network restructuring.

Given the findings reported in Section 4.1.1, it seems American transit agencies are using network restructuring plans to cater to current residential and employment patterns, while Canadian transit agencies are using it to strengthen key corridors and improve ridership where it already exists.

4.1.3 Other Initiatives

The questionnaire included a question on what other initiatives aside from network restructuring transit agencies are embracing to attract more transit riders. While responses varied, they can generally be classified in select themes.

4.1.3.1 Pass Programs

Many transit agencies have some form of pass program that targets specific groups. One of the most common programs is the Universal Transit Pass, known as "U-Pass". The U-Pass usually allows postsecondary students unlimited access to transit services for a fee that's included in students' tuition statements.

The U-Pass provides benefits such as increased demand for transit services, which in return would generate transit service improvements for surrounding areas (City of Edmonton, 2019). It would also reduce parking demand, traffic congestion, and greenhouse gas emissions for areas around campuses (City of Edmonton, 2019; UMSU, 2019; LUSU, 2014). Many Canadian transit agencies already have a U-Pass program for students, and from the questionnaire responses, some American agencies are considering a U-Pass program as another initiative to improve ridership.

Another pass program some transit agencies are pursuing is an employee pass program through partnerships with third party organizations. The features vary between different agencies, but the core feature of the program is to offer transit passes at discount prices. It is hoped that employee pass programs would entice more workers to ride transit to work instead of driving, especially in downtown cores.

A third pass program that a few transit agencies have implemented or are considering is a low-income bus pass program. In Mississauga, residents who fall under the Low-Income Measure bracket (shown in Figure 4.2) are eligible for a 50% discount in their monthly pass (City of Mississauga, 2019).

Household size	After-tax income
1 person	$22,133
2 persons	$31,301
3 persons	$38,335
4 persons	$44,266
5 persons	$49,491
6 persons	$54,215
7 persons	$58,558

Figure 4.2: Mississauga's Affordable Transit Pass program and thresholds that households must meet to qualify for the discount.

4.1.3.2 Service Hour Improvements

Many transit agencies have sighted the need to improve service hours, especially on weekends. While some regions may have decent service on weekdays, they may not have the same level of service on weekends or outside peak periods.

However, transit ridership has shown the most growth outside peak periods. Jaffe (2014) examined the New York City subway, which has shown greater ridership growth on weekends compared to weekdays (10% vs 7%) between 2007 and 2012. Similar trends occurred in Minneapolis-St. Paul and Los Angeles, where improvements to off-peak transit service helped increase ridership for those two regions (Jaffe, 2014; Walker, 2014).

Some questionnaire respondents highlighted the need for consistent service throughout the week and focusing more on evening and weekend service. Other transit agencies emphasized extending service hours, improving frequencies, and providing a transit network that can be used outside peak periods.

4.1.3.3 Wayfinding and Amenities

Another initiative for transit agencies is to improve wayfinding and amenities, whether it's online or along transit facilities. Some initiatives from respondents include improving signage, mobile fare payment system, improving bus shelters, real-time bus information, e-ticketing, and on board wi-fi.

4.1.3.4 Microtransit

Microtransit can come in the form of providing on-demand service or dial-a-ride service, especially in areas with lower transit demand. In some cases, this service can be provided via smaller transit vehicles or contracted out to vans, taxis, or ride sharing services. Cities such as Los Angeles and Austin are two large areas that are considering this approach in serving lower transit demand neighbourhoods (Tchir, 2019).

Some respondents are considering or piloting some variation of microtransit as an alternative way to provide service to areas where a fixed bus route would be difficult to serve. One transit agency is providing microtransit via a mix of smaller buses, subsidized taxis, and ridesharing in areas with demand for transit service, but a lack of arterial or grid network in neighbourhoods to financially support it. Another agency uses vanpooling to serve similar neighbourhoods, while some others partner up with Lyft or Uber to provide on-demand service.

By providing microtransit service in areas where fixed route service is costly, it allows lower density neighbourhoods to have equal access to the transit network (Greater Dayton RTA, 2019). It also enables residents to travel without the need to consult a timetable, since they can call for service once they are ready.

4.1.4 Summary

Chapter 4 presents findings from the questionnaires sent to all North American transit agencies having a service area population between approximately 100,000 and 1,000,000 residents. Questions were asked on population and ridership trends, whether the transit agency has considered or completed a network restructuring plan, and other initiatives the transit agency is considering in improving transit ridership.

While there were some key differences among Canadian and American transit agencies in recent trends and future initiatives, they were aligned in acknowledging that transit networks should evolve to adapt to population, land use, and employment trends. Transit planners also agree on considering a toolbox of other initiatives for attracting more riders, such as offering pass programs, increasing service hours especially in off-peak periods, improving wayfinding and amenities, and providing microtransit service in areas where a fixed route service would not be feasible.

4.2 Semi-structured Interviews

I conducted semi-structured interviews with five transit planners, three in Columbus and two in Kansas City. I chose these two regions as they are both mid-sized regions that have either underwent or are in the process of network restructuring. These two transit agencies had provided in-depth responses to the questionnaire and are two regions not heavily researched by transit experts. Planners from both regions also expressed strong interest in being interview subjects, and were willing to schedule an hour to be interviewed on their role in their agency's transit network restructuring process.

Columbus completed their network redesign on May 1, 2017, named the "Transit System Redesign", with the objective of simplifying routes, creating a frequent transit network, connecting to more places, and reducing bus congestion downtown (COTA, 2017). Kansas City is in the progress of conducting a system redesign with a similar focus on simplifying routes and improving service on key corridors. The transit agency had their kickoff meeting in early 2019, and are considering data that would be useful in developing an existing conditions report.

Central Ohio Transit Authority – Columbus, Ohio

The Central Ohio Transit Authority (COTA) is the transit agency serving the Columbus metropolitan area. It has a service area population of just over 1.06 million residents, and had a total ridership of over 18.9 million in 2017 (APTA, 2016; COTA, 2018). With a ridership growth of 3% from 2017, it was one of the few American transit agencies that improved their ridership amid a declining trend in transit riders in the US (Schmitt, 2018).

Columbus is one of the largest American metropolitan regions without any intercity or intracity rail service (Reeves, 2013). However, the region makes it up with a wealth of bus options available, with local bus service (see Figure 4.3), a free downtown circulator bus called CBUS that serves the city's core neighbourhoods (see Figure 4.4), and a bus rapid transit service named CMAX (see Figure 4.5). COTA is funded by a 0.25% local sales tax and a 0.25% renewable local sales tax through 2026 (COTA, 2018). The agency also offers the C-pass, funded by public-private partnerships, which allows free transit passes for downtown employees (COTA, 2018).

COTA overhauled the entire bus network on May 1, 2017, through a four-year process of evaluating the network, public input, and targeted marketing campaigns. The Transit System

Redesign focused on frequent service, connecting people to jobs, and daily consistent service throughout the metropolitan region (COTA, 2017). Figures 4.6 and 4.7 show the comparison between the old and new bus network for Columbus, with the second figure clearly showing its frequent transit network.

With the implementation of the Transit System Redesign, launch of the CMAX bus rapid transit service in 2018, and the C-pass program, COTA has seen significant investments that resulted in a ridership increase (see Figure 4.8).

Figure 4.3: A local COTA bus at Easton Transit Center, one of COTA's new mobility hubs after the Transit System Redesign went into effect (So, 2019).

Figure 4.4: A downtown circulator CBus on High Street in Downtown Columbus (So, 2019).

Figure 4.5: A CMAX rapid transit bus on High Street in Downtown Columbus (So, 2019).

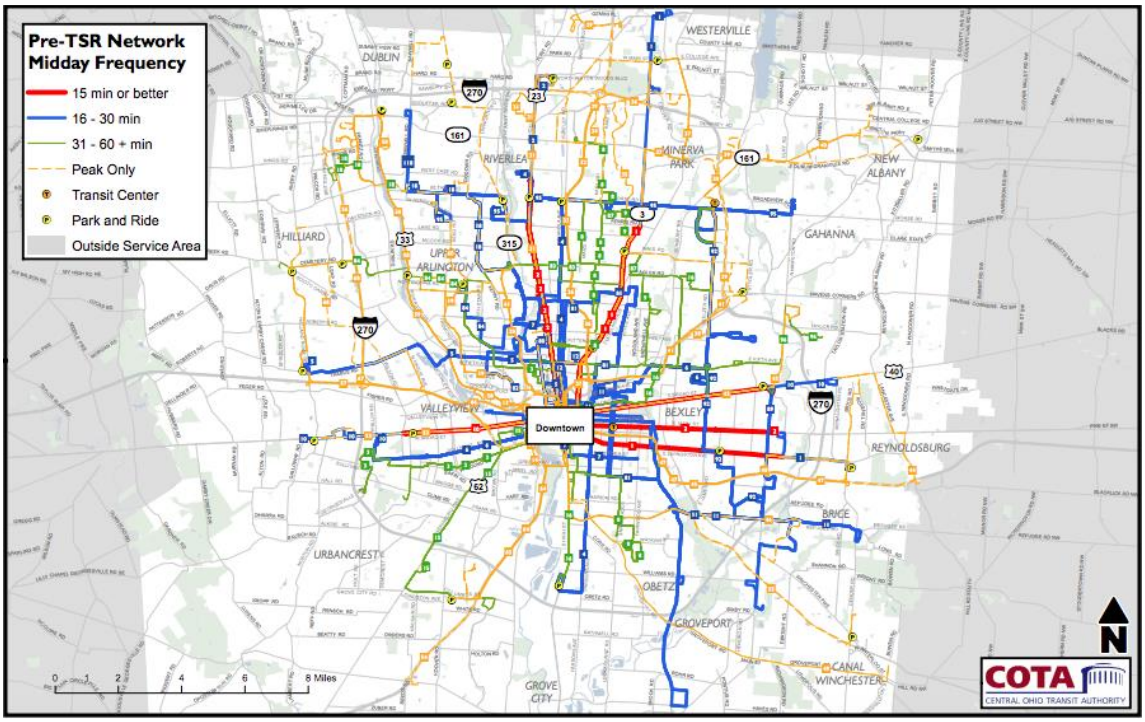

Figure 4.6: COTA's bus network before the 2017 Transit System Redesign, showing the extend of frequent transit service during off-peak periods in red (Source: Central Ohio Transit Authority, 2017, received thru e-mail and published with permission).

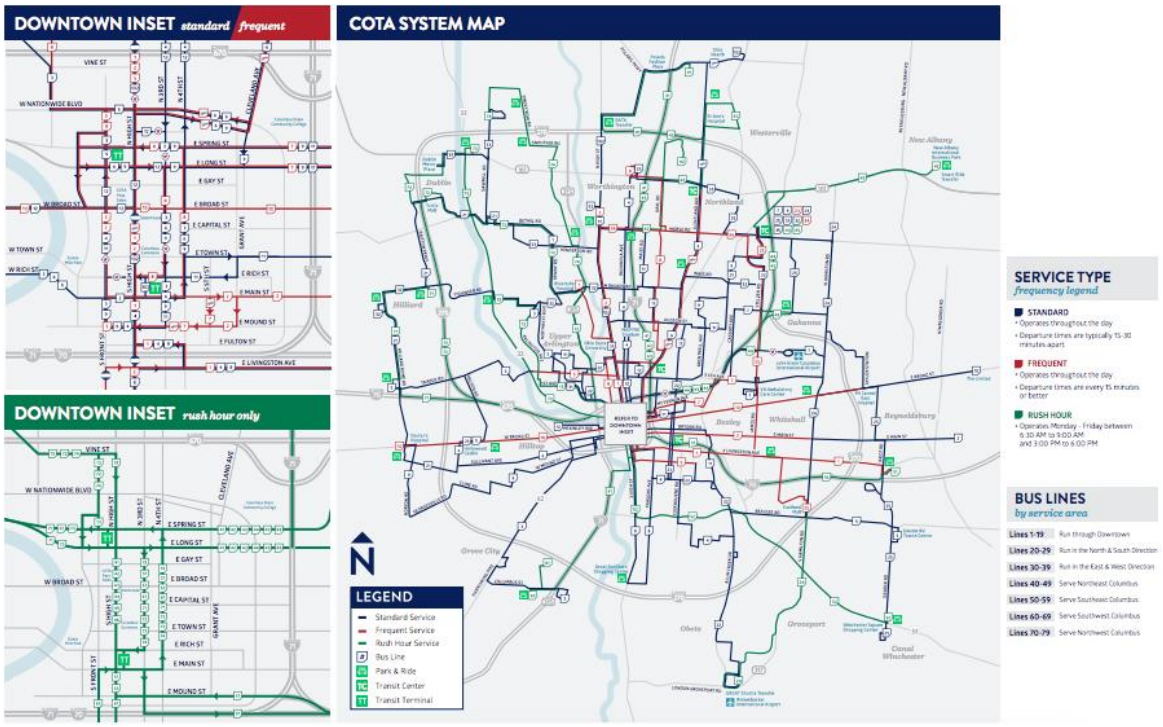

Figure 4.7: COTA's bus network after the Transit System Redesign. Note the different line colours now representing standard, frequent, and rush hour routes (Central Ohio Transit Authority, 2019).

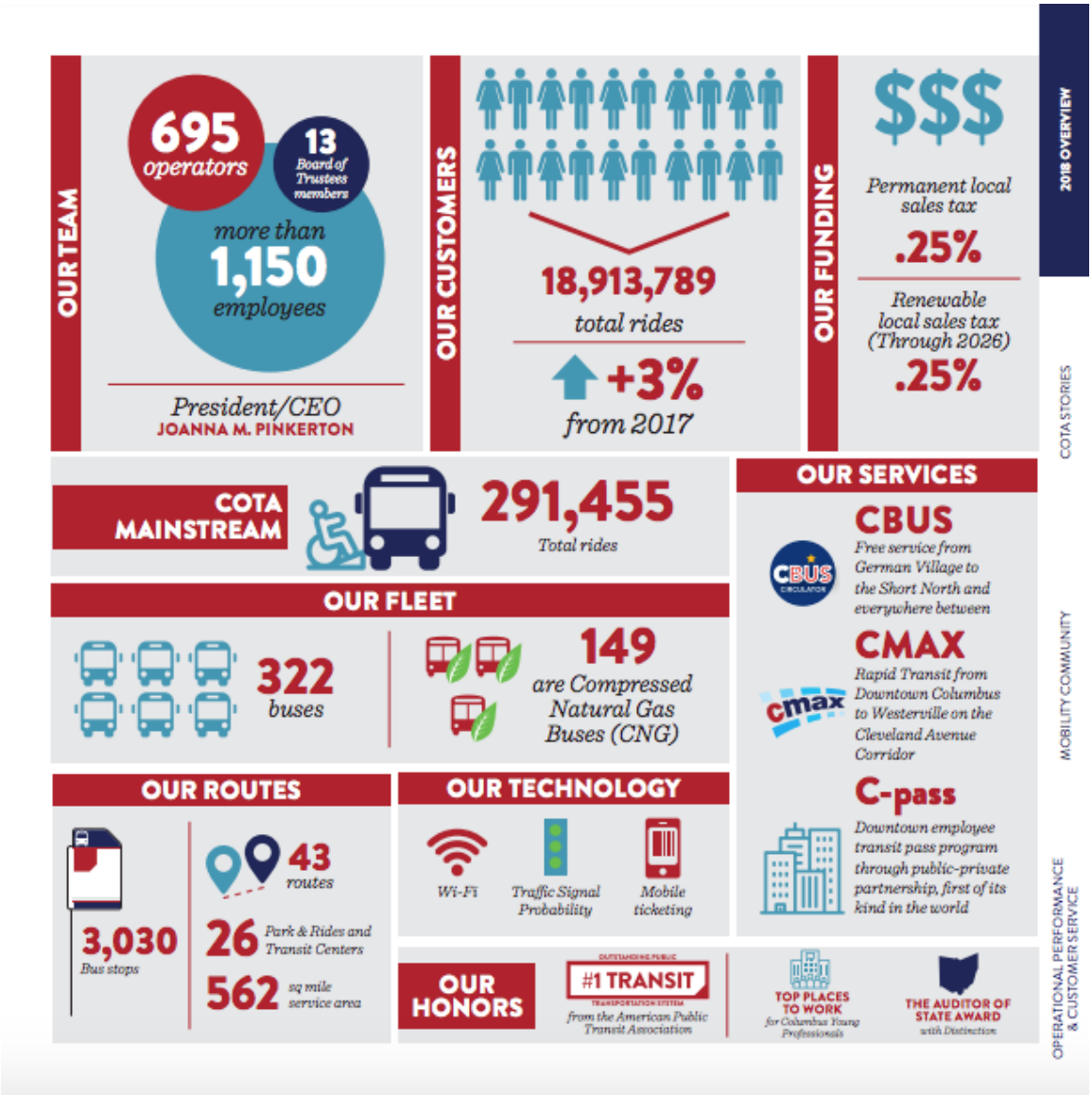

Figure 4.8: COTA's 2018 annual report in infographic form (Central Ohio Transit Authority, 2018).

Kansas City Area Transportation Authority – Kansas City, Missouri

The Kansas City Area Transportation Authority (KCATA) is the transit agency that serves the Kansas City metropolitan area, which covers parts of Missouri and Kansas. It has a service area population of about 800,000 residents, and had a total ridership of over 13.7 million in 2016, a 9.46% decrease from 2015 (APTA, 2016).

The transportation authority also covers the Kansas City Streetcar, a streetcar line that connects Union Station with Kansas City's downtown core. The streetcar has seen a steady ridership increase since its introduction in May 2016, carrying over 2.1 million riders in 2018 (KC Streetcar, 2019; see Figure 4.9). KCATA also operates two bus rapid transit lines called the

MAX, and is planning to open a third MAX line in late 2019. Figure 4.10 shows the current KCATA network in Kansas City, Missouri. Figures 4.11, 4.12, and 4.13 show the different transit equipment that operates in Kansas City, including a MAX bus, a regular bus, and the streetcar.

KCATA is in the planning stages of redesigning the bus network to focus on frequent service, connectivity to key corridors, and considering microtransit service in less dense neighbourhoods.

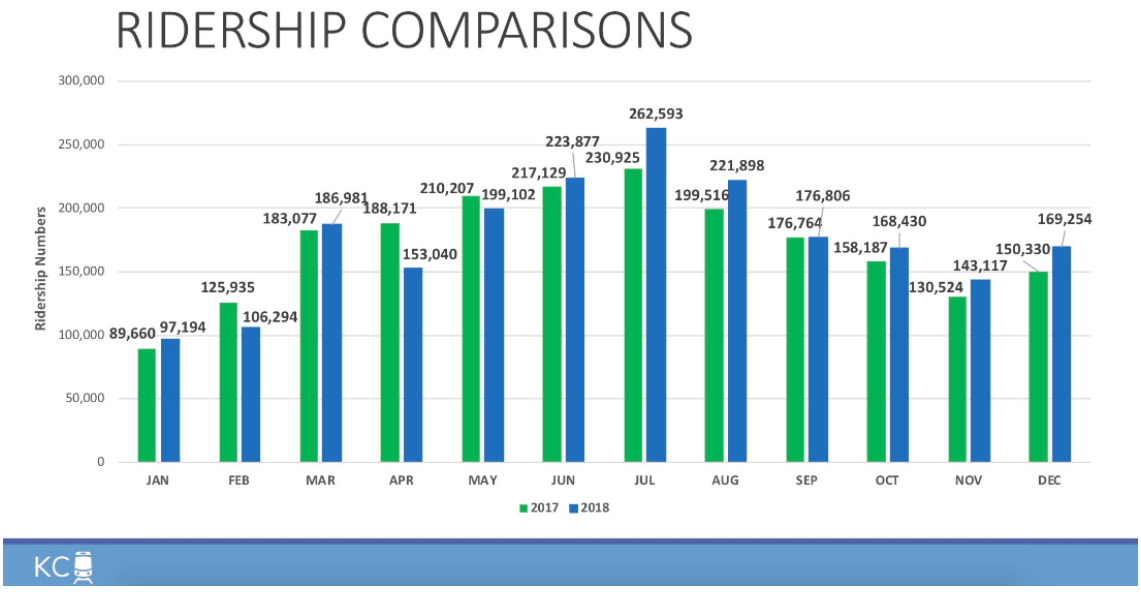

Figure 4.9: Ridership numbers on the Kansas City streetcar between 2017 and 2018. (KC Streetcar, 2019)

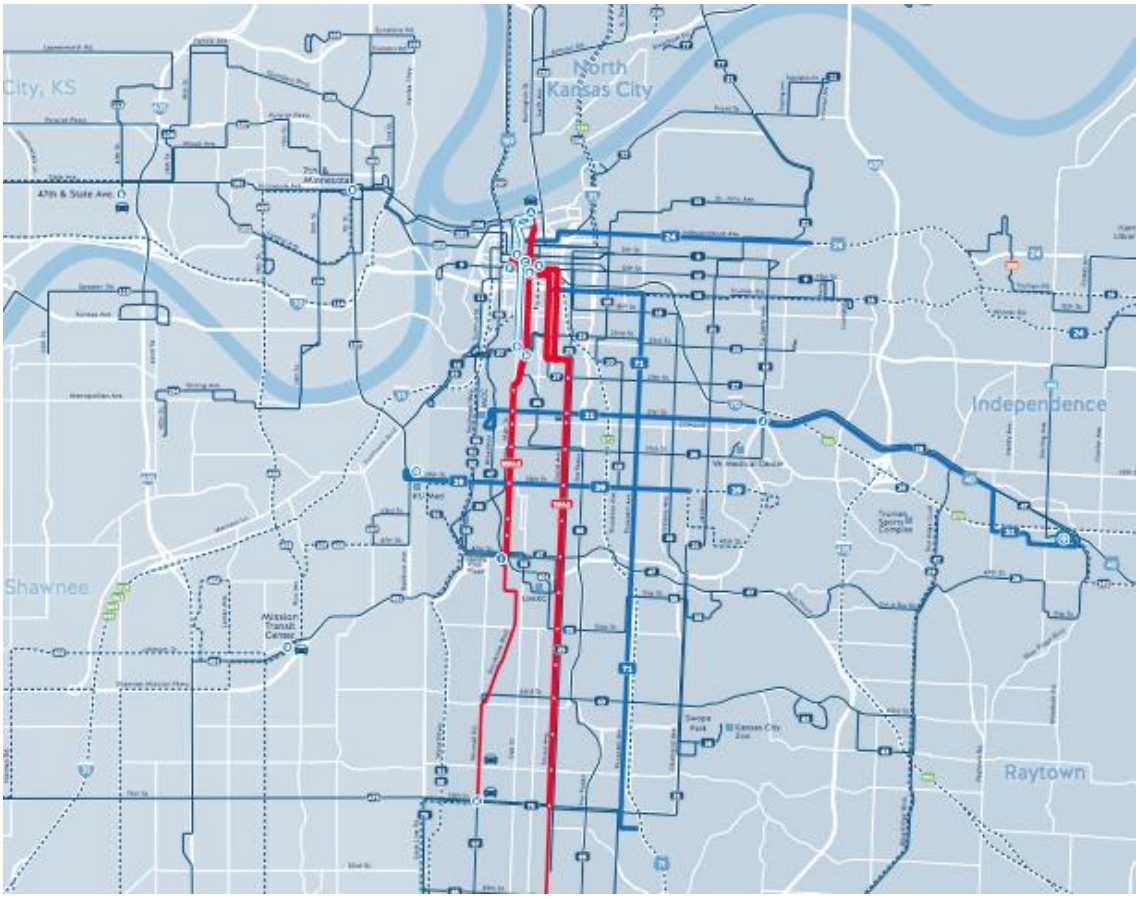

Figure 4.10: The current KCATA transit network in Kansas City, Missouri. Red lines include the MAX bus rapid transit lines, the thicker blue lines represent frequent service up to every 15 minutes during weekdays, and the thinner blue lines represent daily service of every 30-60 minutes. Dashed lines represent weekday service only. (RideKC, 2018)

Figure 4.11: A MAX bus rapid transit vehicle in Downtown Kansas City (So, 2019).

Figure 4.12: A regular RideKC transit bus in Downtown Kansas City (So, 2019).

Figure 4.13: A Kansas City Streetcar vehicle in Downtown Kansas City (So, 2019).

Given the different stages of transit network restructuring for Columbus and Kansas City, I had two sets of interview questions for the two regions (see Appendix B). While the first half of the questions were the same for both agencies, one set focused on the progress, performance metrics, and if the new transit network was deemed a success, while the other set asked about current challenges, engagement strategies, and expecting opening date for the new transit network.

Planners from both transit agencies covered many similar key themes that are important to consider when creating a transit network redesign strategy. These key themes are summarized in the sections below.

4.2.1 Title VI

Title VI is an act unique to the United States, as part of the Civil Rights Act of 1964. The core fundamental of Title VI is “no person in the United States shall, on the ground of race, color, or national origin be excluded from participation in, be denied the benefits of, or be

subjected to discrimination under any program or activity receiving Federal financial assistance" (COTA, 2017).

COTA has a planner dedicated to Title VI analysis, and to ensuring that the transit network is in compliance with the Act. Any changes to the network must guarantee that service to low income or minority areas are kept. When COTA planners were planning the Transit Service Redesign, they had to balance between building the frequent service network and ensuring service is kept in low income neighbourhoods. A question the planners asked themselves was whether it is more cost effective to divert a route to serve the low income neighbourhood, or create a new route that serves that neighbourhood.

Per KCATA planners, the burden of Title VI is shared amongst every employee in the agency. 34 of the agency's 61 bus routes are classified as "minority routes", where the route serves a higher than the region's minority population share (KCATA, 2016). All vehicles and transit facilities have a Title VI notice and how customers can file complaints if they feel Title VI is being violated. Moreover, KCATA planners are looking at more microtransit service to serve neighbourhoods that could not sustain a fixed route service, but are in areas of low income, elderly, or consist of many households with no access to vehicles.

4.2.2 Relation to the Transportation Master Plan

In Columbus, the Transportation Master Plan is initiated by the Mid-Ohio Regional Planning Commission (MORPC), which oversees planning in the Columbus metropolitan area. Called the Metropolitan Transportation Plan, the latest released 25-year plan was in 2016 (see Figure 4.14), and the commission is currently doing a 2020 update of the plan, which would extend to 2050.

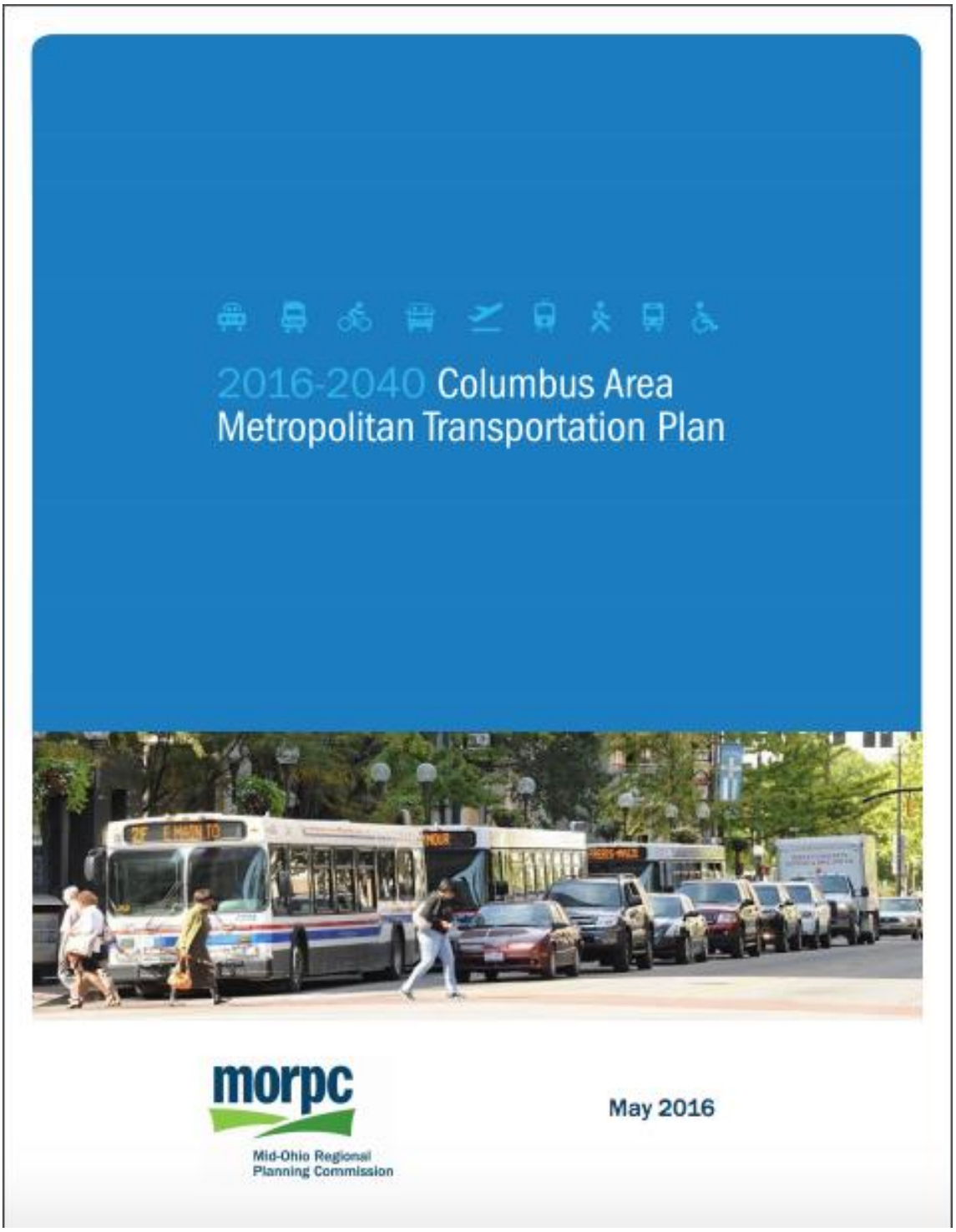

Figure 4.14: The cover of the 2016 Columbus Area Metropolitan Transportation Plan (Mid-Ohio Regional Planning Commission, 2016)

As part of the 2020 update, COTA planners mentioned that the MORPC is conducting a study on high capacity transit in Columbus and identifying corridors that can support rapid transit, including bus rapid and light rail transit.

COTA's Transit System Redesign is included as part of a Regional Plan that supports the Metropolitan Transportation Plan. The master plan highlights four key transit strategies that COTA planners are engaged in:

- Improve fixed route and demand response transit service
- Improve connections and coordination with other transit operators and modes of transport
- Improve human services transportation and coordination with transit
- Support efforts to introduce fixed guideway service
  (Mid-Ohio Regional Planning Commission, 2016)

COTA's Transit System Redesign supports the first strategy of improving fixed route and demand response service. By designing a frequent service network and simplifying routes, passengers can get from one place to another more efficiently. COTA planners highlighted Easton as an example of MORPC and the Transit System Redesign working together, as the suburban mobility hub is close to a shopping mall and major employment centres. The hub is now served by many local routes, two frequent crosstown routes, and a couple of hub and spoke routes connecting downtown.

Figure 4.15: A COTA bus at Easton Transit Center, a suburban mobility hub formed from the Transit System Redesign (So, 2019).

One COTA planner emphasized that there can be improvements in coordination between COTA and MORPC, especially in rapid transit implementation and the dispersal of employment in the region. With the second strategy of "improving connections and coordination with other transit operators and modes of transport", MORPC hosts monthly meetings with COTA and other regional transit agencies to identify and tackle common issues in transit mobility (Mid-Ohio Regional Planning Commission, 2016).

Human service transportation includes a broad range of transportation service options for elderly, disabled, or lower income populations (Federal Transit Administration, 2019). Fixed guideway service includes rapid transit of all kinds, which COTA currently runs the CMAX bus rapid transit service. Both initiatives are important for planners as they tackle two different segments of transit riders: Those that are elderly, disabled, or lower income, and those looking for an efficient way to travel along a major corridor.

Kansas City's long-term transportation plan is called Smart Moves 3.0, a 20-year transportation plan for the Kansas City region. The plan outlines a vision of "viable mobility solutions for empowered residents, successful residents and vibrant communities" (Mid-America Regional Council, 2017). Updated in 2017, the long-term plan would shape transit and mobility in the Kansas City Region until 2040.

Figure 4.16: The cover of SmartMoves 3.0, Kansas City's transit and mobility plan (Mid-America Regional Council, 2017).

There were some similarities in Smart Moves 3.0 and Columbus's Metropolitan Transportation Plan, such as focusing on high-demand corridors (see Figure 4.17 for Kansas City's future fast and frequent network) and creating mobility hubs. KCATA planners admitted that the plan does not lay out a lot of details, but it does define what and where the most important corridors in the region are. Currently the planners say none of the projects are funded and the budget does not allow for increased service, therefore it would have to take the existing system and restructure it in a way that can be expanded over time.

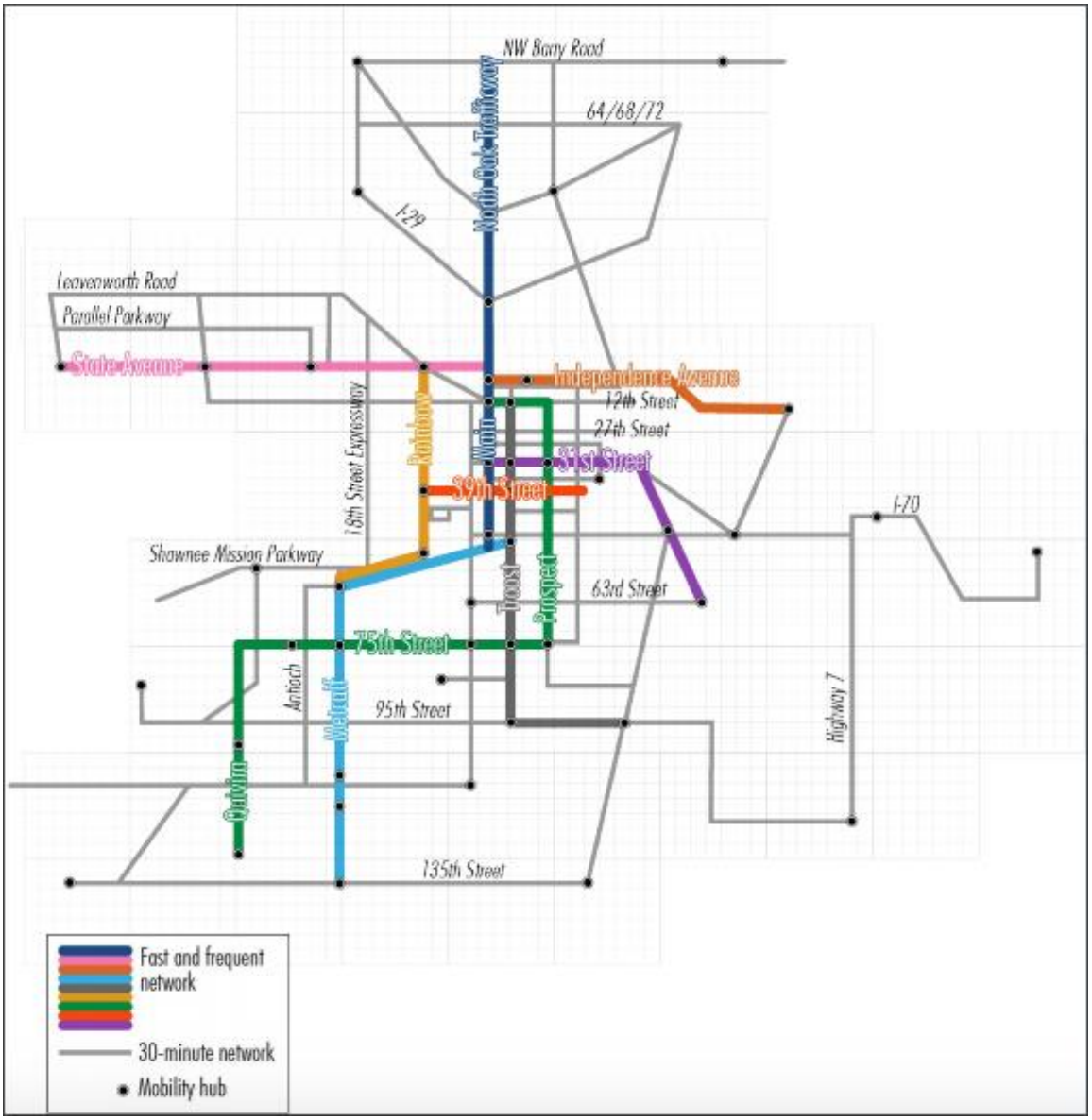

Figure 4.17: Future fast and frequent network as shown in Smart Moves 3.0 (Mid-America Regional Council, 2017)

Smart Moves 3.0 also highlights current challenges and gaps, which was similarly reflected in the interviews. Currently, only 5% of jobs are accessible via transit in the morning and 3% in the evening for an average worker with a 60-minute commute (Mid-America Regional Council, 2017). KCATA planners believe that the proposed fast and frequent network would better connect residents to employment hubs, in addition to other initiatives such as microtransit for lower density neighbourhoods.

In addition to a frequent network and creating more mobility hubs, Smart Moves 3.0 recommends better zoning to create vibrant neighbourhoods that support transit and building partnerships with third-party agencies that support improving transit for its users. KCATA highlighted in the questionnaire that they are looking at a U-Pass program with universities in the region, which would see benefits highlighted in Section 4.1.3.1.

4.2.3 Outreach and Engagement

A project as ambitious as a transit network redesign plan needs an effective outreach and engagement strategy to maximize support and minimize confusion from residents. When COTA planners undertook the planning stages of the Transit System Redesign, they listed key goals such as looking at current resources and finding better usage for them given the limited budget, improving service overall, and improving transit ridership. There were also several metrics planners mentioned they looked at, such as ridership, jobs, and population within a ¼ mile in planning the new routes.

COTA's outreach and engagement strategy was very thorough. One planner explained that they improved on the Houston model of engaging residents by having several public meetings beyond downtown, focus groups early in the process, materials that show neighbourhood specific changes and systemwide changes, and an engaged street team. COTA also launched a website specific to the service changes, which included a trip planner to show the before and after of their commuting route.

> *"We had several public meetings beyond downtown, materials catered to specific communities and macro level, focus groups early in the process. All staff went out in the first couple of days of the TSR in the downtown area, talked to passengers leading to it and several days after to figure out where their transfers will be." – COTA Planner 1*

COTA planners are very supportive of their street team, who were important in the outreach aspect of informing residents about the changes. There was a street team hired specifically for the Transit System Redesign, and they were riding routes and visited major mobility hubs to inform residents where they need to go. The planners were impressed with how the street team turned out that they started an ambassador program led by administrative staff focusing on outreach and engagement. The ambassador team can be seen wearing red jackets, and can be seen in different mobility hubs guiding passengers on where to go.

Other strategies COTA planners undertook included flyers in mailboxes of neighbourhoods that would be ¼ mile from a frequent service route, adding messages in every bus stop on how to reach their destination after redesign implementation, and audio announcements reminding passengers about upcoming changes. Despite the extensive outreach and engagement strategy by COTA planners, there were still confused passengers on the first day of the new transit network, however all COTA planners agreed that there will always be people not happy, and the general population overall positively rated the new transit network. Figure 4.18 shows the first day of the Transit System Redesign, with two employees taking down the old bus stop sign and replacing it with the sign for new routes.

Figure 4.18: The first day of COTA's Transit System Redesign, with two COTA employees taking down the old route sign and replacing it with a new one (Central Ohio Transit Authority, 2017, received from email and published with permission).

KCATA is planning to conduct their outreach strategy for their redesign plan in mid-2019. However, the planners mentioned that a consultant team will lead most of the engagement plan, while KCATA staff will be kept in the background. The planners were concerned that Kansas City residents might not receive the changes positively compared to other successful regions due to its political stance, and one planner reflected on past campaigns that there was little success in their ability to speak to the public. One major concern from planners is that there would be no net new service added with the redesign, which means there will be neighbourhoods with dramatic reductions in service and changes to coverage. The consulting team must communicate why these changes are being made, which may be a hard sell to residents if they are transit passengers.

4.2.4 Politics

With every transit strategy comes the political barriers that transit agencies must overcome for it to become reality, and my interviews showed that Columbus and Kansas City are no different. Columbus had multiple political obstacles they had to work around, while Kansas City is in progress of tackling some other barriers as well.

All three COTA planners agreed that no matter what transit agencies do to change the network, there will always be people who are not happy. For example, there was a bus route that had historical significance which would have been cut since it's sandwiched between two nearby frequent routes, but the community successfully protested to keep the route, in which the resources could have been used to improve service in another major corridor or neighbourhood (see Figure 4.19).

Figure 4.19: Bryden Road is sandwiched between two frequent service routes (shown in red), but residents protested to keep the route due to its historical significance (Central Ohio Transit Authority, 2018).

Transportation and land use are intertwined, especially in transit network planning. A major challenge that all five planners interviewed agreed on is the lack of accessibility in suburban neighbourhoods. As both a COTA and KCATA planner mentioned, running a fixed bus route in a neighbourhood filled with cul de sacs can be costly, and given the low population density of suburban developments it ends up not being cost effective. In fact, that planner mentioned that, when the Transit System Redesign rolled in, COTA had to cut service to some areas with decent ridership as it was against the principle of providing service on the main routes. Despite the Columbus region having a complete streets policy, it is not always followed, and all COTA planners interviewed have expressed concerns about lack of sidewalks and amenities that are necessary to provide transit service in those neighbourhoods.

With transit planning, there may be different parties at stake when planning transit routes. This was prevalent in Kansas City, as KCATA is one of the few transit agencies that crosses a state line. In fact, KCATA is even more unique that the state line is a street instead of a river, and a KCATA planner highlighted that as a concern for operation, since transit is not as free flowing as people who drive across state boundaries. With the transit agency crossing two states, it must compete with two pots of state money and have contracts to serve both states, each city, and each county.

Kansas City is unusual in how the transit agency is funded, which may also pose challenges in future transit expansion (see Figure 4.20). One KCATA planner broke down how the transit agency is funded, in which they do not have their own regional tax base. Kansas City, Missouri does have a sales tax that funds transit in that city, but the surrounding counties are funded by general funds, which generate less money for the transit agency. The planner also highlighted a study done by the Mid-America Regional Council comparing Kansas City to other mid-size regions, and KCATA is one of the smallest transit agencies and has one of the lowest riderships due to a lack of regional tax base.

> *"We're unique in that we don't have our own tax base. Most other agencies have their own tax base (sales tax, property tax, etc). We rely on contracts from various cities. Kansas City Missouri does have a sales tax that funds us, but that's only in KCMO. Therefore, we must have individual contracts with each city, and it's usually out of the general funds, with no tax base. That's one of the reasons our transit system is so small compared to most other regions of our size. The Mid-America Regional Council has done a study comparing Kansas City to other mid-size cities, and our system is smaller and lower ridership due to a lack of regional tax base. We also have a state line in the middle of the region that complicates*

things further. It makes it difficult to do true regional planning and service operations when as soon as the bus reaches the city boundary, you need a contract with the next city to fund it going further. If you cross a state line, then you're dealing with a different pot of state money and processes with federal money. We're a bit unique in that department, along with St. Louis, Cincinnati, etc. but in those cases, you have a river separating while we only have a street. People travel without regard of the state boundary, but it affects operations here." – KCATA Planner 2

KCATA
SUMMARY BUDGET
REVENUES

Account Name	2019 Budget	2018 Projected	2018 Budget
Passenger Revenues	$ 9,165,350	$ 8,983,169	$ 9,535,501
Kansas City, Mo - 3/8 cent tax	36,308,746	32,394,678	29,562,165
Kansas City, Mo - 1/2 cent tax	28,935,823	27,412,537	29,448,861
Kansas City, Mo - Capital Charges	3,250,317	3,202,283	3,163,621
Community Partners	6,571,270	5,718,291	5,872,850
Other Local Funding	562,512	212,636	599,521
Federal Transit Administration	23,649,148	26,248,833	21,984,779
State of Missouri	430,579	463,592	438,445
Advertising	400,000	365,000	450,000
Other Operating	738,719	693,246	799,201
Non-Operating	1,086,991	1,151,115	1,138,041
	$ 111,099,455	$ 106,845,380	$ 102,992,985
NET INCOME (LOSS)	$ (6,291,704)	$ (2,432,376)	$ (5,363,553)

Figure 4.20: KCATA Summary Budget Revenues. Note that only Kansas City, Missouri is funded by a tax base. Other areas are funded by community partners and local funding. (Kansas City Area Transportation Authority, 2019)

KCATA also has had problems retaining service in the past 4 years, as one KCATA planner said there has not been any new service in the core, and they cut 17% of service in Fall 2017 due to declining ridership, stagnant tax base, and rising costs. Both planners are hopeful that the service redesign strategy would be a plan that can be presented as logical and thoughtful to the public, especially since there have been several defeated proposals and referendums for higher capacity transit such as light rail. With the redesign strategy, the planners are also looking at microtransit, which could help in serving low density neighbourhoods and reallocating buses to areas of higher demand.

A political hurdle not often talked about, but is important in Kansas City's context, is the union structure and driver retention. A KCATA planner outlined the current contract with drivers, and the contract creates new challenges such as a different rate of pay per vehicle size (smaller buses = lower pay, see Figure 4.21), which limits how schedulers can schedule vehicles since it minimizes cost saving measures such as interlining. There is also the inability to retain and hire new drivers, and both planners admitted that there are days where full service could not be provided due to a lack of drivers.

Figure 4.21: An example of a smaller bus operated by RideKC. Because of KCATA's union structure, drivers who drive these buses get paid lower compared to those driving regular-sized buses (So, 2019).

4.2.5 Summary

Both the questionnaires and interviews uncovered issues with transit planning and how redesigning a transit network is something that does not happen overnight. With a declining trend in ridership in many mid-size transit agencies, many transit agencies are either in progress

or have completed some form of transit network restructuring, and those who have completed one have been positive results in ridership growth.

Some reasons why transit agencies are considering a network restructuring project were fixing outdated routings, improving frequency in key corridors, integration with any rapid transit service or surrounding transit agencies, and designing a transit network that reflects current land use and employment patterns. Canadian transit agencies focused more on frequency and service integration, while American transit agencies focused more on restructuring routes and creating new mobility hubs.

Interviews in Columbus and Kansas City uncovered obstacles transit agencies need to overcome for a successful network restructuring strategy, such as integration with the transportation master plan, coordination with other parties and influencers, an effective engagement and outreach strategy, and being able to persuade users about the ambitious plan. All planners interviewed agreed that politics will be the biggest obstacle for transit agencies that are considering a rethink of their transit network, and potential transit planners working on such project must accept that no plan will satisfy the entire passenger base.

5. Analysis

This chapter relates the interview findings in Chapter 4 to the Literature Review in Chapter 2. The chapter highlights the obstacles and innovative strategies transit planners should consider to build a culture that supports improving transit service and improving ridership in regions.

5.1 Planning and the Political Environment

Transit planning is a contentious political issue for many regions, with different stakeholders involved and having priorities that may conflict with one another. For major service planning initiatives, such as redesigning a transit network, the issue becomes magnified as almost all areas of a metropolitan region would potentially be affected.

A point highlighted in the literature review is transit riders value frequency the most when deciding how to get from point A to point B, which is the reason why a frequent service network is the focal point of any transit network restructuring strategy. By consolidating one's limited resources to enhancing service in key corridors where many residents live or work, more people would be attracted to considering transit over driving.

While providing frequent service in major corridors seems simple in theory, there are many political obstacles involved. If a transit agency uses all its resources on creating frequent service corridors, there would be minimal service outside major corridors and in lower density neighbourhoods. As the interviews with Columbus highlighted, there will be pushback from residents who may complain about their potential loss of service, and political bodies will likely influence how the final product will be shaped. A COTA planner suggested that a 70-30 split would best balance the interests of residents in outlying neighbourhoods and the need to provide frequent service along major corridors.

The political environment gets more difficult if multiple parties are involved, which was the case in Kansas City. In a region that has seen consistent service cuts and ridership decreases, it can be difficult to gain the public's trust that the transit agency would be developing a strategy that could make transit more convenient to its residents. Moreover, having the transit agency cross into different counties and states in an area that lacks regional governance further complicates how funding is given. Unfortunately, while many transit agencies without regional governance must consider these political boundaries, most car drivers can across county and state

boundaries without difficulties. The political complications combined are one of many reasons why KCATA planners said Kansas City's transit network restructuring plan will mainly focus on the core city of Kansas City, Missouri, since it is the only area where KCATA is funded by the tax base and not general revenue.

Another political hurdle is that some politicians may want to see immediate results from any transit related changes. However, as COTA planners experienced, riders will be slow to adapt to the changes and ridership growth will be steady, especially if no additional funding is provided for a network restructuring plan and adding more vehicles to the transit network. Trying to convince politicians that a transit restructuring process will be a long-term plan to increase ridership, may not go well in the political climate. A progressive political environment would consider funding transit agencies that are undergoing a network restructuring plan or other operational improvements as a complement to capital improvements like light rail or bus rapid transit (Lewis, 2015).

> *"Try to accept the fact you're not going to get exactly the way you want it. We made some sacrifices to the system to fit what residents wanted. It's not going to be overnight; it will take time. Ridership will be slow to grow and react to the changes. I would encourage this type of thinking to make systems more useful, so if you have an opportunity to make your system more useful for customers, you should be given a chance." – COTA Planner 2*

5.2 Transportation, Land Use, and Innovation

A continuing major barrier in providing fixed route transit to lower density neighbourhoods, is the cost-benefit ratio of providing such service. In many regions, it is costly to provide service to low density areas since they are neighbourhoods that are large but lack a grid or connective network to focus transit routes on, and the ridership in lower density neighbourhoods tends to not support such investment. However, there are transit agencies who are experimenting with innovative strategies to provide service to these neighbourhoods while minimizing costs.

The most common form of innovative transit is in the form of "flexible" or microtransit, which may include dial-a-ride service, subsidized carpooling, ridesharing, or any other form that does not require a regular bus driving on a fixed route. For example, Waterloo Region introduced three flexible routes as part of a pilot project, and highlighted the following reasons for selecting these routes:

- Lack of a grid of arterial and connector roads
- Neighbourhoods with winding streets, cul-de-sacs and limited connections to major roads
- Lack of sidewalks, and buildings set far back from the street
- Physical barriers such as rivers, highways and steep grades
- Lower-density and new growth areas
- Transit-dependent facilities (apartments, medical buildings, large employers, seniors' complexes) located far from transit.

(Grand River Transit, 2017)

An example of microtransit can be seen in Figures 5.1, 5.2, and 5.3.

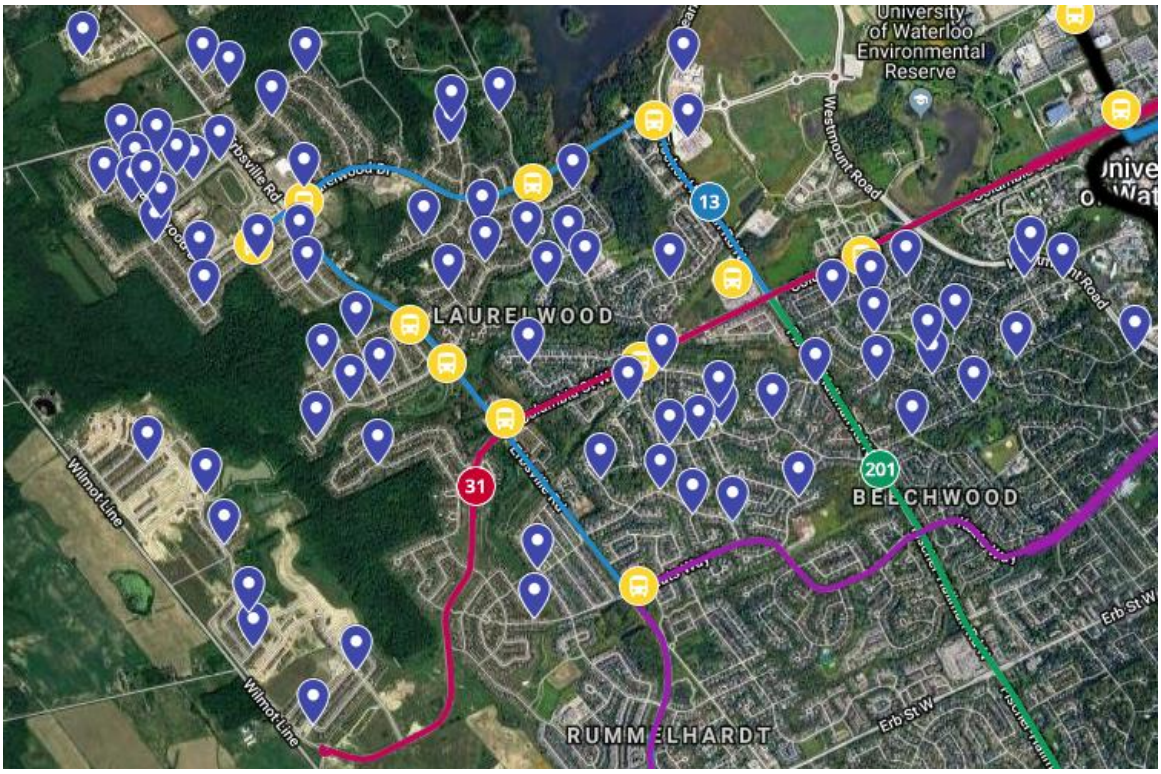

Figure 5.1: An example of a microtransit route in Waterloo, with blue markers indicating all stops where riders can request service (Grand River Transit, 2017).

Figure 5.2: A dial-a-ride van in York Region (So, 2015).

Figure 5.3: A bus on a dial-a-ride route in Winnipeg (So, 2018).

In the interview with Kansas City planners, they explained that KCATA is currently testing out microtransit service in Johnson County, one of Kansas City's suburban regions, because current demand and land use patterns make it unfeasible to operate a fixed bus route. There is a zone that is marked for on-demand service (see Figure 5.4), where users can call a number or use an online computer application to request service in that neighbourhood. The planners have overall been satisfied with the project, but acknowledged that they do not have the riders per hour to accommodate a fixed bus route. Expanding microtransit in Kansas City is also part of Smart Moves 3.0, as one of their recommendations is to explore ridehailing or ridesharing, using it as a last mile connectivity solution from fixed routes to areas away from major corridors.

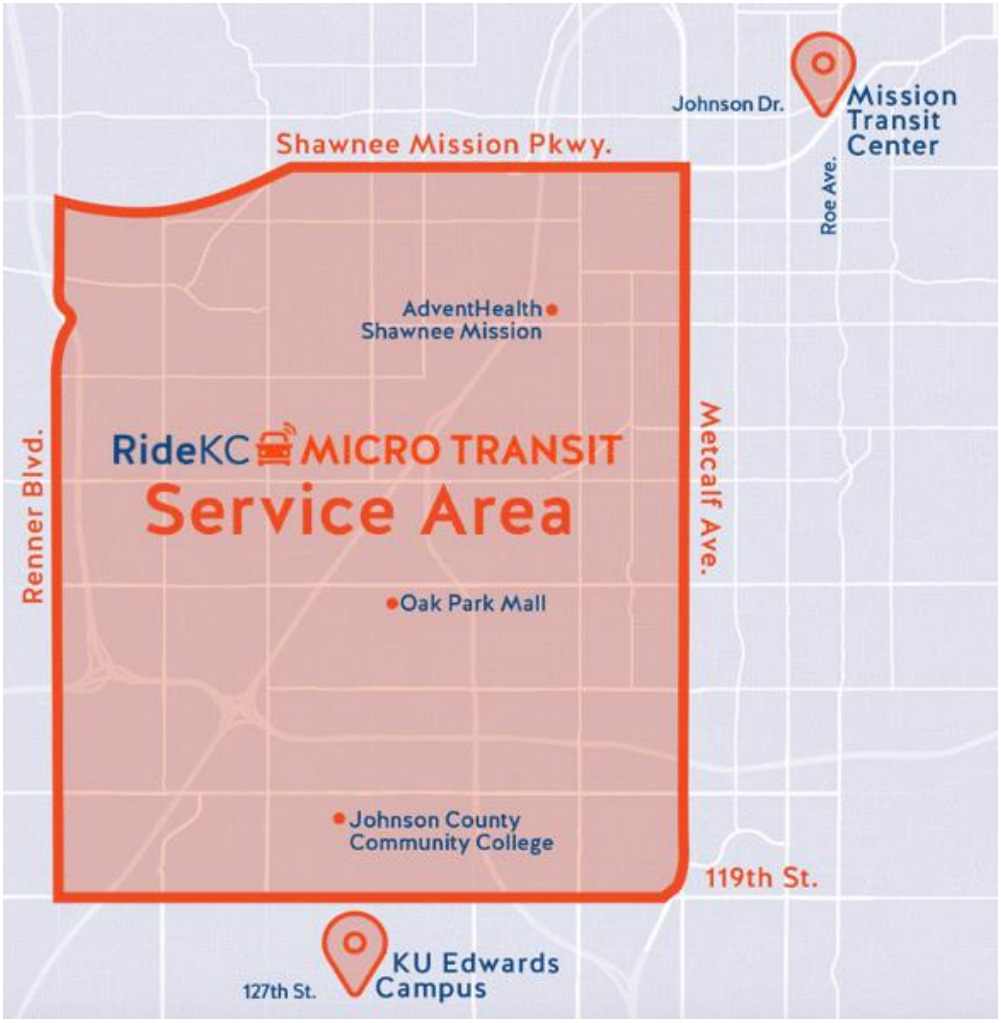

Figure 5.4: RideKC's microtransit service area in Johnson County (RideKC, 2019).

"One of the ideas is that there's certain parts of the region where it makes no sense to send out a fixed route with a bus that picks up no passengers. To figure a way to better serve that area would be a zone-based service with a smaller vehicle that can be on-demand, such as calling a number or use an app. We have a pilot project in Johnson County, and it's done fairly well but not enough riders per hour to replace a poor fixed route. We're trying to get a handle on how that looks like and what parts of the city would benefit from that service." – KCATA Planner 1

There has been research arguing both ways on whether microtransit would benefit transit agencies in the long run. Walker (2018) designed a flow chart that explains the general logic behind transit agencies considering microtransit, which can be seen in Figure 5.5. Unfortunately, he argues regardless of reasons to provide microtransit, it does not work in neighbourhoods due to lower efficiency, compared to a fixed bus route, and any efforts to subsidize the lower efficiency would increase either vehicle miles travelled or economic inequity. Hernandez (2018) and Jin et al (2018) further argue that since many microtransit systems use online computer applications to request service, this may exclude lower income populations who may not own a smartphone.

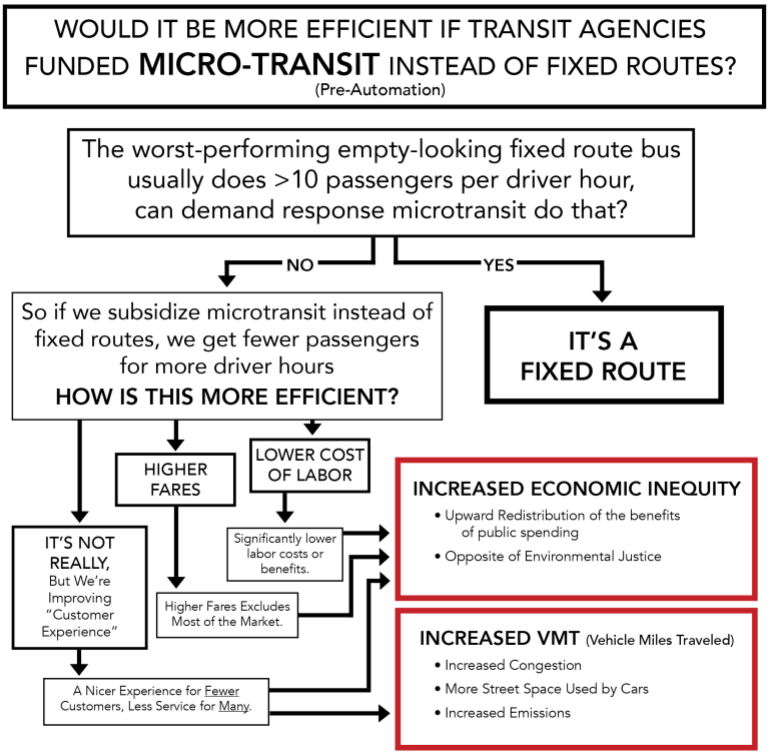

Figure 5.5: A flow chart on the potential drawbacks of microtransit (Walker, 2018).

In a contrary position, Werckmeister (2018) sees potential in microtransit in areas of low population density and scattered demand. However, the transit agency should be clear in defining the goals of microtransit. Is it to improve coverage and accessibility? Save on environmental or financial costs? Microtransit should also be implemented carefully, as implementing it in neighbourhoods that may compete with public transit might shift riders to microtransit, which may reduce the efficiency of public transit and make transit less environmentally sustainable. If a transit agency is to partner up with a third-party agency to subsidize a form of microtransit in neighbourhoods, they should be used to complement fixed route transit, not compete with it. Jin et al (2018) summarized the different impacts microtransit can have in both a taxi and public transit environment, shown in Figure 5.6.

	Transportation efficiency			**Economic efficiency**
	Congestion	Accessibility	Safety	
Ridesourcing vs. taxi	• Reduces or increases congestion in the city center?	• Reaches poor neighbourhoods with insufficient taxi services	• Drivers and passengers feel safer than when in taxis • Insufficient driver training and insurance gap	• Better matching demand and supply • Reduces transaction cost
Ridesourcing vs. public transit	• High-density area: Competes with public transit	• Temporal: Complements public transit at night and weekends • Spatial: Serves as feeders for public transit		• Low-density area: Cost efficient to substitute certain transit routes with ridesourcing

Figure 5.6: The potential impacts of microtransit in taxi services vs. public transit. (Jin et al, 2018)

Microtransit and other innovative modes of ridesharing continues to be a growing trend in public transportation, with more transit agencies trying it out as pilot projects in lower density neighbourhoods. There are arguments for and against subsidized microtransit, but more research would need to be done in this topic to see whether microtransit has had a positive impact in growing transit ridership and fixing the Network Design Problem in regions.

5.3 Rider Incentives

More transit agencies are implementing rider incentives to attract more transit users that are beyond traditional incentives such as discounts for buying fares in bulk or monthly passes. The most popular rider incentive cited was the Universal Transit Pass, and many Canadian transit agencies stated in the questionnaires that they already have a Universal Transit Pass (U-Pass) implemented for postsecondary students, while some American counterparts are considering a U-Pass program as a future initiative. Some questionnaire respondents also indicated a low-income transit pass pilot program as a rider incentive.

The discounts that postsecondary students receive from a U-Pass program can vary. For example, students from the University of Waterloo paid $281.73 in their tuition fees for a 12-month U-Pass, compared to $1,032 if students had to purchase a 12-month adult monthly pass (Graduate Student Association, 2018; Grand River Transit, 2017). U-Passes are beneficial for students, as they need not worry about paying fares each time or needing to purchase passes every month. Students, who already need to pay tuition, benefit from spending less for travel, parking, and not needing to purchase a vehicle, which may improve transit ridership and encourage more trips to be done by transit.

A U-Pass program also benefits transit agencies in trying to attract more riders. Han et al (2019) researched the process of implementing a U-Pass program, and discovered key findings such as improved off-peak ridership, increased service hours, new routes centered around campuses, and increased frequencies for transit agencies that implemented a U-Pass program. By encouraging a transit-driven behaviour for students, they may be more inclined to continue using public transit after graduation. Given in the literature review that riders value frequency and reliability the most in using transit, investing in a U-Pass program would also have a net benefit beyond students, as other riders can take advantage of improved frequencies and service hours for various routes.

Low-income transit programs are more complicated to start, as the definition of "low income" may be subjective. Generally, there are two accepted definitions of low income: households that fall below the Low-Income Cut-Off point, and those who fall below the Low-Income Measure point. The Low-Income Cut-Off is set at where a household would spend over 20% more of its income on necessities than the average household, while the Low-Income

Measure Point fixes it at where the average household spends at least 50% of its income on necessities (Statistics Canada, 2015).

From the questionnaire responses, Mississauga is the only North American city that has a low-income bus pass program. Further research indicated that nineteen transit agencies in Canada have a similar program (Beveridge, 2016) and transit agencies in the United States including Seattle have also adopted this idea (Bliss, 2018). Mississauga uses the Low-Income Measure point as their qualification for the low-income transit pass, as shown earlier in Figure 4.2 (Beveridge, 2016).

By lowering the price of a monthly pass for low income residents, they would have more money to spend for other necessities such as food or rent. It also brings the idea that mobility should be a right, not a commodity to be purchased (Bliss, 2018). The increased incentive to ride transit would also mean improved ridership and potentially more transit investment for other riders. Since many of these programs are at its infancy, further research would be required on whether a low income monthly pass has had a net positive impact on overall transit ridership and employment participation rate for low income residents.

5.4 Summary

Transit network analysis and the restructuring of transit networks involves a lot of parties, stakeholders, and various interest groups. While the goal of a transit network should be serving the most riders possible given its resources, there will always be political influences that may require other areas to be served that may not be the most efficient use of resources. An efficient transit network should have approximately 70% of its resources dedicated to ridership routes and 30% dedicated to coverage routes.

There are also neighbourhoods where it may be too costly to operate a fixed bus route, such as those that lack a grid network or direct connectivity to major arterial roads. In some transit agencies that are in progress of network restructuring, planners are looking at subsidizing microtransit service, such as ridesharing, dial-a-ride service, vanpooling, automated driverless shuttles, or any other service that does not involve a fixed bus route. However, microtransit has its benefits and drawbacks. While microtransit can complement with public transit by allowing planners to reallocate fixed bus resources to higher demand routes, questions arise on whether if it would truly reduce costs for the transit agency or increase overall economic equity.

Furthermore, many microtransit platforms use online computer application technology to request service, which may be a detriment to low income riders who may not be able to afford a smartphone to access the service. Overall, microtransit is a developing trend in transit network planning and has potential to evolve into something that can complement a public transit system, but careful implementation is needed to ensure microtransit does not end up competing with public transit for riders.

Transit agencies are increasingly looking at rider incentives to encourage more transit usage. For instance, in Columbus the C-pass program has encouraged more employers and employees working downtown to use transit at no cost. The most common non-traditional rider incentive is the Universal Transit Pass, or U-Pass program, targeted towards postsecondary students. Many Canadian and American transit agencies have or are considering a U-Pass program, in which students pay through their tuition fee to allow unlimited access to transit, usually at a discount. U-Pass programs have benefitted in increasing off-peak transit ridership and investment, especially for routes that serve postsecondary campuses. By offering unlimited access to transit for postsecondary students, they may be more inclined to continue using transit after they graduate, especially if the experience was positive for them.

Low income transit passes are also an emerging trend in many transit agencies, targeting those who could not afford a regular monthly pass. There are two accepted measures of a low-income household: Those under the low-income cut-off point or those under the low-income measure point, and different transit agencies use either measure to determine who qualifies for these passes. By reducing the cost of passes for these users, they would be more able to use transit for work and leisure, which would increase ridership and new service opportunities.

Transit network planning is about being able to optimize one's resources given a fixed budget. By allocating its majority of resources to where the highest density of riders is, a transit agency would have the greatest potential for ridership growth. Today, many planners have other toolkits that can encourage more riders, such as microtransit and various pass programs. By designing a transit network that can balance different people's needs, a transit agency can achieve its highest potential for ridership growth and encouraging more potential residents to use transit.

6. Conclusion

6.1 Significance of Project

Transit network analysis is an emerging research field in transportation planning, given Houston's radical approach in restructuring its entire transit network overnight. This research is significant, as it addresses how mid-size regions can improve ridership by designing an efficient transit network that focuses on frequency and ridership growth, why investing in public transit is important for cities and regions in reducing demand for single vehicular travel, and uncovers reasons to the decline in transit ridership across North America in recent years.

6.1.1 Research Gap: Reasons for Declining Transit Ridership

The recent trend of transit systems in North America rethinking their networks to combat declining ridership, has opened questions on whether there is a theoretical framework to balance ridership and coverage goals for each transit system. While there has been documentation on Houston's network restructuring strategy, there is a research gap in how transit networks can evolve with ongoing employment and commuting trends in mid-sized regions of under 1 million. It is hoped that the questionnaires, semi-structured interviews, and further research of transit systems in mid-sized cities would contribute in bridging that gap and support future research in how mid-sized regions can improve transit modal share.

6.1.2 Personal Interest + Advocacy for Increased Transit Investment

I am a regular transit rider and an advocate of increased investment in transit agencies, both for capital projects and good maintenance (operations). However, governments in both countries are reporting they face challenges in sustaining their funding for transportation projects. In the U.S., the Fiscal Federalism Initiative (2015) highlighted increasing shortfalls in the Highway Trust Fund, being the main source of transit funding, largely due to decreased gas tax revenue from improved fuel efficiency and change in driving habits, such as making fewer car trips. State funding for roads and transit decreased by 15% between 2002 and 2012, during a time where funding for transportation infrastructure should be increasing.

Transit investment is equally as dire in Canada. Canada is the only G8 country that still does not have a National Transit Strategy (Canadian Urban Transit Association, 2007), and

recent investment in transit infrastructure does not satisfy today's needs for capital and operations. If higher level authorities are unable to fund transit infrastructure, it is up to transit agencies to find ways to maximize benefits to transit riders for the limited funding they receive.

6.1.3 Guideline on Designing Transit Systems for Mid-Sized Cities

The practicum provides a guideline on how mid-sized regions of under 1 million can develop a transit network that balances ridership and coverage needs. The decrease in transit funding has caused financial challenges for transit agencies and its riders, and transit ridership has decreased or stagnated in several cities in the past couple of years.

Mid-sized cities contain a large percentage of the populations in many states and provinces. Sotomayor and Flatt (2017) found that mid-sized cities represent nearly 45% of Ontario's urban population, however there are a lack of planning models that suit their needs. While mid-sized cities may be limited in terms of economies of scale and employment opportunities, Sotomayor and Flatt (2017) highlighted mid-sized cities being better suited for emerging economic trends without severely affecting the quality of life or affordability. The emerging trend of rethinking the transit network to support employment and commuting changes has huge potential to succeed in mid-sized cities, given renewed political leadership and higher civic engagement (Sotomayor and Flatt, 2017).

6.1.4 Transit Operations Planning in Improving Bus Ridership

There are many factors transit planners consider in everyday operations planning in improving bus ridership, such as headway, frequency, stop spacing length, access, and travel time, and how they interact with one another. Planners must balance whether to have shorter stop spacing for better rider access at the expense of increased travel time and operating costs, or longer stop spacing for reduced travel time and operating costs at the expense of reduced rider access. (Stewart and El-Geneidy, 2015).

By enacting policies such as a walking threshold of 800 metres, transit planners can evaluate whether there are redundant bus stops that can be eliminated without reducing rider access while reducing travel time for riders along that route. However, Jaffe (2014) emphasizes transit agencies needing the clear goal of improving ridership or coverage along that route, since

ridership routes would require minimal overlap of what transit planners determine the walking threshold to be, while coverage routes would benefit more from closer spaced stops.

6.2 Review of Research Questions

This practicum focused on transit network analysis in mid-sized agencies and different factors transit planners consider when redesigning a transit network. A mid-sized transit agency was defined as a service area population between approximately 100,000 and 1,000,000 residents. It also focused on other initiatives transit agencies are considering to attract more riders, such as microtransit and transit pass programs targeting different audiences.

This section revisits the research questions and answers them given the research completed in this practicum.

Question 1: What factors are considered when redesigning transit networks?

The question was asked to determine a starting point in what transit planners should consider or encounter if planning a network redesign strategy. It was answered through semi-structured interviews conducted in Columbus, where COTA successfully redesigned their transit network in 2017, with some further insight by Kansas City planners who are in the early stages of this project.

Redesigning a transit network is something that does not happen overnight, and ridership after a redesign project will be slow to grow. COTA's transit system redesign took approximately 3 years from initial planning to completion, while KCATA planners said they had their launch meeting in early 2019 and do not expect to have a final product until mid-2020. There are many parties involved and factors to consider to successfully orchestrate a transit network redesign project. The biggest factor the planners highlighted is politics, since transit planning is something that could directly impact residents' lives. Regardless of how planners may want to get everything perfect in a network redesign, sacrifices may have to be made to fit what residents want. Politicians may also want to influence a network redesign by campaigning to keep service in an area that was planned to be removed in favour of increased core service.

Outside politics, another factor in redesigning a transit network is to find a way to operate more efficiently given available resources, increase ridership, and provide better service for riders. COTA planners looked at route directness, major destinations for riders, and where the

largest employment lands are. With the network redesign, COTA now serves places where they didn't serve before, and it was made possible due to a reallocation of resources.

Planners also should consider how to reallocate resources to ridership routes and coverage routes. COTA planners went for a 70-30 split, meaning 70% of its resources went to routes designed for high ridership, mainly along major corridors, while 30% went to ensuring there is decent coverage service for neighbourhoods away from major corridors. Transit planners may opt for other splits such as 75-25 or 80-20, but it is a factor that would be different for each transit agency depending on the road network and how transit planners want to focus on its core routes.

In American transit agencies, a unique factor transit planners must consider is Title VI, which is a civil rights act that ensures non-discriminatory access to transportation regardless of race and income. COTA planners had to redirect service to low income neighbourhoods despite not being near major corridors, and KCATA planners are also taking Title VI into consideration in their redesign progress.

Question 2: What metrics were used for transit agencies redesigning their networks to evaluate their goals?

The question was asked for transit planners to evaluate their network redesign using metrics that quantify whether the new transit network is meeting the goals. It was answered through semi-structured interview questions on what their goals and performance metrics are with the redesign strategy.

COTA and KCATA planners evaluated their goals using different metrics. COTA planners looked at ridership, jobs, and population within ¼ mile of transit. With the new transit network, 100,000 more Columbus residents and 110,000 more jobs were within a 5-minute walk of a frequent bus route, and service increased by 50% on Saturday and 120% on Sunday (Miller, 2017). Per COTA planners, with the increase of access to frequent transit for Columbus residents, COTA was one of the few American transit agencies with an increasing trend in ridership. The planners admitted that some aspects are hard to quantify, such as whether trips were made shorter, however they received some successful stories from everyday riders that their trips are more convenient with the redesign, and there was positive feedback on improving access to employment centres outside downtown.

In their planning for a network redesign, KCATA planners look at detailed metrics on both an individual route and system-wide basis. The agency publishes monthly reports on route performance and ridership statistics, and keeps other detailed metrics including riders per hour, cost per rider, and direct operating costs vs. passengers per hour. The planners acknowledge that most transit agencies, including KCATA, do not make a profit, but they want to get close to breakeven as possible while being relevant. They also use stop level analysis to recommend changes or modify routes, such as which neighbourhood or section has higher transit demand. The data and analysis from the metrics is what KCATA uses to formulate a budget and expected revenue from its transit network.

From the interviews and researching different transit agencies, there are different ways to evaluate the performance of a transit network. However, a common trait is that most transit networks have some political influence to it. Planners from both transit agencies cited that despite some underperforming routes, they were forced to keep them due to complaints from residents and pressure from city councillors. KCATA also has the additional obstacle of serving two states, meaning the transit agency must deal with two different sets of policies and budgets.

Question 3: How do transit agencies determine the optimal balance between providing high frequencies on core routes and equitable coverage for other routes?

The question was asked to determine how transit agencies determine their allocation of resources for ridership routes and coverage routes. This was answered through secondary research with Houston METRO's precedent and semi-structured interviews with COTA, however there was limited research and analysis in determining how transit agencies determine these are the optimal numbers to pursue for ridership-coverage goals.

COTA planners used Houston as a model in determining what the optimal ridership-coverage ratio is for its transit network. The planners looked at ways to make the transit system more efficient, such as eliminating duplicate routes and unnecessary diversions to neighbourhoods. They also determined that if most residents are within a quarter mile of a frequent transit service, then the tradeoff of eliminating diversions of core routes to neighbourhoods makes sense. More importantly, with an increase of frequent service routes, there is a higher chance that while residents might need to walk farther to their bus stop, the bus route would be more frequent than if it stopped near their place. Ultimately COTA planners

came up with a 70-30 ridership-coverage ratio, meaning 70% of its resources are dedicated to ridership routes and 30% are dedicated to coverage routes. In comparison, Houston used an 80-20 ridership-coverage ratio in their transit system rework (Walker, 2014).

Another factor in determining the appropriate ridership-coverage ratio is looking at where key density and employment areas are. For COTA, planners admitted that their old transit network was too downtown-centric, despite new employment areas and development in the northeast sector of the region. By decentralizing the network and focusing on major corridors and other high density/employment areas beyond downtown, COTA's new network is useful for more residents who may consider transit for commuting or leisure purposes, especially if downtown is not their main destination.

6.3 Further Areas for Study

Transit network restructuring is an emerging topic with many transit agencies still testing the waters of how to effectively undertake restructuring. This practicum only examined two mid-sized transit agencies having either completed or in progress of a network restructuring process, therefore the research opens opportunities for further research as to what planners in other transit agencies consider in developing their strategy.

KCATA would be a potentially informative case to revisit once their transit agency is deeper into the planning stages for their network restructuring plan. Given their political climate and the need to communicate between different cities, counties, and states, there may be further unique obstacles that KCATA planners will encounter in selling the idea of a transit network restructuring plan to its politicians, riders, and residents.

Further research can also be done of those Canadian transit agencies having undergone a transit network restructuring plan. Given the higher share of transit riders in Canada, there may have been a more profound effect on what making an efficient transit network would do to ridership and modal share. Unfortunately, in this research, no mid-sized Canadian transit agency was available for an interview during the time I had allotted. Canadian transit agencies may also have different obstacles that planners must encounter compared to American transit agencies, and it would be interesting to do a comparative analysis on the effects of transit network restructuring in both a Canadian and American setting.

The topic of social equity can be further developed, especially with the growing trend of low income transit passes. Further research can look at whether there has been a positive effect on transit modal share or ridership, with lower income residents having improved access to the transit system.

It would also be interesting to study a transit system in a mid-size winter city, as they may have added challenges to designing an efficient transit network, such as needing to adjust metrics for how far residents should walk to a transit route. Some mid-size winter cities of interest include Saskatoon, Regina, Winnipeg, or Quebec City.

Finally, one of the research questions was not fully answered due to a lack of research and data available. Interviewees had difficulty answering how they determined the optimal balance between providing frequency and coverage in redesigning a transit network, since there were many factors involved in the planning process, and how land use patterns may affect what the final frequency-coverage ratio would be. The issues involved in the question cannot be fully addressed as part of a one-hour interview, and could potentially be explored as an individual research topic. This was also the reason why I did not include that question in the questionnaire, since it would be difficult to concisely respond in less than three lines.

Ultimately, this practicum examined important areas of what is needed to successfully execute a transit network restructuring strategy, and looked in depth at two transit agencies: one that recently completed a network restructuring plan and another that is in progress of planning one. While many challenges are common in successfully redesigning a transit network, there may also challenges that are unique to specific regions, depending on political, land use, financial, or other circumstances.

6.4 Closing

The goal of this practicum was to provide an understanding of the ingredients needed for a successful transit network restructuring strategy and how different transit agencies are tackling this emerging trend. Given already available research for large transit agencies such as Houston, this practicum looked at mid-size transit agencies with a population serving area between approximately 100,000 and 1,000,000 residents.

The focus was in two transit agencies located in Columbus and Kansas City, with Columbus completing their network restructuring plan in 2017 and Kansas City in progress of

planning a similar strategy. While there were similar challenges facing both transit agencies in developing their network restructuring plans, there were also challenges that were unique to both agencies, especially from a political standpoint.

This practicum examines major issues that transit planners may encounter in redesigning a transit network, but it is by no means exhaustive. Each transit agency is unique having its own sets of challenges that may influence how a redesigned transit network would look like, but the basic goals remain the same: Providing the optimal balance between ridership routes and coverage routes, and designing a transit network that allows for off-peak travel to multiple nodes across a region. With more transit planners rethinking of their transit network, it is important to ensure the needs of many outweigh the wants of a few, and that frequency is the main tool in encouraging more residents to consider transit.

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8. Appendices

Appendix A: Questionnaire

Transit Agency:

City/Region:

Role:

1. What is the population serving size of your transit agency?
   - Under 1 million
   - 1-2 million
   - 2-3 million
   - 3-4 million
   - 4-5 million
   - 5+ million

2. What is the current annual ridership of your transit agency?
   - Under 20 million
   - 20-40 million
   - 40-60 million
   - 60-80 million
   - 80-100 million
   - 100+ million

3. In the past five (5) years, has ridership for your transit agency increased, decreased, or remained stable (stable = less than 5% change)?
   - Increased
   - Decreased
   - Stable

4. In the past five (5) years, has population in your city or region increased, decreased, or remained stable (stable = less than 5% change)?
   - Increased
   - Decreased
   - Stable

5. Has your transit agency undergone some form of network restructuring process?
   - Yes (please answer #5a and #5b)
   - In progress (please answer #5a and #5b)
   - No (go to #6)

a) What factors triggered the need to restructure the transit network?

b) Did the transit agency restructure its entire network, or did it use a piecemeal approach (focusing on specific areas at a time)?
   Entire Network
   Piecemeal

6. What other strategies is your transit system considering in improving bus ridership?

Appendix B: Semi-Structured Interview Questions

Interview schedule for all transit agencies:

1. Describe your role and how it relates to the transit agency.
2. What is the current state of the transit system with regards to meeting ridership growth targets?
3. What percentage of commuters in the city or region use transit?
   a) Do you use transit for work?
   b) For leisurely purposes?
4. Has there been a recent survey done by your transit agency on what factors residents value in using public transit? Explain.
   a) If not, what factors do you think residents value in using transit?
   b) If yes, would I be able to obtain a copy?

Additional questions for transit agencies that underwent a network restructuring plan:

1. What were the transit agency's goals when designing the network restructuring plan?
2. What were some performance metrics that the transit agency used in evaluating the restructured system network?
3. How does the network restructuring plan complement with the city or region's transportation master plan?
4. How did the transit agency engage with riders and residents on the restructuring plan?
   a) What were some of the key feedback received on what riders and residents think is important in considering transit over driving?
5. Were there any challenges in developing the new network strategy?
   a) If so, what were some challenges?
   b) If there were not any challenges, why not?
6. How long did the restructuring process take from planning to implementation?
7. Was the restructured transit network a success?
   a) If so, why?
   b) If not, why not?

8. What do you consider are some important takeaways that other similar-sized transit systems can learn when considering a restructuring of their transit network?

Additional questions for transit agencies in the progress of a network restructuring plan:

1. What are the transit agency's goals in designing the network restructuring plan?
2. How does the agency plan to evaluate them?
3. How does the network restructuring plan complement with the city or region's transportation master plan?
4. Does the transit agency plan to restructure its entire network at once, or via a piecemeal approach, focusing on each sector for example?
5. Has there been any engagement with riders and residents yet on the restructuring plan?
    a) If so, what were their responses?
    b) If not, how does the transit agency plan to engage with them?
6. How long has the process been taking?
    a) When does the transit agency envision a full rollout of its restructured network?
7. Has there been any challenges so far in designing the network restructuring design?
    a) If so, what were some challenges?