Back to the Future: Insights into Public Transit Service through the Lens of Historical Streetcar Routes

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ABSTRACT

At its height, Milwaukee, Wisconsin's streetcars were an integral part of the transportation system. Like most American cities, the streetcar routes were dismantled and replaced with buses after WWII. This paper examines the question of what portion of the 2010 Milwaukee population would be served by the city's historical trolley system if it were not demolished. It was found that modern bus lines occupy many of the same routes as historical streetcar lines while exceeding prior service levels in terms of population served and geographic extent. Historical streetcar routes reimplmented in Milwaukee would not offer any significantly better or worse level of service than bus routes outside of mode-specific benefits. While reimplementation of the 1917 trolley network as a light rail system would potentially provide some benefits to the city of Milwaukee, these benefits would not be a result of the network. Further, the historical routes transplanted into a modern context may actually be worse than the existing bus networks due to a limited network geographic extent that excludes a large proportion of the Milwaukee MSA population.

1. INTRODUCTION

The history of Milwaukee's streetcar largely mirrors the history of other streetcar systems, but with some differences regarding its spatial structure. For reasons of concentrated population near job centers, compact city development, and the inability of lower class citizens to afford fares, Milwaukee's streetcar network focused service more on the downtown area and less on outlying areas when contrasted against comparable cities (Simon 1996 pp.).

In spite of its lower than average utilization at the turn of the century, it is important to recognize that the Milwaukee streetcar system remained an essential part of the transportation network, especially into the 20th century. According to a 1928 report, streetcars comprised 5% of vehicles entering the city but over 47% of passengers; by comparison, automobiles comprised 77% of all vehicles, but only 45% of passengers (Moore 2014).

This level of ridership would not be sustained, however. In March of 1958, the streetcar system was scrapped, finally succumbing to a combination of "(1) consumer preference, . . . ; (2) the capitalistic ambitions of pro-roads industrialists; (3) federal economic incentives, . . . ; and (4) simple (myopic) planning preference[,]" in addition to legal issues and constraints specific to Milwaukee (Moore 2014).

The national dismantling of streetcar systems is associated with the emergence of the private automobile as the principle form of transit, among other factors. But have the streetcar routes that once served so many people remained important into the future? Is it the case that all public transit was dismantled, or rather, that old trolley lines were replaced with buses, retaining the previous level of service? To answer these questions, we will overlay the historical trolley routes of Milwaukee over census blocks from the 2010 census to estimate the total population served by current bus routes and historical trolleys. This will guide an empirically based assessment of the past network by today's standards to better understand the growth of cities and how future light rail projects should be planned.

2. METHODOLOGY

The trolley system in Milwaukee was not static. The system generally expanded since its founding until the early 20th century, declining thereafter. To estimate our population served, we will use the system as it was in 1917; this is when the system was at its maximum length.

It is important to compare historical transit routes against a modern analogue, and for this we used the bus routes published by the city of Milwaukee in their open data portal (MCLIO Open Data 2016). While the new bus routes were easy to find from a well-maintained public source, there is no such central repository for historical trolley routes. Digitization of these streetcar routes is often left to the individual researcher through manual mapping from historical images and documents. In the case of Milwaukee, the original KML file used for this project was manually created for a blog post about the new Milwaukee trolley "The Hop (Joe Powell 2015)" by re-tracing routes in Google Maps; their source was a personal website dedicated to rail and transit systems in the Midwest(Bill Vandervoort). Maps in both locations visually align well with a newspaper publication about the history of the Milwaukee streetcar published for the local

NPR station(Mikkelson 2016). It would be ideal to have a scholarly source for the maps, but the data in question is difficult to come by. Still, the alignment between two separate sources from different authors validates that the maps provided in the KML are of a high enough quality to use with caution.

One large assumption of the current analysis is that a person can conceivably get on a bus or could have gotten on a trolley at any point along its route. This doesn't matter as much for trolleys, but for buses this can lead to an especially large over-estimate of population, particularly in the case of the northbound bus routes extending out of the city. These particular routes were not adjusted in order to keep the same assumptions across all lines.

Trolley routes were imported into PostGreSQL using the `ogr2pgsql` command line utility. The national 2010 census block population counts (US Census Bureau) were imported from a shapefile into PostGreSQL using the same utility. Once in PostgreSQL, routes and population blocks were loaded into QGis for easier manipulation and re-projection to NAD83/UTM zone 16N. Finally, a shapefile of bus routes was loaded into QGis. Each layer was exported from QGis to standard ESRI shapefiles for use in the final analysis.

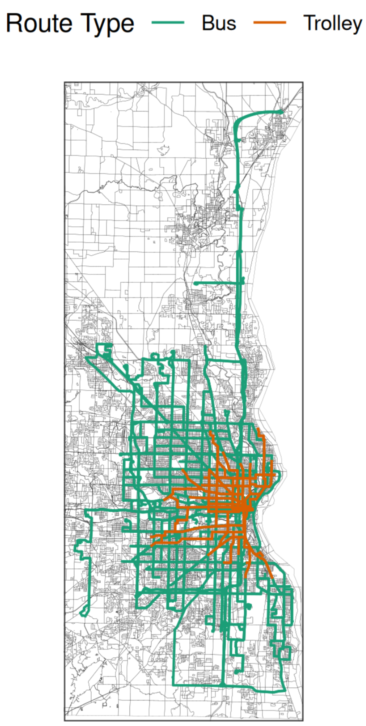

Figure 1: Current bus routes and 1917 trolley routes of Milwaukee laid over 2010 census blocks. All census blocks in the Milwaukee CSA are considered in this paper, but the visualized is truncated for legibility.

For each route system, we create a buffer of 1km around each transit route. With these buffers we find the intersection of the buffer polygons and census blocks. For any partial overlap, we calculate the percentage of overlap using a ratio of the intersection area and the original census block area. Assuming a uniform population distribution within each census block, we multiply the population by this ratio to find an estimated population served by a transit route.

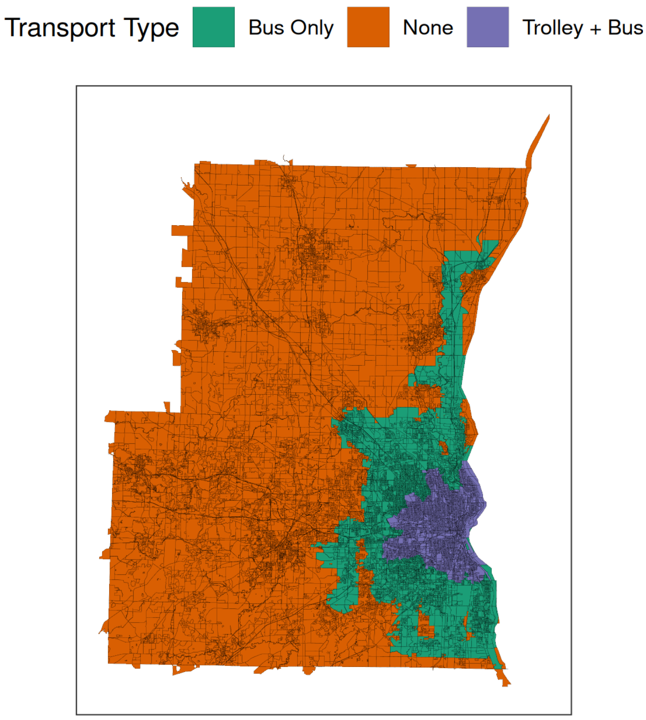

Figure 2: Map of the 4 counties comprising the Milwaukee MSA. The majority of the MSA by land area is not served by public transit into Milwaukee proper. The 1917 trolley network serves Milwaukee's downtown, while the buses serve only the outer city and inner suburbs.

This analysis is performed twice. First, we do this on each individual trolley route and bus route. This allows us to estimate the total population served by each route. However, this creates an issue of multiple counting - a particular block can be (and often is) served by multiple bus and trolley lines. These estimates are useful when comparing line by line, but not for aggregation.

To examine fully aggregated results, we combine the route geometries into a single geometry as a union of each route. Once this is complete, we repeat the prior analysis for the aggregated polygon. This yields an estimate of population served without the problem of multi-counting.

3. RESULTS

Simple overlays (see Figure 1) of the historical streetcar routes and modern bus routes show a strong overlap between the systems. In fact, there are no census blocks in Milwaukee that are covered by a historical trolley route but not by a modern bus route. Buses completely supplanted the streetcar in Milwaukee, and newer bus routes extend well beyond the historical trolley network (see Figure 2 for more detail).

Table 1: Total population served by trolley network of 1917 and modern bus routes. Population per line and per kilometer is rounded to nearest integer.

Mode	Pop	Pop/Line	Route-Km	Pop/Km
Bus	957103	5663	2958	324
Trolley	450780	5931	332	1358

Table 2: Two sample t-test comparing population density (population per square kilometer) of census blocks served by a trolley line and those served exclusively by a bus line.

Mode	Mean	95% CI	t-score	p-value
Trolley	3769	(3669, 3869)	35.25	0
Bus	1828	(1786, 1869)	NA	NA

Therefore, in terms of the physical routes involved, the 21st century bus lines should be offering the same physical mobility to residents that the older lines did. This finding echoes the results of another study examining the role of historical streetcar routes in Hartford, Connecticut, which found that new bus lines also shared the same transit corridors as older streetcar lines (Polinski 2015).

This does not confirm that levels of service were identical in the years following the dismantling of the trolley system, since our particular snapshots of the data are separated by around 100 years. Further, without data on headways and transit times as in the Hartford study, we cannot say how well these lines actually serve the population that lives within a census block.

In total, modern bus routes serve 53 percent more people than trolleys, but with 89 percent more route-kilometers. This indicates that more people are served by bus routes than trolley routes, but the new routes that have been added serve a small number of additional people relative to length of route required. For raw figures, please refer to Table 1.

We will compare our trolley-served blocks against those census blocks served only by bus routes in order to quantify the difference. Because the Census Bureau creates blocks to have roughly equal population but with varying size, we divide the population of a block by its area to calculate the population density. The results of the two sample t-test are in Table 2. The differences between these two groups are highly significant. Census blocks with access to a trolley route, on average, have a density of 3769 people per kilometer; by comparison, census blocks served only by bus routes have an average density of 1828 (52 percent lower).

The empirical findings here follow the literature and traditional wisdom of American city development. But it is also interesting what has not changed since 1917 - the census blocks in the center of the city, despite a general decrease in population, remain the most densely populated, with measured densities north of 3,000 people per square kilometer, or about 7,700 people per square mile.

The bus routes that serve the greatest number of people

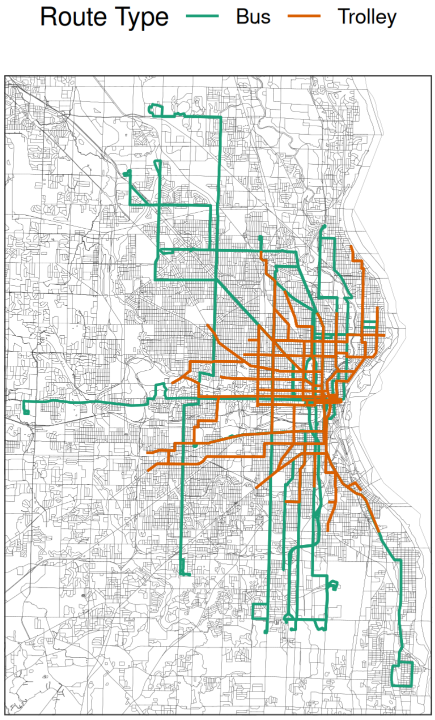

Figure 3: The 20 bus routes serving the highest number of people (adjusted) overlaid over the 1917 trolley network. Most of the bus routes follow along the same corridors as trolley routes.

have the most overlap with the original streetcar network (see Figure 3). In general, the greater portion of overlap a bus route has with a historical trolley route, the higher the total population served (see Figure 4).

4. DISCUSSION

Given that many of the routes are similar and the old network continues to serve the densest part of Milwaukee, what would be the effect of replacing the new bus routes with the trolley network?

In short, the new rail lines would not add any areas currently under-served by buses to the greater transit network. Next, if bus routes were removed and the entire bus network were replaced with a new light rail system along historical lines, the total population within 1km of a line would be reduced by 53 percent.

Transit is a trade-off between massification and atomization (Rodrigue 2017), and the effect of a light rail system is to add a high-mass transportation mode between destinations or along a given route. But if adding new high-capacity routes simultaneously decreases the number of people within access of those routes, utilization goals may be undermined and equity issues may emerge.

Many transportation scholars and studies find that transit ridership is not dramatically improved through creation of light rail (William T. King 2014; Mallett 2014). Other studies have found the opposite to be true. In particular, another study of a light rail extension in Salt Lake City, UT

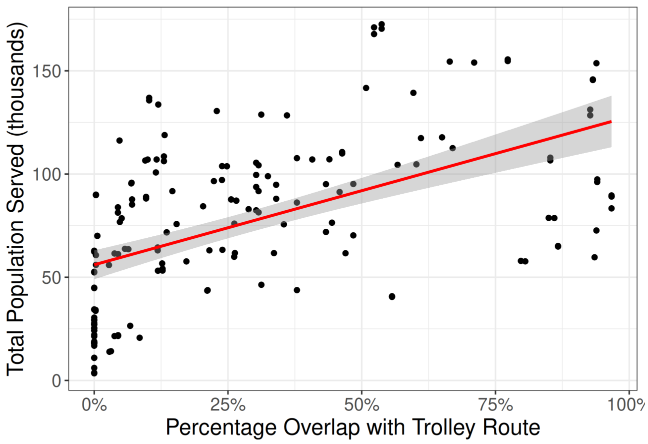

Figure 4: Bus routes plotted by percentage overlap with a trolley route against their total population served. Those bus routes which overlap a prior trolley route, on average, have a higher population served.

estimated a 670 percent increase in ridership over the bus line it replaced and no change within a second urban bus line used as a control group (Werner et al. 2016). Yet another study of light rail usage found increased utilization of around 84% for non-work trips in Minneapolis, MN against a within-city urban control corridor (Cao and Schoner 2014).

The reviewed literature suggests a wide range of utilization estimates but also provides an empirical context in which to evaluate our hypothetical network. According to the Milwaukee County Transit Service annual report, buses provided about 29 million rides in 2019 (2019 Year In Review 2020). Let's assume these rides were restricted to those census blocks estimated to be within access of a bus route and use the adjusted population calculated previously to estimate a number of rides per person. This yields an average ridership of 30.3 rides per person per year. If the bus routes were to be completely replaced by historical trolley routes, these trolley routes would take up a smaller percentage of the Milwaukee area. In order to match the total number of rides and compensate for the lost bus ridership, the new "trolley-only" riders would need to increase their average number of rides per year to 64.3, a 112 percent increase. This increase would further need to come from people who are already more likely to be within walking distance of their destinations.

This increase is on the high end of estimates from the literature, though not the highest. In the cases of Tuscon, AZ and Minneapolis, transit successes were also accompanied by increased residential and mixed-use development and higher property values within the corridors of interest (William T. King 2014; Cao and Schoner 2014). However, transit investment in Atlanta and a separate corridor in Tuscon failed to yield increased property values. Infact, these corridors saw property value decreases similar to the rest of the city over the study period (William T. King 2014).

These instances speak to the role of streetcar networks as enablers, but not drivers, of economic activity. Density is a critical ingredient in the success of light rail networks, so it should not be a surprise that the busy streetcar networks of early 20th century American cities operated at a time of higher densities.

Ultimately, the benefits of light rail over a bus line are fairly limited until the surrounding environment is allowed to change to support it. Transit-oriented development policies are a common theme in the literature, and can be the difference between a successful and failed light rail initiative. Once these policies are enacted, new light rail projects stand a better chance of success in the metrics by which they are commonly judged, such as increased property values and economic activity and decreased congestion and pollution.

To this end, Milwaukee is one of the many cities experimenting with new streetcar/light rail routes. Its new system, "The Hop" is a private-public partnership that primarily serves Milwaukee's downtown area and neighborhoods of the Third Ward. Instead of being viewed as a transportation project, it is primarily seen as a driver of economic development. The Hop's route coincides with some older routes, but does not go to nearly as many destinations and lacks interconnectivity with other transit options required to be fully utilized as a primary means of transportation (Diciaula 2019).

This method of transit development is valid, but it is tangential to the primary purpose of transit - to serve as a linkage between people, goods, and services. Economic development and even aesthetics may be benefits of transportation projects, but if the transportation mode does not actually serve any the derived demands along its routes, the mechanism by whch the stated benefits accrue is unclear. The number of people transported is dependent on their spatial organization and activities more than what transit option is provided, as cities that do not implement these supporting policies may find their light rail initiatives falling below expectations (William T. King 2014).

Light rail cannot be evaluated in a vacuum separate from TOD policies. If Milwaukee's trolley tracks had never been ripped up and replaced with buses, their routes would still connect to areas of decreasing population in the downtown core. To claim otherwise, one would have to assume that a light rail project would attract enough people to transit over the buses that replaced them to undo the well-noted de-densification and population exodus from central cities. Given what we know about the symbiotic relationship of light rail projects and transit-oriented development, there appears to be little evidence that the replacement of modern bus routes with trolleys would offer any genuinely new benefits without complementary policy action.

In fact, the replacement of bus routes with this more limited network of historical trolleys could also cause serious equity issues. One common criticism of transit-oriented development is that the positive effects also bring gentrification. While not unequivocal, there is evidence in the literature that light rail projects increase the property values of nearby homes and businesses. In Milwaukee's case in particular, The Hop mostly accrues benefits to the downtown core and private entities therein, and the residential neighborhoods served by the line tend to be more affluent than average (Diciaula 2019)

Therefore, in our hypothetical transit network, we may be accelerating gentrification effects in the short-term. In the long-term, we may also be increasing the amount and types of housing avaiable, including smaller than currently allowed homes and apartments. This new supply *could* generate new affordable housing options through a supply-side increase, but for a displaced resident asking “will I still be able to live here?”, “eventually” is an insufficient answer.

Further, this growth may come at the expense of outlying areas. Roughly 489,000 people live in areas served only by buses, approximately 31 percent of the Milwaukee MSA population. Our hypothetical light rail system, by contrast, serves only ˜451,000 (29 percent of the MSA). This would leave 1.106 million people in the Milwaukee MSA without no access to public transit at all. The outcome of this would be both a large number of Milwaukee transit riders unable to get to jobs in central Milwaukee and another large percentage of them now driving cars into the city, undoing some of the anti-congestion benefits of the light rail; considering how many people would no longer be served by buses, the number of new drivers could be substantial. It is true that eventually, many citizens from suburbs and outlying areas may move into the central city as density increases, but this is a very disruptive change in the short term.

5. CONCLUSION

Urban planners often cite the need to reduce automobile traffic through transit utilization. Light rail propositions are a new yet altogether familiar piece of technology, at once both a sign of progress and a callback to an earlier time of growing, vibrant, and perhaps idealized cities.

If Milwaukee is any indication, many urban problems of congestion and pollution can be solved by looking to the past for inspiration. But the city has changed too much since 1917 to re-use the historical trolley network without other policies in place. Implementing such a network would result in 53 fewer people within 1 mile of a transit option. Assuming that this would still leave the city with an increase in transit ridership simply due to the change in mode-share would require some fairly optimistic projections to come true, and it would leave an incredibly large number of people currently served only by buses with no transit option whatsoever.

For this reason, the hollowing out of American cities can not be undone by reverting back to an earlier time. The spatial reality of Milwaukee demonstrates that major changes would need to be enacted in order to encourage light rail utilization without risking increased traffic congestion or severe economic consequences, whether through an extension of older trolley lines into suburbs, densification of transit corridors, or both. New strategies, such as commuter rail from outlying areas to the city center, may also be required to meet accessibility demands for outlying areas.

Recent research has shown that implementing light rail along with transit-oriented development policies can generate large economic and community benefits, reducing congestion and increasing walkability. However, to implement the historical trolley network in the name of revitalizing downtown and strengthening communities would be callously destructive in its own way, with no guarantee that the proposed benefits would outweigh the economic consequences.

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