An Evaluation of Comprehensive Transit Improvements— TriMet's Streamline Program

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Abstract

Transit performance is influenced by a variety of factors in an urban environment. Making transit more convenient and competitive with automobile travel is a key objective for the Tri-County Metropolitan Transportation District of Oregon (TriMet). TriMet's goal is to have a "Total Transit System" that makes transit an attractive choice for riders. Portland's Streamline program has been a significant effort toward meeting these goals. The program has resulted in operating and capital cost savings for TriMet by delaying the need to add more buses to the fleet as well as operating savings due to reductions in running time variability. Further, the way the program was implemented resulted in a greater increase in ridership than would have been achieved had the service increases been spread more evenly around the system, confirming that the BRT approach serves transit agencies effectively by concentrating improvements on corridors.

Introduction

The Streamline program, a joint effort of TriMet and the City of Portland, is a package of capital projects and service improvements designed to improve service to all passengers and provide operating efficiencies to TriMet. The program resulted from a $4.5 million federal earmark to the City of Portland under the Transportation Equity Act for the 21st Century (TEA-21), and was implemented through an Intergovernmental Agreement (IGA) between the City of Portland and TriMet, which was signed in July 2000 and which expired at the end of 2005.

This program required investments both on the part of TriMet and the City of Portland. Key investments on the City's part were the installation of transit signal priority at 275 intersections and installation of signal priority emitters on nearly the entire TriMet bus fleet. TriMet's key investment was an annual contribution toward the operating cost of the City's streetcar line. Other changes included installing curb extensions, consolidating bus stops, removing bus pullouts, and improving service quality.

The intended goal was that TriMet would recoup its investment through running time saved by streamlining—in other words, if four or five peak buses could be saved, the bus operating cost savings would offset the investment in transit preferential treatments paid for through TriMet's contributions to the overall program.

As little documentation could be found related to whether a transit system in the U.S. had tried a systematic streamlining program anywhere close to this scale before (the program included 12 routes), there was no past history to use to evaluate the validity of the program's expectations. However, now that five years have passed, it is possible to evaluate how the program has impacted TriMet.

Streamline Program Summary

The Streamline program supports TriMet's strategic direction by enhancing operating efficiency and improving service quality, thereby attracting new ridership. This section provides an overview of how streamlining accomplishes these objectives; subsequent sections provide the details.

Operating Efficiencies

Operating efficiencies arise through reductions in the time scheduled for buses to operate on a route. The cost of operating a route is directly related to the number

of buses assigned to it. If it takes a bus two hours to make a round trip, including layovers, and a route operates at 15-minute headways, it takes eight buses to serve the route. If the time required to serve the route increases, so must the number of buses if the headway is to be maintained. For example, if the round-trip time increases to 2 hours, 10 minutes, then 9 buses would be required to serve the route. Assuming the extra bus operates 8 hours a day (e.g., only during peak periods) and assuming TriMet's FY2004 bus operating cost of $69 per vehicle hour, the extra bus would require an additional operating expense of approximately $140,000 per year. In addition, the extra bus requires an addition to the fleet, with new buses costing approximately $300,000 each.

In an ideal situation, the time saved through streamlining would allow TriMet to remove a bus from a route, allowing service to be increased on another route or the annual operating budget to be reduced. However, to achieve this reduction, the time savings must equal or exceed the route's headway—a maximum of 15 minutes on a Frequent Service route, and often less during peak periods. More commonly, streamlining saves time, but not enough to save a bus. However, the time saved postpones the year when a bus must be added to a route to maintain headways. The number of years saved depends on (1) the rate at which time is being added to the schedule to compensate for congestion and (2) the amount of time saved through streamlining. If, for example, congestion causes scheduled round-trip travel times to increase by one minute every two years, on average, and streamlining saves three minutes, then the need to add a bus is postponed by about six years. (Streamlining can also reduce the rate at which time is added to the schedule [e.g., in this hypothetical example, from one minute every two years to one minute every three years], which would make the time saved last longer before a bus would need to be added.)

The time saved by streamlining comes from two main sources: *running time savings* and *recovery time savings*. Transit signal priority, curb extensions, and queue jump lanes help a bus travel its route faster than it otherwise would have. Signal priority also helps reduce the variability in the time buses take to make a trip from one end of a route to the other, allowing schedulers to reduce the amount of recovery time provided between trips. Recovery time is an allowance for late trips, ensuring that a bus can depart on time for its next trip.

Service Quality Improvements

Many of the performance measures historically used in the transit industry reflect the business aspects of providing transit service. However, an emerging area of

transit performance measurement addresses the impact that transit has on its passengers and the community as a whole. For example, the *Transit Capacity and Quality of Service Manual* (TCQSM) (Kittelson & Associates 2003) provides measures that reflect the quality of service provided to passengers. It was with the customer point-of-view in mind that the Streamline program provided the following service quality improvements:

- *Improved frequencies*. All of the streamlined routes are also Frequent Service routes, operating at 15-minute or better headways throughout the day, each day of the week. Of the 12 streamlined routes, 9 have had at least a 5 percent increase in service hours between 1999 and 2005, 7 have had at least a 10 percent increase, and 5 have had at least a 20 percent increase. In comparison, TriMet's non-Frequent Service routes have had a 2.4 percent reduction in service hours over the same period. Improved frequencies reduce the time that passengers wait for the bus (which passengers perceive as being twice as long as the actual time). Frequent service also makes short and spur-of-the-moment trips more feasible, as passengers can be confident of not having to wait long when they do not know the route's schedule.
- *Improved travel times*. Time saved through more efficient routings and through transit signal priority reduces passengers' overall trip times. Passengers board and alight low-floor buses more quickly than high-floor buses, allowing a bus to continue its trip sooner. Consolidating bus stops also reduces delays due to bus deceleration/acceleration at stops and delays merging back into traffic. Although the number of passengers served at a given stop increases, the overall time spent serving passengers should not change over the length of the route, as the extra passengers would simply have been served at a nearby stop before.
- *Improved reliability*. Transit signal priority helps maintain schedule reliability. The system gives late buses an opportunity to recover time, while maintaining the schedule for on-time and early buses (which are not granted priority). More reliable service reduces passenger wait time at stops and also helps maintain even loads across buses, as late buses tend to pick up more passengers than usual and thus fall farther behind schedule. Consolidating bus stops also helps reduce travel time variability, as buses are more likely to stop each time at the remaining stops. Reductions in travel time variability allow reductions in schedule recovery time at the end of the trip.

If the combination of recovery time and travel time savings is at least one headway, a bus can be saved.

- *Improved passenger infrastructure*. Items like TriMet's new blue bus stop poles, ADA concrete landing pads, and shelters help announce the presence of bus service even when buses are not in the vicinity at that moment. Stops can sometimes be moved to locations that favor signal priority and provide more room for passenger infrastructure. New sidewalk construction, curb ramps, and ADA landing pads make stops more accessible for all persons; therefore, these features likely reduce riders' reliance on much more costly paratransit service and provide greater flexibility for when riders can travel.
- *Improved information*. The on-board automatic vehicle location (AVL) system is at the heart of TriMet's TransitTracker™ real-time passenger information system, which provides bus arrival information over the Internet, by phone, and at nine bus stops equipped with electronic signs. The upgrade of TriMet's communications system, made possible with Streamline funds, will provide buses with Automated Stop Announcement (ASA) capabilities, similar to what already exists on TriMet's light rail vehicles.
- *Curb extensions*. Curb extensions reduce the distance that pedestrians are exposed to traffic while crossing the street on their way to or from the bus stop. They also make passengers more visible to bus operators, and provide additional area to place bus stop amenities.

Ridership

Between 1999 and 2005, the number of vehicle-hours allocated to the 12 streamlined routes increased 16.3 percent, while ridership on those routes increased 18.2 percent. In contrast, over the same period, the number of vehicle-hours allocated to non-Frequent Service routes decreased 2.4 percent and ridership on those routes decreased 0.7 percent.

The change in ridership on the non-Frequent Service routes corresponds to an elasticity of 0.30—that is, for every 1 percent increase or decrease in service hours, ridership increases or decreases by 0.3 percent. In the absence of other changes, this observed elasticity would be typical for urban systems with routes operating at 30-minute or better headways (Evans 2004). In contrast, the elasticity observed for the streamlined routes was 1.11—that is, ridership increased at a faster rate than service was added. Elasticities this high are normally only seen in suburban systems that operated at 60-minute headways prior to the service increase. This

high level of ridership increase on urban routes suggests that other factors were at work beyond the service frequency increase, although it undoubtedly played a large role.

Over a six-year period, there are a number of external factors that can also affect ridership, including fare increases, population growth, and service restructuring (e.g., due to the opening of new light rail lines). The first and third, of these factors should generally affect Frequent Service and non-Frequent Service lines equally, given TriMet's fare system and route structure that has most routes serving downtown Portland and/or connecting to light rail. While the population of the Portland region, where many non-streamlined routes operate, has grown, the population of the city of Portland itself, where most streamlined routes operate, has held relatively steady, with only a 0.8 percent increase from 2000 to 2004 (Bureau of the Census 2004). The area of Portland that experienced strong population growth during that time—the Pearl District—is served by streetcar rather than by streamlined routes. Finally, the rate of ridership growth relative to service changes on the streamlined routes from 1999-2005 was greater than the rate of growth on the light rail system, which included the effects of three line extensions. Therefore, it can be concluded that other changes implemented at the same time as the service increases (e.g., Frequent Service branding and streamlining improvements) also contributed to the much greater change in ridership seen on the streamlined routes, compared to the non-Frequent Service routes.

Methodology

The evaluation of four specific measures is considered in support of our documentation of benefits for the Streamline program. These measures include a review of the following: ridership changes, additional fare revenue, on-time performance, and round trip time savings.

Ridership Changes

TriMet's 1999 bus ridership was 200,040 passengers per weekday. Ridership has increased over time and, as a part of this, vehicle hours increased by 3.6 percent between 1999 and 2005. If the service increase between 1999 and 2005 had been spread throughout the TriMet system, and not accompanied by streamlining and marketing activities, the change in ridership likely would have been similar to that observed for the non-Frequent Service routes. Given the 3.6 percent increase in overall bus service hours from 1999 and 2005, and applying the observed non-Fre-

quent Service elasticity of 0.30, weekday bus ridership would have been expected to increase from approximately 200,040 passengers in 1999 to 202,200 in 2005, all other things being equal. Instead, weekday ridership increased to 214,230 passengers, a difference of approximately 12,000 passengers per weekday

Additional Fare Revenue

Fare revenue is closely related to ridership data, but, as it is a different source of data, it is relevant to our assessment of the program. Based on 2004 National Transit Database data, TriMet's average bus fare per boarding was $0.57. (This value includes discounted fares, boardings that were transfers, and boardings in the downtown Fareless Square.) Multiplying 12,000 additional weekday passengers by 250 weekdays per year equals 3 million additional annual bus boardings. The corresponding fare revenue is approximately $1.7 million.

On-Time Performance

The average on-time performance for streamlined routes (weighted by daily vehicle hours operated on each route) went from 80.6 percent in 2001 to 78.0 percent in 2005, a drop of 3.3 percent. On-time performance of non-Frequent Service routes went from 79.0 percent in 2001 to 74.2 percent in 2005, a drop of 6.1 percent.

Round-trip Time Savings Compared to Non-Streamlined Routes

On average, the 12 streamlined routes operate 0.8 minutes faster per round trip in 2005 than in 2000, while 7 comparative non-streamlined Portland routes operate 1.3 minutes slower. The difference is 2.1 minutes. The scheduled round-trip time of the non-streamlined routes has increased an average of 0.25 minutes per year. If the round-trip time of the streamlined routes increases at this rate from this point forward, it will take 8 years to use up the 2 minutes saved. Any recovery time savings that can be quantified in the future would postpone the need to add buses by additional years. This calculation assumes that the rate of increase in round-trip times will remain constant into the future—if future congestion causes scheduled times to increase at a faster rate, the years of savings will be less. The calculation also assumes conservatively that streamlining does not reduce the rate at which round-trip times increase due to congestion. The travel time reduction is associated with signal priority and curb extension delay savings, each of which are described in the following paragraphs.

Signal Priority

The street with bus service typically has a green signal 40-50 percent of the time, which means that the signal is red 50-60 percent of the time (ignoring the relatively small time the signal is yellow). With 50 percent red time and a 70-second cycle, a bus could be delayed up to 35 seconds. With 60 percent red time and a 100-second cycle, a bus could be delayed up to 60 seconds. There are more widely documented benefits elsewhere (Koonce et al. 2002).

Curb Extension Delay Savings

The TCQSM gives average delay values for buses merging back into a street, where vehicles are arriving randomly (Kittelson & Associates 2003). The delay ranges from 1 second for streets with 100 vehicles per hour in the curb lane to 15 seconds for streets with 1,000 vehicles per hour in the curb lane.

At traffic signals, with no compliance with yield-to-bus laws, a bus would need to wait for the queue of vehicles to clear once the signal turned green (a process that takes approximately 2 seconds per car), and then wait for a sufficiently long gap in traffic to safely merge back into traffic (determined from the TCQSM). For example, with a 250-foot queue (10 vehicles) and moderate traffic volumes on the street (500 vehicles per hour), it would take 20 seconds to clear the queue, and an additional 5 seconds on average to get a long-enough gap.

If a curb extension extends the width of the parking lane (8 feet), then two curb extensions reduce the crossing distance by 16 feet. At a pedestrian speed of 4 feet per second, the pedestrian crossing time is reduced by 4 seconds.

One cannot simply add up the potential savings of each streamlining improvement along a route to determine how much time might be saved. Some of the localized time savings will not translate into actual travel time reductions over the length of the route, generally depending on whether a bus is able to get through a downstream traffic signal that it otherwise would have missed in the absence of streamlining treatments. Because passenger boarding activity, traffic volumes, the allocation of green time to the bus street at traffic signals, and other factors vary from one trip to the next, it is generally not possible to be more definitive about the actual time that is saved by a given improvement. The streamlining improvements work in combination to give a bus the best possible chance of saving time along its route.

Results

The following is a summary of the streamlining impacts that can be quantified to date:

- The time savings resulting from streamlining has not allowed TriMet to permanently reduce the number of peak buses on a route. As a result, there have been no short-term operations savings.
- The 12 streamlined routes, on average, operate a round trip 0.8 minutes faster now during the weekday a.m. peak than they did in September 2000. In comparison, 7 non-streamlined routes that mainly operate in the city of Portland operate a round trip 1.3 minutes slower on average, and 4 primarily suburban routes operate a round trip 2.3 minutes slower on average.
- The full impacts of streamlining on running time variability have not yet been quantified. A study conducted by Portland State University (Kimpel et al. 2005) compared travel time variability on six routes (109, 12, 112, 14, 72, and 94). This study found minimal reductions in recovery time on average (0.1 minutes per trip), although Routes 12 and 94 outbound during the weekday p.m. peak showed substantial reductions (10 to 14 minutes per trip, respectively). However, the study did not address changes in peak-period, off-peak-direction variability (which impacts round-trip times), net increases in ridership, or changes in running time variability on other routes. Furthermore, the study's timeframe was before other streamlining improvements were implemented and before the threshold for activating signal priority was reduced from 90 seconds late to 30 seconds late.
- The running time savings that have been achieved through streamlining have postponed the need to add buses to streamlined routes by eight years, at the current rate that scheduled times are increasing due to congestion. Assuming an annual $140,000 operating cost saved per peak bus, multiplied by 12 routes over 8 years, equals about $13.4 million in long-term savings in present dollars. The value of postponing the purchase of 12 additional buses for 8 years would be an additional capital cost savings. Any recovery time savings that can be quantified would be an additional operating cost savings.
- The combination of focusing service increases on Frequent Service routes, accompanied by streamlining and marketing efforts, has resulted in 12,000 more weekday bus boardings than would have occurred had the service increases been spread system-wide and no other efforts made. These addi-

tional riders translate into $1.7 million additional farebox revenue annually.

- On-time performance has declined systemwide from 1999 to 2005. However, the on-time performance of streamlined routes has declined at half the rate of non-Frequent Service routes.

In summary, the Streamline Program is a long-term investment for TriMet. The payoff will primarily be in the future, as additional service will not need to be added as soon to streamlined routes. Because ridership has increased on the streamlined routes by a substantially larger percentage than can be attributed to just the increase in service, some portion of the $1.7 million additional annual farebox revenue can be attributed to streamlining, although the exact contribution cannot be quantified.

Conclusions

This study found that the intended short-term benefits of reducing operating costs to offset TriMet's contribution to the program were not achieved, mainly because of the difficulty of accumulating enough time to save a bus on a route. On TriMet's Frequent Service routes, 15 minutes of time savings (a typical headway) are needed to be able to save a bus, and streamlining has not yet been able to achieve that level of savings.

However, the time savings that streamlining has achieved to date will result in long-term benefits for TriMet, as it postpones the year when a bus needs to be added to a streamlined route. Over time, these time savings will result in operating and capital cost savings for TriMet. At the current rate at which round-trip times are increasing in Portland due to congestion, the need to add a bus to streamlined routes has been postponed by eight years on average, equating to a long-term $13.4 million operating savings. There will be additional savings from postponing the need to purchase additional buses for these routes by eight years. There are likely additional long-term operating savings due to reductions in running time variability (allowing scheduled recovery time to be reduced); however, these savings have not yet been quantified.

In addition, the way that service was increased—focusing added service on Frequent Service routes, in combination with Frequent Service marketing and streamlining improvements—resulted in a greater increase in ridership than would have been achieved had the service increases been spread more evenly

around the system. Approximately 12,000 more passengers ride TriMet buses each day than would have otherwise, resulting in $1.7 million in additional fare revenue annually.

Next Steps

There is much that can still be done with streamlining to further expand its benefits. Within the city of Portland, some of the program pieces have yet to be implemented (e.g., additional bus stop consolidation, transit signal priority activation points, etc.). Some of the next steps are technical in nature, while others are institutional.

Continuing Partnership with the City of Portland

One of the key accomplishments of the Streamline program has been the establishment of a partnership between the City of Portland and TriMet. This relationship has eased the implementation of signal priority and construction of physical improvements that lead to operational efficiencies. These investments have lead to institutional cooperation that will allow continued improvements in productivity of the system, leading to a more sustainable transit network.

Building Partnerships with the Suburban Agencies and ODOT

Much of TriMet's service area lies outside of the city of Portland. In fact, scheduled round-trip times on suburban routes appear to be increasing at nearly twice the rate as routes operating primarily in Portland. Potential suburban routes to apply streamlining on are being considered. Longer routes offer the greatest potential for time savings that can allow TriMet to achieve its initial objective related to saving peak buses on routes.

Reinvestment in the System

One of the benefits of the Streamline program lies in technology investments that have resulted in long-term improvements to the system. Features such as the Automated Stop Announcement and Real-Time Passenger Information systems, among others, result in improved customer satisfaction and in some cases, compliance with federal accessibility guidelines. Integrating these devices has reduced overall procurement costs and ongoing maintenance activities. Continued technological advancements, such as the integration of trigger points for signal priority activation and more closely integrated scheduling into the process, would further improve the system and allow more effective operations to meet tomorrow's chal-

lenges. TriMet's Automatic Vehicle Location system has been further strengthened by its use as an integrated system for bus data, which results in improved planning and scheduling for the agency.

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