FEHR PEERS

Memorandum

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Subject: Case Studies for VRT State Street Operational Analysis

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Introduction

The purpose of this memo is to summarize the case studies reviewed for Valley Regional Transit's (VRT's) State Street corridor Transit Operations Analysis (TOA). Case studies were identified from transit agencies that share similarities with VRT and service corridors similar to the State Street corridor. The case studies focused both on newer bus rapid transit (BRT), enhanced bus, and frequent transit lines that are on busy suburban arterials like State Street and that have similar features to how VRT plan to implement its "Best in Class" service. The case studies were carried out through interviews with agency staff and the review of studies and reports of specific transit route speed and reliability studies or overall agency strategies to improve speed and reliability on major arterial routes. The agencies evaluated for these case studies were, Community Transit (Snohomish County, Washington), Utah Transit Authority (Salt Lake City / Provo Metro Areas, Utah), and Regional Transit District (Denver Metro Area, Colorado).

Community Transit

Community Transit is the transit agency operating in Snohomish County, Washington, which is part of the Seattle-Tacoma Metro area. The county has a population of about 830,000 (United States Census Bureau 2022) and is a mix of suburban and rural development patterns. Within the county, Community Transit largely focuses service on the denser, suburban areas closest to Seattle (there is relatively sparse transit coverage in the northern and eastern parts of the county).

The agency operates two high-frequency bus routes: the Swift Green Line and the Swift Blue Line. These routes are defined as "BRT-light" as they share some characteristics with full BRT systems (off-board fare payment, all-door boarding, near-level platforms, special design/livery on the buses), but generally do not operate in exclusive bus lanes. Fehr & Peers gathered information on the agency and its routes through an interview with BRT Program Manager Christopher Silveira from the agency and a review of the before-and-after study of the Swift Green Line corridor (Community Transit, 2020).

Bus Route Operating Characteristics

The two Swift lines operate on corridors that are generally 5-7 lanes with annual average daily traffic (AADT) of 20,000 to 50,000. Speed limits on these routes range between 40 and 50 miles per hour. Both routes have local bus routes overlapping the same routes every 30-60 minutes. Swift buses operate on 10-minute headways from 6 AM to 7 PM on weekdays and 20-minute headways during other times and the weekends.

Bus Stop Design

Most of the bus stops on these routes are in-lane stops, though the design of each stop is context sensitive. Community Transit noted that although concerns have been raised regarding the impacts of in-lane bus stops to general purpose traffic, the dwell times of buses on the Swift routes is generally within the 12-17 second range, resulting in minimal delays to traffic. To keep dwell times low, Community Transit designs the stations to accommodate near-level boarding and procured buses that accommodate on-board bike racks inside of the bus. In several cases, roadway widening has led to Community Transit adopting pull-out stops where future Business and Transit (BAT) lanes will be introduced. For stops that do still utilize pull-out stops, Community Transit strategically uses Transit Signal Priority (TSP) to force gaps to allow buses to merge back into traffic once the bus finishes loading passengers. All Swift bus stops offer off-board fare payment, which is particularly beneficial for quick loading at high-ridership stops.

Community Transit performed a before-and-after study following implementation of the Swift Green Line (Community Transit, 2020). The study assessed the performance of bus operations, the impacts on general traffic performance, and safety around in-lane bus stops. When reviewing the study, the majority of the Green Line improvements involved stop consolidation, construction of near-level boarding platforms with off-board fare payment, and the elimination of most of the pull-out stops along the route. Related to safety, Community Transit found that crashes around stations decreased by 37% after the opening of the Green Line, with no substantial changes in the types of crashes (e.g., there was not a substantial change in the proportion of rear-end or sideswipe collisions with the new in-lane stops). These findings helped to quell the concerns of those (including from the Washington State Department of Transportation, which owns a portion of the route that the Green Line operates on) that thought that in-lane bus stops would increase the frequency of crashes, particularly rear-end collisions. They also found that although there was

measurable queuing behind stopped busses, the queues did not become substantial enough to lead to operational issues due to the short bus dwell times and thus short durations of vehicle queuing. In other words, there was no substantial increase in general purpose vehicle delays from the in-lane bus stops.

Transit Signal Priority

In partnership with Snohomish County, Community Transit implemented global positioning system (GPS) activated TSP and adaptive signal control with implementation of the Swift Green Line. The before-and-after analysis indicated that while bus speeds did not necessarily improve, transit reliability did. Discussions with the agency indicate that TSP was not established to speed-up buses (which operate in the major traffic direction of a busy arterial corridor where additional green signal time has limited benefits), but rather to help maintain bus headways when buses fall behind schedule. Interestingly, while bus travel times did not significantly improve, vehicular travel times along the bus corridor slightly improved, as they likely benefited from the adaptive signal control system providing more green time to the dominant movement.

One interesting anecdote offered up in the interview was that Community Transit will be implementing the TSP system on the upcoming Orange Line to move buses out of pull-out stops. In this case, Community Transit will be building new Swift stops in their final location, even in road segments that will need future widening by Snohomish County. This will create temporary pull-out stops (typically on the far side of intersections) that will result in substantial delays for Swift buses. To compensate for these delays, Community Transit will be implementing TSP for all bus trips (as opposed to their general practice of implementing TSP only for buses running more than a few minutes behind schedule) at the pull-out stops. This TSP will extend the red time or result in an early termination of green time for oncoming traffic to provide a gap for the bus to enter traffic. This is a relatively novel use of TSP that could be implemented by more transit agencies.

Transit Priority Lanes

About half of the Swift Blue Line operates in BAT lanes (lanes that require general purpose vehicles to turn right at each signalized intersection but where buses can travel through). The BAT lanes were originally built by Sound Transit, which was considering running express bus service on the Blue Line corridor, but eventually implemented bus service on I-5, handing the BAT lanes over to Community Transit. The other portions of the Blue Line corridor that were already built to six-lanes did not have the existing general-purpose lanes reallocated as BAT lanes.

About a quarter of the Swift Green Line operates in HOV lanes, largely in the segment of the route that approaches the Boeing manufacturing facility, which operates at higher speeds and has fewer driveways than the more suburban portions of the route. The HOV lanes all existed prior to implementation of the Green Line to provide access to the Boeing facility.

Community Transit has partnered with Snohomish County Public Works and the Washington State Department of Transportation on several queue jump lanes on both the Green and Blue Lines. These queue jump lanes have been put in place in the most congested sections of the corridors (near freeway interchanges or major intersections) to strategically allow buses to bypass congestion in a cost-effective way.

Overall, in discussions with Community Transit, they acknowledge the benefits of BAT, HOV, and queue jump lanes (these lanes principally allow the buses to bypass congestion), however they also note that they are very expensive to build and may require extensive and sometimes controversial public engagement. Therefore, most of the transit priority lanes have either been built by other agencies, with just a handful tactically implemented by Community Transit. This strategy allows Community Transit to focus more of their funding on operations and less on capital and use existing partnerships with other agencies to build the more complex and controversial transit priority lanes.

Other Operational Concerns

There were a handful of other concerns mentioned in the interview with the agency. One issue that they faced with the conversion from traditional to BRT-light routes was the number of driveways on some road segments. The high driveway count led to safety concerns from operators, which has prompted an effort to work with local cities and the county to consolidate driveways with redevelopment. There have also been concerns about bicyclist safety around busses, although there is not a quantitative basis to demonstrate that buses and bikes are in strong conflict along the Swift routes. Community Transit does, however, support a bike lane design that guides bicyclists around the far side (further toward the curb or building face) of bus stops.

Community Transit also operates Swift on a headway-based (as opposed to schedule-based) system. In other words, there are no committed or printed schedules for the Swift Routes, but rather a goal to provide reliable headways between buses. To do this, the agency has dedicated dispatchers and divides the routes into 3-4 operating segments where buses have hold-points if they are operating at less or more than the target headway.

Summary

When asked what the primary advice he had to help improve operations on routes of this type, Christopher Silveira replied that keeping busses in their lanes for stops and giving busses priority at congested intersections are the two biggest tools. In-lane bus stops have been effective at improving operations of the two Swift lines while they have not been shown to have negative impacts on safety or substantial impact on the operations of automobile traffic due to the low dwell times of the buses. This finding is notable given the high speeds and AADTs of the Swift corridors. The combination of strategically implemented TSP and adaptive signal control have

been positive for the Swift Green Line in terms of schedule reliability. Community Transit is currently working with the cities and Snohomish County to implement adaptive signal control on the older Blue Line (which already has TSP) in the coming years.

Community Transit was fortunate to have "inherited" many of the transit priority lanes along the Swift corridors, but they are strategically implementing new queue jump lanes in the areas with greatest congestion as funding allows. This approach of assembling a mixture of tactical treatments (bus stop improvements, in-lane stops, strategic queue jumps) is very similar to what VRT is proposing for the State Street corridor and has worked well for Community Transit.

Utah Transit Authority

Utah Transit Authority (UTA) is the transit operator in the Salt Lake City-Provo region of Utah. Most of the transit routes the agency operates are in Salt Lake County (population 1,200,000), with some routes extending into Utah County (population 660,000) (United States Census Bureau 2022). UTA operates two rapid bus routes, MAX in Salt Lake County[1] and UVX in Utah County.

The MAX route operated primarily on an arterial of 7 lanes with AADT in the 20,000 to 45,000 range and speed limits ranging from 35 to 45 miles per hour. The UVX line operates through variable traffic conditions ranging from 3-lane roadways with AADT of 7,000 daily vehicles and 25 miles per hour speed limits to 7-lane roadways with AADT of 60,000 daily vehicles and speed limits between 35 and 45 miles per hour.

Bus Stop Design

UTA does not have a standard for bus stop designs for choosing between in-lane and pull-out stops, as bus stop design is context dependent and revolves around existing roadway configuration. However, for the MAX and UVX, bus stops in mixed traffic are predominantly in-lane. UTA stated that as long as bus stops are far-side of the intersection, the traffic implications of in-lane operations have not generated safety or operations concerns. Pull-out bus stops exist in these corridors, but only in locations where there is a shoulder as opposed to a typical curb lane. In general, UTA defaults to building an in-lane stop wherever feasible and there has not been any substantial community or agency opposition to buses stopping in-lane.[2]

Related to bicycle-bus interactions, UTA also mentioned that they encourage bus stop design that does not put bicyclists in between motorists and busses and prefers bikes be routed behind bus stops.

[1] MAX has ceased operating during the COVID-19 pandemic,
[2] Because of this practice, UTA does not have any studies or data on the travel time savings of in-lane versus pull-out stops.

Transit Signal Priority

TSP historically was a major component of the MAX and UVX and these were among the first routes in the UTA system to employ this technology. However, the TSP used on these systems has become outdated and no longer functions. While in operation, TSP for the UVX line was only used when the bus was behind schedule. UTA stated that, while TSP is a significant factor in improving the operation of the rapid bus lines, the more critical elements for speed and reliability include off-board ticketing to lower dwell times and far-side stops to get the bus through intersection delays. UTA is currently working on a systemwide implementation of TSP (focused on all routes, and not just BRT), which will re-introduce TSP to the BRT routes.

Transit Priority Lanes

UTA considers both the MAX and UVX routes to be BRT, but like Swift in Washington State, there are very little portions of dedicated transit lanes on these routes. The MAX route operated almost exclusively in general purpose traffic. The UVX line operates roughly half on dedicated lanes and half in mixed traffic. The dedicated (median-running) portion of UVX is on the busiest segment of the corridor that is most prone to traffic congestion (between I-15 and the BYU campus).

Summary

Although UTA does not have strict guidance as to when to make bus stop in-lane or pull-out, the vast majority of stops for their BRT routes are in-lane. Potential unintended impacts of in-lane bus stops have not been studied rigorously, but the agency has not received strong objections to the in-lane stopes from the public or other partner agencies. TSP has been an important part of the rapid bus lines for UTA and the agency is prioritizing a rollout of TSP for all routes in the system based on the successes seen on the BRT routes. UTA also noted the strong benefits of off-board fare payment and far side bus stops to keep their rapid buses operating on a reliable schedule.

Regional Transit District

Regional Transit District (RTD) is the transit agency operating in the Denver Metro area. The agency operates in a variety of different contexts, from downtown Denver to suburban bus routes. The primary route of interest under the jurisdiction of RTD is route 105, a rapid bus route that operates on Havana Street in Aurora, Colorado (population 390,000) (United States Census Bureau 2022). This route was selected because Aurora is more similar in its suburban land use form and density to the Boise metro area than routes in more urban Denver. Havana Street is also a large multi-lane commercial arterial with heavy auto dependence and abundant driveways, similar to State Street.

Information for this route and on RTD's policies were gathered through an interview with Douglas Monroe, a Corridor Planning and Operations Manager at RTD and review of an analysis of RTD routes in April 2018 (RTD 2018). Havana Street is a north-south corridor ranging from a 2-lane

road with 10,000 AADT to a 7-lane road with 50,000 AADT and a speed limit of 45 miles per hour. Route 105 had 1,500 daily boardings in each direction in 2018 (RTD 2018). There are no dedicated transit lanes for Route 105.

Bus Stop Design

RTD opts for in-lane bus stops at most locations. Pull-out bus stops are only utilized on 2-lane roads where stopped buses would block traffic. There is one pull-out bus stop on the Route 105 corridor at Alameda Ave, which is planned to be updated to an in-lane bus stop. Based on an analysis of bus stop configurations, in-lane stops result in a saving of about 10 seconds of delay over a pull-out bus stop, resulting in a median travel time savings of roughly 2 minutes for the entire route, which is about a 5 percent improvement in travel times (RTD 2018). RTD recommends that in-lane bus stops are suitable for traffic speeds up to 45 miles per hour. In addition to the travel time savings for transit vehicles, they recommend in-lane bus stops to enhance safety by removing the reentry conflict and reducing crossing distances for pedestrians where the pull-out would have widened the crosswalk.

Transit Signal Priority

Route 105 currently only has TSP at the intersection of Havana St and E Colfax Ave. However, TSP is currently under consideration at 9 additional intersections on the route. TSP is estimated to save up to 15 seconds per intersection. The standard for the decision to implement TSP for RTD is based on the effects of TSP on net person delay at an intersection or along a corridor (RTD 2018). Bypass or queue jump lanes are also considered by RTD on other corridors for ways to reduce transit vehicle delay at intersections, but none are currently planned for Route 105.

It should be noted that the TSP benefits for transit vehicles cited by RTD differ from what was identified by Community Transit (i.e., RTD identified more transit delay reduction from TSP than did Community Transit). This may have to do with the geographic differences between the Denver and Seattle areas. Seattle is highly constrained topographically and the majority of the traffic (and transit) flows are north-south. Denver is a less constrained metro area and there are busy streets in all directions, which may enhance the benefits of TSP. The TSP benefits for State Street are more likely to reflect those of Community Transit rather than RTD given that there are only a handful of busy cross streets of State Street, however, additional analysis would help to refine the benefits that VRT could gain from TSP.

Summary

When asked about the most powerful tools for improving operations on bus routes such as these, Douglas Monroe answered that in-lane bus stops and TSP are the biggest factors that can help. RTD nearly exclusively makes bus stops in-lane on roads with more than one lane in each direction with speed limits up to 45 miles per hour. TSP is also considered on an intersection basis for when it would provide a net improvement on the person delay.

Case Studies Summary

Fehr & Peers researched agencies and transit lines to serve as case studies for VRT's State Street bus corridor. Information was gathered from published documents and interviews with agency members from Community Transit, UTA, and RTD, with a focus on bus stop design and transit signal priority application on frequent bus corridors.

For each of the case study agencies, a strong preference is given to in-lane bus stops on their most frequent routes. Of note, all three agencies cited in-lane stops as a critical factor for successful rapid bus implementation. Community Transit and RTD use in-lane stops on roads up to 50 miles per hour and 45 miles per hour, respectively, and have reported no safety issues for transit and automobile trips. Operations issues with in-lane stops are also not a concern given the limited dwell time of the buses. TSP is also an important tool for each of these agencies, which can be used to improve the reliability of travel times for transit vehicles or to reduce the net person delay at intersections.

Overall, the team recommends that VRT and ACHD consider implementing a series of tactical improvements as the State Street corridor is built out over the coming years. Based on the case studies, these tactical improvements include the following:

- Constructing in-lane stops with bicycles routed behind the bus stop. The research finds no specific evidence for safety concerns, strong transit operations and access benefits, and limited impacts on general purpose traffic.
- Implement TSP along the corridor. Given that VRT and ACHD already have the capability to implement TSP, this is a low-cost strategy to improve transit travel time reliability. Given the conditions on the State Street corridor (the predominant vehicle movements are aligned with the bus route), TSP will be most beneficial to maintaining headways and schedule reliability for State Street buses rather than increasing speeds and reducing overall travel time. A schedule adherence threshold should be established to enable TSP such that it does not substantially impact other traffic on State Street. While there was no consistent threshold identified in the case studies, considering the headways on State Street, a bus schedule adherence threshold of 3-5 minutes seems reasonable (i.e., TSP is activated for any bus running at least 3-5 minutes behind schedule). TSP should be considered to create gaps for any pull-out stops that remain on the corridor.
- Upgraded bus stops. Near-level boarding and off-board fare payment can reduce dwell times and are implemented by most BRT/rapid bus agencies. For State Street, implementing these types of improvements, particularly at high ridership stops or those where there are more people that may request the bus to kneel or roll strollers/walkers on would be the top priorities. Low ridership stops may not warrant any specific improvements.

By implementing these strategic improvements over time, VRT can maximize its funding, improve the rider experience, and have minimal impacts on general purpose traffic.

References

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