American Public Transportation Association

APTA BRT ROADWAYS SUBCOMMITTEE WHITE PAPER

Bus Rapid Transit (BRT) Roadway/Infrastructure Design & Best Practices

FEBRUARY 2024

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CHAPTER 1 — BACKGROUND

INTRODUCTION

So, what is Bus Rapid Transit (BRT)? According to the Federal Transit Administration (FTA) BRT is a high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms, and enhanced stations.

Over the last couple of decades, the interest in implementing BRT by transit agencies has grown significantly, particularly given its flexibility and cost to implement, as compared to rail. Because BRT contains features very similar to light rail, it is often considered more reliable, convenient, and faster than regular bus service. With the right bus priority features, BRT can avoid the delays that can slow regular bus services, like traffic congestion, long waits at traffic signals and other intersection delays, or long dwell times at stops waiting to pay and/or board the bus. In addition to improving operational conditions including increased bus speed and reliability, these bus priority features can also contribute to a safer operating environment, improve the customer experience, and reduce operating and maintenance costs. BRT is a combination of improvements (which can be done incrementally) that can increase the efficiency and effectiveness of the service, increase transit ridership, and improve air quality.

Cleveland, Ohio - Healthline

APTA BRT COMMITTEE

The **Bus Rapid Transit Committee** provides a forum to exchange information regarding Bus Rapid Transit (BRT), from funding and project planning to service implementation. As part of an effort led by the APTA BRT Committee, three subcommittees were established to focus on three specific areas of interest, including roadway infrastructure, BRT policy, and vehicles and/or vehicle technology. This white paper focuses on the work conducted by the Roadways Subcommittee over the past year regarding roadway design and infrastructure. Its purpose is to share best practices from those who have implemented or are about to implement BRT, hear about lessons learned, and what types of things one should seriously consider when planning and designing BRT in order to achieve its maximum benefits and effectiveness.

PROBLEM STATEMENT

As congestion continues to grow in most cities, transit travel speeds have declined significantly, creating the need for faster, more comfortable, and more affordable and efficient transit alternatives like BRT. With the high cost associated with rail, environmental concerns, and limited resources, if implemented right, BRT can offer significant benefits to a bus system at a much lower cost (generally about 20% of the cost of fixed rail). Particularly since for a majority of cities, buses will continue to be the predominant mode of public transit for most riders, even after some planned rail system expansions in many cities.

STUDY OBJECTIVE

Over the years, there has been a lot written and published on BRT and its potential benefits and/or challenges, as well as the various design elements that should be considered when implementing BRT. Every design element and how they are applied can help contribute to the level of improvement and/or success achieved with BRT. There are also many organizations who have studied, analyzed, and developed BRT design guidelines for those contemplating BRT, including the National Association of City Transportation Officials (NACTO), Institute for Transportation and Development Policy (ITDP), the Transit Research Board (TRB), and many others. However, this effort attempts to reach out directly to those transit agencies who have implemented BRT to learn what roadway design elements they specifically implemented, how they worked and/or did not work, lessons learned, and what they might have done differently in hindsight should they plan for another BRT system. This information could then be shared with others contemplating BRT. This subcommittee also wanted to learn a little more about how transit agencies enforce bus lanes and what ITS elements they have incorporated into their project.

CHAPTER 2 — STUDY APPROACH

In looking further into roadway design/infrastructure, the Roadways Subcommittee took a two-pronged approach. To begin with, the group first developed a survey with a set of questions specific to roadway design/infrastructure and lessons learned. This survey was then posted on the APTA site under APTAconnect/BRT Committee.

In addition, the members of the Roadways Subcommittee also conducted several case studies. As part of the case studies, subcommittee members were responsible for directly contacting those agencies with an active BRT system to interview.

CHAPTER 3 — SURVEY RESPONSES

The survey consisted of a total of sixteen (16) questions regarding roadway design, as well as a few questions on bus lane enforcement and the implementation of ITS elements. The survey was distributed through APTA-connect—APTA's members-only secure online community space specifically designed to connect to one's peers, colleagues, and friends. The survey went out through this channel to the APTA BRT Committee. The subcommittee received a total of twelve (12) survey responses representing nine (9) separate transit agencies with at least one (1) BRT line. Agencies surveyed included: New York City DOT; City of Madison; AC Transit; Pace Suburban Bus; Valley Transportation Authority (VTA); Community Transit (Comm Trans); Tri-County Metropolitan Transportation District of Oregon (Tri-Met); Jacksonville Transportation Authority (JTA); and Pinellas Suncoast Transit Authority (PSTA). Below is a summary of what we learned from the survey responses.

GUIDEWAY/DESIGN FEATURES IMPLEMENTED BY AGENCIES

Preferences among respondents emphasize the need for flexibility in design to meet the unique demands of the BRT system. On average, respondents selected six (6) out of the eleven (11) potential bus priority tools. This underscores a collective interest in a holistic approach that combines physical infrastructure improvements with operational enhancements. Tools can be deployed in tandem with one another in the same corridor to provide cumulative benefits. For example, implementing dedicated guideway along portions of (or an entire) corridor in combination with transit signal priority (TSP) at intersections can improve operations throughout the corridor by mitigating congestion and reducing overall delay.

Approximately 75% of BRT systems from survey responses have some type of dedicated guideway (median, side or curb running) and 75% of systems operate in mixed flow, for some or all of their corridor, which highlights the flexibility of BRT. Notably, participants also introduced novel elements such as "5-door buses," "BAT lanes; HOV lanes," and "truck/transit priority streets or busways," indicating a willingness to explore innovative solutions. The variation in support for Transit Signal Priority suggests differing perspectives on the balance between schedule adherence and operational flexibility.

WHAT AGENCIES WISHED THEY KNEW BEFORE IMPLEMENTING BRT

The responses to the inquiry on insights desired before embarking on BRT roadway infrastructure planning and design provide valuable perspectives from experienced practitioners. A consistent theme is the crucial need for upfront agreements and strong leadership among collaborating agencies, as exemplified by a representative from NYCDOT with extensive BRT corridor experience. The preference for median stations emerges as a recurrent focal point, grounded in their perceived advantages in construction feasibility, cost-effectiveness, and enforcement challenges. Transit Signal Priority (TSP) is emphasized as an ongoing process requiring continuous monitoring and adjustment for optimal performance, highlighting its dynamic nature.

The paramount importance of community engagement is evident, with respondents expressing a desire for early and inclusive involvement, recognizing the substantial influence of community opinions on project outcomes. Other notable insights include the absence of AASHTO standards for BRT design elements, challenges in persuading cities to prioritize transit over automobiles, and the evolving nature of toolkits and enforcement methods. Collectively, these responses underscore the nuanced nature of BRT planning, advocating for comprehensive agreements, sustained community engagement, and a nuanced understanding of the local context and stakeholder dynamics for successful and sustainable implementation.

San Bernardino, CA - SBX

WHAT WOULD AGENCIES CHANGE IN HINDSIGHT

Through analysis of survey responses on retrospective insights into BRT roadway infrastructure, a clear and unanimous theme emerges – the vital need for improved delineation and separation of bus-only lanes. Respondents uniformly advocate for clearer demarcation, emphasizing measures like barrier separation and red-carpet lanes, recognizing their significance in enhancing operational efficiency and traffic management within BRT systems.

Simultaneously, a consistent concern is identified — the call for enhanced maintenance practices to ensure the reliability and safety of BRT infrastructure, including snow removal, trash clearance, and warning edge strip repair. Additionally, the consideration of queue jumps or dedicated right-of-way surfaces as pivotal for prioritizing BRT within traffic flow. Strategic reflections on route alignment underscore the importance of meticulous planning for passenger safety, and concerns about station placement, signage, and Transit Signal Priority (TSP) infrastructure are raised. The responses also highlight the need for adaptive toolkits, emphasizing annual adjustments to suit specific corridor needs in dynamic urban environments.

TOUGH DECISIONS MADE IN PLANNING/DESIGN OF BRT THAT WORKED OUT

Survey responses on tough decisions in the planning and design of BRT roadway infrastructure reveal a collective willingness among respondents to prioritize efficient bus operations over ideal traffic conditions. The most common sentiment, expressed by many, underscores the importance of making strategic trade-offs for the overall functionality of the BRT system. This theme is evident in decisions like acquiring surface parking lots to compensate for the loss of parking, maintaining center-running bus-only lanes despite resistance, and investing in roadway infrastructure.

Simultaneously, the responses showcase a diverse range of tough decisions, including addressing traffic congestion, removing parking, and cutting landscaping beds. Notable choices involve innovations like shared pedestrian/bike platforms and independent investments in roadway infrastructure, reflecting a commitment to explore unconventional yet effective solutions. However, the complexity of decision-making in BRT planning is underscored by some respondents expressing regret for opting for complex construction solutions, emphasizing the need for simpler approaches. In essence, the survey responses highlight the intricate balance required in navigating competing priorities for optimizing functionality and ensuring the long-term success of BRT projects.

BUS LANE WIDTHS

Bus lanes implemented at those transit agencies surveyed ranged from 10 to 12-feet, however, they also acknowledged that the wider the bus lanes, the better. They believed that anything under 11-feet seemed to cause incidents and/or concerns. Highway-based BRTs prefer a minimum of 11-feet and range up to 17.5 feet (Pace Suburban Bus, Chicago).

POTENTIAL CONFLICTS/SAFETY ISSUES

One of the questions asked of the transit agencies was regarding any conflicts/safety issues they may have experienced along the roadway between buses, pedestrians, and bicycles. Below is a summary of responses:

- Issues in curb lanes
- Pedestrian crossings at signalized and unsignalized intersections did raise some safety concerns, including left turn movements and conflicts with pedestrians from vehicles illegally using the bus lanes
- Issues with multiple municipalities and DOT requirements regarding signalized intersections and control of roads. Agencies were required to make pedestrian improvements to roads that the agency doesn't control. This caused hang up with regulatory controls (this isn't an agency concern- rather a responsibility of the city, traffic engineers and DOT's). Agencies also cited cyclists using the bus lane as a bike lane as a conflict/safety issue.
- Bus-Bike lane conflicts; cars behind the bus and cars already in the interior lane- near misses often occur
- Concerns expressed over shared bus/bike lanes pointing to the need to implement protected bike and bus lanes
- Some issues expressed with parallel bike lanes at stations
- Some stated issues with the pull out on major corridors
- Issues with motorists using the through lanes to make turns rather than the BAT lanes- causes collisions and near misses

ADVICE AGENCIES WOULD GIVE OTHERS REGARDING BRT PLANNING

All of the agencies surveyed seemed more than willing to provide advice to those who might be contemplating BRT for the first time. Some of the suggestions are included below:

- Visit other agencies to meet with their operations, maintenance, and safety staff
- Agencies considering precision docking should build a training station platform for drivers to practice
- Agencies should identify and coordinate with all stakeholders: Cities, traffic engineers, transit provider, DOTs - work on MOU's early in the planning stages
- Use Median running ways- construction, costs and fleet costs can be high otherwise
- Plan the service before you plan the infrastructure
- Be bold with the 1st build- it sets expectations on additional lines – including pushing for the maximum amount of dedicated lane mileage possible.

WHAT ELEMENTS OF BRT BELIEVED ESSENTIAL TO ITS SUCCESS

Most agencies clearly indicated that the number one key element of BRT is dedicated bus lanes. Bus lanes coupled with Transit Signal Priority (TSP), which all agencies have implemented, provide the greatest benefits and improvement in travel time and service reliability. Although some agencies have either some segments of their BRT and/or all of their BRT in mixed flow, the implementation of dedicated bus lanes maximizes the potential of operational advantages and success. This, however, speaks to the flexibility of BRT in that you can have a mix of BRT configurations in order to accommodate the different rights-of-ways along an alignment and still see significant improvements, particularly when combined with other BRT elements. Other elements employed by agencies include median-running and left-door boarding; fiber and communications at signalized intersections and stations, highly visible stations with strong branding, proper scheduling and operations, dispatching, and a variety of curb-running, center/median – running and mixed flow BRT.

ENFORCEMENT OF BUS LANES

Bus lane enforcement and/or lack of bus lane enforcement may result in some impact on the effectiveness of bus lanes. The lack of enforcement could lead to many violations by regular vehicles opting to operate in them anyways or illegally parking in the lanes. A notable number of the agencies surveyed reported the absence or lack of enforcement of their dedicated bus lanes. Some agencies, however, rely on police enforcement, although this is typically not a high priority for law enforcement. Some other agencies have implemented other sophisticated measures, such as camera enforcement using a combination of on-bus and fixed street cameras. Other agencies find that painting the bus lanes red helps with enforcement, thereby reducing violations, while others rely mostly on signage and street markings.

PAINTING OF BUS LANES (RED)

Many agencies have chosen to paint their bus lanes red. This practice has become more than just an aesthetic consideration, but has proven to have other benefits as well, such as fewer bus lane violations and conflicts. The red bus lanes clearly delineate where regular vehicles should and should not operate. Several participants acknowledged the use of red paint in bus lanes, noting an apparent improvement in adherence by regular vehicles, although quantifying this improvement remains challenging. A recurring theme regarding the painting of the bus lanes red is the cost-effectiveness debate, balancing better compliance against the maintenance cost and upkeep of red lanes. The insights suggest that while red lanes are visually striking and potentially improve rule adherence, their upkeep is resource-intensive, raising questions about long-term sustainability and effectiveness. Some agencies are choosing to not use red lanes, but instead continue to mark bus only lanes through the use of signage.

NYC – Select Bus Service

POTENTIAL SAFETY ISSUES WITH VEHICLES TRAVELLING IN BUS LANES

Dedicated bus lanes can also improve safety by reducing conflicts between buses and vehicles, thereby potentially reducing accidents on those streets. Of the 12 responses received, many participants indicated minimal safety concerns, with one mentioning the benefits of 24-hour lanes for traffic calming. Another response highlighted some initial issues with a contra-flow bus lane leading to crashes, but these diminished over time, suggesting a learning curve for drivers. Key insights from these responses include plans for implementing safety measures such as flexible delineators, enhanced pavement markings, and additional signage. One notable approach involves designing lanes where unauthorized use by drivers is inconvenient rather than dangerous, indicating a strategic balance between safety and practicality.

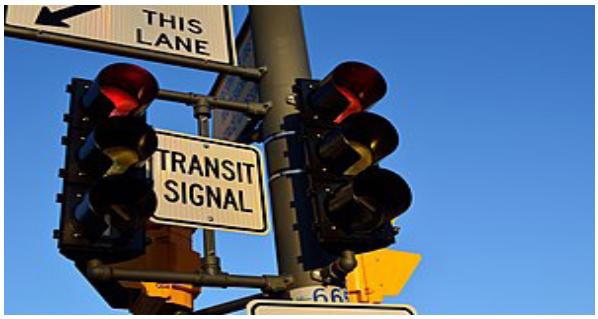
OTHER ITS ELEMENTS IMPLEMENTED WITH BRT

Of the responses received, the following are some of the key ITS elements employed as part of their systems:

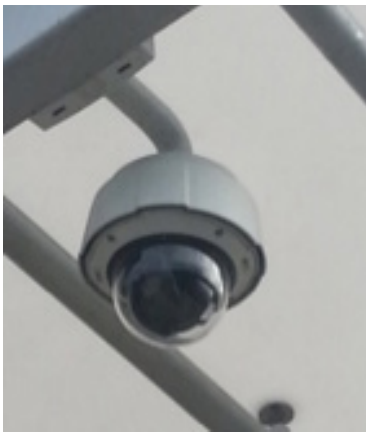
- Transit Signal Priority (TSP), various types including cloud-based GPS; reduces the amount of time a bus is sitting at a red light
- CAD/AVL-based lane control
- Headway management is the process of controlling the spacing and timing of vehicles in a transit system. It is very different than your typical schedule-based service.
- Cameras
- Passenger information signage/next bus systems
- SCADA Systems / Operations Control Center

In terms of any issues related to some of the ITS elements, TSP raises the most concerns for several agencies, concerning its effectiveness and ability to obtain regular reporting. Some agencies are transitioning to cloud-based technology to improve TSP. GPS/cloud-based TSP is best as the maintenance is minimal and priority can be easily adjusted remotely.

Next Bus Information Displays



Transit Signal Priority


Security Cameras

Emergency Phones


Ticket Vending Machines

POTENTIALLY OUTDATED AND/OR UNDERPERFORMING TECHNOLOGY

There was definitely a consensus on the suboptimal performance of TSP, though the exact causes of these shortcomings were not always clear. Respondents pointed out policy restrictions, such as limited frequency of TSP activation, and the impending obsolescence of certain hardware components, necessitating upgrades.

One agency had concerns with Ticket Vending Machines (TVMs) on their system being overbuilt and having maintenance concerns. These responses underscore the challenges in integrating advanced technologies within existing policy and infrastructure frameworks, highlighting the need for continual assessment and adaptation of technological strategies in BRT systems.

IMPLEMENTATION OF NEWER AND/OR MORE ADVANCED TECHNOLOGIES

There was a common theme of dissatisfaction or challenges with TSP systems. Some respondents indicated that TSP is not performing as well as expected, but the specific reasons for this underperformance were ambiguous. It is suggested that the issues might relate to various factors, including operational practices, bus schedules, or inherent roadway issues. The responses also touch upon external policy constraints that impact the efficiency of TSP systems.

Additionally, the necessity for technological upgrades was highlighted, with a specific mention of the need to replace communication modules soon due to support and compatibility issues. This response underscores the ongoing challenge in BRT systems of keeping up with technological advancements and ensuring that existing infrastructure remains functional and effective.

CHAPTER 4 — CASE STUDIES

CASE EXAMPLE 1 – Connecticut Department of Transportation (CTDOT)

The Connecticut Department of Transportation is responsible for the development and operation of highways, railroads, mass transit systems, ports and waterways in Connecticut. CTDOT manages and maintains the state highway system.

https://www.cttransit.com/about/about-ctfastrak

CASE EXAMPLE 2 – OmniTrans (San Bernardino, CA)

Omnitrans is the public transit agency serving the San Bernardino Valley, providing safe, reliable, affordable, friendly and environmentally responsible transportation. Omnitrans currently operates local and express bus routes, sbX bus rapid transit service, and Access, a paratransit service for the disabled.

https://omnitrans.org/routes/sbx-green-line/

CASE EXAMPLE 3 – Metro Transit (Minnesota)

Metro Transit is the transportation resource for the Twin Cities, offering an integrated network of buses, light rail, BRT and commuter trains as well as resources for those who carpool, vanpool, walk or bike. Metro Transit is developing a network of enhanced transitways throughout the region.

https://www.metrotransit.org/brt

CASE EXAMPLE 4 – The Capital District Transportation Authority (CDTA)

CDTA provides mobility solutions that connect the Capital Region with support from a large network of partners. CDTA is focused on expanding their mobility menu to offer a cohesive and flexible transportation network for their customers that includes regular routes, bus rapid transit, express, on-demand transit (FLEX), bike share (CDPHP Cycle!), electric car share (DRIVE), seasonal trolleys, park and ride, and paratransit service for customers with disabilities.

https://www.cdta.org/

CASE EXAMPLE 5 – Milwaukee County Transit System (MCTS)

The Milwaukee County Transit System (MCTS) is innovating the way people across southeast Wisconsin get to work, school, medical appointments, entertainment and anywhere else they need to go. The East-West Bus Rapid Transit (BRT) route called CONNECT 1 gives riders convenient access to employment, education and recreation in downtown Milwaukee, Milwaukee's Near West Side, Marquette University, Wauwatosa and the Milwaukee Regional Medical Center. Planning is underway to develop a second CONNECT BRT to improve one of the busiest routes in their system along 27th Street.

https://www.ridemcts.com/who-we-are

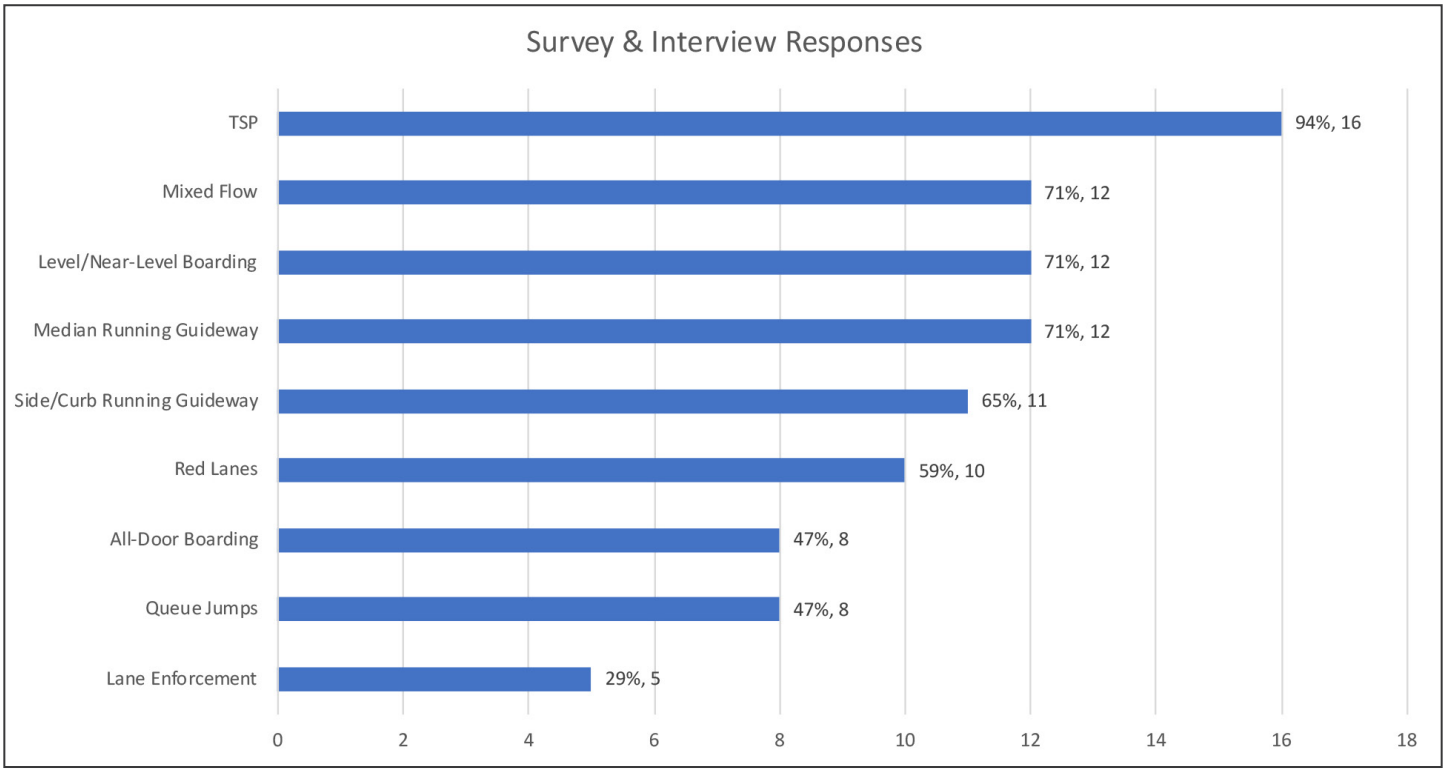
CASE EXAMPLE 6 – Greater Cleveland Regional Transit Authority (RTA)

The Cleveland Regional Transit Authority (RTA) provides transportation services for 150,000-200,000 customers on a typical weekday, or about 45 million rides annually, through a variety of services. BRT – The HealthLine on Euclid Avenue provides service and operational characteristics associated with rail, with rubber-tired Rapid Transit Vehicle (RTVs). The HealthLine operates 24/7, with a rush-hour frequency of every 8 minutes. In December 2014, RTA added a second BRT service, the Cleveland State Line, which connects the West Shore communities with Downtown, via Clifton Boulevard.

https://www.riderta.com/overview

CHAPTER 5 — SUMMARY OF RESPONSES

Below is a table summarizing all of the survey and interview responses.



CHAPTER 6 — LESSONS LEARNED

As a result of this work effort, we found that all of the agencies surveyed and/or interviewed had many lessons learned that they were more than willing to share with those contemplating BRT. One of the most prominent lessons learned was the need to coordinate early with your Department of Transportation (DOT) and City Traffic Engineers. It is important to bring your DOT in as an actual project partner, as they need to be more than just a stakeholder.

Other lessons learned included:

- Be bold with first build if it's even remotely possible, as it sets expectations for future lines; start with the most assertive design and then compromise where necessary
- Make sure to visit other systems; talk to operations, maintenance, and safety teams; build a "training station platform" at the facility for drivers to train on for precision docking; establish inter-local agreements with roadway owners for long term maintenance
- Implementing BRT requires a mind shift in how we allocate space on the roads to protect long-term capacity not just short-term solutions to increase vehicular traffic flows

- Consider what roadway jurisdiction may have as permitting requirements early; signal upgrades at one agency triggered full intersection reconstruction with new stormwater facilities; involving the City earlier as part of the project could have changed the outcome at one agency

- Work hard to coordinate between City DOT (or whomever owns the streets) and the transit operator; have MOU that determines who is responsible for what; work constantly at coordination and understanding each other's issues; coordination at the highest levels between operating agency and DOT/Streets agency is critical; decide who decides what

- Plan the service before planning the infrastructure; if flexibility is needed to reflect changing travel patterns and travel demand, then choose side-running lanes; analyze who will benefit and who will be burdened by the lanes; remove left turns and set up an MOU to help protect that decision (center/median running)

- Opposition will be likely if converting a general use lane into a BRT lane if there is not a lot of service operating in the lane or high ridership in the corridor; service is what generates ridership, not infrastructure; the two are needed together to get good results and make a strong case for the capital investment

- Know why — and make it be known; build political will early and often; identify stakeholders; create a space where the rider has a voice

- Communicate that BRT is more than a new bus line

CHAPTER 7 — CONSIDERATIONS/BEST PRACTICES

In conducting this effort, including both the survey and individual interviews/case studies with transit agencies, there were some definite overarching themes and/or thoughts on best practices when considering BRT. Some of these overarching themes include:

- Bus lanes/dedicated ROW recognized as providing the greatest speed and reliability benefits of all BRT elements; Those with mixed flow only may want to really consider this as possibly a next phase

- TSP is second most important BRT element particularly when applied along with dedicated bus lanes; however, even without bus lanes, improvements in travel times can be realized with TSP, particularly with some of the other BRT elements like less frequent stops

- Most agencies had a combination of mixed/side/or center/median running BRT which illustrates the flexibility of BRT vs. rail

- Most had things they felt that they could have done better, or had lessons learned while implementing BRT

- Some preferred median running bus lanes as they believed that they created a better sense of permanence however, not doable at all agencies, hence the use of multiple configurations for many properties

- Most agencies did not have lane enforcement, though more than half had red painted lanes which helped but also requires more maintenance

- ITS elements mainly included TSP and some ITS elements at stations

CHAPTER 8 — CONCLUSION

The Roadway Subcommittee, and APTA BRT Committee as a whole, hope that the information provided in this White Paper aids in the successful implementation of numerous BRT systems. The goal is to provide both the benefits and challenges of implementing BRT through an unbiased presentation of survey results and case studies.

The results of the roadway infrastructure and design questions demonstrate the flexibility of BRT systems. Flexible systems are important, especially since many BRT systems operate in dynamic urban environments. Respondents utilized a mix of roadway infrastructure tools to implement various unique BRT systems. While a majority of BRT in this survey operate at least a portion of the system in some form of dedicated bus lanes (median, side, or curb-running), a majority also have a portion of the system that also operates in mixed flow, which highlights the flexibility of BRT. It was frequently mentioned that upfront agreements and strong leadership, along with community engagement, are vital in the planning of BRT systems.

Many of the challenges associated with implementing BRT are related to making strategic trade-offs for the overall functionality of the BRT system, including repurposing parking and general travel lanes, and impacting existing curbside use. Other challenges noted include the struggles of efficiency and effectiveness of TSP. However, respondents are hopeful that a shift toward GPS and cloud-based TSP systems will increase reliability. Another key theme of TSP is that it requires a continual assessment and adaptation (don't "set it and forget it").

What's next? The survey responses noted that there is a lack of national standards. Moving forward, the transit community would benefit from unified standards and best practices. The Roadway Subcommittee is optimistic that national standards will be adopted across the industry, and excited to see what innovative solutions our industry develops!

APTA Roadway Subcommittee Members

Martha Butler, Los Angeles Metro (Chair)

Steve Scheerer, AECOM (Vice Chair)

Adam Halpin, Parsons

Angela Cristo, AECOM

Arturo Herrera, VIA Metropolitan Transit

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The Roadway Subcommittee would like to thank APTA BRT Committee Chair Mark Huffer for his guidance and feedback on this white paper.

APPENDIX A — Study Survey

APTA BRT Committee – Roadway Subcommittee

Survey Questions for Transit Agencies and Local DOTs

ROADWAY INFRASTRUCTURE/DESIGN

1. Please provide a brief overview of your BRT roadway infrastructure (type of guideway or other design features to reduce delays and improve the performance of the BRT system). (Median guideway, side/curb running guideway, mixed flow, red lanes, TSP (conditional or unconditional), queue jumps, lane enforcement, all-door boarding, level/near-level boarding, other)

2. What do you wish you knew before you began the planning and/or design of your BRT roadway infrastructure?

3. What, if anything, would you change with respect to your BRT roadway infrastructure in hindsight (e.g., near-side vs far-side stations, jay walking at stations, etc.)?

4. What tough decision did you make in the planning and/or design of your BRT roadway infrastructure that in hindsight you are glad you made (loss of parking, some element you wanted to include but couldn't, etc.)?

5. What are the widths of your bus lanes? If you could revise the design, would you change the bus lane widths and why?

6. What are some of the conflicts/safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?

7. What advice with respect to BRT roadway infrastructure would you give to other agencies or cities who are embarking on their first BRT system?

8. What elements of your BRT infrastructure is essential to its success?

9. Who maintains the different elements of your BRT roadway infrastructure?

10. Is there anything else you would like to share with us about your system?

ENFORCEMENT OF BUS LANES/BRT SYSTEM

1. Do you have enforcement of the dedicated bus lanes? If yes, what type of enforcement is used (dedicated police or camera enforced, any other means of enforcement)? If not, do you plan to implement enforcement in the future?

2. Do you utilize red coloring in any of your bus lanes? If so, do you have any insights into general purpose compliance with red lanes vs. those without red coloring? Pros and cons of end-to-end painted bus lanes, including maintenance of the painted lanes.

3. Have you experienced any safety related concerns due to general purpose vehicles traveling in the bus lanes? If so, how are you approaching the issue?

ITS RELATED

1. What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?

2. What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations?

3. Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology in optimizing BRT performance and managing bus signal priority, traffic, etc., along roadways?

APPENDIX B — CASE STUDIES/INTERVIEW RESPONSES

APTA BRT Committee – Roadway Subcommittee

Survey Questions for Transit Agencies and Local DOTs

NAME OF AGENCY: Connecticut Department of Transportation (CTDOT)

Interview conducted by Steve Scheerer on 9/7/2023

Contact Name: Mike Sanders with Rich Armstrong

Contact Information: Mike was CTDOT's Transit Administrator during the planning, design development, and construction. "Godfather of CTfastrack". Rich highway background. Team of PMs and engineers when with DOT. Was going to be d/b originally; needed legislative approval. Managed design process with several consultants.

Struggle through new starts, politics. More of an operations guy. Wacky architects. Worked on soup to nuts. regional study, EIS, funding channels, post-op adjustments

ROADWAY INFRASTRUCTURE/DESIGN

1. **Please provide a brief overview of your BRT roadway infrastructure (type of guideway or other design features to reduce delays and improve the performance of the BRT system). (Median guideway, side/curb running guideway, mixed flow, red lanes, TSP (conditional or unconditional), queue jumps, lane enforcement, all-door boarding, level/near-level boarding, other)**

   Type of guideway: dedicated guideway. At-grade intersections (3-5); signalized. Have worked on signal preference (originally actuator with pavement loops). 300 yards – 500 yards; generally worked ok. Extensions of 9.6-mile guideway at intersections. Enforcement by state police. All-door and level boarding. All platform access payment; no payment on bus. Rub rail on platform. level boarding for floor height. Boarding ramp for wheelchairs. The ramps couldn't deploy. Stripe for operators to align front door.

   Working on autonomous operations – precision docking – the technology contractor is asking to back out (from New Flyer). Some rub rails have taken a beating, but buses have been generally ok – minor markings from rub rail. Deceleration length and approach angles help with docking. Passing lanes – bus pullout – at each station. Architects went with 90' instead of 120' platforms – wish they would have gone with 120'. Two artics can't dock.

2. **What do you wish you knew before you began the planning and/or design of your BRT roadway infrastructure?**

   Architects and engineers are highway and don't understand BRT. "just building a highway" – but didn't understand transit amenities. Shelters don't reach the edge of platforms – get wet between shelter and

bus. Gaps in sidewalls of shelters due to design issues. DOT didn't have dedicated PM. Fought for concrete roadway, only got concrete at stations – thankful for no asphalt rutting at stations, would have liked full concrete. Life cycle cost analysis? One of first to go through new start. Applied earlier than they should have. Start/different marketing from the very beginning. Promote as a grander system. Called New Britton to Hartford busway originally – many people didn't understand/care. Too many cooks in the kitchen; too many consultant designers; expected coordination, but not much incentive.

Internal opposition at DOT.

3. **What, if anything, would you change with respect to your BRT roadway infrastructure in hindsight (e.g., near-side vs far-side stations, jay walking at stations, etc.)?**

   Ped signals with push buttons and crosswalks; no RRFBs at the time – eventually built
   Station landscaping; parking lot design – minor issues

4. **What tough decision did you make in the planning and/or design of your BRT roadway infrastructure that in hindsight you are glad you made (loss of parking, some element you wanted to include but couldn't, etc.)?**

   One section was going to be one-way due to budget, but bids came in low so they could change order "full" design. Cost effectiveness measure from New Starts. Why not just buy the railroad? Amtrak wanted out at the beginning. Maybe a little light on parking. Bought out 3 businesses. Didn't get a lot of "why didn't you do this" after operations started.

   (Spent a lot of money on RR issues 100/500 million – ROW acquisition, bridge over RR, at-grade crossing, rail traffic control)

5. **What are the widths of your bus lanes? If you could revise the design, would you change the bus lane widths and why?**

   12' – no median barrier, rumble strips (?) (wanted them, but DOT maybe said no?)
   Limited shoulders; 12' bus pull-off stops with median barriers

6. **What are some of the conflicts/safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?**

   4-5 miles of SUP parallel. Only interaction at stations

7. **What advice with respect to BRT roadway infrastructure would you give to other agencies or cities who are embarking on their first BRT system?**
   Different advice for fixed vs on-street. Service planning – try to sell benefits of dedicated lanes. Reliability, frequency of service.

8. **What elements of your BRT infrastructure is essential to its success?**

   Guideway, shelters (with heat – presence detectors), off board fare collection (proof of payment), "make it pretty". "Didn't go cheap", built things that look nice, and maybe cost more.

9. **Who maintains the different elements of your BRT roadway infrastructure?**

   DOT – state highway number; amenities "we" maintain, DOT via contract – shelters, TVM
   Roadway/signals – DOT.

10. **Is there anything else you would like to share with us about your system?**

    Meet between highway and transit design. Neither side can be too rigid. Original haters are now in support.

ENFORCEMENT OF BUS LANES/BRT SYSTEM

1. **Do you have enforcement of dedicated bus lanes? If yes, what type of enforcement is used (dedicated police or camera enforced, any other means of enforcement)? If not, do you plan to implement enforcement in the future?**

2. **Do you utilize red coloring in any of your bus lanes? If so, do you have any insights into general purpose compliance with red lanes vs. those without red coloring? Pros and cons of end-to-end painted bus lanes, including maintenance of the painted lanes.**

3. **Have you experienced any safety related concerns due to general purpose vehicles traveling in the bus lanes? If so, how are you approaching the issue?**

ITS RELATED

1. **What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?**

2. **What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations?**

3. **Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology in optimizing BRT performance and managing bus signal priority, traffic, etc., along roadways?**

OTHER DISCUSSION

Fiber the entire length? Either in guideway or along Amtrak
Occasional trespassers (vehicles)
Cameras along length
Some drug user issues at stations

NAME OF AGENCY: sbX Green Line

Interview conducted by Peter Merry on 6/26/2023

Contact Names: Anna Jaiswal, Development Planning Manager; **Ben Greenbeck,** System Coordinator for ITS; **Thomas Dahlin,** Capital Project Services Manager

1. **What are the infrastructural elements of this BRT Line?**

- 15-mile corridor, 5 miles of which are dedicated median-running
- Elevated 13in. platforms with level boarding
- Center running is left-door boarding, side-running is right-door boarding
- TSP system connects to wireless network which "checks in" with the next intersection
  - No feedback from the intersection controller
  - 10-year-old system has aged the system, repairs currently in progress

2. **Is there anything that you wish you knew before you began the planning or design of your BRT infrastructure?**

- Lack of communication with the jurisdiction over funding (city was in bankruptcy)
- Many municipalities have not worked with TSP
- Many cities don't have emergency vehicle preemption
- Municipalities are worried about cyber-security (traffic data being sent to the control center and potentially being hacked into)

3. **In hindsight, is there anything that you wish you could change with respect to your BRT infrastructure?**

- Due to lack of right-of-way acquisition, a jog in the lane at some intersections has caused safety concerns for drivers
- Installing physical barriers (curbs in the median), to prevent people from making left-turns out of driveways into bus lanes
- The unique branding of sbX has caused many customers to think it's a completely different agency. New branding will incorporate the Omnitrans brand more fluidly.
- In core urban areas, station stops were too far away, causing some people to not want to walk. The next line will have stops more frequently in dense areas.

4. **What are the widths of your bus lanes? If you could revise the design, would you change the bus lane widths and why?**

   - 11ft. minimum, but most are 12 ft.
   - Lanes can feel tight on winding roads, but hasn't been a safety issue

5. **What are some of the conflicts/ safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?**

   - There are intersections with left-turn pockets to the right of the bus. When the bus gets a green, cars will often jump out in front of the bus assuming it's also going to make a left turn

6. **What advice with respect to BRT would you give to other agencies or cities who are embarking on their first BRT system?**

   - Take care of utilities early in order to avoid any surprises later down the road
   - Ensure that there are no issue areas along the route with regard to utilities
   - Get lots of peer-review on the plans
   - Make sure the agency in question is deeply involved with the design, particularly people in operations

7. **Who maintains the different elements of your BRT roadway infrastructure?**

   - Omnitrans maintains the immediate station areas and the cities maintain everything else (landscaping, dedicated lane medians)
   - Make sure to be very specific about who does what when in the planning phase

ITS RELATED

1. **What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?**

   - Some of it is cloud based, and they are moving further in that direction.

2. **What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations?**

   - The heat, in addition to the age of the system, has led to a fair amount of maintenance and replacement. And much of the technology is now out of date.

3. **Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology, in optimizing BRT performance?**

   - A 3-year contract for TSP monitoring and control from a 3rd party that will oversee and maintain the whole system.

ENFORCEMENT

1. **Do you have enforcement of dedicated bus lanes? If yes, what type of enforcement is used**

   - There is a patrol in the evening hours, and the police have a general knowledge of enforcement, but there is very little enforcement.
   - Bicyclists often get in the median lanes

2. **Do you utilize red coloring in any of your bus lanes? If so, do you believe there is any impact on compliance with red lanes vs. those without red coloring**

   There is a general consensus that red lanes lead to a better compliance with the rules.

NAME OF AGENCY: Metro Transit (Minnesota)

Interview conducted by Angie Christo

Contact Name: Jonathan Ahn

Contact Information:

ROADWAY INFRASTRUCTURE/DESIGN

1. **Can you please provide a brief overview of your BRT roadway infrastructure (median guideway, side or curb running, other design features to reduce delays and improve the performance of the transit system, etc.)?**

   Currently not major dedicated BRT infrastructure. Metro Gold Line will be the first dedicated guide-way. Currently block by block designation need Lake St. Highway BRT (red & Orange). A line is arterial BRT (no dedicated lanes, does run on shoulder for parts of Hwy 51).

2. **What do you wish you knew before you began the planning and/or design of your BRT roadway infrastructure?**

   Better coordination with the roadway authorities on project timing. Impacts project development and timing. If BRT in the corridor does not line up with City/ County timelines that creates issues. Example, Lake St was reconstructed recently, so this constrained BRT project elements.

3. **What, if anything, would you change with respect to your BRT roadway infrastructure in hindsight (e.g., near-side vs far-side stations, jay walking at stations, etc.)?**

   Far side by default, and MT is happy with that configuration. Any near-side is due to constraints. Some location specific coordination is done for shared local & BRT platforms. Looking at longer term coordination of overall routes and BRT.

4. **What tough decision did you make in the planning and/or design of your BRT roadway infrastructure that in hindsight you are glad you made (loss of parking, some element you wanted to include but couldn't, etc.)?**

   Originally A line platform (1st BRT) designed with BRT stopping in front, local buses behind (in a slight cutout). There is a splitgate at some locations. Passengers are confused about where to wait, and this impacted dwell time. Scrapped practice after A line. BRT platform is now shared with local routes, so there is one stop location.

5. **What are the widths of your bus lanes? If you could revise the design, would you change the bus lane widths and why?**

   Preferred is 11 ft, absolute minimum is 10.5 ft. Absolute minimum may be on a curb lane (with extra 2 ft).

6. **What are some of the conflicts/safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?**

   9 in boarding platform and seeing some incidents where the mirror is within the platform area when docking.

7. **What advice with respect to BRT roadway infrastructure would you give to other agencies or cities who are embarking on their first BRT system?**

   Not an isolated corridor, design decision will impact future BRT and local routes. Take your time making system wide decisions (such as platform height, fleet, platform locations, left loading door etc., impacts the whole system).

8. **What elements of your BRT infrastructure is essential to its success?**

   Higher platform and off-board fare payments at all stations, consistency is essential.

9. **Who maintains the different elements of your BRT roadway infrastructure?**

   MT maintains BRT stations. Road authority maintains roadways, including red paint. Working to have a cost sharing agreement to maintain the red paint. MT would an exclusive guideway (in future when Gold Line is operating).

10. Is there anything else you would like to share with us about your system?

    Trying to be flexible and nimble of what the system looks like. Highway BRT, arterial BRT and guideway. Working to be consistent under the branding to provide service quality to customers. Using different tools for different contexts.

ENFORCEMENT OF BUS LANES/BRT SYSTEM

1. **Do you have enforcement of the dedicated bus lanes? If yes, what type of enforcement is used (dedicated police or camera enforced, any other means of enforcement)? If not, do you plan to implement enforcement in the future?**

   No current enforcement. Working with roadway authorities to formalize the agreement on how this will work. MT does have its own Police force.

2. **Do you utilize red coloring in any of your bus lanes? If so, do you have any insights into general purpose compliance with red lanes vs. those without red coloring? Pros and cons of end-to-end painted bus lanes, including maintenance of the painted lanes.**

   Yes, there are currently some in blocks and for queue jumps. Costs of paint have been significantly higher in the past couple of years. Looking into options / alternative painting that is consistent with MUTCD (waiting for new guidance to be published).

3. **Have you experienced any safety related concerns due to general purpose vehicles traveling in the bus lanes? If so, how are you approaching the issue?**

   Not a large number, so it may be more of an issue with vehicles parking in the bus lane. Not a safety concern at this time.

ITS RELATED

1. **What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?**

Cad AVL is the same system as the local buses. TSP at most intersections in the BRT corridors. The parameters for BRT station intersections are different than local routes (varies by near and far side). Not sure of pros and cons, they do not have access to the roadway signal logs, would need to get a data request to know if the TSP call was accepted.

2. **What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations?**

   Not sure if the TSP is performing up to expectations (based on #1).

3. **Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology in optimizing BRT performance and managing bus signal priority, traffic, etc., along roadways?**

   Started looking into next generation TSP, that provides a more predictive technology and reliability. Looking at active headway management (vs measuring schedule adherence). Would look at headway-based service.

NAME OF AGENCY: Capital District Transit Authority

Contact Name:

Contact Information:

ROADWAY INFRASTRUCTURE/DESIGN

1. **Can you please provide a brief overview of your BRT roadway infrastructure (median guideway, side or curb running, other design features to reduce delays and improve the performance of the transit system, etc.)?**

   CDTA operates two BRT lines (Redline in 2011/Blueline in 2020) with a third (Purpleline) coming online on November 5, 2023. All three include a combination of Traffic Signal Priority (TSP) and Queue Jumpers with dedicated bus only lanes (for QJ only) and curb bump outs and cut ins at select locations. Limited stops, near side stops, combined with TSP, QJ, and 8-15 minute frequencies help to optimize the overall performance. The third BRT will have a dedicated roadway through the University at Albany campus, which will be built by CDTA. Also, CDTA built a traffic circle at the entrance to the largest major shopping mall in the region, which is also a key timepoint along the BRT line designed to improve the overall running times and performance of the route and general traffic flows. Traffic simulation modeling is underway to assess the effectiveness of traffic signal preemption at three intersections along the newest BRT line to minimize the overall impact on traffic flow within the City of Albany.

2. **What do you wish you knew before you began the planning and/or design of your BRT roadway infrastructure?**

   The largest challenges surrounding the project elements involve third party stakeholder cooperation. At least a couple of bus stops were either moved or eliminated based on community feedback and NIMBY resistance to BRT station construction at certain locations. The larger TSP, QJ, and dedicated bus lane infrastructure required similar cooperation with third party stakeholders. The latter (dedicated bus lanes) proving to be much more difficult along the Purpleline BRT through the NYS Harriman Office Campus in Albany. More recently, local pro-pedestrian groups in the City of Albany requested to have permanent pedestrian first calls without activation at every intersection in the City of Albany (76 total), which if passed, would remove any existing benefits of traffic signal priority. This remains under discussion with some consideration being given to several alternative approaches. Finally, the project would have benefited greatly by having a better understanding of the underground infrastructure layouts at all BRT stop and construction locations. Moreover, there were several long lead times for critical infrastructure such as signal poles and cabinets, which could have been mitigated with a better understanding of these risks.

3. **What, if anything, would you change with respect to your BRT roadway infrastructure in hindsight (e.g., near-side vs far-side stations, jay walking at stations, etc.)?**

   One obvious change would be to ensure no turn on red adjacent to traffic signal priority intersections, queue jump lanes, traffic signal preemption, and bus pads at all stations.

4. **What tough decision did you make in the planning and/or design of your BRT roadway infrastructure that in hindsight you are glad you made (loss of parking, some element you wanted to include but couldn't, etc.)?**

   The planning for enough space for possible conversion to a mobility hub with future electric bikes and charging stations. Most importantly, ensuring plenty of conduit for various communications, power, and related technology upgrades in the future.

5. **What are the widths of your bus lanes? n/a If you could revise the design, would you change the bus lane widths and why?**

   No change to the design was considered.

6. **What are some of the conflicts/safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?**

No significant conflicts occurred. On a related note, CDTA recently implemented video detection with traffic signal priority to gather more data and identify future opportunities to adjust traffic signal timing plans and add other pedestrian amenities, such as information kiosks. CDTA will be able to follow up on this later this year as data is collected and analyzed.

As was mentioned above, there are local pro-pedestrian groups in the City of Albany requesting to have permanent pedestrian first calls without activation at every intersection in the City of Albany (76 total), which if passed, would remove any existing benefits of traffic signal priority. This remains under discussion with consideration to several alternative approaches.

7. What advice with respect to BRT roadway infrastructure would you give to other agencies or cities who are embarking on their first BRT system?

The most important factor is cooperation and partnership or a lack thereof. If possible, establish any necessary partnership and/or agreement early on in the project as part of the funding application process by including secured agreements and/or memorandums of understanding. This will help avoid conflicts or issues after the project starts. Some more specific roadway infrastructure examples include snow removal, curb bump outs, cut ins, etc.

8. What elements of your BRT infrastructure is essential to its success?

The larger elements that put the rapid in bus rapid transit include but are not limited to traffic signal priority/preemption, queue jumpers, station cut in design/improvements, and of course, the aesthetic design improvements at each station including related community improvements such as landscaping, lighting, and cameras for safety (or at least the perception of safety).

9. Who maintains the different elements of your BRT roadway infrastructure?

The majority of roadway infrastructure is maintained by each of the different municipalities where it resides. All infrastructure connected directly to the station is maintained by CDTA, including TSP and QJ, shelters/stations, and related amenities such as landscaping, garbage cans at select locations, and any response to acts of vandalism or safety.

10. Is there anything else you would like to share with us about your system?

The project is not only a way to increase the overall running times of services, but a way to correct age old infrastructure issues. The coordination with municipalities and other stakeholders to work together to solve overall transportation issues is a rare opportunity to make on street improvements that are visible to the community at large. This also helps to build stronger relationships with stakeholders, while also making streets safer and more efficient for general traffic flow.

ENFORCEMENT OF BUS LANES/BRT SYSTEM

1. **Do you have enforcement of dedicated bus lanes? No. If yes, what type of enforcement is used (dedicated police or camera enforced, any other means of enforcement)? If not, do you plan to implement enforcement in the future?**

   Nothing planned at this time.

2. **Do you utilize red coloring in any of your bus lanes? Yes for QJ and bus only approach lanes. If so, do you have any insights into general purpose compliance with red lanes vs. those without red coloring? Pros and cons of end-to-end painted bus lanes, including maintenance of the painted lanes.**

   No significant pros or cons. They have held up well (since 2011 with first redline BRT) and compliance issues are kept to a minimum, which is likely due to the lower traffic volumes in the Capital Region.

3. **Have you experienced any safety related concerns due to general purpose vehicles traveling in the bus lanes? If so, how are you approaching the issue?**

   Only, occasional use by unsuspecting drivers.

ITS RELATED

1. **What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?**

   CAD/AVL, RTPI-GTFS, Cameras, TSP, QJ

2. **What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations? Fiber.**

   We have moved on to cellular. It works really well and reliably. Fiber optic communications infrastructure proved to be unnecessary. Kiosks and digital displays have been rethought several times. Solar powered kiosks with limited to no power infrastructure requirements have proven to be the most effective solution. E.g. https://soofadigital.com/

3. **Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology in optimizing BRT performance and managing bus signal priority, traffic, etc., along roadways?**

   - We are moving to the cloud for pedestrian and vehicular video detection and TSP with a new Miovision/GTT solution in the City of Albany at 76 intersections.

- We are utilizing more crowdsourced big data with Replica, Remix, Microsoft, and Moovit to analyze origin-destination travel patterns.
- We are considering digital bus stop signs to replace analog signage.
- We are expanding our network of solar powered information kiosks to select BRT timepoints and mobility hub locations.
- A more advanced mobility as a service mobile application with on-demand Microtransit, payment integration, and advanced trip planning with bikeshare, Uber and Lyft is to be deployed in late 2023.

NAME OF AGENCY: Milwaukee County Transit System (MCTS)

Interview conducted by Scott Tallman (HNTB) on 8/21/2023

Contact Name: David Locher- Manager of Enhanced Transit

Contact Information: dlocher@mcts.org, 414.343.1727

ROADWAY INFRASTRUCTURE/DESIGN

1. **Can you please provide a brief overview of your BRT roadway infrastructure (median guideway, side or curb running, other design features to reduce delays and improve the performance of the transit system, etc.)?**

   East-West Bus Rapid Transit (BRT) is Milwaukee County's 9-mile, regional, modern transit service connects major employment, education, and recreation destinations through downtown Milwaukee, Milwaukee's Near West Side, Marquette University, Wauwatosa, and the Milwaukee Regional Medical Center. BRT provides improved access to the region's most vital, most traveled and most congested corridor.

2. **What do you wish you knew before you began the planning and/or design of your BRT roadway infrastructure?**

   If you know the vehicle specifications, everything else will flow from that. For example, MCTS was going to pursue a purist BRT with 14" curb heights. However, as a mixed fleet operation (BEB and diesel), 12" became required. A difference in bus ride height would offer an inconsistent product when boarding or alighting the vehicle. Designing to cover your fleet initially is much easier than mid-way through.

3. **What, if anything, would you change with respect to your BRT roadway infrastructure in hindsight (e.g., near-side vs far-side stations, jay walking at stations, etc.)?**

   Maximizing far-side stations would be a great idea. However, in BRT design, MCTS adopted a lot from previous routes and complete re-design or ground-p design was not always possible. Where room

was tight at stations, some concessions may be necessary. For example, providing consistency to ADA ramp design is very important. If you are going to have a sloping ramp and a step-down on either side of the platforms you're not delivering consistency. Having sloped ramps are either side would be ideal, if possible.

4. **What tough decision did you make in the planning and/or design of your BRT roadway infrastructure that in hindsight you are glad you made (loss of parking, some element you wanted to include but couldn't, etc.)?**

   Dropping from 14" to 12" curb height proved to be a good decision in a mixed fleet operation. There is a trend for low floor 40' buses and getting close to the curbs at stops. With a 12" curb height MCTS anticipates greater longevity for the vehicles and platforms.

5. **What are the widths of your bus lanes? If you could revise the design, would you change the bus lane widths and why?**

   12 ft in the wider locations down to 11ft. MCTS would never go below 11 feet based on the width of the vehicles.

6. **What are some of the conflicts/safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?**

   The Milwaukee BRT is still relatively new. However, they have approximately 3200 average riders on a weekday and operated for Summerfest recently where the ridership was over 6000 per day. Fortunately, there have been very few conflicts to date.

7. **What advice with respect to BRT roadway infrastructure would you give to other agencies or cities who are embarking on their first BRT system?**

   Connect with utilities as soon as possible and make connections in the community early. Also make design second to outreach. Members of the community need to clearly understand what BRT will mean to their communities and roadways. It will prevent misunderstandings and upset in the long run.

8. **What elements of your BRT infrastructure is essential to its success?**

   There is not one element in particular but four items which are essential. The combined groupings of dedicated lanes and traffic signal prioritization are key. Additionally the pairing of platforms and off-board fare collections are essential to successful operations.

9. **Who maintains the different elements of your BRT roadway infrastructure?**

   It is a shared responsibility between MCTS, the respective municipalities and Milwaukee County. MCTS maintains the property in the stations themselves and has an underground snow melt system. The city sidewalks behind the platforms are maintained by respective municipalities and the county maintains the roads. However, where there are dedicated lanes for bus-only, MCTS receives an invoice for services rendered.

10. **Is there anything else you would like to share with us about your system?**

    MCTS has the first and only BRT in the State of Wisconsin.

ENFORCEMENT OF BUS LANES/BRT SYSTEM

1. **Do you have enforcement of the dedicated bus lanes? If yes, what type of enforcement is used (dedicated police or camera enforced, any other means of enforcement)? If not, do you plan to implement enforcement in the future?**

   There is a partnership with local and county law enforcement who deter and monitor the route. There are four cameras at each platform being constantly monitored by MCTS staff. We monitor use of the dedicated lanes and have recorded 85-90% compliance.

2. **Do you utilize red coloring in any of your bus lanes? If so, do you have any insights into general purpose compliance with red lanes vs. those without red coloring? Pros and cons of end-to-end painted bus lanes, including maintenance of the painted lanes.**

   No. Pigmentation was considered, however in a harsh uneven pavement and cold weather environment such as Wisconsin, it was deemed impractical.

3. **Have you experienced any safety related concerns due to general purpose vehicles traveling in the bus lanes? If so, how are you approaching the issue?**

   No. MCTS relies on local law enforcement to deter and prevent unauthorized use of the lanes. MCTS trains the bus operators thoroughly to be aware of hazards present. There are sections where we share the lane with bicyclists and the operators are trained to use a safety buffer to prevent incidents.

ITS RELATED

1. **What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?**

1. Traffic signal prioritization
2. Variable message signs
3. GPS

2. **What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations?**

   There are certainly bugs in every system. Most issues with current technology can be traced back to human error. It is essential to make sure MCTS keeps data clean in order to receive correct outputs. For instance, completely understanding the functionality of software to identify bus activity is key. If you are not correctly telling the system what is occurring, bad reporting on scheduling may occur.

3. **Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology in optimizing BRT performance and managing bus signal priority, traffic, etc., along roadways?**

   MCTS already has TSP installed and it is viewed as a key element to the BRT success. There is strong consideration being given to lane delineators or rounded curb ridging to deter entrance to the lanes by unauthorized vehicles. This is still under consideration and may be used in future segments.

NAME OF AGENCY: Greater Cleveland RTA

Contact Name: Joe Shaffer

Contact Information: jshaffer@gcrta.org, 216-356-3269

ROADWAY INFRASTRUCTURE/DESIGN

1. **Please provide a brief overview of your BRT roadway infrastructure (type of guideway or other design features to reduce delays and improve the performance of the BRT system). (Median guideway, side/curb running guideway, mixed flow, red lanes, TSP (conditional or unconditional), queue jumps, lane enforcement, all-door boarding, level/near-level boarding, other)**

   1. Median guideway with Near-level boarding
   2. Mixed use lanes with standard curb heights
   3. One Queue Jump
   4. All-door boarding
   5. Business Access Transit lanes

2. **What do you wish you knew before you began the planning and/or design of your BRT roadway infrastructure?**

    1. We wish we knew all the hassles that TVM's on the platforms would bring. We now have fareboxes on the vehicles again. It does affect dwell time. But there were just too many issues with the off-board fare collection.
    2. GCRTA expanded the area for end of line operations at Windermere.

3. **What, if anything, would you change with respect to your BRT roadway infrastructure in hindsight (e.g., near-side vs far-side stations, jay walking at stations, etc.)?**

    1. Not much
    2. Uplights in the 4' paved medians all failed within a year. That aesthetic feature was a waste of money

4. **What tough decision did you make in the planning and/or design of your BRT roadway infrastructure that in hindsight you are glad you made (loss of parking, some element you wanted to include but couldn't, etc.)?**

    1. There was about a mile of overhead power. Although it was expensive and a lot of work, we are very glad to have coordinated with Cleveland Public Power to get the overhead power lines re-built underground.

5. **What are the widths of your bus lanes? If you could revise the design, would you change the bus lane widths and why?**

    1. 12' – No change is needed.
    2. Rumble strips have been effective
    3. Embedded reflectors were installed at intersections – but they have all been destroyed.

6. **What are some of the conflicts/safety issues you may have encountered along the roadways between buses, pedestrians, and bicycles?**

    1. Riders on the platforms stand too close to the boarding edge and have been struck by the mirrors of the bus.

7. **What advice with respect to BRT roadway infrastructure would you give to other agencies or cities who are embarking on their first BRT system?**

    1. Make a plan for continued city coordination on TSP

8. **What elements of your BRT infrastructure is essential to its success?**

    1. Dedicated lanes
    2. Portions that exhibit true permanent investment

9. **Who maintains the different elements of your BRT roadway infrastructure?**

    1. GCRTA maintains stations – glass elements are standard sizes (Bryan Moore could elaborate on station maintenance)
    2. City maintains signals – TSP has rarely been functioning as desired.
    3. City maintains street – brick pavers crosswalks have been failing

10. **Is there anything else you would like to share with us about your system?**

    1. HealthLine vehicles has wheels for operator use in precision docking (New Flyer will void warranties if those are on new vehicles, so GCRTA is going to a UHMW PE Bus curb)
    2. No platform snowmelt are on the platforms – that was felt to be a good decision.
    3. Shelters were UL-listed and pre-manufactured, which made installations simple.

ENFORCEMENT OF BUS LANES/BRT SYSTEM

1. **Do you have enforcement of the dedicated bus lanes? If yes, what type of enforcement is used (dedicated police or camera enforced, any other means of enforcement)? If not, do you plan to implement enforcement in the future?**

    1. Rely on City Police for enforcement.

2. **Do you utilize red coloring in any of your bus lanes? If so, do you have any insights into general purpose compliance with red lanes vs. those without red coloring? Pros and cons of end-to-end painted bus lanes, including maintenance of the painted lanes.**

    1. No red pavement used.

3. **Have you experienced any safety related concerns due to general purpose vehicles traveling in the buslanes? If so, how are you approaching the issue?**

    1. Some bicycles use the bus lane, but it has not been a significant issue.

ITS RELATED

1. **What types of ITS are you using in your BRT system? Based on your experience, what are the pros and cons of the system?**

    1. Opticom was installed originally. The system worked fine when is was operating as designed. City tinkered with signal timings.

2. **What technology did you implement in your BRT roadway infrastructure that is now out of date, or did not perform up to expectations?**

    1. Camera detection is being replaced with radar detection, as the cameras were often too dirty to function.

3. **Are you considering the implementation of newer and/or more advanced technology, such as moving towards a more cloud-based technology in optimizing BRT performance and managing bus signal priority, traffic, etc., along roadways?**

    1. That would be ideal, but we would have to have the City of Cleveland lead that effort. And it is not high on their priorities right now.