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Authority
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Los Angeles, CA

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REVISED
PLANNING AND PROGRAMMING COMMITTEE
MARCH 17, 2021

SUBJECT: BUS RAPID TRANSIT VISION AND PRINCIPLES STUDY

ACTION: APPROVE RECOMMENDATIONS

RECOMMENDATIONS

CONSIDER the following BRT Vision and Principles Study recommendations:

1. DIRECT staff to apply both the BRT Standards and Design Guidelines developed through the BRT Vision & Principles study to all Metro-funded BRT projects and initiate the process to refine the design guidelines further into design criteria; and

2. APPROVE the recommended five top-performing Bus Rapid Transit (BRT) candidate corridors for future project development consideration and advance the Broadway corridor as a first decade Measure M project, subject to available funding.

ISSUE

The Bus Rapid Transit Vision and Principles study (BRTV&P) establishes a cohesive set of guidelines and standards to direct Metro investment in on-street BRT projects. Metro's existing BRT guidance pertains almost entirely to projects constructed on exclusive rights-of-way such as the G Line (Orange Line). The adoption of new BRT guidelines and standards will ensure a high-quality customer experience for our transit patrons while increasing transparency with our local agency partners and our community stakeholders by clarifying the types of street improvements required to deliver a BRT project.

The study further identifies and prioritizes strong BRT candidate corridors based on indicators of service demand, equity and capacity for BRT supportive elements. Using a multi-tier screening process that applies both quantitative and qualitative indicators, the study examined potential BRT corridors throughout Los Angeles County to identify where BRT would best be deployed as a mobility solution. The results of the screening provided in the BRTV&P final report (Attachment A) provide a road map for future BRT investments that can be used by Metro, local agencies and municipal bus operators alike.

BACKGROUND

As required under the Measure M Administrative Guidelines, Section XVIII, Countywide BRT Expansion, the BRTV&P develops requisite guidance for Measure M BRT program funds and projects. Specifically, the Measure M guidelines committed Metro to revisit the study of BRT corridors identified in the Metro 2013 Bus Rapid Transit (BRT) and Street Improvement study, Mobility Matrices, and/or any potential corridors that may fill missing gaps in the countywide BRT network, excluding those already funded. The BRTV&P final report (Attachment A) and Design Guideline Manual (Attachment B) complete this analysis, providing the following key deliverables:

- Metro BRT standards
- Metro Design Guideline handbook
- Final Report with a recommended list of potential BRT corridors

The work completed through this study establishes a local definition of BRT, supportive design guidelines and identifies the corridors where BRT can best be deployed to meet Metro mobility goals as defined in the Vision 2028 Strategic Plan.

Relation to Other Metro Bus Improvement Initiatives
This BRT study was closely coordinated with ongoing bus improvement initiatives, including the NextGen Bus Plan and Speed and Reliability program, which fall under the umbrella of the new Better Bus Initiative (to be introduced during the March 2021 Board cycle). Each of these initiatives, BRT included, draws from a common bus improvement toolkit. This toolkit includes, but is not limited to, bus-only lanes, transit signal priority, all-door boarding, station amenities and frequent, reliable service.

While these bus improvement initiatives share a common toolkit and goal of improving service for our customers, the investment of time, resources, planning horizon and scope vary. Nevertheless, the work here is not mutually exclusive and equally important. Planned long-term investments in BRT invite opportunities to engage communities and municipal partners early to explore potential for early action items such as dedicated bus lanes and transit signal priority that can provide immediate benefits to our customers. Additionally, early engagement may lay the groundwork for future BRT investment.

In addition, the intention of Metro's bus projects and programs are to improve service across the bus network as well as focus improvements on specific BRT corridors where warranted. Some projects are intended to build the full complement of improvements in the BRT toolkit along a specified corridor or route, while other projects and programs, such as all-door boarding, transit signal priority, and congestion hot spot treatments through NextGen are aimed at deploying such improvements across the bus network. Ongoing collaboration across these initiatives will ensure that the focus centers on our customers and the community needs.

DISCUSSION

BRT offers the potential to deliver reliable, high-quality rail-like service at a substantially lower cost. It is unconstrained by track or existing rail rights-of-way and can more easily be deployed in an on-street environment to connect communities at pedestrian scale. The inherent flexibility of BRT makes it a valuable tool in Metro's mobility toolkit that complements parallel efforts such as NextGen, the Bus Speed Improvement Working group and the Measure R & M rail expansion.

Measure M provides funding for both BRT projects and Countywide BRT program funds. In order to ensure that BRT service quality and infrastructure is commensurate with Metro investment, staff have developed BRT standards, design guidelines and identified corridors suitable for BRT investment.

BRT Standards

Standards provide the foundational definition of BRT. The standards define which types of bus improvements and performance standards at what thresholds constitute a BRT project. The purpose of the standards is to provide guidance for Metro BRT projects and establish eligibility criteria for Measure M BRT program funds.

The standards are both prescriptive and performance-based and include the following elements:

Standard	Description
Headway	Average interval of time between vehicles
Speed	Average corridor speed inclusive of dwell time with provisions for percent improvement over existing speeds
On-Time Performance/Reliability	Percentage of on-time arrival at stations
Dwell Time	Average time per person per boarding or average per station
Dedicated Lanes	Percentage of corridor with dedicated bus lanes
Intersection Priority	Percentage of signals in a corridor with active signal priority
Station Amenities	Expressed as percentage of stations that provide specific amenities at each stop
All-Door Boarding	Provided on vehicles and available at all stations
Branding	Design and logo distinguishing BRT from local service

The standards are further delineated into tiers: Full BRT and BRT-Lite. The differentiation in standards is not only to provide for context sensitive solutions in a county as large as Los Angeles but also in recognition that service performance should drive infrastructure investment. In this way, the whole of the standards is greater than the sum of its parts with performance-based standards of speed, dwell time, headway and on-time performance necessitating the use of prescriptive standards to achieve the requisite performance levels identified in the standards. The full description of standards, tiers and thresholds can be found in the BRTV&P final report (Attachment A, page 24, Table 6).

Design Guideline Manual

The design guidelines expand on the BRT standards to define the key attributes and elements that comprise a BRT project. The design guideline manual is made up of both required and recommended elements and provides the necessary guidance to the designer/builder. The six chapters of the design guideline manual include the following chapters:

- Stations and Platforms: adapting the Metro Rail Kit of Parts to an on-street setting, this chapter details station footprint and configuration, shelter design, materials and finishes, lighting, landscaping, passenger amenities, systems components and public art. The design elements use a kit of parts approach so stations can be expanded and contracted to adapt to space-constrained environments and a variety of BRT running-way alignments: side-running, curb-running and center-running.
- Running Ways: provides guidance on considerations of selecting a running-way alignment such as side-, curb- or center-running. Also details roadway and intersection geometrics, street signing and striping, traffic operations, utility considerations and green streets.
- Intelligent Transportation Systems (ITS): details the technologies and systems deployed for BRT, including roadside elements, stations, vehicles and control center elements, operations & data.
- Operations: provides guidance on route length, station spacing, travel speed, service frequency, span of service, fare collection and boarding protocols, other services sharing a BRT corridor and service reviews.
- Branding: provides guidance on consistent application of graphics tone and images to reinforce an identifiable brand that enhances customer experience. The chapter guidance includes consideration of branding opportunities at stations, on vehicles and running ways.
- Transit Oriented Communities (TOC): reinforces and applies existing TOC policies such as first/last mile access, transfer considerations, joint development opportunities, managing mobility access and addressing the urban heat island effect.

Full details are provided in the design guideline manual (Attachment B).

BRT Corridor Screening Process

The corridor screening process produced two complementary deliverables: Top Five BRT corridors and the Strategic BRT Network. The two deliverables can be seen as a continuum of viable BRT corridors, where the top five identify where BRT investment should begin and the BRT network is where it may continue subject to available funding or investment from local municipalities or municipal bus operators.

Identification of corridors for study began with an initial literature review of prior Metro BRT studies, subregional mobility matrices, as well as any Board motions or directives. To ensure that no potential high-quality BRT corridors were overlooked, a parametric screening tool was applied to develop a heat map of potential corridors using indicators of service demand as well as the Equity Focus Community (EFC) metric that was developed through the Metro Long Range Transportation Plan.

Given the large number of potential corridors, in keeping with common transit planning practice, a three-level screening process was used, wherein each successive screening level introduced additional data to arrive at a prioritized set of corridors. The initial level 1 screening analyzed corridors based on network connectivity, land use, points of interest, education facilities, demographics and Metro's EFC metric.

In the second level screening, additional parameters were entered into the model, including a corridor's suitability for supporting Transit Oriented Communities, corridor constructability, transit propensity (as developed through NextGen), trip lengths in the corridor, travel delay, network connectivity and EFCs.

The third and final screening process incorporated quantitative and qualitative analysis. Included in this analysis were qualitative evaluations of TOC and transit-friendly plans and policies in the corridors, a qualitative assessment of travel time savings potential, surveys of ground conditions, assessment of alignment with local government's specific modal vision for any identified corridor and input from key stakeholders. This final assessment brought the final list of corridors to a top five list, which are highlighted below. The complete accounting of the screening process and corridors analyzed can be found in the attached final report. A map illustrating the top five corridors has also been attached to this report (Attachment C).

BRT Top 5 Corridors (listed in alphabetic order):

Atlantic Blvd---East Los Angeles Gold Line terminus to downtown Long Beach
The Atlantic corridor is 19.64 miles in length. It provides high-capacity network coverage in southeast LA County, from the San Gabriel Valley to the City of Long Beach. In comparison to the other top five corridors, this corridor has a moderate level of network connectivity. Atlantic had Metro Rapid service until recently as far south as the C Line (Green). Long Beach Transit operates frequent service on the southern end of the corridor. Atlantic also has a moderate opportunity to build BRT-friendly infrastructure and realize travel time savings, although sidewalks are wide relative to other corridors, allowing more opportunity to build stations with full BRT passenger amenities. Although this corridor has a comparatively low ridership score, it does provide access to industrial jobs.

Broadway---Little Tokyo Gold Line Station to Imperial Highway
The Broadway corridor is 9.64 miles in length. It is a vibrant transit corridor with very high network connectivity and is also a NextGen Tier One corridor (and former Metro Rapid corridor). This corridor had a very high score in the Equity Focus Community index. Broadway runs through two City of LA Community Plan areas which feature TOC and transit-supportive policies. This corridor has moderate level ridership and a moderate opportunity to build BRT-friendly infrastructure and realize travel time savings. A future Alternatives Analysis could consider both Broadway and Figueroa, which closely parallel each other and perform comparably.

Cesar Chavez/Sunset--- Atlantic Blvd via Vermont/Los Feliz/Central to Broadway
The Cesar Chavez/Sunset corridor is 13.64 miles in length. It has a very high network connectivity score and connects East Los Angeles through the eastern edge of Hollywood/Los Feliz neighborhood then northwest to downtown Glendale. Cesar Chavez is a NextGen Tier One corridor that has existing Metro Rapid service through East LA. Sunset is a NextGen Tier One corridor that runs through six City of LA Community Plan areas which feature or are being updated to feature TOC and transit-supportive policies. The corridor segment across from Los Feliz to Glendale is also part of a NextGen Tier One corridor. This corridor has a moderate-level ridership and a moderate-level opportunity to build BRT-friendly infrastructure and realize travel time savings.

La Cienega---Santa Monica Blvd via Obama/Jefferson to Slauson
The La Cienega corridor provides high-capacity north-south network coverage on the westside,

linking cities and communities including West Hollywood, Beverly Grove, eastern Beverly Hills, Pico-Robertson and Culver City. It runs through three City of LA Community Plan areas which feature or are being updated to feature TOC and transit-supportive policies. Culver City has recently completed a TOD Visioning Study, and West Hollywood has TOC-supportive policies in place that could support the implementation of a BRT on the La Cienega corridor. La Cienega has a moderate-level opportunity to build BRT-friendly infrastructure and realize travel time savings. This corridor has a low network connectivity score, low ridership score, it is a NextGen Tier One corridor and has previously enjoyed Metro Rapid service. It has a low score in the Equity Focus Community Index.

Venice Blvd---Pacific Avenue via Flower Street to 7th Street
Venice has a very high network connectivity score and a very high ridership score. Venice is a NextGen Tier One corridor with existing Metro Rapid service and with a high-level opportunity to build BRT-friendly infrastructure and realize travel time savings. This corridor has pedestrian-friendly features along much of its distance with a strong mix of land uses oriented to the street. The Venice corridor runs through seven City of LA Community Plan areas which feature TOC and transit-supportive policies. Culver City has recently completed a TOD Visioning Study, which includes Venice. Venice has communities with strong transit-supportive policies along corridor and it is an LADOT high-priority corridor.

Recommended Corridor for Further Study
Staff recommends that Broadway be advanced for further study as the initial BRT corridor eligible for Countywide BRT program funds. Each of the top five corridors presents excellent opportunities for BRT investment, but none are without challenges. Among the top corridors, Broadway ranks highest in terms of equity considerations as measured through the EFC metric, scoring near the top of all corridors analyzed. With the Board's recent adoption of the NextGen bus plan, Broadway is also slated for five-minute service frequencies.

Supportive BRT infrastructure in the Broadway corridor would ensure the most prudent use of service hours and improve travel speeds for our transit riders. In addition, the Broadway corridor has been identified for multiple potential improvements by the City of Los Angeles, which could be leveraged to advance a Broadway BRT corridor project.
Subsequent decisions on sequencing of the remaining top four corridors should be coordinated concurrent with the decennial Measure M review process which, per the Measure M ordinance, begins in Fiscal Year 2027. This would allow the Board discretion to review funding availability and mobility needs supported by the most current data.

Strategic BRT Network
The Strategic BRT Network is a complementary effort that builds on the top five BRT corridors. It is a strategic unfunded list of potential BRT projects that Metro or other local agencies could pursue should additional funding become available. The Strategic BRT network builds upon the strong candidate corridors that were identified in the multi-step screening process used to develop the top five corridors and applies a gap analysis to connect potential BRT corridors to Metro's existing and planned BRT and rail system. A map of the Strategic BRT network is included in Attachment A, including a list of corridors and a full description of the process.

Project Coordination

Metro currently has multiple initiatives underway to improve bus speeds and bus service. Most visible among these efforts are the NextGen Bus Study, which encompasses routing, frequency and network design improvements as well as speed and reliability improvements through the Bus Speed Engineering Working Group.
Identification and selection of the top five corridors was closely coordinated with these groups throughout the study process in the interest of sharing information, identifying areas for potential improvements and validating findings. In addition, Metro is poised to launch the Better Bus Initiative in March 2021, which seeks to align all bus improvement efforts under one umbrella to establish a comprehensive and unified approach to elevating the quality of the bus system to the benefit for the riders.

Outreach

Staff developed a comprehensive outreach program designed to inform, educate and solicit input from a variety of stakeholders, including Metro employees, municipal transit operators, city officials, elected officials, community and transit organizations and members of the general public. Throughout the project, stakeholder engagement at all levels was conducted to complement and help inform the technical process. Activities have included stakeholder workshops, presentations and project briefings, countywide survey engagement, and formation of a Technical Advisory Committee.

Staff also worked closely with Metro's NextGen Bus Plan project staff to leverage opportunities for outreach at public meetings and collaborate where possible to assist in maximizing outreach options and stakeholder relationships and share data relevant for both projects. Outreach was tailored to be inclusive and gather feedback that accurately reflects the diversity of LA County's population including ethnicity, race, age, language, income levels and level of transit access and utilization.

A full accounting of the outreach effort can be found in the outreach summary (Attachment C).

Equity Platform

The BRT Vision & Principles study leverages Pillar I of the Equity Platform: Define and Measure. Per Board direction the Equity Focus Communities (EFC) criteria was applied and carried through the corridor prioritization screening process of candidate corridors to ensure consideration of vulnerable communities.

DETERMINATION OF SAFETY IMPACT

The BRT Vision & Principles study did prioritize safety in its design criteria. This Board action will have no adverse impact on safety standards for Metro.

FINANCIAL IMPACT

Approval of the recommended actions would have no financial impact to the agency.

Impact to Budget

There is no impact to the current fiscal year budget. Completion of the study was included in the current fiscal year budget.

The recommended actions identify a top five list of potential BRT candidate corridors, one of which may be carried into project development at a future date based on available funding. Any programming of funds and recommendation to carry a BRT corridor into project development would be a subsequent action presented to the Board. Any prospective study should identify funding of capital investment in BRT infrastructure, fleet and service levels. Ongoing service operations and facility maintenance would be fiscally sustained and operationally integrated with the existing NextGen network.

IMPLEMENTATION OF STRATEGIC PLAN GOALS

The BRT Vision & Principles study furthers the first strategic plan goal to “provide high quality mobility options that enable people to spend less time traveling.”

Specifically, Goal 1.2 calls for improvements to LA County’s overall transit network and assets, committing Metro to:

- Expand the BRT program along major arterials and highways throughout Los Angeles County
- Use Metro funds to provide incentives for regional partners to accelerate the delivery of elements that are critical to BRT success, such as signal priority and exclusive lanes
- Convert strategic Metro Rapid corridors to BRT corridors
- Develop BRT implementation details through the BRT Vision & Principles study

The completion of the BRT Vision & Principles study including the adoption of the standards, design guidelines and top five priority corridors provides the foundational steps to delivery of the above strategic plan goals.

ALTERNATIVES CONSIDERED

The Board could elect to plan BRT projects absent a cohesive set of standards and guidelines. This is not recommended as BRT project development is a collaborative process with our local agency partners that is best facilitated with clear standards and guidelines that provide transparency in each partners’ respective roles and responsibilities. The Board could also reject the prioritization of BRT corridors. This is also not recommended as the top five corridors provide staff with guidance on which BRT corridors to advance in future years and to guide future programming decisions relative to the Measure M Countywide BRT program funds.

NEXT STEPS

Upon Board approval, staff will proceed with the continued application of BRT standards and design guidelines to our BRT mobility corridor studies. In addition, staff will take the necessary steps to incorporate the design guidelines into select administrative and technical documents where necessary to ensure adherence to the adopted guidance. Staff will return to the Board with recommended programming actions of Measure M Countywide BRT Program funds to advance one of the top five BRT corridors into project development, subject to available funding.

ATTACHMENTS

Attachment A - BRT Vision and Principles Final Report
Attachment B - BRT Vision and Principles Design Guideline Manual
Attachment C - Outreach Summary Report
Attachment D - Amendment by Directors Bonin, Solis, and Hahn

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visioning BRT

BUS RAPID TRANSIT VISION & PRINCIPLES STUDY

Metro®

Final Report
November 2020

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Executive Summary

In November 2016, LA County voters passed Measure M, a half-cent sales tax measure that provides funding for mobility projects, including a total of four specific Bus Rapid Transit (BRT) projects, as well as a countywide BRT program to deliver additional BRT projects with funding available in each of the next five decades.

With Metro and municipal transit agencies poised to make major BRT investments, the BRT Vision & Principles Study was undertaken to establish a cohesive set of guidelines and standards to direct Metro investment in on-street BRT projects. The majority of Metro's existing BRT guidance pertains only to projects constructed on exclusive right-of-ways, such as the L line (Orange Line). As such, this study establishes a local definition of BRT, supportive design guidelines and identifies the corridors where BRT can best meet Metro mobility goals as defined in the Vision 2028 Strategic Plan. The adoption of these BRT guidelines and standards will ensure a high-quality customer experience for our transit patrons, while increasing transparency with our local agency partners and our community stakeholders by clarifying the types of street improvements required to deliver a BRT project. In addition, the study further identifies and prioritizes strong BRT candidate corridors based on indicators of service demand, equity and capacity for BRT supportive elements.

Overall, the BRT Vision & Principles Study generated the following guiding deliverables:

> Metro BRT standards

> Metro Design Guidelines Manual

> Final Report with a recommended list of potential BRT corridors

The BRT Vision & Principles Study was conducted through close coordination with the following separate but parallel Metro efforts to enhance bus service and improve mobility in the region: the Long Range Transportation Plan (LRTP), the NextGen Bus Plan and the Bus Speed Improvement Working Group. The coordinated effort ensured that future plans for BRT systems and bus lane improvements were in close alignment.

Study Purpose, Vision, Guiding Principles, Goals & Objectives

The purpose of this study is to provide a foundational definition of BRT that sets high performance standards, while establishing clear eligibility criteria for Measure M Countywide BRT program funds. This study helps improve LA County's public transit network and ensures that BRT will fulfill a distinct role as a mode of transportation that enhances and integrates with existing LA County mobility services and future mobility hubs, as part of the world-class transportation system envisioned for all Metro customers. This purpose is supported by the study's vision statement, "BRT-the Convenient Choice for Connecting Customers and Communities" and the guiding principles on the following page.

TABLE 1: BRT VISION & PRINCIPLES STUDY - GUIDING PRINCIPLES

Guiding Principles	Description
World-class	Offer exceptional service, operations and amenities that enhance the customer experience.
Equitable	Focus on on understanding and meeting the mobility needs of underserved communities.
Customer-centric	Prioritize the needs of our customers over public agency challenges and constraints.
Reliable	Run on time, eliminates bus bunching and provides accurate, real-time information.
Safe and Secure	Operate safely and has secure stations and vehicles with proper lighting and visible security measures.
Integrated and Connected	Seamlessly connect people and places with existing and planned transportation services across the region.
Community-focused	Promote and support vibrant communities around transit through community investment, including walking and biking infrastructure.

The following goals were developed to guide implementation of the LA County BRT Network:

> Provide an attractive, convenient and reliable mode choice that is a safe, secure, inviting and comfortable experience for all users for the entire trip.

> Fulfill a distinct role that enhances and integrates with existing mobility services.

> Connect people to where they need and want to go.

> Operate at high-performance levels allowing users to bypass congestion.

> Provide excellent infrastructure, vehicles, amenities and customer service.

> Consider community needs and enhance quality of life.

> Align design standards and service needs to maximize benefits.

In order to realize these goals, specific objectives were developed to detail the activities necessary to achieve them. These objectives informed several key areas of the study, including BRT standards, performance indicators, design guidelines and corridor selection. (Refer to **TABLE 5:** BRT GOALS & OBJECTIVES)

BRT Standards

Standards provide the foundational definition of BRT. The standards define which types of bus improvements and performance standards, and at what thresholds constitute a BRT project. The purpose of the standards is to provide guidance for Metro BRT projects and establish eligibility criteria for Measure M BRT program funds.

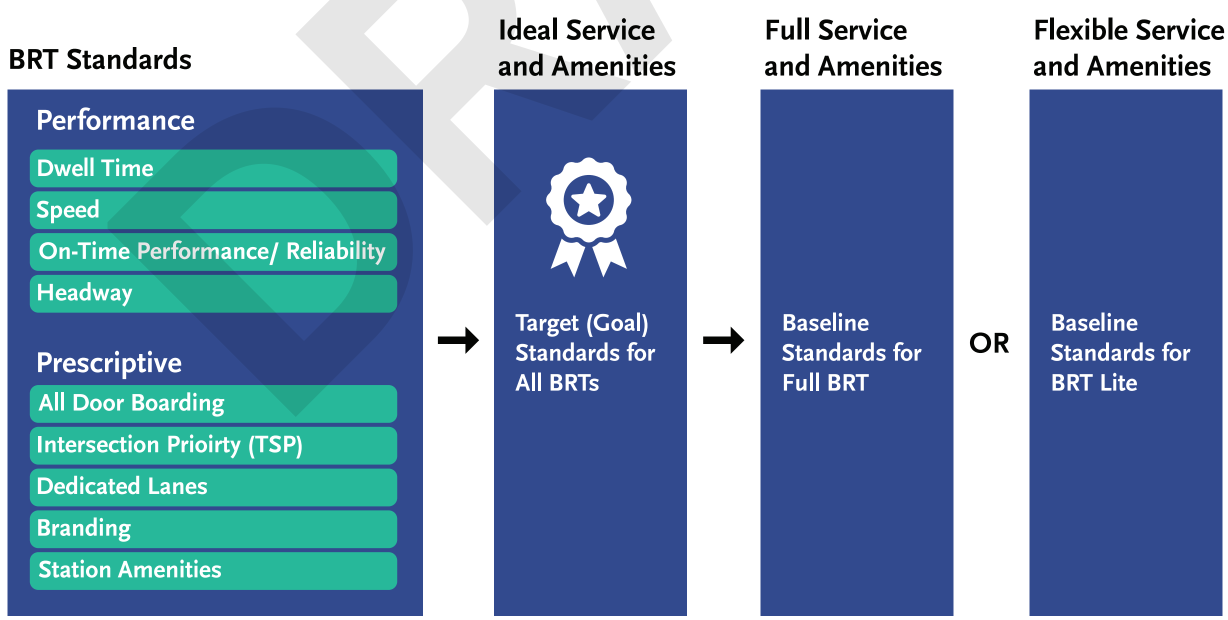
These standards are further organized and defined in two distinct tiers, Full BRT and BRT Lite, that set an "ideal" and mimum level of service which are also separated into performance and prescriptive based standards. These are further delineated by tiers of performance (speed, dwell time, headway and on-time) and prescriptive-based standards (all-door boarding, intersection priority, dedicated lanes, branding and station amennities). (Refer to **FIGURE 1:** BRT VISION & PRINCIPLES STUDY - GUIDING PRINCIPLES)

The differentiation in standards is not only to provide for context sensitive solutions in a county as large as Los Angeles, but also in recognition that service performance should drive infrastructure investment. In this way, performance-based standards necessitate the use of prescriptive standards to achieve the requisite performance levels identified in the BRT standards.

TABLE 2: ORGANIZATION OF BRT STANDARDS

Standard	Description
Headway	Average interval of time between vehicles.
Speed	Average corridor speed inclusive of dwell time with provisions for percent improvement over existing speeds.
On-time Performance/ Reliability	Percentage of on-time arrival at stations.
Dwell Time	Average time per person per boarding or average per station.
Dedicated Lanes	Percentage of corridor with dedicated bus lanes.
Intersection Priority	Percentage of signals in a corridor with active signal priority.
Station Amenities	Expressed as percentage of stations that provide specific amenities at each stop.
All-door Boarding	Provided on vehicles and available at all stations.
Branding	Design and logo distinguishing BRT from local service.

FIGURE 1: BRT VISION & PRINCIPLES STUDY - GUIDING PRINCIPLES



All standards, both performance and prescriptive, result in better transit performance independently. However, various combinations can produce synergist improvements. Therefore, comparing Full BRT versus BRT Lite might result in similar overall benefits with Full BRT having the highest overall benefit.

The following are categorical benefits expected from both Full BRT and BRT Lite:

> Improved Travel Times

> Quick Boarding and Alighting

> Brand Recognition

> Station Amenities

And the following tools will enable improved travel times for both Full BRt and BRT Lite:

> Improved or Dedicated Running Ways

> Intelligent Transportation Systems (ITS)

> Intersection Priority (TSP)

BRT Design Guidelines

The following BRT design guidelines align with the BRT vision, goals and objectives, and draw on best practices from BRT systems across North America and around the world. The BRT Design Guidelines Manual, a separate companion document to this final report, provides recommendations on six interconnected aspects of BRT:

> Stations and Platforms

> Running Ways

> ITS

> Operations

> Branding

> Transit-oriented Communities (TOCs)

These design guidelines are flexible enough to address potential site-specific constraints and/or applicable local ordinances. They will be used by Metro in updating its existing BRT Design Criteria Manual, and by municipal transit agencies wishing to run new BRT lines under Measure M's BRT Program, facilitating the implementation of the county's next iteration of BRT services.

BRT Corridors

The screening and selection process was designed to identify the corridors where BRT is best deployed as a mobility solution. These have characteristics that include an optimal intersection of need and opportunity, meaning that there is not only a demand for service, but the corridor contains the requisite characteristics to support BRT infrastructure.

The main features Metro considers of primary importance in this selection include: service demand, regional connectivity, along with an opportunity to improve bus speeds, supportive infrastructure and equity. Three primary sources were used to identify potential corridors:

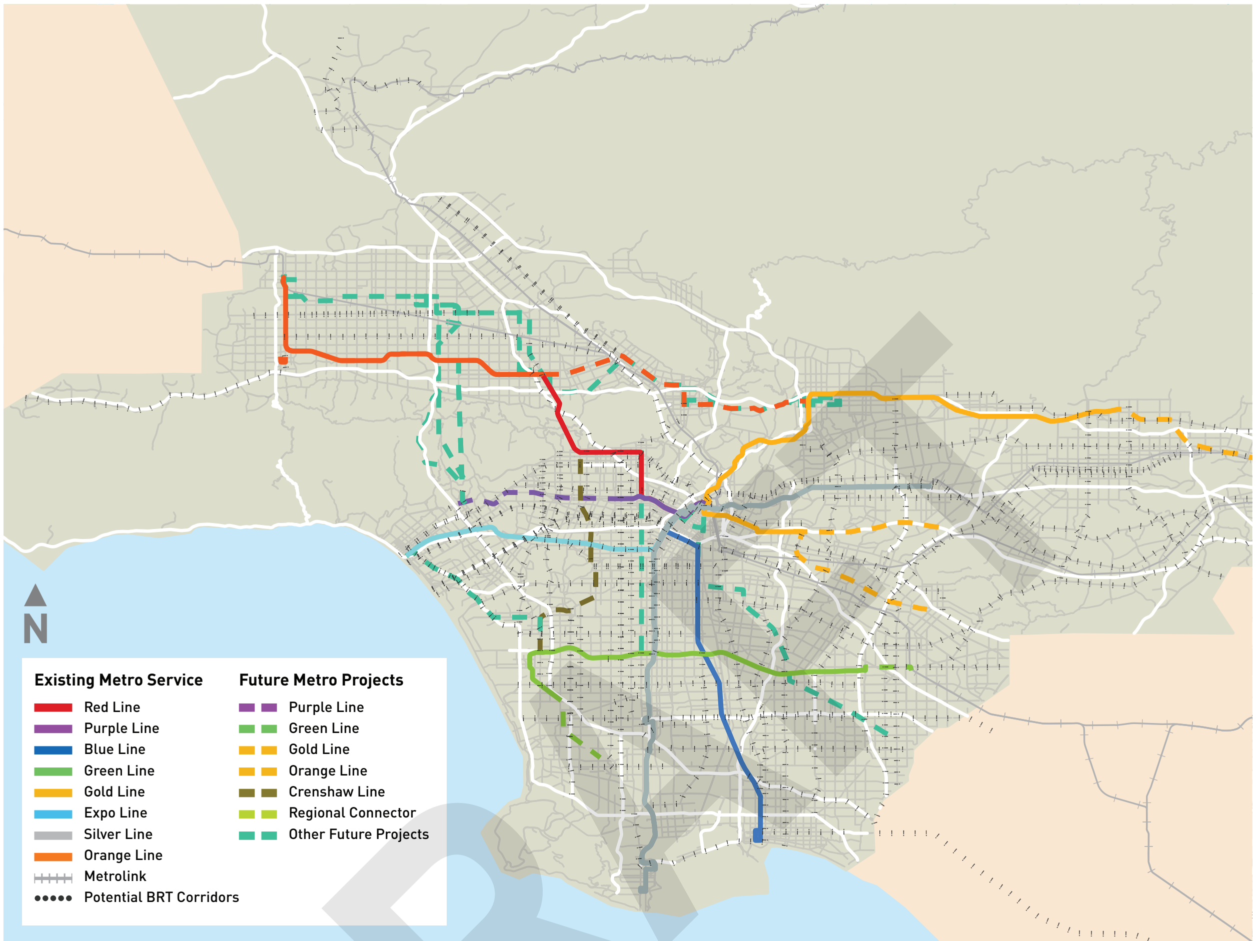
> BRT candidate corridors identified in recent planning studies and efforts by Metro

> Direct input from the project's targeted stakeholders

> Use of a parametric design tool to identify promising corridors not identified through the efforts mentioned above

The map on the following page depicts the universe of potential BRT corridors.

FIGURE 2: UNIVERSE OF POTENTIAL BRT CORRIDORS IN LOS ANGELES COUNTY



Corridor Screening Process

Given the large number of corridors a three-level screening process was used, wherein each successive screening level introduces additional data to arrive at a prioritized set of corridors.

Level 1 Screening

To begin the evaluation process, all potential corridors were reviewed for "fatal" flaws and either eliminated from consideration or their routing was adjusted. After this initial screening/refinement, the remaining corridors were loaded into the parametric model that analyzed network connectivity, land use, points of interest, demographics and Metro's Equity Focus Community (EFC)[1] metric. The model compared the area within ¼ mile of each corridor relative to the area along every other corridor and generated a score for each option. A total of 30 corridors, shown on the following map, were selected for Level 2 analysis.

1 As part of the LRTP, Metro has defined "Equity Focus Communities" (EFCs) as communities representing geographic areas that have the following socioeconomic characteristics; more than 40% of households are low-income and either 80% of households are non-white or 10% have no access to a vehicle.

FIGURE 3: TOP 30 BRT VISION & PRINCIPLES STUDY CORRIDORS MAP

Level 2 Screening

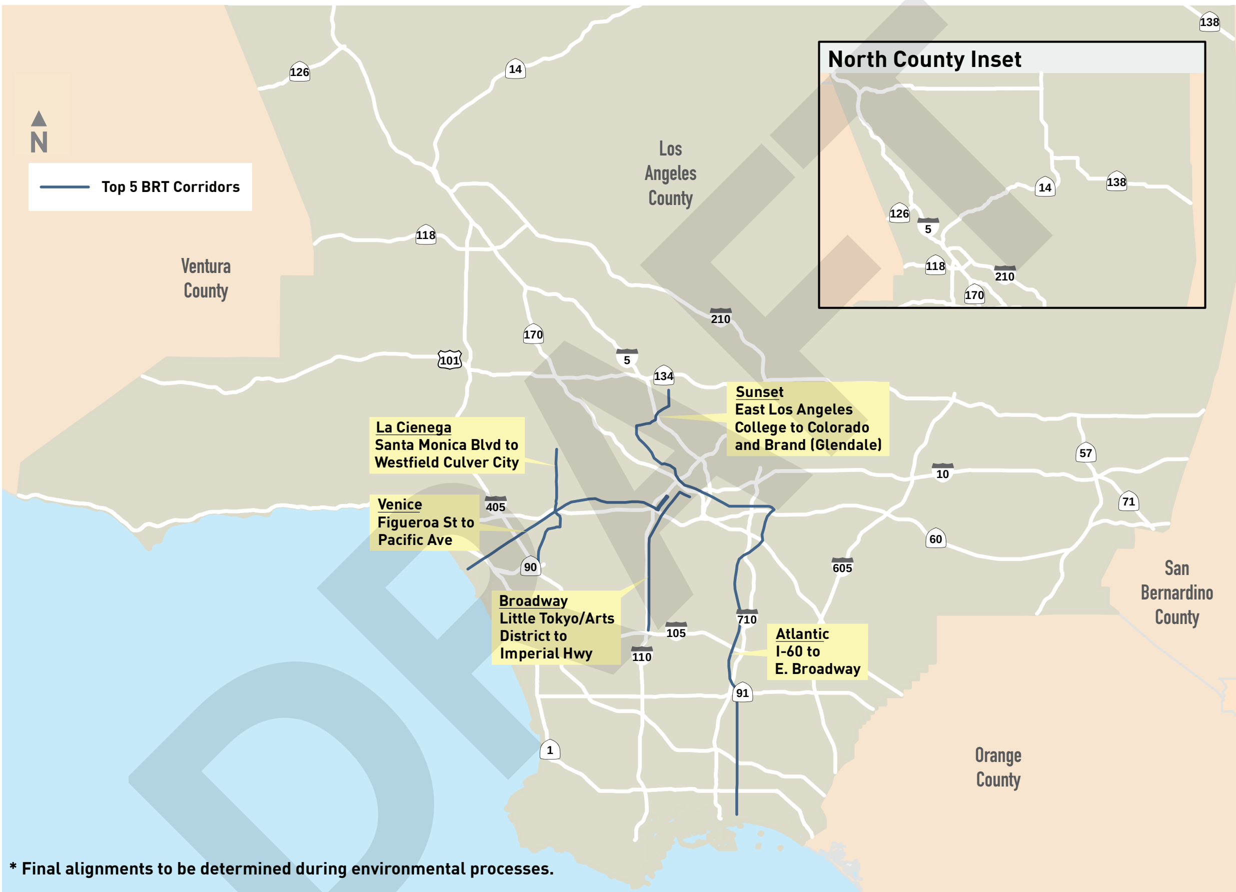
The 30 most promising corridors identified in the Level 1 screening were put through a second level of parametric analysis with additional criteria added, including: supporting TOCs, trip length, travel delay, network connectivity, equity, corridor constructability and transit propensity (as developed through NextGen). This second screening was coupled with another visual inspection process, which allowed the team to identify any other attributes of or difficulties with the corridor that would assist in the identification of the most promising and best performing 15 corridors.

FIGURE 4: TOP 15 BRT VISION & PRINCIPLES STUDY CORRIDORS MAP

Level 3 Screening

The third and final screening process further reviewed the top 15 performing corridors with additional quantitative and qualitative analysis. Network connectivity, transit propensity and equity were carried forward from previous screening with new criteria including: qualitative evaluations of TOC and transit-friendly plans and policies in the corridors, a qualitative assessment of travel time savings potential, surveys of ground conditions, assessment of alignment with local government's specific modal vision for any identified corridor and input from key stakeholders. This final assessment identified the top five performing corridors to support future BRT service.

FIGURE 5: TOP FIVE BRT VISION & PRINCIPLES STUDY CORRIDORS MAP



Top Five BRT Corridors

Metro has identified the following as the top five candidates eligible for Measure M Countywide BRT program funds, including: Atlantic Blvd (East Los Angeles Gold Line terminus to Downtown Long Beach), Broadway (Little Tokyo Gold Line Station to Imperial Highway), Cesar Chavez/Sunset (Atlantic Blvd via Vermont/Los Feliz/Central to Broadway), La Cienega (Santa Monica Blvd via Obama/ Jefferson to Slauson), and Venice Blvd (Pacific Avenue via Flower Street to 7th Street). Each of these present excellent opportunities for BRT investment. Of these top five BRT corridors, Metro staff will present a recommendation to the Metro Board of Directors for the initial advancement of one these corridors into project development, subject to available funding. The balance of the remaining corridors would be eligible for Measure M Countywide BRT program funds in subsequent years as funding becomes available.

Atlantic

The Atlantic corridor provides high-capacity network coverage in Southeast LA County, from the San Gabriel Valley to the City of Long Beach, connecting cities and communities. When compared to the other top five corridors, this corridor has a moderate level of network connectivity and opportunity to build BRT-supportive infrastructure and realize travel time savings, although sidewalks are wide relative to other corridors, allowing more opportunity to build stations with Full BRT passenger amenities. Although this corridor has a comparatively low ridership score, it provides access to industrial jobs for lower-income workers, addressing Metro's equity goals.

Broadway

Broadway is a vibrant transit corridor with very high network connectivity and is also a NextGen Tier One corridor. When compared to the other top five corridors, this corridor had a very high score in the Equity Focus Community index and is a high-priority corridor per Los Angeles Department of Transportation's (LADOT) assessment. Broadway runs through two City of LA Community Plan areas which feature TOC and transit-supportive policies. This corridor has moderate level ridership and a moderate opportunity to build BRT-friendly infrastructure and realize travel time savings. A future alternatives analysis could consider both Broadway and Figueroa, which closely parallel each other and perform comparably.

La Cienega

The La Cienega corridor provides high-capacity north-south network coverage on the Westside, linking cities and communities, including West Hollywood, Beverly Grove, eastern Beverly Hills, Pico-Robertson and Culver City. It runs through three City of LA Community Plan areas, which feature or are being updated to feature TOC and transit-supportive policies. Culver City has recently completed a TOD Visioning Study, and West Hollywood has TOC-supportive policies in place that could support the implementation of a BRT on the La Cienega corridor. In comparison to the other top five corridors, La Cienega has a moderate-level opportunity to build BRT-friendly infrastructure and realize travel time savings. This corridor has a low network connectivity score, low ridership score, it is not a NextGen Tier One corridor and it has a low score in the Equity Focus Community Index.

Sunset

The Sunset corridor has a very high network connectivity score and connects downtown Los Angeles with the San Fernando Valley. Sunset is a NextGen Tier One corridor that runs through six City of LA Community Plan areas, which feature or are being updated to feature TOC and transit-supportive policies. When compared to the other top five corridors, this corridor has a moderate-level of ridership and a moderate-level opportunity to build BRT-friendly infrastructure and realize travel time savings.

Venice

Venice has a very high network connectivity score and a very high ridership score. Venice is a NextGen Tier One corridor with a high-level opportunity to build BRT-friendly infrastructure and realize travel time savings. This corridor has pedestrian-friendly features along much of its distance with a strong mix of land uses oriented to the street. The Venice corridor runs through seven City of LA Community Plan areas, which feature TOC and transit-supportive policies. Culver City has recently completed a Transit Oriented Development (TOD) Visioning Study, which includes Venice. Venice has communities with strong transit-supportive policies along corridor and it is an LADOT high-priority corridor.

Strategic BRT Network

The Strategic BRT Network is a complementary effort that builds on the top five BRT corridors. It is a strategic unfunded list of potential BRT projects that Metro or other local agency could pursue should additional funding become available. The Strategic BRT Network derives from the strong candidate corridors that were identified in the multi-step screening process used to develop the top five corridors and applies a gap analysis to connect potential BRT corridors to Metro's existing and planned BRT and rail system. This network provides a roadmap for future BRT expansion in LA County that Metro or other local agencies could pursue should additional funding become available. Staff examined local city plans, Council of Governments studies, and other regional transportation plans to identify locally preferred transit corridors to assure alignment between our proposed corridors and those our local partners may have already identified. Input was also solicited on the network from local agency partners – including the study Technical Advisory Committee (TAC), as well as through individual meetings with local agencies and key stakeholders.

Conclusion and Next Steps

Metro is making unprecedented investments in our LA County mobility system, including specific investments in BRT. The work completed through the BRT Vision & Principles study establishes the necessary foundation to guide those BRT investments into the foreseeable future.

With three early potential BRT projects currently in some level of study, and more to follow, the completion of this work is timely and necessary. Upon Board approval, staff will proceed with the continued application of BRT standards and design guidelines to our BRT mobility corridor studies. In addition, staff will take the necessary steps to incorporate the design guidelines into select administrative and technical documents where necessary to ensure adherence to the adopted guidance. Staff will also present this top five list to the Metro Board for consideration, recommending that one of these corridors be taken into project development in the near-term, subject to available funding. With Board concurrence on a specific corridor, staff will return to the Board with recommended programming actions of Measure M Countywide BRT Program funds to advance one of the top five BRT corridors into project development, subject to available funding.

Background

BRT is generally defined as a high-quality bus service that provides fast, reliable and convenient service through the use of several key attributes, including, dedicated bus lanes, branded vehicles and stations, frequent service, intelligent transportation systems, and all-door boarding or off-board fare collection. These improvements allow BRT systems to minimize or avoid many of the delays typically experienced by local bus service and therefore have the potential to improve regional mobility, reduce transportation costs, and ease commutes. Local examples of BRT service in LA County include the Metro G Line (Orange), serving the San Fernando Valley and the Metro J Line (Silver) serving El Monte, downtown LA and San Pedro.

While Metro has detailed design criteria to guide the development of BRT systems constructed in exclusive rights-of-way (such as the G Line), guidance for on-street BRT operations is limited. With Metro and municipal transit agencies poised to make major investment in BRT systems in the future, the BRT Vision & Principles Study was undertaken as a comprehensive effort to guide the development of future on-street BRT systems. This study expands on previous Metro BRT studies such as the 2013 LA County Bus Rapid Transit and Street Design Improvement Study (CBRT) to develop standards and design guidelines for on-street BRT systems and also refreshes prior corridor analyses with new data sets.

Metro's Current Transit Service[1]

Metro service includes a variety of transit modes that fulfill various connectivity and passenger needs, including five types of bus service and two types of rail service .

> **Bus** – The five types of bus service currently provided by Metro include:

- **Shuttle** – operates on local streets with closely spaced stops (0.25 mile) and predominantly serves riders traveling between neighborhoods
- **Local Service** – operates on major arterials with stops at least 0.25 miles apart and serves riders traveling inter-community
- **Rapid** – operates on the highest ridership corridors where demand warrants additional capacity beyond that offered by Local service
- **Express** – operates on major arterials and freeways with stops at least 1.25 miles apart and serves riders traveling between communities and regionally
- **BRT Service** – operates on either a dedicated right-of-way, a major arterial or in High-Occupancy Vehicle/High-Occupancy Toll lanes, and stops about 1.25 miles apart and serves riders traveling inter-community

> **Rail** –Both of Metro's rail options operate along dedicated right-of-way and are powered by electricity. There are a total of 93 stations in the system, each offering connections to Metro bus service. The two types of rail service currently provided by Metro include:

- **Heavy Rail** – a subway system that includes two lines, served by the D Line (Red) and the B Line (Purple)
- **Light Rail** – consists of four lines, A Line (Blue), C Line (Green), E Line (Expo) and the L Line (Gold)

The work completed through this BRT Vision & Principles study pertains exclusively to the BRT service category noted above.

1 This list does not include micro mobility and microtransit services, which are emerging Metro transit programs

Key Advantages of BRT

BRT is an assemblage of bus speed improvement strategies, operational enhancements and infrastructure that when combined, create a distinct mobility solution. The primary attributes that make BRT an attractive and distinct transit option for select corridors in LA County are:

> **Context Sensitivity -** Provides flexibility in the standards and design guidelines to accommodate the diverse needs of the various cities and transit operators in the region, while not diluting the overall operational and physical characteristics that distinguish BRT from regular or Rapid bus service.

> **Leverages Existing Infrastructure -** Presents the ability to use the streets and highways that are already accessible as right-of-way. If conditions change over time along a BRT route, it is possible to adjust alignments more readily than for LRT.

> **Cost-Effective -** Offers a cost-effective way to provide mass transit. Even at the highest levels of infrastructure investment, BRT is a fraction of the cost of both light and heavy rail options. Based on BRT projects currently in development by Metro, as well as a review of recently constructed BRT lines around North America, the cost per mile for BRT implementation falls roughly within the following ranges shown in **TABLE 3**.

TABLE 3: ESTIMATED RANGE OF COSTS PER MILE FOR A BRT IMPLEMENTATION

LOW RANGE ESTIMATE	MEDIUM RANGE ESTIMATE	HIGH RANGE ESTIMATE
$10-15 million/mile	$25-30 million/mile	$100+ million/mile
BRT Lite; about 20% of route has a dedicated running way, no or minimal right-of-way acquisition, no grade-separation	Full BRT; at least 50% of route has a dedicated running way; no or minimal right-of-way acquisition, no grade-separation	Full BRT; at least 80% of route has a dedicated running way; extensive right-of-way acquisition and/or grade-separation

Study Purpose

The BRT Vision & Principles Study develops a comprehensive vision for BRT project development, selection and operation in LACounty. BRT standards provide a foundational definition of BRT that not only sets high performance standards but establishes clear eligibility criteria for Measure M Countywide BRT program funds. Design guidelines assist Metro and other municipal transit operators in the planning, design and operation of an efficient and effective BRT system.

Performance indicators developed through the study provide the necessary tools to monitor system performance and customer satisfaction. A BRT corridor selection process has been developed that screens projects based not only on indicators of service demand and equity but on assessments of constructability. Finally, using the aforementioned tools, the study identifies and prioritizes corridors that are best suited for future BRT project development.

Project Vision & Guiding Principles

Given that there is some variability in national and international definitions of BRT and even within those definitions some latitude for variability in implementation, an initial vision and guiding principles was developed to orient all subsequent work. This initial step not only allowed for a pragmatic assessment of desired BRT outcomes but also allowed for the assessment of alignment with supportive Metro policies, such as Vision 2028 and the Equity Platform.

The five overarching goals of the Vision 2028 plan provided a customer-centric framework that was critical to crafting the vision for the BRT Vision & Principles Study. Similarly, the Metro Board's adopted Equity Framework provided guidance on considerations pertaining to vulnerable populations. The study team also considered parallel studies and guiding documents, such as the NextGen Bus Plan and the Long-Range Transportation Plan to ensure cohesion with their respective goals and objectives.

The vision statement chosen for the study is "BRT-the Convenient Choice for Connecting Customers and Communities." In addition to the vision statement, seven guiding principles were identified that influenced the development of goals for this project, shown in **TABLE 4** below.

Vision Statement: BRT-the Convenient Choice for Connecting Customers and Communities

Guiding principles were developed to assist the project stakeholders in expressing a common set of values. This study continued with a process that recognized the important attributes of BRT for LA County, based on these principles and through the creation of a set of goals and objectives which, in turn, supported the development of key performance indicators, standards and design guidelines for BRT.

TABLE 4: BRT GUIDING PRINCIPLES

Guiding Principles	Description
World-class	Offer exceptional service, operations and amenities that enhance the customer experience.
Equitable	Focus on on understanding and meeting the mobility needs of underserved communities.
Customer-centric	Prioritize the needs of our customers over public agency challenges and constraints.
Reliable	Run on time, eliminates bus bunching and provides accurate, real-time information.
Safe and Secure	Operate safely and has secure stations and vehicles with proper lighting and visible security measures.
Integrated and Connected	Seamlessly connect people and places with existing and planned transportation services across the region.
Community-focused	Promote and support vibrant communities around transit through community investment, including walking and biking infrastructure.

Project Goals & Objectives

Goals Tailored for the Region

Goals developed for this study express specific and desired outcomes for LA County BRT services and infrastructure. The purpose of the goals is to answer what we intend to accomplish or achieve with the BRT network, while ensuring alignment with the values expressed in the guiding principles. In this study, the goals directly influenced the development of objectives, performance measures and key performance indicators (KPIs). KPIs provide a mechanism of accountability for Metro and other municipalities and transit service providers as BRT projects work toward achieving the goals.

The following goals were developed to guide implementation of the LA County BRT Network:

> Our BRT will provide an attractive, convenient and reliable mode choice that is a safe, secure, inviting and comfortable experience for all users for the entire trip.

> Our BRT will fulfill a distinct role that enhances and integrates with existing mobility services.

> Our BRT will connect people to where they need and want to go.

> Our BRT will consistently operate at high-performance levels allowing users to bypass congestion.

> Our BRT will provide excellent infrastructure, vehicles, amenities and customer service.

> Our BRT will consider community needs and enhance quality of life.

> Our BRT will align design standards and service needs to maximize benefits.

Development of Objectives to Realize BRT Goals

In order to realize BRT goals, specific objectives were developed to detail the activities necessary to achieve the corresponding goal. The process allows for a more precise and fully measurable outcome that can be tracked over time where necessary. These objectives informed several key areas of the study, including BRT standards, performance indicators, design guidelines and corridor selection. **TABLE 5** includes the complete list of detailed objectives and related goals.

TABLE 5: BRT GOALS & OBJECTIVES

RELATED GOAL	OBJECTIVE
Our BRT will provide an attractive, convenient and reliable mode choice that is a safe, secure, inviting and comfortable experience for all users for the entire trip	Achieve a minimum 90% on-time arrival rate.
	Achieve excess wait time in the peak-period of no more than one minute.
	Limit travel time variation for Full BRT to no less than 25% MPH average speed improvement over regular bus service from end-to-end (or point-to-point where there is no comparable service).
	Offer a pleasing, rail-like passenger experience to BRT riders specifically with regard to travel times, dwell times, speeds and amenities.
	Achieve incident rates 15% below the Metro average per operational mile.
	Achieve on-board passenger security incident rates 15% below Metro average.
Our BRT will fulfill a distinct role that enhances and integrates with existing mobility services	Maximize the percentage of passenger transfers between BRT and other high-frequency transit or mobility services which can be made within 10 minutes (combined walk time and average waiting time).
	100% of stations will offer amenities and access to first/last mile supporting services, including dedicated transportation network company (TNC) drop off/pick up, shared scooter/bike, bike lockers, etc.
	Provide personalized relevant information to customers on mobility options at their destination and measure based on customer opinion survey.
	Develop unique vehicle branding approaches that distinguish BRT as different from standard bus service and flexible enough to accommodate vehicles on multiple BRT routes.
Our BRT will connect people to where they need and want to go	Connect to one or more major BRT or light rail transit (LRT) stations or other major intermodal points to support larger transportation network connectivity.
	Equity Focus Community indicators will be considered at least as strongly as population and employment density in route selection and design.
Our BRT will consistently operate at high-performance levels allowing users to bypass congestion	Achieve an average peak-period end-to-end running time inclusive of stops within 1.8x (for Full BRT) and 2.4x (for BRT Lite) of the baseline free-flow travel time (inclusive of stops).
	Improve reporting rate on BRT locations to at least every 10 seconds.
	Achieve a 90% non-cash payment by 2028.
	Limit need to kneel bus to 10% of stations.
	Measure and estimate signal-based intersection delay and reduce by 20%.
	Reduce the number of signalized stops for the bus by 25%.
	Achieve average station dwell times of 12 seconds or 1.7 seconds per person.
Our BRT will provide excellent infrastructure, vehicles, amenities and customer service	Achieve an 80% positive approval through a periodic customer survey quality rating for vehicle and station condition and cleanliness.
	All public-facing BRT infrastructure achieve same mean time between failure (MTBF) as Metro rail system counterparts.
	BRT will be the proving ground for emerging technologies and strategies.

RELATED GOAL	OBJECTIVE
Our BRT will consider community needs and enhance quality of life	Ensure customized wayfinding and mode transfer options for first/last mile at each station.
	Identify and improve major barriers to walking or rolling to each station; develop and collaborate with partners to achieve improvements.
	Involve the community through walk-audits, site-surveys, design charrettes and other inclusive community engagement strategies for every BRT project.
	Achieve an 80% positive approval rating in a post-implementation community survey for enhanced quality of life perceptions.
	Ensure that BRT network corridor selection processes include equity criteria to serve vulnerable communities and strive to continuously refine said criteria to best serve these communities.
	Undertake authentic engagement that centers on the voices of vulnerable communities.
	Implement an ongoing consultation process with all stakeholders in the public sector (e.g., police), the private sector (e.g., merchants, real estate interests) and the general public as part of planning and implementation to support place-making and place-keeping.
	Provide cities and residents along the BRT corridor alignment with toolkits and data to promote TOC outcomes, while providing protections for affordable housing stock.
Our BRT will align design standards and service needs to maximize benefits	Select corridors based on technical analysis and expressed community needs and ability to meet BRT design standards.
	Secure memo of understanding or policy agreements from local jurisdictions to provide BRT priority through infrastructure, operating strategies or policies.

Combined with best practices, these objectives provided the best and most complete information required to move forward with the development of the following subset of BRT study products.

> **Standards:** Tracking back to the vision, goals and objectives ensured that the proposed BRT standards include thresholds that reflect consideration of baseline conditions and capabilities of Metro and local agencies that will need to implement them during the deployment of BRT.

> **Performance Indicators:** The planning elements were instrumental in the development of key performance indicators (KPIs) such as those that help the BRT planning and operations leadership create and adjust new BRTs as needed to meet envisioned service and infrastructure. As the stewards of Measure M, Metro will also use the KPIs to monitor the performance of BRT lines implemented using Measure M funds by both Metro and municipal transit agencies.

> **Design Guidelines:** Every section of the design guidelines developed as part of this study resulted in BRT design guidance that clearly reflects the vision and supports a design that can meet the expectations of Metro and the jurisdictions responsible for planning and development of a BRT.

> **BRT Corridors:** The corridor selection criteria were mapped to the planning elements to ensure that quantitative and qualitative analyses of potential study corridors were measured against the principles and values.

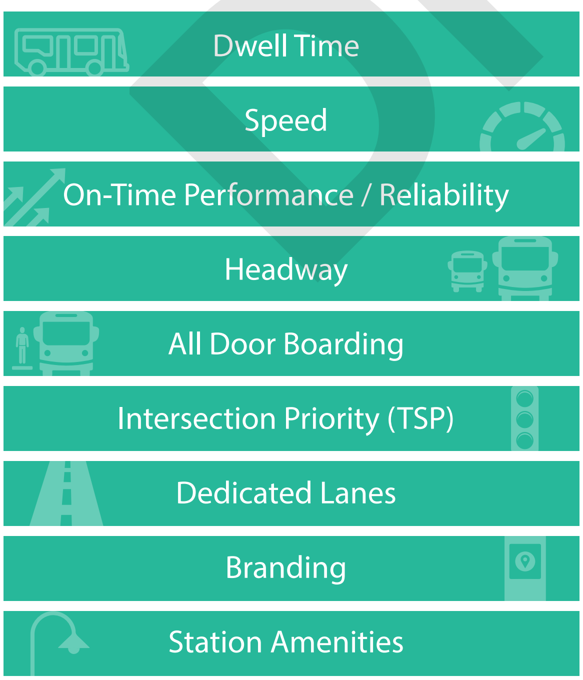
BRT Standards

While there are numerous reputable BRT standards and guidance that have been published both at the national and international level, strict adoption of any one of those standards to an area as large and diverse as LA County proved impractical. Therefore, this study drew upon existing national and international guidance to develop a local BRT standard, adapted to the specific context-sensitive needs of LA County.

The standards developed through this study provide the foundational definition of LA County BRT, including improvements, components and thresholds constituting BRT. This foundational definition of BRT is important not only to establish consistency in BRT project development but also to establish eligibility criteria for Metro Countywide BRT program funds.

As shown in **FIGURE 6**, the standards draw from a familiar mix of service parameters, enhancements and infrastructure that, when combined, provide a baseline definition for high-quality BRT service.

FIGURE 6: CATEGORIES OF BRT STANDARDS



The operational and brand consistency derived from the standards conveys multiple benefits, including but not limited to:

> Provide the transit rider with a consistently high-quality, seamless and reliable user experience across the entire LA County BRT network, whether operated by Metro or a municipal transit agency.

> Increase transparency with community members and public agency partners by setting clear expectations of what a BRT project entails.

> Ensure that the investment of public resources in infrastructure is commensurate with service.

> Provide consistency in approach to BRT investments.

Experience with BRT has shown that the best systems are not simply a sum of their parts. High-performance BRT systems are usually the result of ensuring that the individual components (e.g. running ways, stations, ITS elements, operating plans) work well with and reinforce each other. The standards proposed here, and the subsequent design guidelines, are aimed at ensuring this level of tight integration among BRT's components.

Organization of Standards for BRT

Standards developed in this study are organized in two distinct BRT tiers for performance and infrastructure. The tiers of standards support BRT's distinctive and premium levels of service and amenities, while providing flexibility to accommodate a variety of regional conditions under which BRT will be implemented. This approach allowed for a context-specific application of national and international standards in LA County, consistent with the goals established for the project.

This includes identifying where flexibility for those standards exists, and where standards are best represented by a single set of criteria or by multiple levels of criteria for different levels of BRT service.

Tiered BRT Standards

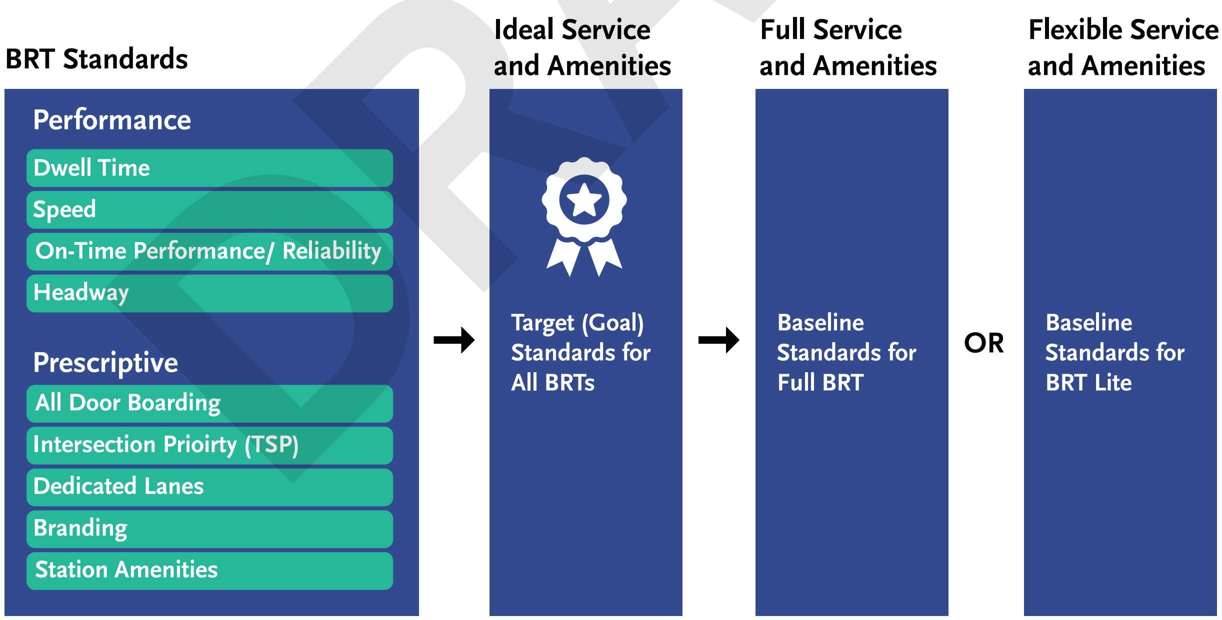
The two-tiered BRT standard sets a minimum standard for service to be considered BRT, as well as an ideal BRT standard of service. These are labeled as Full BRT and BRT Lite, respectively. This tiering of standards allows local jurisdictions and Metro to deploy BRT systems in areas where it may not be possible to achieve Full BRT standards but enhancements to service are warranted. This will ensure that BRT services can be directed to areas that need it most, while distinguishing the level of BRT service from other Metro or municipal transit services. The two levels of BRT service are defined as follows:

> **Full BRT:** A high-capacity, high-mobility, and high-amenity level of BRT service that is comparable to light rail transit (LRT). Full BRT has rail-like stations, a high percentage of dedicated running ways, and highly reliable, yet flexible service.

> **BRT Lite:** The minimum level of BRT, positioned between current Metro Rapid bus service and Full BRT. It still offers high levels of amenities and flexibility, but with a somewhat lower level of dedicated running ways and speed and reliability enhancing features.

In addition to BRT tiers, a target goal set of standards is included that represents an ideal BRT project implementation. Target standards are illustrative of opportunities to further enhance BRT performance beyond baseline requirements. The delineation of standards by tiers, performance and prescriptive-based standards is shown in **TABLE 7**.

FIGURE 7: ORGANIZATION OF BRT STANDARDS



Performance and Prescriptive Standards

Standards are further designated as prescriptive or performance-based. The use of both prescriptive and performance-based standards is intended to create an interdependency that drives the need for infrastructure. The additional benefit is the inherent flexibility of the application of the standards: a range of prescriptive-based improvements can be deployed to achieve performance outcomes.

Performance Standards: Performance standards are outcome-based, focused on operational performance of the BRT service. Flexibility allows for meeting at least three of the four standards for the following areas:

FIGURE 8: BRT PERFORMANCE STANDARDS

Prescriptive Standards: Prescriptive standards require that specific criteria are met, irrespective of outcomes. These are directed towards the physical and as-built characteristics of the BRT corridor defined within five standards:.

FIGURE 9: BRT PRESCRIPTIVE STANDARDS

All-door Boarding

Intersection Priority (TSP)

Dedicated Lanes

Branding

Station Amenities

The use of peak period lanes and station amenities based on headways are examples of flexibility in applying standards. In addition to minimum standards, standardized targets were also identified to achieve if possible, for Full BRT and BRT Lite. These minimum and target standards represent the foundation by which BRT will be measured in LA County. Collectively achieving these standards along each BRT corridor will help to ensure a high-quality, attractive BRT service that distinguishes itself from other services in the region.

Considerations for BRT Implementation

As we consider the characteristics and benefits of BRT implementation, it is important to remember that the individual standards are interdependent, each element or treatment, building on the benefits of the others. That is not to say that certain standards do not have greater impact on performance outcomes, but that the whole of the standards is greater than the sum of each individually.

Full BRT provides the most complete implementation in terms of service and facilities and is designed and constructed to approximate LRT. This level of BRT adheres to the highest level of standards as defined though this study for the BRT network in LA County. Within this high standard, there is built-in flexibility to accommodate the diverse conditions within the communities along the corridor without sacrificing reliability; however, the corridors selected through this study include characteristics that provide the best opportunity for a Full BRT implementation.

The characteristics and benefits of a Full BRT implementation are:

> Full BRT implementation provides the greatest opportunity for realization of improved travel times along a corridor, giving priority to the efficient movement of people over vehicles. The goal of Full BRT is to provide fast (average speed, including dwell time, 18 MPH), frequent (10 minute headways) and reliable service (80% on-time).

> Full BRT quick boarding and alighting (two second/person or 15-second/stop dwell time average) contributes to the overall speed and efficiency of the BRT operation. BRT riders benefit from reduced travel times along the corridor when stops and dwell times are expedited.

> Full BRT is branded and recognized by the traveling public as a distinctive and premium transit service through a BRT designator on stations and vehicles that includes a distinctive design, logo and colors.

> Full BRT implementation relies on a significant percentage (50%) of dedicated running ways, offering a more rail-like experience for the rider, less interference from other transportation modes, and less traffic congestion-related delays.

> Full BRT running way alignment is laid out to minimize conflict with other modes, including common points of conflict, such as vehicle turning movements, on-street parking, ingress and egress from adjacent commercial and retail establishments, delivery vehicles, and taxis or transportation network company (TNC) vehicles. Proper alignment adds the benefit of improved safety and fewer delays along the route.

> Full BRT implementation includes a full complement of station amenities to continue to enhance the rail-like experience and attract additional ridership from transit-dependent and choice riders. While the target is for all stations to have Full BRT amenities, the standard indicates that 90% of stations will include the following amenities:

- Weather protection
- Lighting
- Real-time information
- Trash receptacles
- Seating/lean bars
- Branding
- Metro art

> In space-constrained environments, where the Metro station kit of parts design cannot be adapted, no more than 10% of Full BRT stations may include the following amenities:

- Lighting
- Trash receptacles
- Seating/lean bars
- Branding

> All-door boarding reduces station dwell times by improving boarding and alighting – moving passengers quickly between the BRT vehicle and the station platform. All-door boarding is a characteristic of BRT that is shared by both Full and Lite versions of a BRT implementation.

> Intelligent Transportation Systems (ITS) elements, provide the analytical tools to monitor day-to-day and historical operations, provide faster and more reliable communications, and enhance safety and security for operators and passengers. Many ITS elements such as closed-circuit television cameras, on-board Wi-Fi, vehicle location monitoring and other supporting technology enhancements are ready for implementation now.

> Intersection Priority (TSP) for Full BRT active signal priority at 90% of the signals on the corridor. The primary benefit of more signal priority is the opportunity for the bus to progress along the corridor with less impedance and delay at intersections.

Characteristics and Benefits of BRT Lite Implementation

BRT Lite is another tool in Metro's toolkit that can be applied on corridors with special considerations or constraints. BRT Lite provides the highest levels of flexibility to accommodate corridors where Full BRT deployment may not be necessary or viable. It offers high levels of amenities but with more tractable performance standards that can improve upon existing local bus service.

The characteristics and benefits of a BRT Lite implementation are:

> BRT Lite implementation provides an opportunity for realization of improved travel times along a corridor, giving priority to the efficient movement of people over vehicles. The goal of BRT Lite is to provide fast (average speed, including dwell time, 15 MPH), frequent (12-minute headways) and reliable service (75% on time).

> BRT Lite includes quick boarding and alighting (2.5-second/person or 18-second/stop dwell time average) contributes to the overall speed and efficiency of the BRT operation. BRT riders benefit from reduced travel times along the corridor when stops and dwell times are expedited.

> BRT Lite branding is important in differentiating BRT service such that it is recognized by the traveling public as a distinctive and premium transit service. For BRT Lite, stations and vehicles include a designator at minimum that identifies the service as BRT.

> BRT Lite implementations rely on a dedicated running way (20% of the corridor during peak and 10% at all times) for the BRT vehicles to assist in mitigating interference from other modes and helping to reduce traffic congestion-related delays.

> BRT Lite running way alignment is designed to mitigate conflict with other modes as much as possible and avoid common points of conflict, such as vehicle turning movements, on-street parking, ingress and egress from adjacent commercial and retail establishments, delivery vehicles, and taxis or TNC vehicles. Proper alignment adds the benefit of improved safety and fewer delays along the route.

> BRT Lite's baseline station amenities are consistent with BRT's premium service experience and attract additional ridership from transit dependent and choice riders. Seventy-five percent of BRT Lite stations will include:

- Weather protection
- Lighting
- Real-time information
- Trash receptacles
- Seating/leaning bars
- Branding
- Metro art

> BRT Lite's all-door boarding reduces station dwell times by improving boarding and alighting – moving more passengers more quickly between the BRT vehicle and the station platform. All-door boarding is a characteristic of BRT that is shared by both Full and Lite versions of a BRT implementation.

> BRT Lite's ITS elements provide the analytical tools to monitor day-to-day and historical operations, provide faster and more reliable communications, and enhance safety and security for operators and passengers. Many ITS elements, such as closed-circuit television cameras, on-board Wi-Fi, vehicle location monitoring, and other supporting technology enhancements are mature and ready for implementation now.

> BRT Lite's TSP encompasses 75% of signals with active signal priority on the BRT route and all of guideway signals on the corridor. The primary benefit of more signal priority is the opportunity for the bus to progress along the corridor with less impedance and delay at intersections.

On the following page, **TABLE 6** applies the defined thresholds for Full BRT and BRT Lite conditions, providing an easy accessible summary.

TABLE 6: BRT STANDARDS DEFINITIONS

Minimum BRT Standards				Target (Goal)	Standards Flexibility Options		Special Conditions
Standard	**Performance or Perscriptive**	**Full BRT**	**BRT Lite**		**Alternate**	**Must Meet**	
1. Headway	Performance	10 Minutes (Peak Periods)	12 Minutes (Peak Periods)	Five Minutes (Peak Periods)	Yes	Meet three of four performance standards	Off-peak headways cannot exceed 30 min except on weekends and holidays.
2. Speed	Performance	18 MPH average speed (inclusive of dwell)	15 MPH average speed (inclusive of dwell)	20 MPH average speed (inclusive of dwell)	Yes		Shared street/station environments at terminals can be exempted from standrd if bus circulation is not mixed with autos. MPH data is inclusive of dwells and should include data within 90%. Abnormal major service disruptions and detours can be excluded from standards
Alternative: 2a. Alternative Speed		25% MPH average speed improvement over existing bus service in corridor (inclusive of dwell)	15% MPH average speed improvement over existing bus service in corridor (inclusive of dwell)	30% MPH average speed improvement over existing bus service in corridor (inclusive of dwell)	Yes		
3. On-time Performance/ Reliability	Performance	80% on time (e.g. one minute early/five minutes late)	75% on time (e.g. one minute early/five minutes late)	90% on-time (e.g. one minute early/five minutes late)	No		
4. Dwell Time	Performance	2 seconds per person (per boarding) or average 15 seconds	2.5 seconds per person (per boarding) or average 15 seconds	1.7 seconds per person (per boarding) or average 15 seconds	No		Higher average dwell times can be exempted if per person threshold is met. Abnormal events above 95% of maximum dwell can be exempted. Stations with level boarding and prepaid fares are exempt from this standard.
5. Dedicated Lanes	Prescriptive	50% of corridor	20% of the corridor during peak & 10% at all times	100% of the corridor; remove conflicting left turns and consolidate conflicting driveways	Yes	Must meet or the alternative	
Alternative: 5a. Peak Lanes		N/A	40% during peak	N/A			
6. Intersection Priority (TSP)	Prescriptive	90% of signals with active signal priority (100% of signals on guideways)	75% of signals with active signal priority (90% of signals on guideways)	100% of signals with aggressive active signal priority	No	Must meet	
7. Station Amenities	Prescriptive	90% of Full stations & 10% of Lite stations	75% of Full stations & 25% of Lite stations	100% Full stations	Yes	Must meet or alternative	Shared street/station environments and terminals may have features and information systems that match the greater environment, as long as BRT stops/bays are clearly marked with matching brand elements. If headways are five minutes or less then seating may be replaced by leaning rails in very constrained areas or areas that provide seperate supplementary seating.
Alternative: 7a. High Frequency Station Amenities		If headways 5 min or less - 80% Full stations 20% Lite stations	If headways 5 min or less - 60% Full stations 40% Lite stations				
8. All-door Boarding	Prescriptive	All stations allow all-door boarding	All stations allow all-door boarding	All stations allow all-door boarding	No	Must meet	Up to 10% of Full BRT and 20% of BRT Lite stations can be exempted from all-door boarding if off-board fare payment is used.
9. Branding	Prescriptive	Distinctive design and logo. coordinated colors	BRT designator	Distinctive branding, including design and logo on all stations and vehicles	No	Must meet	

Notes: * Full stations = Weather protection (shelter), lighting, real-time information, trash receptacles, seating/leaning, Other passenger amenities, station IDs, security cameras, art
**Lite stations = Seating, trash recepticles, ID, brand

BRT Design Guidelines

The BRT design guidelines, developed as part of this study along with performance measures, will assist and guide Metro and other municipal transit operators in the planning, design, operation and monitoring of an efficient and effective BRT system. The design guidelines align with the BRT vision, goals and objectives, build upon lessons learned from Metro's existing BRT and rail systems, and draw on best practices from BRT systems across North America and around the world.

The BRT Design Guidelines Manual, a separate companion document to this final report, provides recommendations on six critical and interconnected aspects of Bus Rapid Transit: General Operating Characteristics, the design of BRT Running Ways, Stations, ITS, Branding and integration with Transit-oriented Communities (TOC). The design guidelines also identify creative, adaptable and innovative BRT improvements and solutions, promote BRT as an investment in communities, facilitate safe pedestrian and bicycle connections to the BRT network and encourage holistic planning efforts that support and promote TOC.

The passenger experience, safety, operational and capital requirements and cost-effectiveness were considered when developing these guidelines. The design guidelines are flexible enough to address potential site-specific constraints and/or applicable local ordinances. They will be used by Metro in updating its existing BRT Design Criteria Manual, and by municipal transit agencies wishing to implement new BRT lines under Measure M's BRT Program, ushering in the county's next iteration of BRT services.

FIGURE 11: CRITICAL & INTERCONNECTED BRT ASPECTS

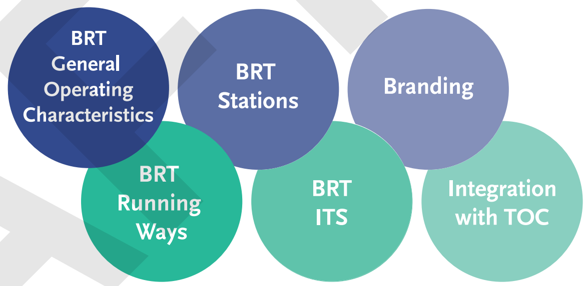
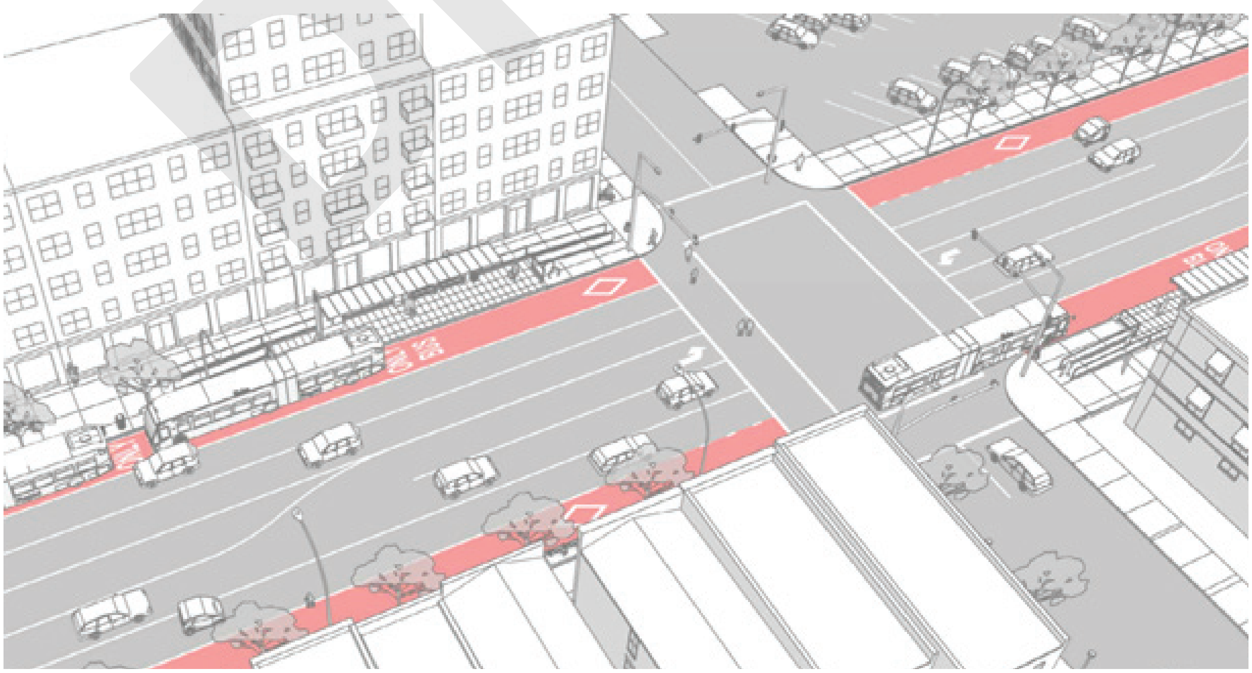


FIGURE 10: CURB RUNNING BRT OPERATION



BRT Corridors

The corridor screening and selection process was designed to identify the corridors where BRT is best deployed as a mobility solution. It is important to note that BRT investment is not appropriate for every high-ridership corridor, nor is BRT the only tool available to improve bus speeds and service reliability. Other speed improvement tools include: queue jumps, bus only lanes, signal priority and more can be selectively deployed to alleviate choke points on any given bus route.

Corridors identified and selected as the best candidates for BRT, through this study, have characteristics that include an optimal intersection of need and opportunity, meaning that there is not only a demand for service, but the corridor contains the requisite characteristics to support BRT infrastructure.

Thematically, the main features that Metro considered of primary importance in the selection of BRT corridors included: service demand, regional connectivity, along with an opportunity to improve bus speeds, supportive infrastructure and Metro's Equity Focus Communities (EFCs).

Corridor Identification

Metro's technical team used three primary sources to gather a broad list of potential corridors for BRT implementation:

> BRT candidate corridors identified in recent planning studies and efforts by Metro

> Direct input from the project's targeted stakeholders

> Use of a parametric design tool to identify promising corridors not identified through the efforts mentioned above

Recent Planning Studies and Efforts by Metro

Recent planning studies and efforts by Metro provided the basis from which to begin the identification and evaluation of potential BRT corridors. A literature review and research initially yielded a list of 34 corridors primarily informed by Metro's Bus Rapid Transit and Street Design Improvement Study (2013) and the Sub-regional Mobility Matrix effort undertaken in support of Measure M. The team also coordinated with other related initiatives, including the NextGen Bus Plan, LRTP, Bus Speed Improvement Working Group and the Metro Vision 2028 Strategic Plan.

Three corridors from the 2013 study and the Mobility Matrix effort are currently in the planning and implementation stages, now known as the North Hollywood to Pasadena, North San Fernando Valley and Vermont corridor projects. In order to avoid any duplication of efforts, none of the aforementioned projects nor any mobility corridor in the Measure M expenditure plan was analyzed through this process.

Technical Advisory Committee Input

To help guide the study process, a Technical Advisory Committee (TAC) was established, comprised of staff from Metro departments, cities and municipal transit operators. The TAC provided insight on the identification and validation of BRT corridors and direction on the identification of the Strategic BRT network. Through the assistance of the TAC, an additional 39 corridors were identified for consideration. This was in addition to the previously identified corridors noted above.

Parametric Design Tool

In order to find promising corridors not yet identified by the two aforementioned methods – corridors from previous studies or stakeholder input – a computational (or "parametric") analysis was utilized. Parametric modeling is a customizable algorithmic process enabling the efficient and effective processing of complex information, associating multiple parameters (or datasets) as design drivers for evidence-based decision making. The algorithms built for the BRT Vision provided parametric analysis for the project in two phases. The first used three criteria (equity, population density, employment density) to ensure the potential BRT routes provided county coverage and specifically served areas with the highest need. The subsequent phase added additional layers of criteria to rank the lines based on performance potential, choosing the best lines to consider.

This type of modeling is an innovative way of leveraging the available analytical technologies to incorporate many disparate datasets into a cohesive and understandable whole, thereby giving each corridor the same level of quantitative analysis.

In this final step to identify candidate corridors, the automated parametric algorithm was used to review every arterial segment in LA County and create a "heat map" of segments that score well in the areas of population density, employment density, intermodal connections, as well as Metro's EFC metric. Use of the parametric tool ensured that no viable BRT candidate corridors were neglected or overlooked due to bias or human error.

The high-performing segments identified through this process were manually combined into corridors. This analysis resulted in 11 new corridors in East Los Angeles, South Los Angeles and the San Fernando Valley, complementing and filling gaps in the corridors identified above.

The Universe of Corridors

Based on previous studies, plans and input from the BRT TAC described in the previous sections, a comprehensive set of corridors was assembled and is depicted in the map in ***Figure 12***, shown on the following page. This set of corridors became the basis for all subsequent analysis and screening activities. This was an important step in providing a foundational set of corridors where all desired BRT routes were considered. After this step, the various criteria for a successful BRT were progressively applied in three screening levels to narrow the field to those routes likely to perform the best and serve the needs of each respective community.

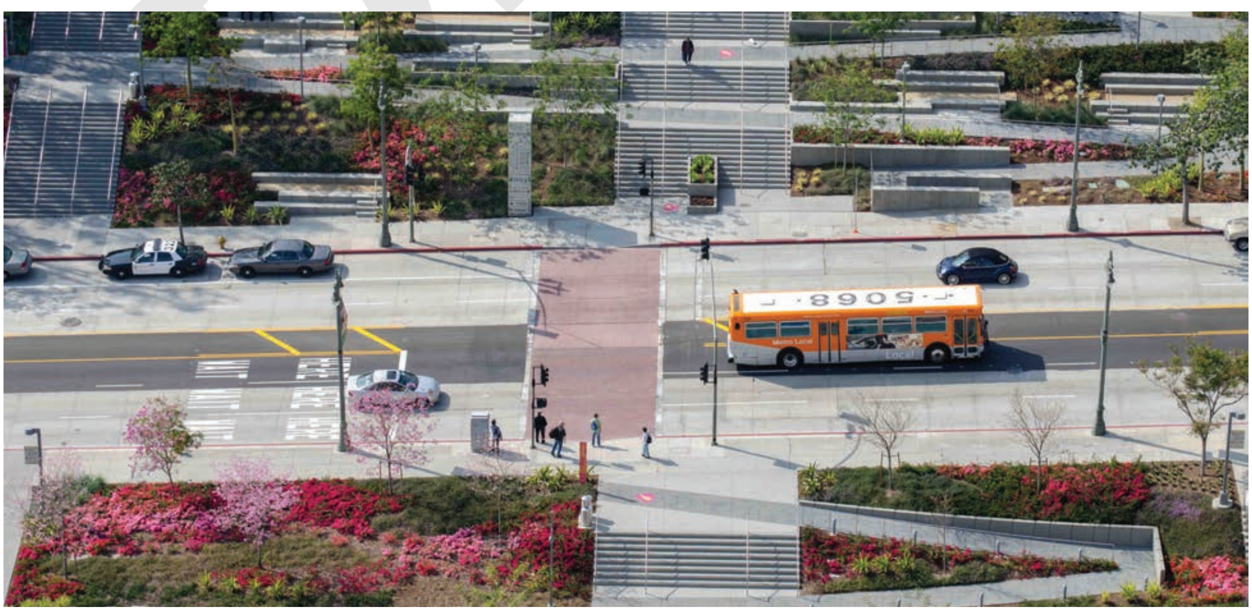
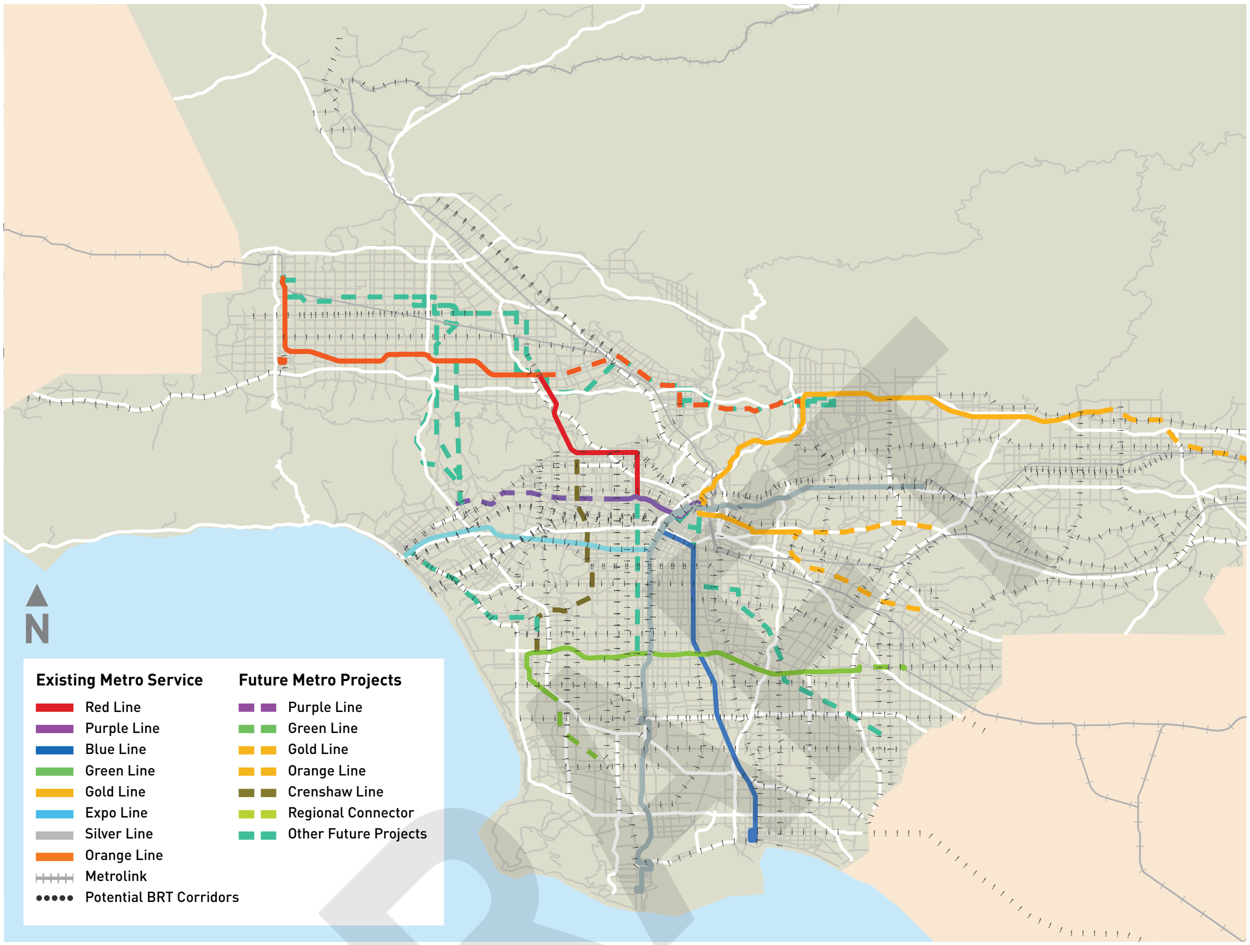


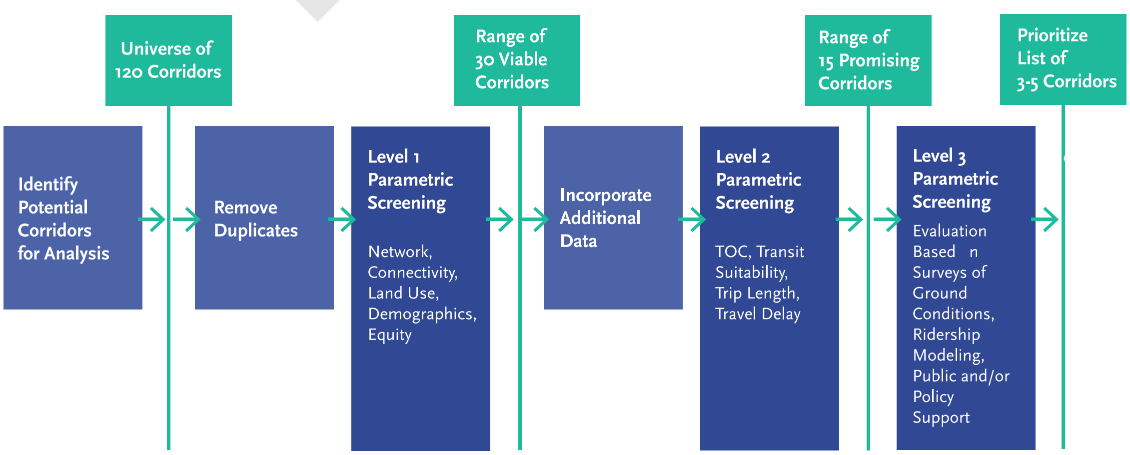
FIGURE 12: UNIVERSE OF POTENTIAL BRT CORRIDORS IN LOS ANGELES COUNTY



Corridor Screening Process

The process chart in ***Figure 13*** depicts the progression and levels of screening used to analyze potential corridors and select the most promising corridors for BRT implementation in LA County. Given the large number of corridors, and in keeping with common transit planning practice, a three-level screening process was used, wherein each successive screening level introduces additional data to arrive at a prioritized set of corridors. The following section provides detail for each level of the process.

FIGURE 13: BRT CORRIDOR THREE-LEVEL SCREENING PROCESS



Level 1 Screening

After compiling the list of potential BRT corridors, the technical team reviewed the results for high-level feasibility. Potential corridors were eliminated from consideration, or their routing was adjusted, for the following reasons:

> The corridor does not begin, end, or connect to existing or planned high-capacity transit services or key activity centers.

> The corridor does not begin or end at key activity centers.

> The corridor is duplicative of existing or planned high-capacity transit.

> The corridor was determined to be infeasible in a prior study.

> The corridor did not meet minimum length requirements (six miles) or was a small extension to an existing or planned transit corridor.

Once the initial screening/refinement was performed, the remaining corridors were loaded into the parametric model for level 1 screening. The screening analyzed network connectivity, land use, points of interest, demographics and Metro's EFC metric. The criteria are listed in ***Table 7***. The model compared the area within ¼ mile of each corridor relative to the area along every other corridor and generated a score for each option. Corridors that best met the criteria — such as those that have higher levels of job or residential density or include a higher proportion of the corridor in an EFC area — received higher scores.

The Level 1 screening resulted in a list of 30 corridors to be taken into the next level screening, as shown in **FIGURE 14**.

TABLE 7: LEVEL 1 PARAMETRIC CRITERIA

CRITERIA	DEFINITION
Network Connectivity	Measures how well connected the corridor would be to other lines of transit service.
Demographics: Population Density	Measures how many people live adjacent to the corridor.
Demographics: Employment Density	Measures how many jobs are adjacent to the corridor.
Equity	Measures how much of the corridor falls within Metro's Equity Focus Communities metric.
Land Use: Educational Facilities	Measures the corridor's connectivity to schools.
Land Use: Transit-supportive Zoning	Measures how much of the corridor is zoned for more transit-supportive land uses (such as multi-family residential).
Land Use: Points of Interest	Measures the corridor's connectivity to points of interest, such as libraries and parks.

FIGURE 14: TOP 30 BRT VISION & PRINCIPLES STUDY CORRIDORS MAP (COLOR)

Level 2 Screening

In this second screening, the team introduced additional parameters into the model. The 30 most promising corridors were put through a second level of parametric analysis, which considered a rating of each corridor's suitability for supporting transit-oriented communities, trip length, travel delay, network connectivity and equity. This second screening was coupled with another visual inspection process, which allowed the team to identify any other attributes of or difficulties with the corridor that would assist in the identification of the most promising and best performing 15 corridors. The criteria used in the Level 2 screening are shown in **TABLE 8**.

TABLE 8: LEVEL 2 PARAMETRIC CRITERIA

CRITERIA	DEFINITION
Transit Propensity	Measures likelihood of residents living along a corridor to take transit.
Trip Length	Average trip length in a corridor based on location-based services data.
Trip Delay	Travel Time Index output from iPEMS, Metro's Arterial Performance database.
Corridor Constructability	Qualitative evaluation of the physical compatibility of a corridor for new BRT service.
Transit Oriented Communities (TOCs)	Qualitative evaluation of TOC potential along a corridor.
Network Connectivity	Measures how well connected the corridor would be to other lines of transit service.
Equity	Measures how much of the corridor falls within Metro's Equity Focus Communities metric.

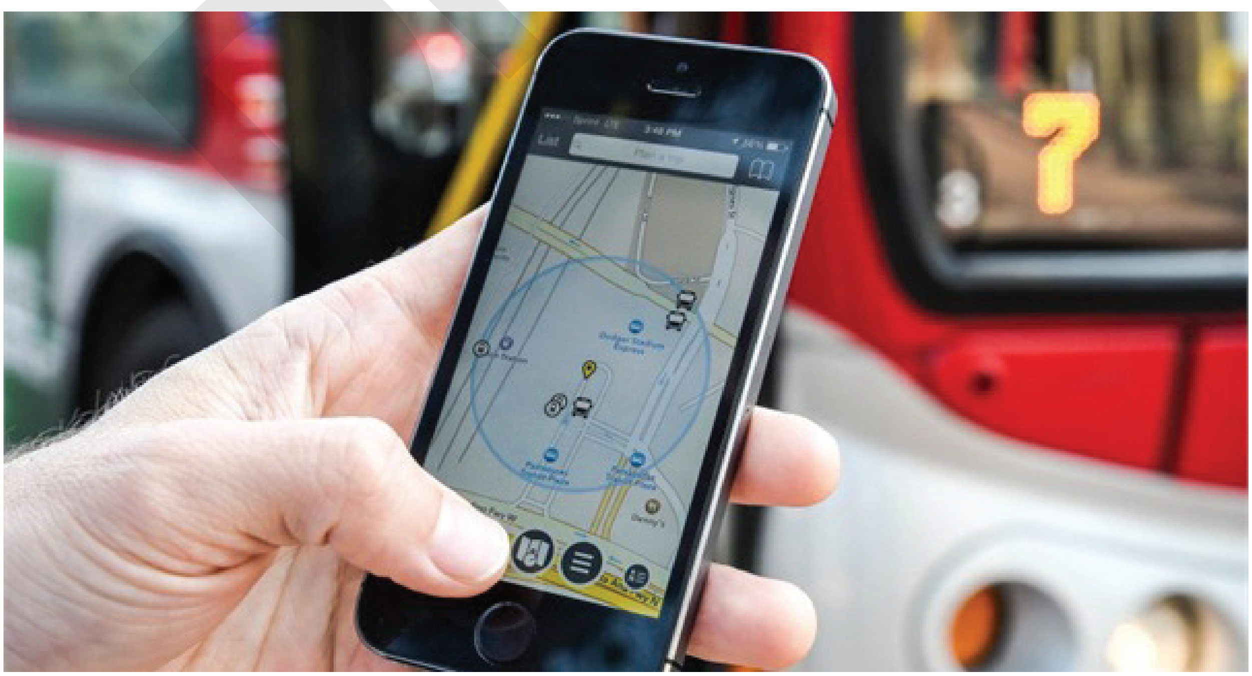


FIGURE 15: TOP 15 BRT VISION & PRINCIPLES STUDY CORRIDORS MAP (COLOR)

Level 3 Screening

The final Level 3 screening process was more qualitative in nature. In this screening, the 15 top performing corridors were reviewed with additional detail incorporated into the analysis. Network connectivity, transit propensity and equity were carried forward from previous screening with new criteria incorporated: qualitative evaluations of TOC and transit-friendly plans and policies, a qualitative assessment of travel time savings potential, surveys of ground conditions, public and political support and input from key stakeholders. This final assessment shortened the list further, identifying the five priority corridors recommended for BRT implementation, as documented in the following section. The criteria used in the Level 3 screening are shown in **TABLE 9**.

TABLE 9: LEVEL 3 CORRIDOR SCREENING CRITERIA

CRITERIA	DEFINITION
Transit Propensity	Measures likelihood of residents living along a corridor to take transit.
Transit-friendly Policies	Qualitative evaluation of transit supportive traffic management plans, policies and infrastructure along the corridor.
Travel Time Savings Potential	A qualitative assessment considering corridor congestion hot-spots from the iPEMS data coupled with the likely constructability of transit-priority measures in the hot-spots.
Existing Right-of-Way and Corridor Constraints	Qualitative evaluation of the physical compatibility of a corridor for new BRT service.
Transit Supportive Land Uses and Plans	Qualitative evaluation of transit supportive plans and policies along the corridor.
Network Connectivity	Measures how well connected the corridor would be to other lines of transit service.
Equity	Measures how much of the corridor falls within Metro's Equity Focus Communities metric.
Public and/or Policy Support	Qualitative assessment of documented support for BRT in the corridor.

Top Five BRT Corridors

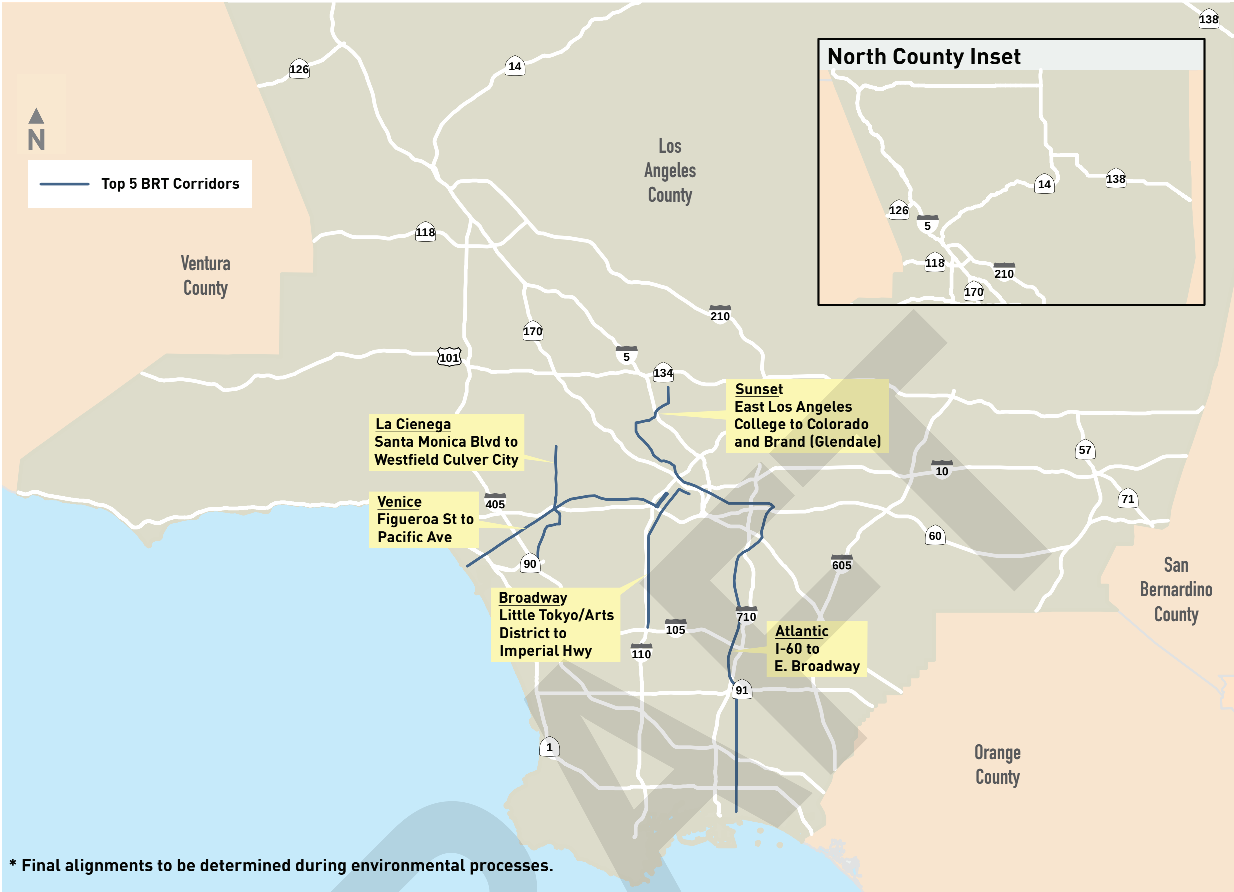
Based on the criteria and rigorous screening process conducted throughout this study, Metro has identified the following five corridors as the top candidates eligible for Measure M Countywide BRT program funds. Each of the top five corridors present excellent opportunities for BRT investment. Of these top five BRT corridors, Metro staff will present a recommendation to the Metro Board of Directors that one of these corridors be initially advanced into project development, subject to available funding. The balance of the remaining corridors would be eligible for Measure M Countywide BRT program funds in subsequent years as funding becomes available. The corridors are listed in alphabetical order. The selected corridors are depicted in the map in ***Figure 16***.

FIGURE 16: TOP FIVE BRT VISION & PRINCIPLES STUDY CORRIDORS

> Atlantic
> Broadway
> La Cienega
> Sunset
> Venice

5

FIGURE 17: TOP FIVE BRT VISION & PRINCIPLES STUDY CORRIDORS MAP (COLOR)

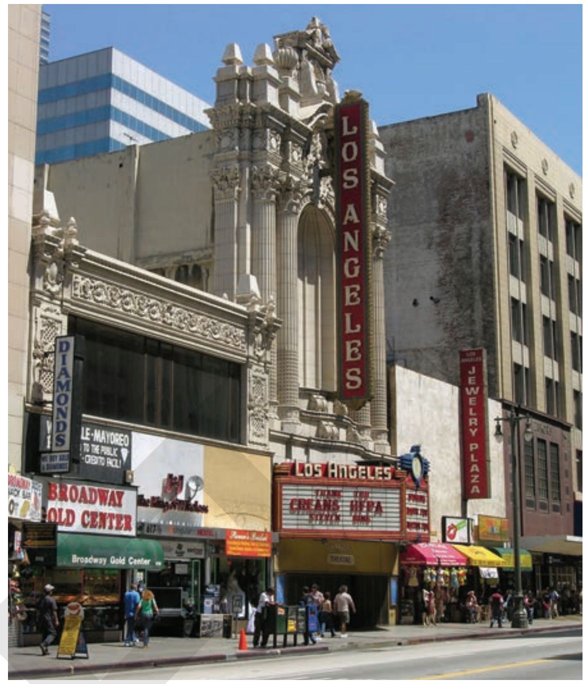


Atlantic

The Atlantic corridor provides high-capacity network coverage in Southeast LA County, from the San Gabriel Valley to the City of Long Beach, connecting cities and communities. When compared to the other top five corridors, this corridor has a moderate level of network connectivity. Atlantic also has a moderate opportunity to build BRT-friendly infrastructure and realize travel time savings, although sidewalks are wide relative to other corridors, allowing more opportunity to build stations with Full BRT passenger amenities. Although this corridor has a comparatively low ridership score, it provides access to industrial jobs for lower-income workers, addressing Metro's equity goals.

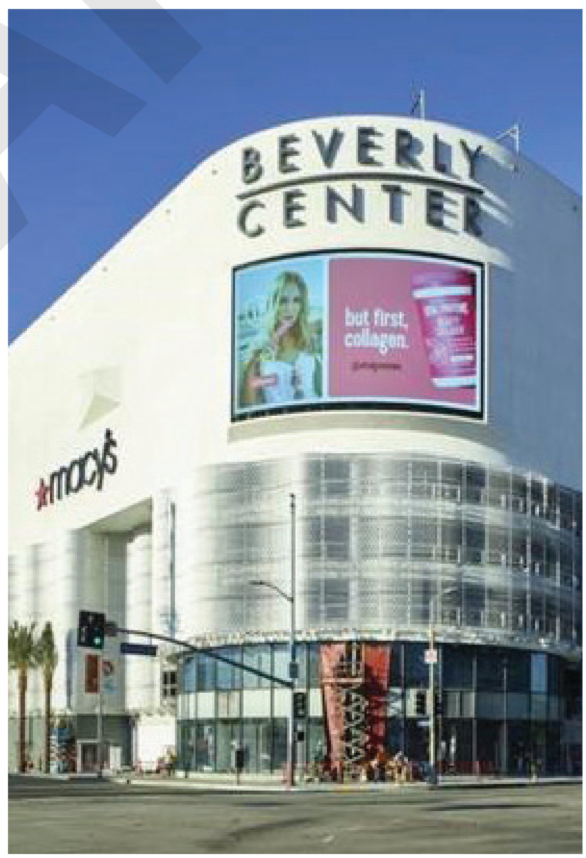
Broadway

Broadway is a vibrant transit corridor with very high network connectivity and is also a NextGen Tier One corridor[1]. When compared to the other top five corridors, this corridor had a very high score in the Equity Focus Community index and is a high-priority corridor per Los Angeles Department of Transportation's (LADOT's) assessment. Broadway runs through two City of LA Community Plan areas which feature TOC and transit-supportive policies. This corridor has moderate level ridership and a moderate opportunity to build BRT-friendly infrastructure and realize travel time savings. A future alternatives analysis could consider both Broadway and Figueroa, which closely parallel each other and perform comparably.



La Cienega

The La Cienega corridor provides high-capacity north-south network coverage on the Westside, linking cities and communities, including West Hollywood, Beverly Grove, eastern Beverly Hills, Pico-Robertson and Culver City. It runs through three City of LA Community Plan areas, which feature or are being updated to feature TOC and transit-supportive policies. Culver City has recently completed a TOD Visioning Study, and West Hollywood has TOC-supportive policies in place that could support the implementation of a BRT on the La Cienega corridor. In comparison to the other top five corridors, La Cienega has a moderate-level opportunity to build BRT-friendly infrastructure and realize travel time savings. This corridor has a low network connectivity score, low ridership score, it is not a NextGen Tier One corridor and it has a low score in the Equity Focus Community index.



1 Corridors analyzed during the development of the NextGen Bus Plan were also considered throughout this study. Additional information about the NextGen Bus Plan can be found at: https://www.metro.net/projects/nextgen/.

Sunset

The Sunset corridor has a very high network connectivity score and connects downtown Los Angeles with the San Fernando Valley. Sunset is a NextGen Tier One corridor that runs through six City of LA Community Plan areas, which feature or are being updated to feature TOC and transit-supportive policies. When compared to the other top five corridors, this corridor has a moderate-level of ridership and a moderate-level opportunity to build BRT-friendly infrastructure and realize travel time savings.

Venice

Venice has a very high network connectivity score and a very high ridership score. Venice is a NextGen Tier One corridor with a high-level opportunity to build BRT-friendly infrastructure and realize travel time savings. This corridor has pedestrian-friendly features along much of its distance with a strong mix of land uses oriented to the street. The Venice corridor runs through seven City of LA Community Plan areas, which feature TOC and transit-supportive policies. Culver City has recently completed a TOD Visioning Study, which includes Venice. Venice has communities with strong transit-supportive policies along corridor and it is an LADOT high-priority corridor.

Strategic BRT Network

The Strategic BRT Network builds upon the top five corridors and utilizes a three-step process to layout a roadmap for future BRT expansion in LA County. If the top five recommended BRT corridors are where investment begins, the Strategic BRT Network is where expansion should continue should future funding become available. The first step in the development of the network was to pull from our initial BRT corridor screening assessment – the 120 corridors evaluated as part of the top five recommended corridors – and utilize the Top 30 corridors identified to develop a "core" network. The top 30 corridors – through virtue of their selection process – are previously identified, high-performing transit corridors that jump ahead of other analyzed corridors for their specific strengths in network connectivity, transit supportive land uses, transit propensity, trip length, trip delay and equity.

The second step was to build off of our core network and build out a countywide network for BRT. Staff conducted a gap analysis with four main objectives: 1) consider the existing and planned rail/BRT network, 2) identify gaps in service coverage area, 3) connect future BRT corridors to one another and the Metro rail network, and 4) leverage corridors identified and screened through the project study. Staff examined local city plans, Council of Governments studies, and other regional transportation plans to identify locally preferred transit corridors to assure alignment between our proposed corridors and those our local partners may have already identified. The second step of the process also involved removing duplicate service – identifying parallel BRT corridors near one another – with priority given to the corridor with the higher opportunity to construct.

Finally, our third step was to solicit input on the network from our local agency partners – including our study TAC, as well as through individual meetings with local agencies and key stakeholders. The third step allowed staff to receive direct feedback from our local partners and make changes where necessary to align Metro's vision for the future of BRT in LA County with that of our local partners.

FIGURE 18: BRT NETWORK

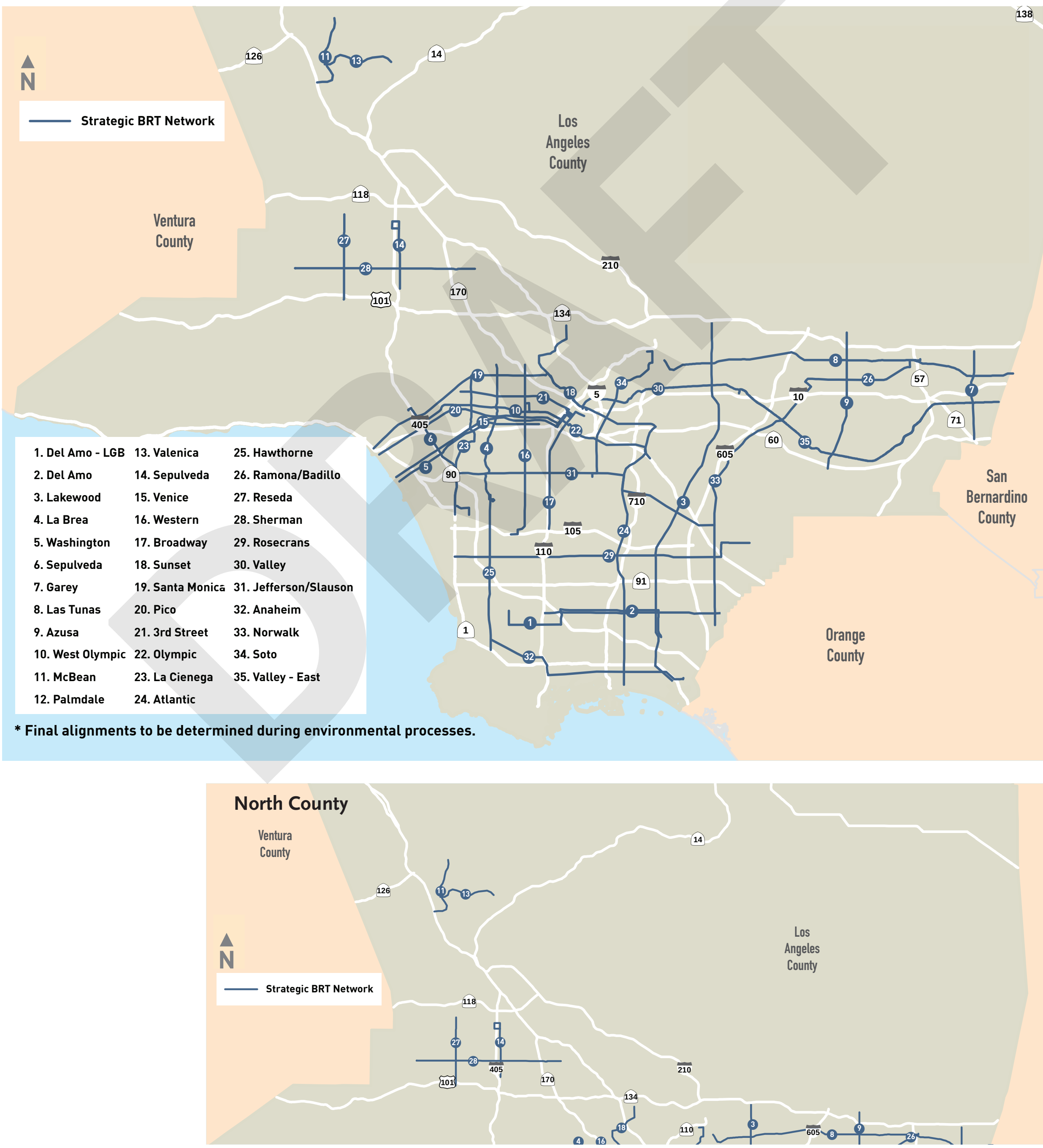
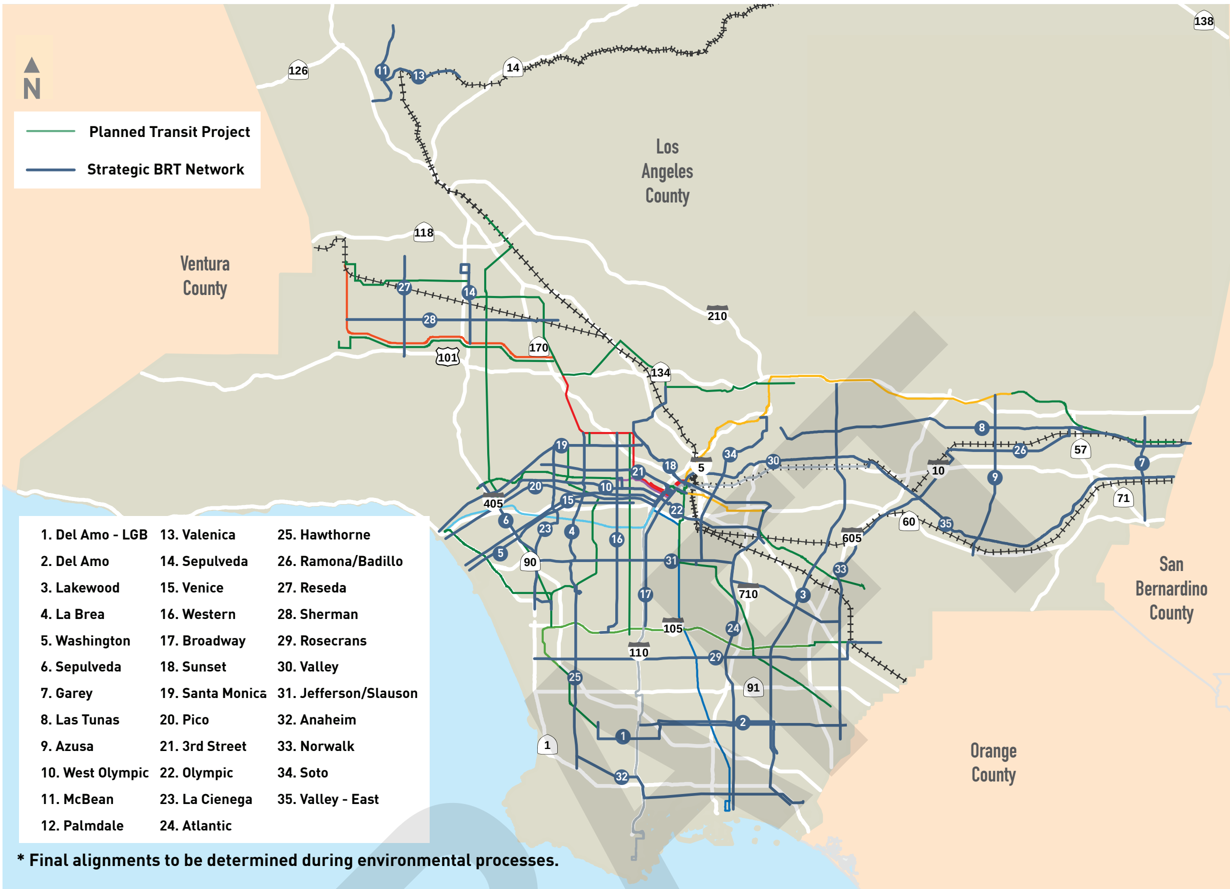


FIGURE 19: BRT NETWORK & THE EXISTING/PLANNED TRANSIT



Conclusion

Metro is making unprecedented investments in our LA County mobility system, including specific investments in BRT. The work completed through the BRT Vision & Principles study establishes the necessary foundation to guide those BRT investments into the foreseeable future. The completion of this work is timely and necessary, particularly as Metro is embarked on three early potential BRT projects, all in some level of study, and with more to follow.

Coordination with the Metro BRT mobility corridor teams has been a continuous feature of this study. Accordingly, BRT projects that are currently in some level of study, as of this writing, are expected to meet the BRT standards established in this document. Future BRT projects will similarly be held to those BRT standards as will any public agency seeking to use Measure M Countywide BRT program funds to develop a BRT project.

The design guideline manual, referenced briefly in this report and available as an accompaniment to this report, will provide the necessary interim guidance for BRT planning work. Next steps for the design guideline manual will be to adapt that work to specific design criteria. This will ensure that as BRT projects move through design and construction phases that the design guidelines are incorporated into the project.

The study identified a top five BRT corridors recommended for future project implementation. These BRT corridors offer the requisite characteristics for successful BRT service. Metro staff will present this top five list to the Metro Board for consideration, recommending that one of these corridors be taken into project development in the near-term. With Board concurrence on a specific corridor, staff will return to the Board at a later date with recommended programming actions and next steps. This will necessarily involve more detailed corridor level analysis, conceptual design work and public engagement with corridor communities and stakeholders.

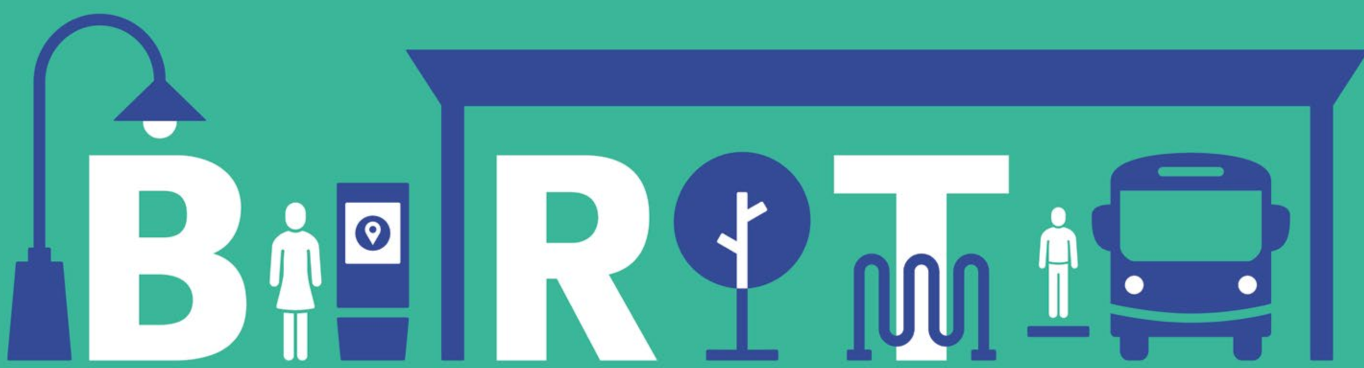
Finally, periodic updates to the standards, design guidelines and design criteria will be undertaken as necessary to stay current with emerging technologies and best practices.

Appendix

Key Transit Terms

TERM	DEFINITION
iPEMS	Metro's online roadway (freeways and arterials) performance monitoring tool to support local agency and sub-regional operations and planning efforts. iPeMs uses HERE real-time crowd-source data and provides real-time continuous speed data every minute.
ITS	Technical innovations that apply communications and information processing to improve the efficiency and safety of ground transportation systems.
Headway	The time that passes between the departure of one bus and the arrival of another.
LRTP	Metro's plan to assess future population increases projected for the county and what such increases will mean for future mobility needs. The plan recommends what can be done within anticipated revenues, as well as what could be done if additional revenues became available. The 2009 LRTP is an update to the 2001 Long Range Transportation Plan for future transportation investments in LA County through 2040.
MTBF	Mean time between failure, or inherent failures of a mechanical or electronic system during normal system operation.
POP	Proof of payment for transit services, such as TAP, reduced fare, low-income fare, or annual fare cards.
Right-of-way	Right-of-way is a type of easement granted or reserved for use by an operator of a transportation project, such as for a BRT running way or station. Ownership of the right-of-way stays with the original owner.
Running way	A transportation corridor dedicated for exclusive or preferential use by public transit vehicles, including rail vehicles, buses, carpools and vanpools.
TAP	Transit pass, a plastic card with an embedded smart card chip, is designed to apply fare payments at fareboxes, ticket vending machines and other participating agencies.
TOC	TOCs include land use planning and community development policies that maximize access to transit as a key organizing principle and acknowledge mobility as an integral part of the urban fabric.
TNC	Transportation Network Companies provide prearranged transportation services for compensation using an online-enabled application or platform (such as smart phone apps) to connect drivers using their personal vehicles with passengers.
TSP	Transit signal priority refers to the functioning relationship between active signals along a corridor. A common cycle length is established for all intersections in the coordinated system. By maintaining a constant relationship between the signals at all times, there is a greater likelihood that mobility will be improved. This does not mean that the signals will provide a green light at the same time for the entire length of a corridor; rather, that each signal will quite literally be synchronized with the entire system, allowing for more efficient mobility.

Los Angeles County
Metropolitan Transportation Authority



visioning BRT

BUS RAPID TRANSIT DESIGN GUIDELINES

Metro

November 2020

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BRT Design Guidelines Introduction

1 Los Angeles County BRT Design Guidelines

- Objectives of the BRT Design Guidelines
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- Section 4 – Intelligent Transportation Systems (ITS)
- Section 5 – Branding Design Elements
- Section 6 – Transit-oriented Communities (TOC)

2 How to Use the Guidelines

3 An Integrated Set of Guidelines for Los Angeles County's BRT System

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1 Los Angeles County BRT Design Guidelines Introduction

As the largest public transportation agency in LA County, as well as the manager of county revenues dedicated to public transportation, Metro is committed to the goal of achieving world class bus system performance and service. Consistent with this goal, Metro has completed a BRT Vision and Principles Study to develop a comprehensive, regional approach to Bus Rapid Transit (BRT) planning, design and operation.

Metro is making unprecedented investments in our LA County mobility system and this includes specific investments in BRT. With our BRT system poised to expand, there is a strong need to define BRT standards, operating characteristics, design guidelines and performance measures, to ensure a consistent and high-quality passenger experience.

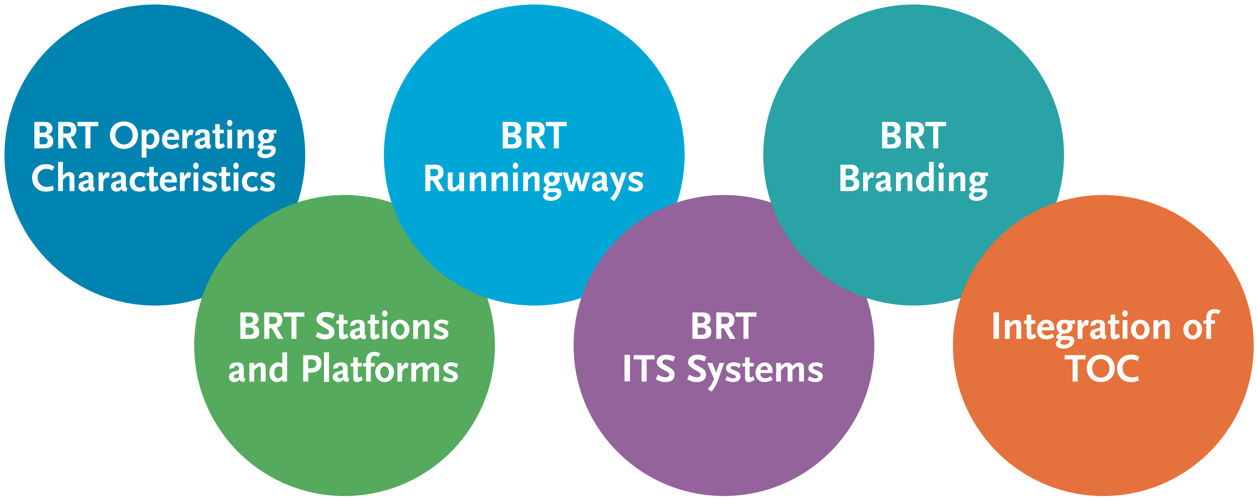
BRT is a bus-based transit service that is flexible and cost-effective, yet can provide faster, more reliable and more convenient service than traditional bus service. BRT is able to achieve these efficiencies through a mix of operational, infrastructure and technological improvements. With the right mix of improvements, BRT can deliver accessible, rail-like service on city streets at a fraction of the cost.

The BRT design guidelines contained herein build upon lessons learned from Metro's existing BRT and rail systems, and draw on best practices from BRT systems across North America and around the world. The intent of the design guidelines is to assist and guide Metro and other municipal transit operators in the planning, design, operation and monitoring of an efficient and effective BRT system.

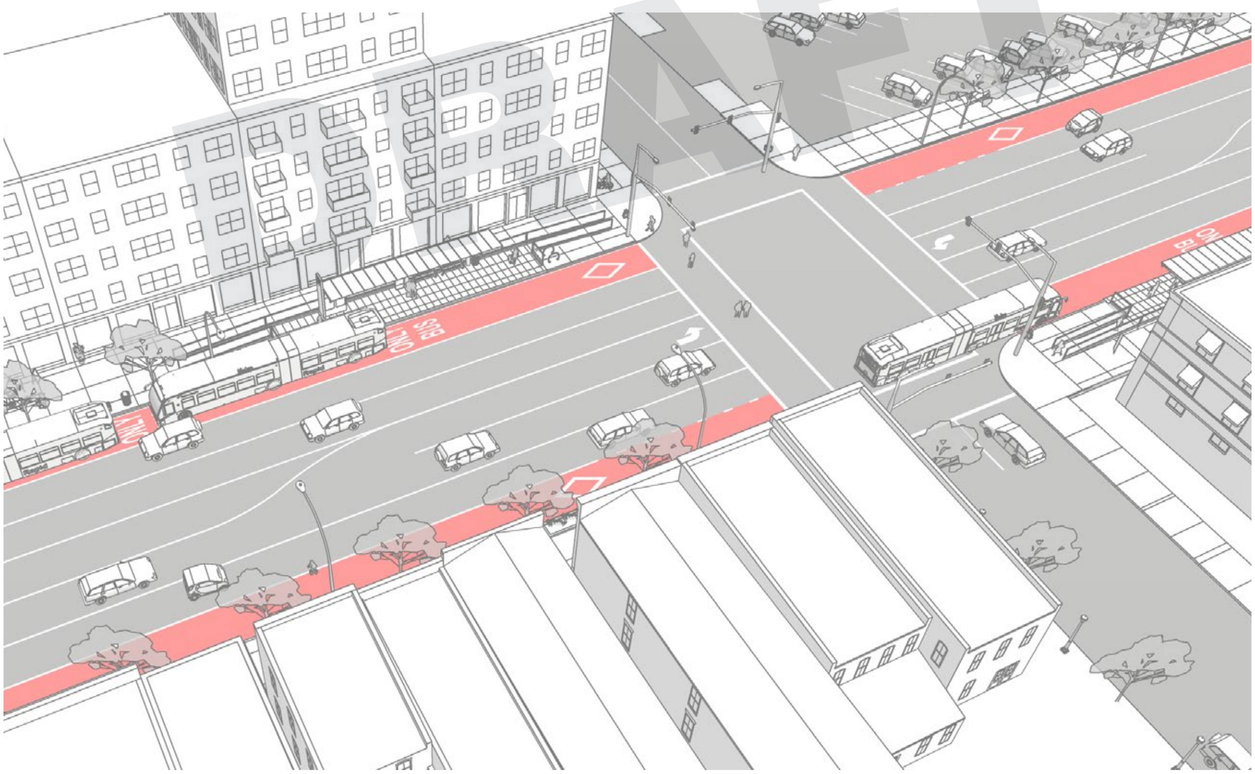
Development of the BRT design guidelines was also informed by the Metro Strategic Plan (Vision 2028) and in close coordination with concurrent Metro efforts including the 2020 Long Range Transportation Plan (LRTP) and the NextGen study. Also taken into consideration were three near-term Metro planning projects: North Hollywood to Pasadena BRT, North San Fernando Valley BRT, and the Vermont Transit Corridor.

Objectives of the BRT Design Guidelines

The Guidelines address six critical and interconnected aspects of Bus Rapid Transit: General Operating Characteristics, the design of BRT Running Ways, Stations, and Intelligent Transportation Systems (ITS), Branding and integration with Transit Oriented Communities (TOC). The design guidelines also identify creative, adaptable and innovative BRT improvements and solutions, promote BRT as an investment in communities, facilitate safe pedestrian and bicycle connections to the BRT network and encourage holistic planning efforts that support and promote Transit Oriented Communities.



The passenger experience, safety, operational and capital requirements and cost-effectiveness were considered when developing these guidelines. The design guidelines are flexible enough to address potential site-specific constraints and/or applicable local ordinances. They will be used by Metro in updating its existing BRT Design Criteria Manual, and by municipal transit agencies wishing to implement new BRT lines under Measure M's BRT Program, ushering in the county's next iteration of BRT services.



The following pages highlight the contents, key guiding principles and major themes from each chapter of the design guidelines.

Section 1 – Operating Characteristics

A BRT's operating parameters and performance, such as frequency, span of service, travel time, and reliability are as important to a rider's experience as its physical attributes. The Operating Characteristics section establishes guidelines and reviews best pratices for a BRT operating plan in LA County, and is oriented around four primary considerations: Context-Sensitivity, Station Spacing, Speed, and Frequencies and Spans.

1

BRT Operating Characteristics

A BRT's operating parameters and performance, such as frequency, span of service, speed and reliability, are as important to a rider's experience as its physical attributes. This section lays out recommended best practices for a BRT operating plan.

1 Summary
2 Introduction
3 Travel Speed
4 Route Length
5 Station Spacing
6 Frequency of Service
7 Passenger Loading
8 Span of Service
9 Service Reliability
10 Travel Time Reliability
11 Fare Collection and Boarding Protocols
12 Other Services Sharing a BRT Corridor
13 Service Reviews

Context-sensitive Guidelines

The operating plans presented are designed for the urban and suburban settings found throughout LA County, with variations designed to accommodate particular operating contexts. The guidelines also offer flexibility when implementing two styles of BRT - "Full BRT" which features a greater investment in dedicated BRT running ways (at least 50% of the route), and "BRT Lite" which achieves speed advantages through more tactical measures such as shorter dedicated lane segments, peak-hour transit-only lanes, and queue jumpers.

Station Spacing

BRT service must balance the need to stop frequently enough to serve transit-supportive land uses and key activity centers with the goal of reducing travel times by limiting stops. As a result, the station spacing requirements analysed the average station spacing found in the Metro Rapid network and increased it to bring it more in line with industy standards for BRT. The guidelines set minimum and maximum average stop spacing distances for dense urban, other urban, suburban, and regional contexts. In general, BRT stations will be spaced roughly 1 mile apart.

Speed

The guidelines recommend that BRT services in LA County achieve minimum end-to-end average speeds (including stops) of 18 mph for Full BRT and 15 mph for BRT Lite. Where unique demand densities, congestion, or right-of-way constraints impact those speeds, the serice should make speed improvements relative to local service of 25% for Full BRT and 15% for BRT Lite. The metrics were designed to address the goals established in Metro's Vision 2028 plan.

Frequencies and Spans

In order to achieve the goal of providing a “rail-like” experience on BRT, the design guidelines establish headways similar to those found on the county’s light rail network. The recommended peak-period maximum headways for BRT are:

> 10-minutes for Full BRT

> 12-minutes for BRT Lite

Service span recommendations are also consistent with Light Rail Transit (LRT), running from 4:00 am to 2:00 am on both weekdays and weekends. In certain suburban contexts that do not connect to the Metro Rail network, service may end at 12:00 am.

In addition to these four considerations, the Operating Characteristics establish guidelines for travel time reliability, fare collection and boarding protocals, and considerations where BRT service shares a corridor with other transit service, all with a view to making BRT in LA County a safe, convenient, attractive and cost-effective mode choice.

Section 2 – Stations and Platforms

Although one of the goals of BRT service is to operate frequently enough that riders do not have to wait long at stations, high-quality station design provides a consistent user experience for passengers and will support positive perceptions of the county’s BRT network as a whole. The Stations and Platforms section provides guidelines for the station footprint and configuration, shelter design, materials and finishes, and integration of other components such as lighting, landscaping, wayfinding, and passenger amenities.

The Stations and Platforms section provides a combination of elements of continuity (those that are present at all stations) and elements of variability (those that are dependent on context) to satisfy four goals:

> Enhance the passenger experience

> Establish a high-quality baseline set of elements

> Provide for seamless integration into right of way

> Use a kit-of-parts approach

2

BRT Stations and Platforms

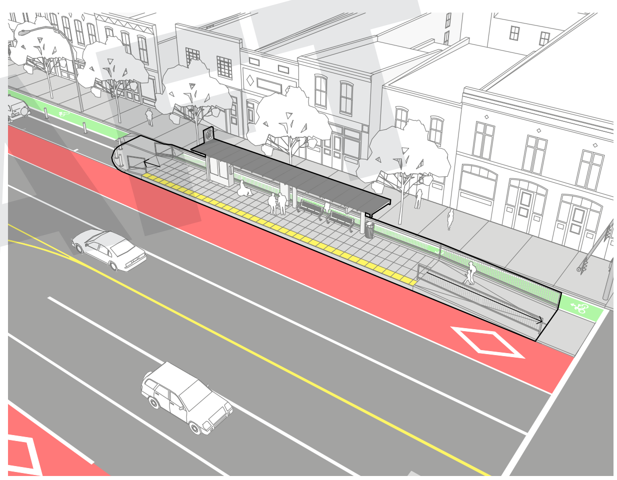
Stations are both the first and last impressions that customers have of a BRT system, and therefore set the tone for the entire rider experience. This section presents the county's standard for BRT Stations, supporting a high-quality, consistent user experience while providing flexibility for space-constrained station areas.

1 Station Design Objectives
2 Station Footprint and Configuration
3 Materials and Finishes
4 Canopy Design
5 Systems Components
6 Lighting
7 Landscaping
8 Wayfinding Signage and Passenger Information
9 Passenger Amenities
10 Public Art
11 Parking
12 Outdoor Rooms/Open Space/Transit Plazas

Major aspects of the station placement and design will be determined primarily by the running way configuration selected for a route (e.g. side versus center running), as well as by available right of way. However, the guidelines also consider approximately two dozen potential components that can be incorporated into stations and platforms. For example, all station platforms will include a ramp or sloped walkway, a canopy/shelter, schedules and wayfinding information, public art and real-time arrival signs. Other elements (such as bike racks or mobile device charging infrastructure) may be deployed as-needed or to enhance stations depending on their particular context.

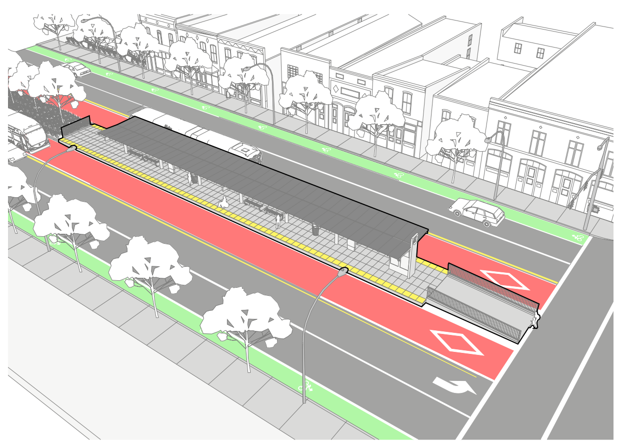
Station Example

Side Running – Bulbout Attached Station



Side Running – Bulbout Detached Station

Center Running – Side/Side Staggered Station



Center Running – Center Island Station

Section 3 – Running Ways

In order to support service reliability and provide the reduced travel times that are consistent with BRT's goals and Metro's Vision 2028 goals, running ways are an essential BRT component. The Running Ways chapter establishes that BRT routes should:

1. Be distinguishable from regular bus service
2. Achieve the highest quality service at the lowest practical cost
3. Make efficient use of existing infrastructure

The guidelines establish three primary running way configurations: curb running, where the lane is immediately adjacent to the sidewalk/curb; side running, where the running way is separated from the curb by parking and/or bike lanes; and center running, where stations and the running ways are situated in the middle of the roadway.

Each configuration is best suited to particular contexts depending on the availability of roadway space, configuration of existing parking and/or bike lanes, adjacent land uses, travel time goals, and cost.

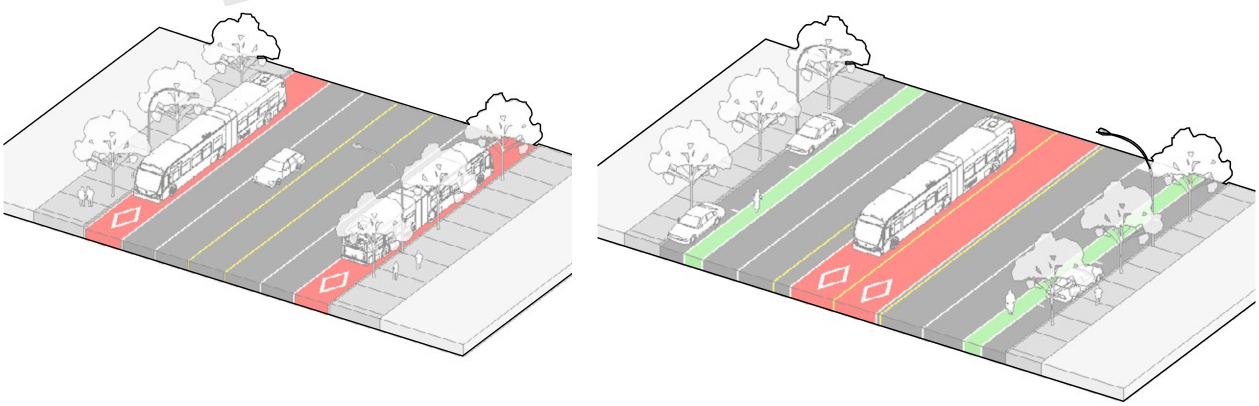
The running ways chapter also identifies unique opportunities for collaboration with local jurisdictions. For example, queue jumpers are a feature that allow buses to bypass traffic at interesections, and that can be incorporated where conditions do not permit a dedicated lane. Running ways can also be coordinated with improvements to the pedestrian environment, bicycle network, and sustainability efforts like green streets initiatives.

3

BRT Running Ways

This chapter provides guidance for the evaluation and development of future BRT corridors, dependent on local conditions. The guidelines are meant to improve the transit experience, and to provide fast, dependable and safe movement of passengers.

1 General Guidelines
2 Running Way Placement Considerations
3 Roadway Geometrics
4 Intersection Geometrics
5 Gates
6 Pavement Sections
7 Street Signing and Striping
8 Green Streets and Landscaping
9 Traffic Operations
10 Utility Considerations
11 Betterments



Running Way Configurations

Section 4 – Intelligent Transportation Systems (ITS)

Technology and data play an increasing role in defining how, when, and why individuals interact with mobility options. Due to the wide range of technologies available, this section provides clarity on the elements that are required for delivery of a high-quality BRT service, as well as those elements that may only be needed under specific circumstances.

ITS treatments apply to roadside elements, stations, vehicles, and to the transit network's control center, operations, and data systems. The ITS chapter provides recommended approaches for successfully using technology to enhance BRT services and safety.

Metro has long incorporated data and technology into its operations, and therefore the ITS guidelines for BRT are designed to integrate existing technology into BRT infrastucture and limit or avoid hardware that is unique to BRT.

At the same time, the guidelines also identify where BRT can be used as a pilot for new ITS functions, as the rapid pace of change in technology can be more easily applied to a fleet that is smaller compared to local bus service.

Technology onboard a BRT vehicle includes fare validation and payment, passenger loading and count information, vehicle tracking, headway management, and other equipment to provide reliable transit service.

Because ITS is dependent on roadside infrastructure in addition to vehicles, it provides uniquely valuable opportunities for collaboaration with and across local jurisdictions. Metro's role in providing service throughout LA County positions the agency well for supporting these efforts to integrate items like signal prioritization.

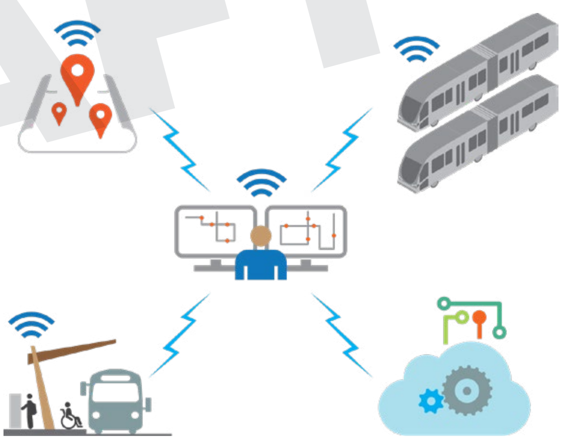
ITS features will also be incorporated throughout BRT stations, and can include real-time passenger information, interactive digital displays, video analyitics, active lighting, and emergency/security features.

4
BRT ITS Systems

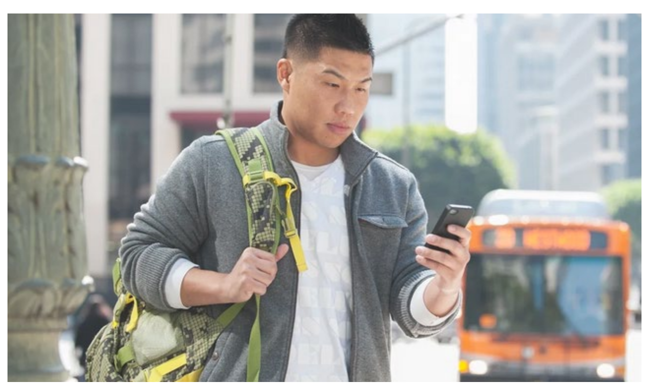
Technologies and data play an increasing role in defining how, when, and why we interact with mobility options. The ITS design guidelines in this section discuss a wide range of technologies and systems that can be deployed for BRT. Some guidelines refer to traditional ITS elements that are already widely deployed and used for BRT, and others look at more emerging elements that are in planning, pilot, or initial deployment phases. ITS elements are grouped and discussed in this section following the categories below. Required elements must be deployed with a BRT system, while optional may be applied depending on the specific characteristics or needs of the BRT system under consideration. Some elements in this section are listed as optional but strongly encouraged and should be deployed if feasible.

1 General

REQUIRED	OPTIONAL
2R Roadside Elements	2O Roadside Elements
3R Stations	3O Stations
4R Vehicles	4O Vehicles
5R Control Center, Operations & Data	5O Control Center, Operations & Data



BRT Employs Integrated Technology



Section 5 – Branding Design Elements

Metro is an industry leader in visual communications and branding. The agency works continuously to improve and coordinate the ways in which the Metro brand is communicated to the public through avenues such as marketing and advertising, community outreach strategies and materials, and station and vehicle design. Local jurisdictions seeking to implement a new line of BRT service can look to Metro standards as best practices for an agency as a whole.

For new lines of BRT service, branding will largely follow existing Metro guidelines and standards in order to build upon the foundation set by past coordination and ensure consistency with the rest of the Metro system.

Existing Metro policies and guidelines that inform BRT branding include:

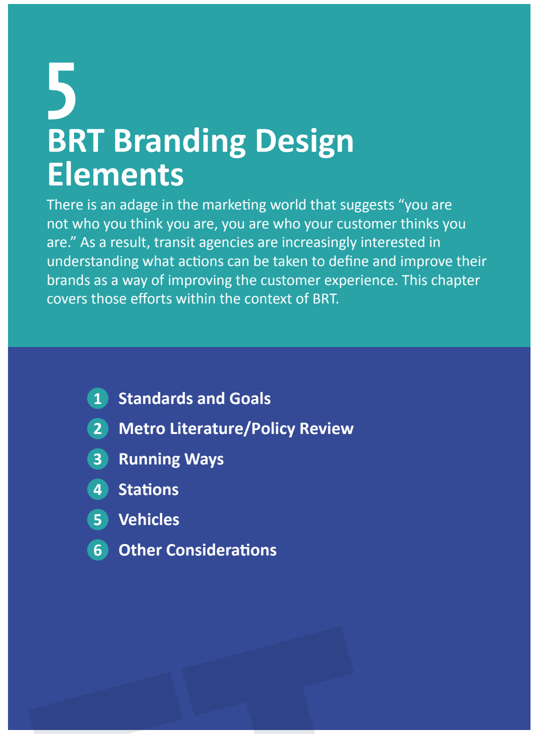
> Systemwide Station Design Standards

> Rail Design Criteria

> Metro Brand Guidelines and Specs

Building on these standards, the section examines how BRT service expands the scope of branding. For example, the ways in which BRT running ways are painted and/or labelled requires coordination with local jurisdictions. Metro will need to consider which elements of these designs will be consistent across jurisdictions, and which elements may vary according to local context.

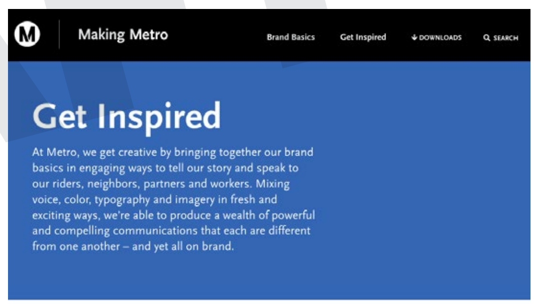
At the station level, Metro projects will follow the agency's "kit-of-parts" approach, but local jurisdictions designing their own system may look to incorporate greater variation to establish a unique BRT brand. As vehicles are selected for BRT service, agencies need to consider how taglines, colors, route numbers or letters, and name badges are displayed on the vehicle body and in its head sign. Finally, this section expolores how branding applies to elements of the customer experience that are not directly tied to transportation itself, such as the location and amount of advertising encountered, or the languages used and types of announcements played over public address systems.

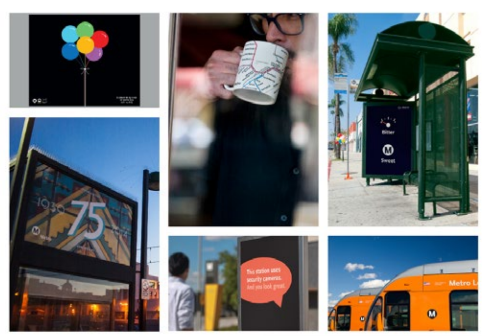

5

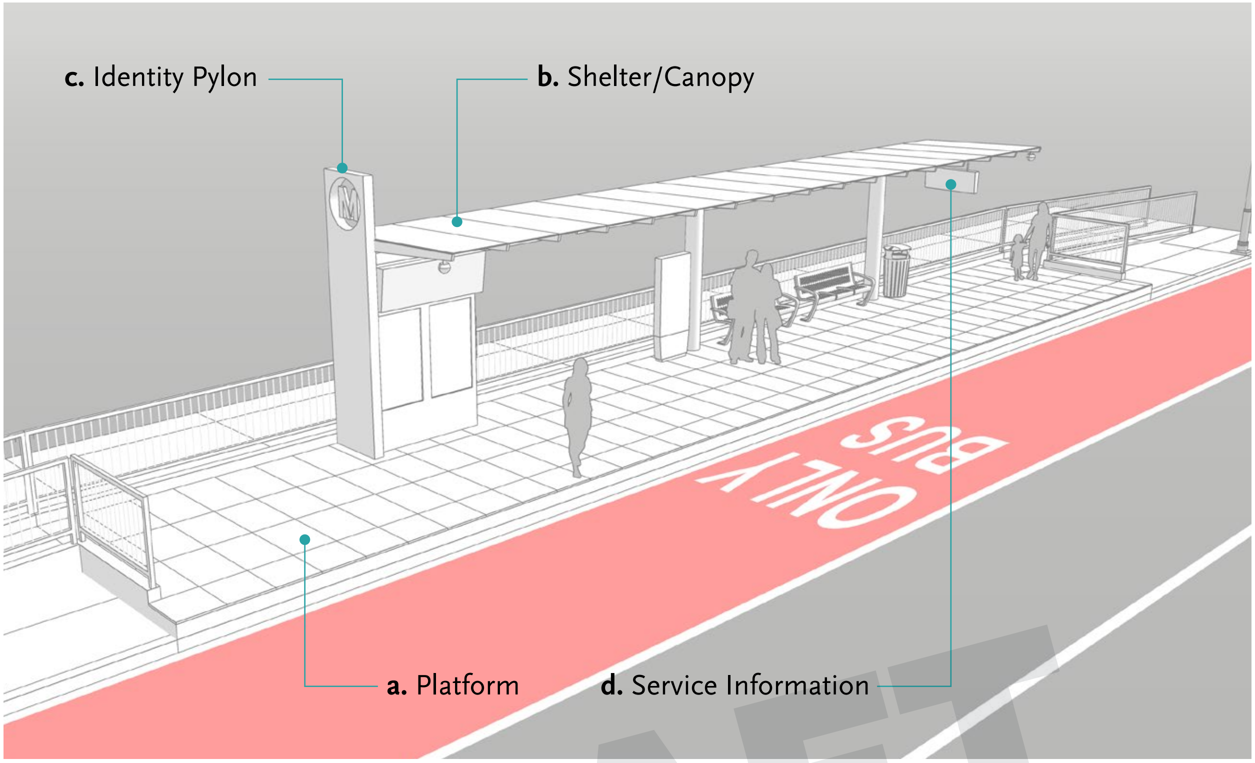
BRT Branding Design Elements

There is an adage in the marketing world that suggests "you are not who you think you are, you are who your customer thinks you are." As a result, transit agencies are increasingly interested in understanding what actions can be taken to define and improve their brands as a way of improving the customer experience. This chapter covers those efforts within the context of BRT.

1 Standards and Goals
2 Metro Literature/Policy Review
3 Running Ways
4 Stations
5 Vehicles
6 Other Considerations







Branding Opportunities at BRT Stations

Section 6 – Transit-oriented Communities (TOC)

Transit-oriented communities enable residents to drive less and take transit more. Metro's Transit Oriented Communities Policy is an evolving effort to support and refine a holistic planning framework that supports the overall goal of TOCs with activities that are either led by Metro, or are coordinated with local jurisdictions and community partners.

TOC activities range widely, from transfer considerations between modes and First/Last Mile planning, to larger-scale joint development projects. This section incorporates the latest policy guidance from Metro's TOC group and connects it to the context of BRT.

Examples of required TOC elements for BRT planning include:

> Corridor Evaluation and Station Location – Potential new BRT corridors and the locations of their stations will be evaluated according to Metro's TOC Policy and Implementation Framework.

6

BRT Planning and Integration Into Transit-oriented Communities

Existing policies related to transit-oriented communities help in evaluating the opportunities and constraints of transit-supportive planning efforts related to BRT and define a vision for integrating TOC principles into the planning of the Countywide BRT network.

1 TOC Design Objectives
2 Policy Context
3 BRT Required and Supporting Elements

> Transfer Considerations – Informed by Metro's Transfers Design Guide, designed to improve the experience of the 64% of riders who transfer at least once during their trip.

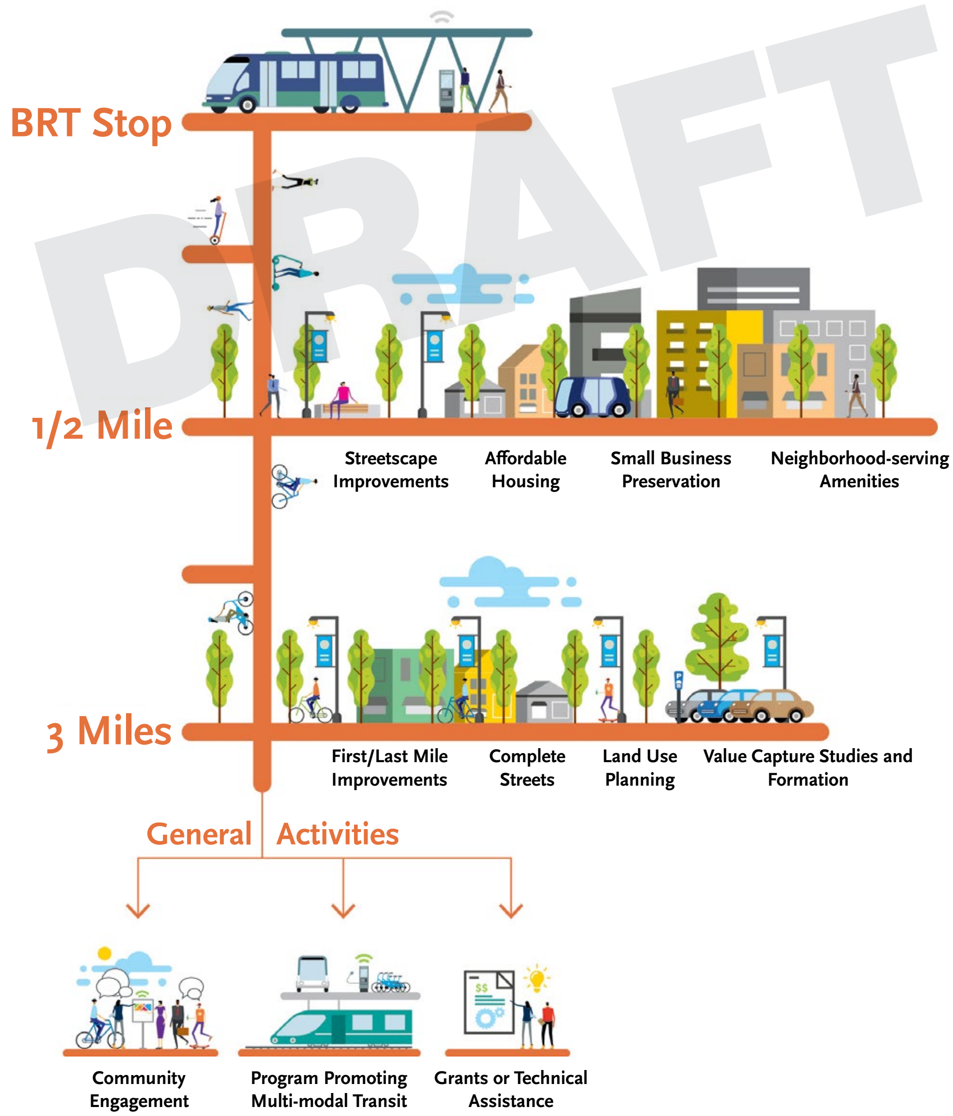
> First/Last Mile (FLM) Planning – A foundational element of TOCs, FLM Planning improves the safety and accessibility of transit by focusing on the space between the transit station and the rider's beginning or end point. FLM amenities can be implemented throughout a BRT station's catchment area and are often focused closer to the station.

Supporting TOC elements for BRT planning are those items which are less likely to be included within the scope of BRT projects, or are not controlled solely by Metro and therefore require additional coordination with local jursidictions. They include:

> Managing Mobility Access – Includes new mobility considerations such as curb management for ride-hail services (such as Via, Uber, and Lyft) and dedicated micromobility parking for scooters.

> Urban Heat Island/Urban Greening Plans – Efforts to mitigate the impacts of urbanization and climate change through sustainable infrastructure outside of the station boundary.

> Joint Development – Efforts to build transit-oriented development are unlikely to occur solely in relation to a BRT line, but may require where BRT intersects another major transit line or key activity center.



2 How to Use the Guidelines

For ease of use, each chapter of the BRT Design Guidelines follows a similar structure. Each chapter begins with an introduction that provides the general approach or design philosophy applied to each subject area. While BRT planners and designers will likely focus on the chapter(s) relating to their specific areas of expertise (such as Station Design or Intelligent Transportation Systems), all planners and designers are encouraged to read the introductory sections of each chapter, and skim their contents, as good BRT design relies on a tight integration of components. It is suggested that this be done periodically as the design progresses as part of a multidisciplinary review process, to identify and correct areas where design elements may not be integrating as intended.

Following the introduction and general material, each chapter provides guidance on the individual sub-components in each area, such as canopies, platforms, or lighting in the Stations chapter. Each section follows a similar layout as shown on the next page.

a. Description

This provides a general definition of the sub-component, its intended function(s), and general guiding principles for its design.

b. Metro Standards

This section summarizes existing design standards to be followed, originating either from the current BRT standard-setting effort, or previously developed applicable standards by Metro, such as the Metro Rail Design Criteria.

8 Wayfinding Signage and Customer Information

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

The primary function of signage at stations is to convey information regarding the BRT system, transit schedule information, and wayfinding information around station areas. Signage should also incorporate the system branding scheme to reinforce the BRT system identity. In addition to static wayfinding signage, the use of dynamic electronic signage is encouraged for such items as route maps, schedules, and arrivals information.

Wayfinding and station identification signs shall be located in the station area at frequent intervals and at visible locations to provide clear directions and information to patrons without additional assistance.

The key passenger information to be located at the stations includes:

> Marker sign with system logo and other branding elements
> Route maps and schedules
> Station identification
> Neighborhood wayfinding

Wayfinding and station identification signs can be internally illuminated as appropriate, but may also be illuminated by general area/station lighting. Reflective materials can be used for certain signs per Metro Signage Standards.

Regulatory and right-of-way signs may be necessary in addition to wayfinding information for safe bus operations.

b. Metro Standards

Graphic standards for signage and wayfinding is outlined in Metro Signage Standards. This includes the details regarding:

> Metro logo
> Signage types and sizes
> Typeface
> Color palette
> Use of pictograms

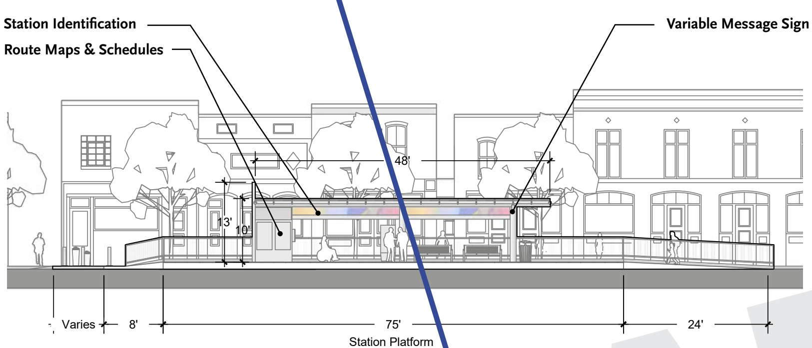
These standards will be the basis of the signage that will be integrated into the stations for future BRT systems. In addition, signs and graphics shall be consistent with ADA and AASHTO standards that include the use of braille as appropriate. Also refer to the Branding chapter of this document for further guidance on that specific matter.

c. Guidelines for Implementation

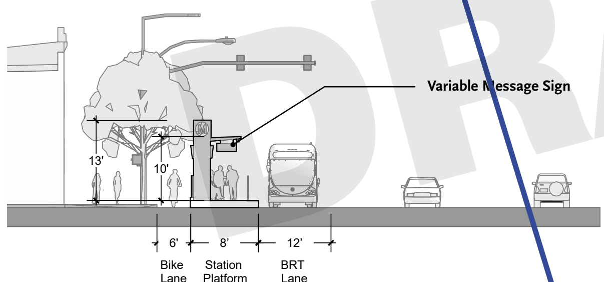
Locations of wayfinding signage and other customer information shall follow in general the exhibit below, however must be carefully considered and optimized for ergonomics, spatial composition, and sight lines – Metro Arts & Design shall review and approve all such placements as a component of an overall review of the signage and environmental graphic design program.

d. Reference Documentation

> Chapter 2.0 Graphic Standards
> Chapter 4.0 Bus Stops and Stations
> Chapter 10.0 Materials and Fabrication
> Chapter 13.0 Digital



S1 / Front Elevation, Location of signage



S1 / Side Elevation, Location of signage

d. Reference Documentation

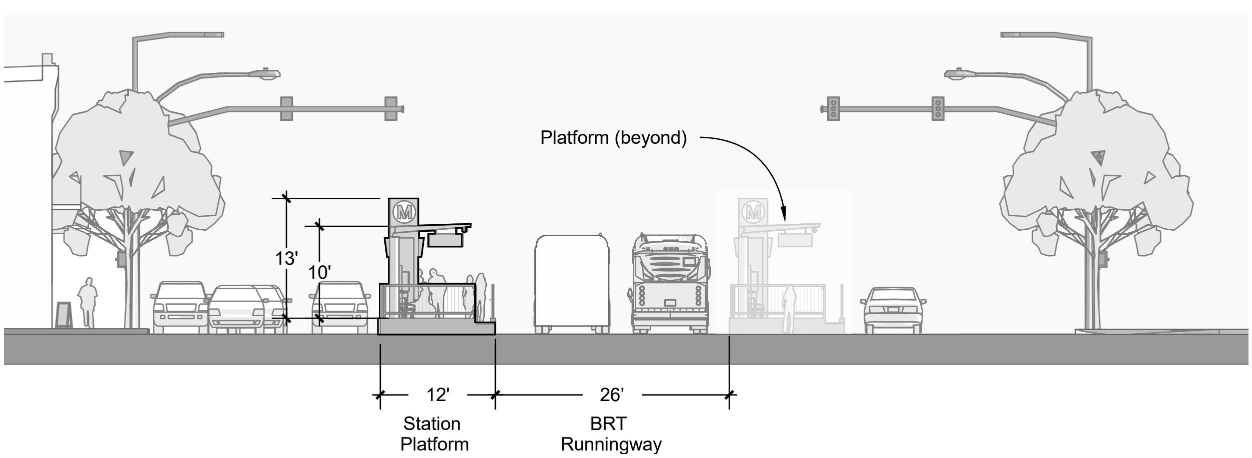
If needed, this section provides further reference to Metro or industry standards, such as ADA requirements, building codes and the like. These may appear in each section or be collected for the entire chapter, as appropriate.

c. Guidelines for Implementation

This section provides the detailed design guidelines that are either required or recommended to meet Metro's BRT standards. This includes items such as recommended dimensions for running ways and platforms, material specifications, and/or functional requirements. Often, illustrations are used to further clarify the requirements. The section may also present Opportunities and Challenges, which capture lessons learned from past BRT projects in LA County, across North America and around the world. As appropriate for subjects where more than a single agency may be responsible for implementation, Roles and Responsibilities are discussed.

3 An Integrated Set of Guidelines for LA County's BRT System

With their focus on an integrated set of BRT elements – Operations, Stations, Running Ways, Intelligent Transportation Systems, Branding and Transit-oriented Communities – that together define a high-quality service, the county's new BRT Design Guidelines set the stage for the next iteration of Measure M-funded BRT services.



1

BRT Operating Characteristics

A BRT's operating parameters and performance, such as frequency, span of service, speed and reliability, are as important to a rider's experience as its physical attributes. This section lays out recommended best practices for a BRT operating plan.

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12 Other Services Sharing a BRT Corridor
13 Service Reviews

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1 Summary

The table below summarizes the major operating recommendations.

		BRT CLASS & OPERATING CONTEXT			
Service Parameter	**Existing Metro BRT Standard**	DENSE URBAN	OTHER URBAN	SUBURBAN	REGIONAL
Route Length					
Minimum	N/A	6 miles	10 miles	10 miles	20 miles
Maximum (1)	N/A	Full BRT: 21 miles BRT Lite: 18 miles		Full BRT: 27 miles BRT Lite: 20 miles	45 miles
Ratio: Average Trip Length to Route Length	N/A	30% or greater			
Station Spacing					
Maximum Average Spacing	1.25 miles	0.75 miles	1.0 miles	1.25 miles	Based on market
Minimum Average Spacing	N/A	0.5 miles	0.75 miles	1.0 miles	1.25 miles
Minimum Distance Between Adjacent Stations	N/A	0.2 miles	0.25 miles	0.35 miles	1.0 miles
Travel Speed					
Average Speed	N/A	15 mph	Full BRT: 18 mph BRT Lite: 15 mph		30 mph
Alternative: Speed improvement over local	N/A	Full BRT: 25% faster than local bus BRT Lite: 15% faster than local bus			
Posted Speed Limit along Route (2)	N/A	25 mph or greater	30 mph or greater		50 mph or greater
Minimum Frequency of Service					
Peak Periods	12 minutes	Full BRT: 10 minutes BRT Lite: 12 minutes		12 minutes	Based on Market
Off Peak Periods	30 minutes	15 minutes		15 minutes	Based on Market
Passenger Loading Standards (3)					
Peak Periods	1.4	1.4			
Off Peak Periods	1.3	1.3			
Weekday Span of Service	4:00 am to 2:00 am (Light Rail Transit)	4:00 am to 2:00 am (4:00 am to 12:00am if no connection to Metro rail)			Based on Market
Service Reliability (4)	N/A	1 minute			
On-Time Performance	80% Systemwide Average	Full BRT: 80% BRT Lite: 75%			
Excess Wait Time	N/A	1 minute			
Travel Time Reliability (5)	N/A	Less than 2.7			

Notes:

1. Dependent on level of protection from general traffic - the higher end of the range is for systems approaching Metro LRT levels of traffic protection
2. Lower speed limits may be possible with lighter signal density (e.g. 2 signals/mile) and/or higher station spacings
3. Expressed as the maximum average ratio of passengers to vehicle size and frequency by direction for a one-hour period, which should not be exceeded for at least 95% of all hourly periods
4. Expressed as how much time the average passenger has to wait for a bus in excess of the waiting time they would experience if the buses were perfectly regular in their arrivals
5. Expressed as the ratio of travel time variability (standard deviation) to the average travel time

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2 Introduction

a. Design Guidelines
b. BRT as a Service Type within the Regional Network
c. Operating Context
d. Demand Density

a. Design Guidelines

The guidelines in this chapter are intended to clarify Bus Rapid Transit (BRT) operating characteristics, particularly in regard to:

> Metro transit service types within the regional network

> Service design (including service frequency, loading standards, and span of service)

> Service performance evaluation, and

> Service change process.

The operations guidelines for BRT do not supersede, replace or otherwise supplant the most recent adopted Metro Transit Service Policy, or those of any other municipal transit agency implementing BRT. The guidelines are intended as recommendations to be considered for adoption into existing service policies, based on best practices in the BRT industry.

The guidelines also offer flexibility when implementing two styles of BRT - "Full BRT" which features a greater investment in dedicated BRT running ways (at least 50% of the route), and "BRT Lite" which achieves speed advantages through more tactical measures such as shorter dedicated lane segments, peak-hour transit-only lanes, and queue jumpers.

While many factors exert an influence over individual operating design guidelines, there are three factors that have an overarching effect:

The Role of BRT Within a Network: that is, the market that BRT service caters to relative to local and other high-capacity, high-speed services in a region;

Operating Context: the nature of the communities within which BRT operates, in terms of demographics, land use types and densities, and trip lengths, and

Demand Density: the range of passenger loads that BRT routes will likely be called upon to serve.

Each of these is briefly described and referred to within the operating design guidelines which follow.

b. BRT as a Service Type within the Regional Network

BRT has already been established as a distinct 'service type' within the regional transit network, which also includes the following fixed-route service types: Heavy Rail (rail rapid transit), Light Rail, BRT, Rapid, Local, Limited, Express and Shuttle[6]. It is particularly important to bear in mind the functional characteristics of BRT relative to its 'adjacent' service types in the network typology, light rail and rapid bus (including the existing Metro Rapid type and future evolution

6 It is understood that the branding and typing of Metro Rapid may change as a result of the NextGen Project. The result of this examination is not assumed to change the distinctiveness of BRT relative to local services.

of this mode per the parallel NextGen project). The guidance in this document is based on the following assumptions about the role of BRT in the regional network:

> For network design purposes, BRT should be considered to be a high-capacity, high-speed service together with light rail transit and heavy rail transit

> BRT would be functionally distinct from Metro Rapid and future "hybrid" service recommended by the NextGen study, with more widely-spaced stations and higher average speed[6]

> The most prevalent context for BRT route placement in the urban and suburban areas would be within or adjacent to an arterial highway

> BRT should not have a local service function; in urban and suburban areas, parallel or adjacent local bus service would provide this function, and

> BRT would serve an intermediate level of demand between Metro Rapid and light rail (see Demand Density section), while providing service characteristics and a rider experience similar to light rail

c. Operating Context

In 1977, the regional transportation planning agency for greater Quebec, Canada, established a useful characterization[7] of three contexts or zones within a metropolitan area:

There is an *urban zone* characterized by:

> Centers of attraction throughout the zone

> A strong and continuous population density

> A high volume of trips made entirely within the zone itself.

There is a *suburban zone* characterized by:

> Fewer major attraction centers than the urban zone

> A moderate and relatively continuous population density

> Many trips made outside the suburban zone

> An average travel time much longer than for trips made within the urban zone.

There is a *regional zone* characterized by:

> A low level of trip attraction within the zone

> A low population density

> Many trips made outside the regional zone, and

> Very long travel times.

These remain useful distinctions that apply to LA County, and from subsequent observations can be expanded upon as follows:

> The *urban zone* has the highest ratio of trip attractions (e.g. jobs) to productions (e.g. residents), and is almost fully developed. Open spaces are clearly purposed (e.g. parks, recreational areas, or institutional grounds). An urban zone will usually contain at least one central business district and/or other significant zones of high density; these are usually distinct enough to warrant separate design treatment[8] as dense urban and other urban.

> The *suburban zone* contains much of a metropolitan area's single-family housing stock. Most land will be developed, but there may be both tracts of undeveloped land and concentrations of retail and other activity centers.

> The *regional zone* will contain substantial amounts of open or undeveloped land, and development will tend to cluster around distinct nodes.

Other service planning frameworks have made use of categories of geographical context or markets as necessary to fit service design guidance or principles. For instance, the Metropolitan Council of greater Minneapolis-St. Paul uses the broadly similar notion of 'transit market areas':

7 Commission de Transport de la Communauté Urbaine de Québec, "Normalisation des Services Phase I: Developpement des Normes de Service'", May 1977. Translation by D. W. Allen

8 As in Chapter 4 of Transit Cooperative Research Program Report 118 (TCRP 118), "Bus Rapid Transit System Practitioner's Guide".

"Transit Market Areas are a tool used to guide transit planning decisions. They help ensure that the types and levels of transit service provided, in particular fixed-route bus service, match the expected demand in a given area. For example, transit service in a suburban community where the automobile is the most convenient mode for the majority of trips might focus on the work commute, providing express bus service to downtown. Transit service in a dense urban core neighborhood might need to accommodate a broader variety of transit service needs that can be met by providing frequent, all-day service to a variety of destinations."

The above frameworks have been used as a starting point to consider the types of markets that BRT may be called upon to serve in LA County. The following contexts are used in this document, with the associated understandings as to the relationship of BRT to local bus services, and the most appropriate levels of BRT service – Full or Lite:

> *Dense urban*, including the central business districts of major cities and other significant zones of high density. Full BRT is often justified due to strong demand, although dedicated full- time lanes may be challenging due to right-of-way constraints. BRT services are assumed to be overlaid or closely parallel to local bus services with more closely-spaced stations.

> *Other urban*, covering the remainder of the urban context. BRT services may be Full BRT or BRT Lite, and are assumed to be closely parallel to local bus services and have more closely- spaced stations.

> *Suburban*. BRT services will most likely be BRT Lite, since the density of demand may not justify significant investments in Full BRT infrastructure, and are assumed to be generally parallel to local bus services with more closely-spaced stations.

> *Regional*. Arterial-running BRT service is typically not justified in low-density areas. In these environments, if BRT services are warranted, they will likely be long- distance commuter-oriented routes using shared freeway infrastructure - HOV, Toll and/ or Managed Lanes. They are not presumed to have a strong relationship to any local transit services which may be offered, except for feeder routes oriented towards BRT stations.

It should be noted that a given BRT corridor may encounter more than a single urban context. A BRT corridor may feature a mix of operating parameters to best respond to the conditions in different segments, such as different station spacings or frequencies in dense urban and suburban segments of the same route.

d. Demand Density

When planning a BRT service, the expected demand profile along the route is a fundamental parameter that influences both the proposed service plan (in simple terms, higher demand will require a greater level of service) and determines the cost-effectiveness of BRT capital investments (the higher the demand, the more that riders will benefit from BRT investments). The demand profile can also serve as a check in determining whether BRT is the appropriate mode for a corridor; too low a demand will make BRT less cost-effective, while too much demand may exceed a BRT's maximum capacity, indicating that a different mode such as light rail transit may be warranted.

In measuring demand, it is more helpful to consider a proposed BRT route's likely passenger traffic density (PTD) as a basis than to focus on estimated peak hour peak demand at the maximum load point, which can be more difficult to estimate in a corridor's planning stages. PTD is the ratio of total passenger-miles traveled (PMT) on a route for a calendar year to the route's length in miles. As such it can usefully be compared across routes and modes, both within a network and among routes or networks worldwide. PTD is a better indicator of operating economy than boardings per mile of route, because average trip lengths can vary considerably. Whenever available demand forecasts include both route length and PMT, PTD can be determined and used as a general benchmark.

9 Several US transit agencies operate services generally regarded as BRT, but do not report them to NTD separately from other fixed-route bus services.

Every transit line has a PTD value, and Figure 1 shows the distribution of PTD values across three groups of services:

> LACMTA's directly operated local bus routes;

> the combined service types of Metro Rapid (i.e. Metro's 700-series routes), BRT, light rail, and heavy rail transit (collectively labeled as "LACMTA High-Capacity Routes" in the figure);

> the systems reported to FTA's National Transit Database (NTD) as 'Rapid Bus', providing a nationwide average for comparison[9].

Table 1 shows the estimated[10] PTDs for LACMTA's High-Capacity transit (both rail and bus), including the Metro Rapid bus routes. Key 'takeaways' from the table and figure include:

> The median PTD for Metro Rapid routes (323,200) is not significantly higher than for local routes (267,800);

> Only one of the Metro Rapid routes (720) has a PTD higher than half that of the two BRT services (G and J Lines);

> Many of the 'Rapid Bus' systems reported to NTD cluster in the range of 625,000 to 850,000 in terms of PTD. Only one Metro Rapid route and four local LACMTA routes fall in this range,

> The highest NTD-reported 'Rapid Bus' operation is MBTA's Silver Line in Boston, at about 2.5 million; both the G and J Lines in greater Los Angeles are at about 1.7 million.

> In terms of PTD, LACMTA's light rail lines range between 3.4 million (C Line) and 8.4 million (E Line).

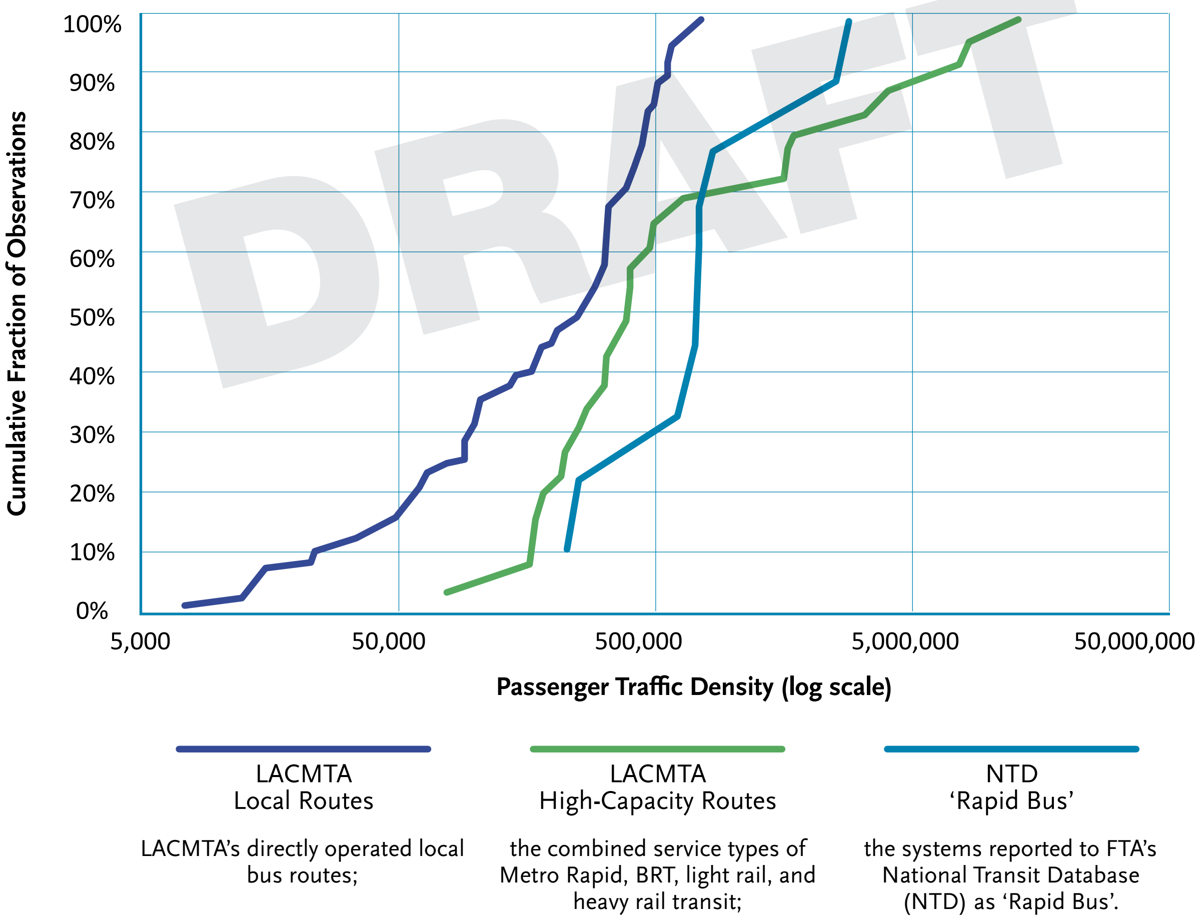

Figure 1. Cumulative Distributions of Route versus Passenger Traffic Density[10]

10 For High-Capacity Routes, derived from 2018 passenger-miles on LACMTA's ridership information website; for Metro Rapid, estimated by IBI Group from data available from LACMTA's website for October 2018.

Route	Estimated PTD (passenger-miles per year per route-mile)
802 - B Line rail rapid transit	13,017,040
806 - E Line LRT	8,421,156
801 - A Line LRT	7,518,142
804 - L Line LRT	4,524,759
803 - C Line LRT	3,364,513
910 -J Line BRT	1,747,665
901 - G Line BRT	1,627,246
720 - Santa Monica - Commerce via Wilshire-Whittier Bls	1,659,047
754 - Hollywood-Athens via Vermont Av	653,045
733 - Downtown LA-Santa Monica via Venice Bl	510,829
734 - Sylmar-West Los Angeles via SSepulveda Bl	483,392
780 - Pasadena-Washington/Fairfax via Colorado-Hollywood-Fairfax	418,626
757 - Hollywood - Crenshaw Station via Western Av	407,593
744 - Northridge-Pacoima via Van Nuys-Ventura-Reseda Bls	397,609
770 - Downtown LA - El Monte Sta Via Garvey - Chavez Avs	358,027
710 - Wilshire Ctr - South Bay Galleria Via Crenshaw Bl	326,839
794 - Downtown LA - Sylmar Sta via San Fernando Rd	323,193
745 - Downtown LA - Harbor Freeway Station via Broadway	275,320
728 - Downtown LA - Century City via West Olympic Bl	258,427
705 - W Hollywood - Vernon via La Cienega Bl - Vernon Av	229,317
762 - Pasadena - Artesia Station via Atlantic Bl	221,661
750 - Warner Ctr - Universal/Studio City via Ventura Bl	185,891
760 - Downtown LA - Long Beach GL Sta via Long Beach Bl	177,892
788 - Metro Valley - Westside Express	175,263
751 - Cypress Park - Huntington Park via Soto St	166,796
740 - Expo/Crenshaw Sta - South Bay Galleria via Hawthorne	79,175

Table 1. Passenger Traffic Densities for Rapid and Metro Rapid Services [10]

The PTD data above suggests some general guidelines that may be used when first defining a new BRT service, based on both conditions in LA County and a comparison to systems around the country. It appears that the form of BRT envisioned for LA County may be most economically efficient between a PTD of 600,000 and 3 million annual passengers per route-mile. Below 600,000, services such as the present Metro Rapid overlay routes or rationalized 'next generation' local bus routes are likely to be more efficient. Above 3 million, light rail is likely to be competitive or superior in terms of cost-efficiency, and above 4.5 million, BRT as envisioned may not even be able to provide the necessary capacity (in the sense defined by the Transit Capacity and Quality of Service Manual (TCQSM)) in an urban context without more than one BRT lane in each direction This is intended as a general guideline; to be considered alongside local factors that may influence choice of technology.

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3 Travel Speed

a. Description
b. Key Considerations
c. Guidelines for Implementation

a. Description

The average operating speed (end-to-end speed including stops) which can be attained by BRT services is determined by a number of factors, most importantly: the maximum authorized speed (MAS); the distances between stations; bus dwell times at stations; the number of traffic signals per mile; the degree of separation from general vehicular traffic; and where bus operations are subject to general traffic congestion, the extent of that congestion, and the mitigation offered by signal priority. On highways, the MAS for most practical purposes is the prevailing posted speed limit. Selecting a route with lower speed limits may limit the station spacing that can be supported, especially if there is a high traffic signal density. Therefore these factors should not be considered in isolation.[11]

b. Key Considerations

When designing a BRT service to attain a target speed, designers have the following major mechanisms available:

> The length of full-time or part-time dedicated lanes (see Chapter 7.3 Running Ways)

> The geometry of the dedicated lane, particularly lane widths. To support the target speed, the minimum recommended lane widths are 12 feet for side running lanes, and 13 feet for center running lanes that are next to each other. Chapter 3 provides further details.

> Other transit-friendly traffic engineering treatments, such as queue jumpers, or reducing left-turns or crossing movements across a running way (also covered in Chapter 7.3)

> Transit signal priority systems (Chapter 7.4 Intelligent Transportation Systems)

> The selection of a corridor with lower traffic signal density and/or higher speed limits

> Station spacing (Section 5 below)

> Boarding protocols to reduce station dwell time (Section 11 below)

c. Guidelines for Implementation

It is recommended that BRT services in LA County are designed to achieve the following minimum end-to-end average speeds, inclusive of dwell-times:

> 18 mph for Full BRT

> 15 mph for BRT Lite

> 30 mph for Regional BRT

It is recognized that some corridors may have demand densities that merit BRT but may have congestion, right-of-way or other constraints that make the above speeds challenging. In such cases, an alternative recommendation is that the

[11] For extensive discussions and treatments of these inter-relationships, the reader is referred to: Chapter 5 of Transit Capacity Research Program Report 118 (TCRP 118), Bus Rapid Transit Practitioner's Guide, and to Chapter X of the third edition of the Transit Capacity and Quality of Service Manual.

BRT service should provide a noticeable speed improvement to any underlying local service, as follows:

> For Full BRT, a 25% average speed improvement

> For BRT-Lite, a 15% average speed improvement

While 18 mph is the general overall goal for BRT average operating speed, and Metro's Vision 2028 goal for its Rapid bus routes (or future equivalents from the NextGen study), in two operating contexts alternative values are more practical for forming guidance on speed

> In the dense urban context, where both stations and traffic signals tend to be more closely spaced, 15 mph is a more realistic expectation for an average speed. Most sections of US BRT systems operating in this context average less than 15 mph, often as little as 10-12 mph.

> In the regional context, bus services tend to be *express* or *limited-stop* services, more analogous to commuter rail systems than to light rail transit or BRT in urban contexts. To maintain reasonable competitiveness with automobile travel, a design average operating speed of 30 mph, roughly the median average speed of North American commuter rail, is more appropriate.

With design average operating speeds in mind for each operating context, guidance can be offered as to the MAS that should be prevalent in a route section, depending on the average distance between stations in the section and the average distance between traffic signals. The more closely spaced signals and stations are, the more time per mile is lost in bus acceleration and deceleration, sometimes to the extent that buses never actually reach the speed limit.

Figure 2 illustrates the speed limits below which a BRT service in a dense urban context would likely

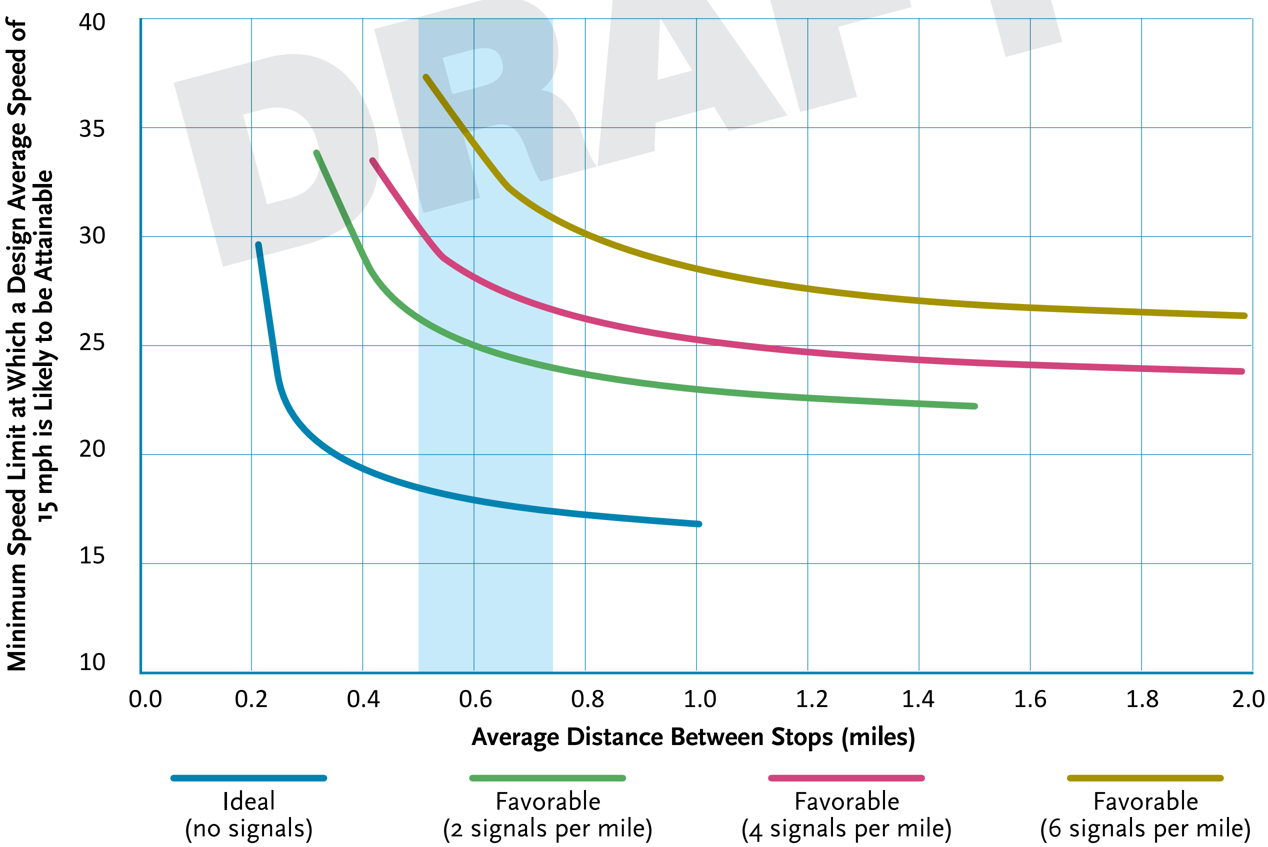

Figure 2. Speed and Spacing Considerations in the Dense Urban Context

Source: IBI Group research based on transit agency published information, the National Transit Database, and direct observations

not be able to meet a design average operating speed of 15 mph in terms of the average distance between stations, assuming that all stops are made. Values are shown for an ideal 'straight line' alignment with no traffic signals, and for a favorable, but not ideal, alignment on an exclusive lane on an arterial roadway with an average of 2, 4, and 6 traffic signals per mile. This figure also shows the range between the recommended minimum and maximum station spacings for this operating context from Table 4. The conditions needed to attain the design speed may not be in reach for some routings in dense urban areas, as is confirmed by the average operating speeds on corresponding sections of BRT projects implemented to date.

To put the BRT in an environment where it is possible to achieve an average operating speed of 15 mph in dense urban areas, it is recommended that routes with a posted speed limit less than 25 mph not be considered for BRT in dense urban areas unless unavoidable, and that routes with the fewest traffic signals per mile be preferred, provided that the route is not taken out of line to avoid them. To compensate for average speed losses in this context, station spacing should be targeted for the upper end of the recommended range.

Figure 3 illustrates the speed limits below which a BRT service in a less dense urban or suburban context would likely not be able to meet a design average operating speed of 18 mph in terms of the average distance between stations, assuming that all stops are made. Values are

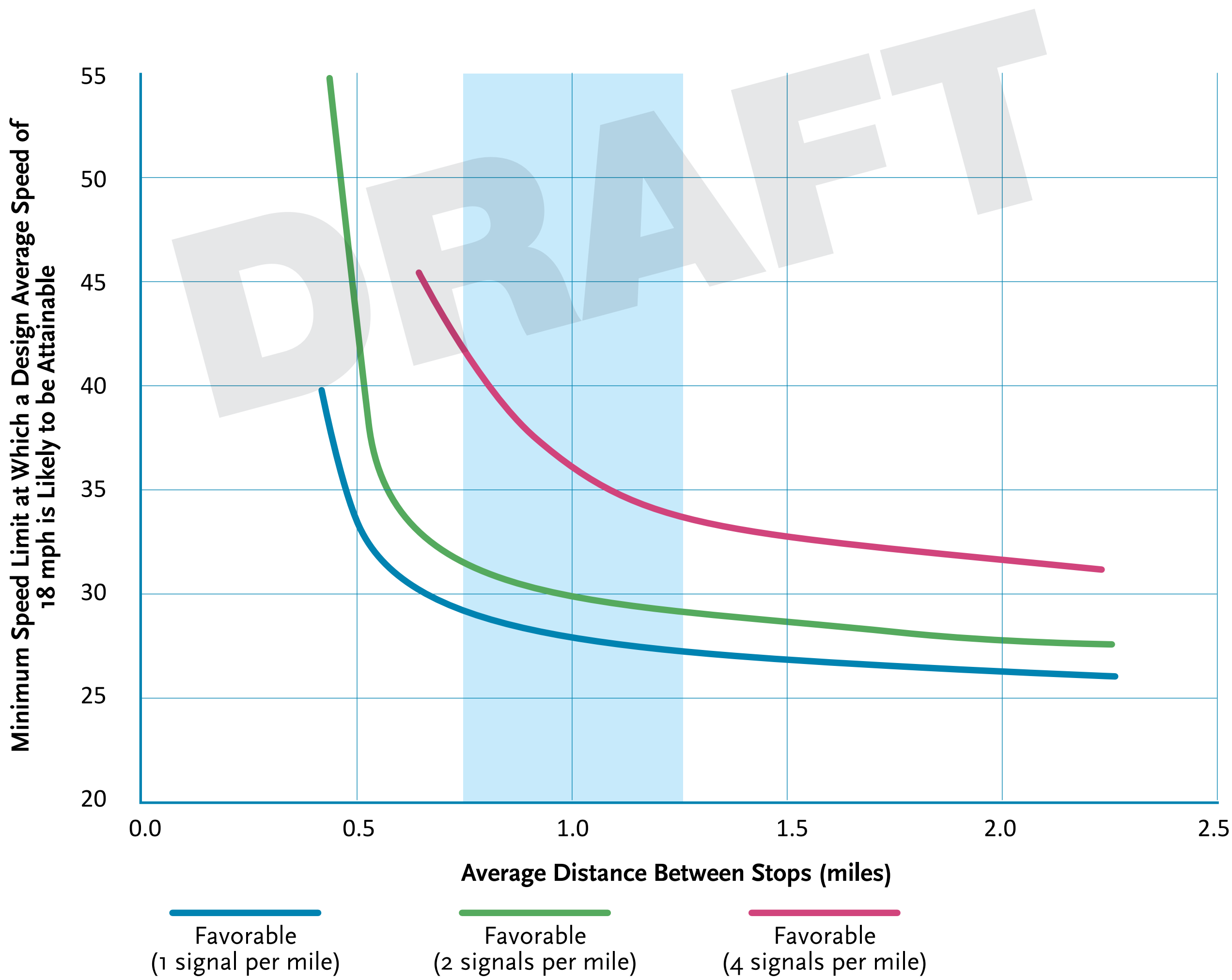

Figure 3. Speed and Spacing Considerations in the Urban Other and Suburban Contexts
Source: IBI Group research based on transit agency published information, the National Transit Database, and direct observations

shown for favorable, but not ideal, alignments on an exclusive lane on an arterial roadway with an average of 1, 2, and 4 traffic signals per mile. Values above 55 mph are not shown because urban transit buses are generally not well suited for higher speeds, and few arterials have speed limits this high.

This figure also shows the ranges between the recommended minimum and maximum station spacings for these operating contexts from Table 4. The conditions needed to attain the design speed may not be in reach for some routings, as is confirmed by the average operating speeds on corresponding sections of BRT projects implemented on arterials to date.

To put the BRT in an environment where it is possible to achieve an average operating speed of 18 mph in Other Urban and Suburban areas, it is recommended that routes with a posted speed limit less than 30 mph not be considered for BRT outside dense urban areas unless unavoidable. Routes with the fewest traffic signals per mile are preferred outside of dense urban areas, provided that the route is not taken out of line to avoid them.

To compensate for average speed losses in this context, station spacing should be targeted for the upper ends of the recommended ranges.

Figure 4 illustrates the speed limits below which a BRT service in a regional context would likely not be able to meet a design average operating speed of 30 mph in terms of the average distance between stations, assuming that all stops are made. Values are shown for a freeway alignment under uncongested conditions with dedicated lanes and on-line stations (ramp off, ramp on) and a less favorable case representing for which buses would leave and re-enter the freeway, the most prevalent arrangement for buses now operating on freeways in the US. Because a regional context might be served by over-the-road highway coaches, values are shown up to the 65 mph California default speed limit.

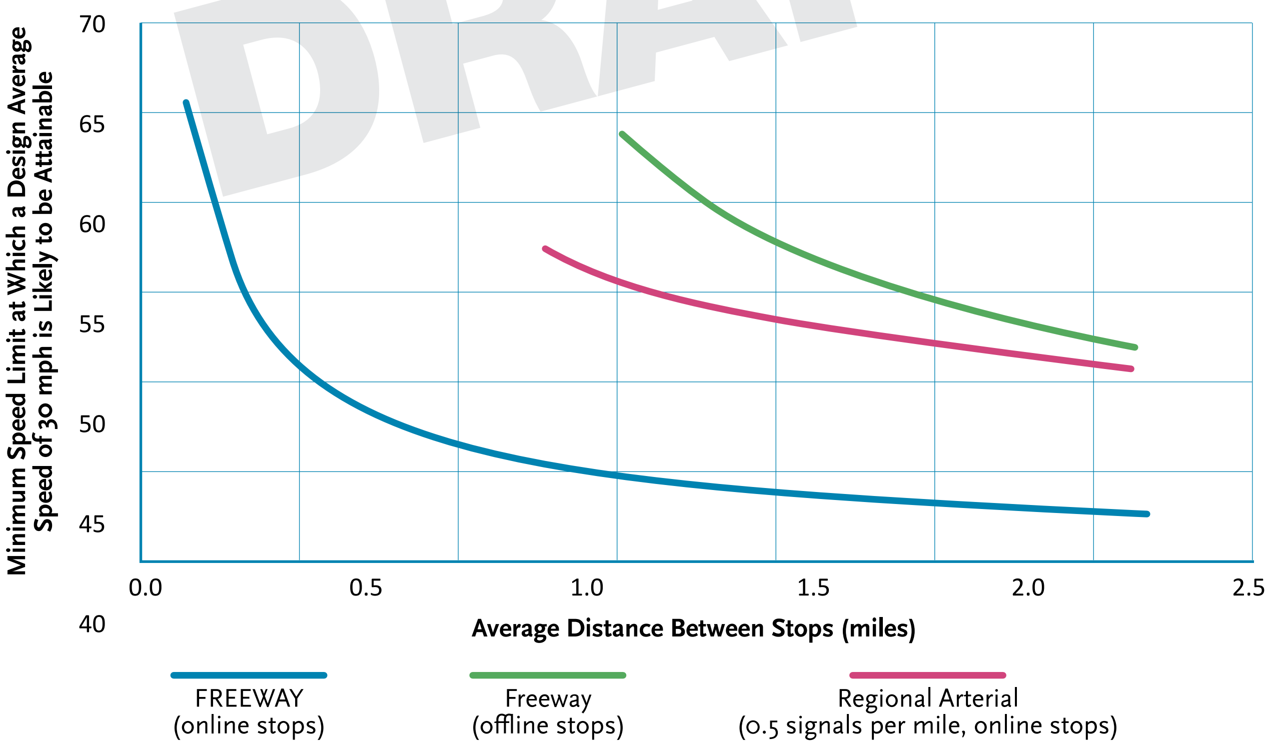

Figure 4. Speed and Spacing Considerations in the Regional Context
Source: IBI Group research based on transit agency published information, the National Transit Database, and direct observations

A design speed of 30 mph is unlikely to be attainable on signalized arterials in the regional context with an average separation of less than eight miles, unless the highway has a posted speed limit over 50 mph and is not congested. In the case of a very high-performance arterial generally paralleling a freeway, at very long station spacings the arterial may be able to offer an alternative routing to a freeway if inline stations are not possible on the freeway. In general, 'rapid' BRT should be freeway-based in the regional context, and inline stations are preferable if an average distance between stations of less than five miles is planned. If the buses are to operate in mixed traffic on congested highway sections, the average congested operating speed can be taken into consideration for station spacing purposes by considering the congested speed as the 'minimum speed limit' in Figure 4.

Based on the relationships shown in Figures 2 to 4, it is recommended that the BRT route planning process seriously consider the trade-off between average operating speed and station spacing in each corridor, and unless the average speed goals are modified, aim towards the maximum station spacings. This relies on the assumption that in the urban and suburban contexts, a parallel local bus service will be in place to meet the needs of customers for whom short walking access distances are important.

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4 Route Length

a. Description
b. Key Considerations
c. Guidelines for Implementation

a. Description

The guidance in this section is intended to apply only to free-standing BRT routes rather than branched systems or hybrids of BRT and services that might operate more like local buses. A route to which these standards apply will have a distinct route identification or branding as 'BRT' between two distinct termini. It will be shown in its entirety on system route maps of high-capacity or 'rapid' service, without branching or having to indicate changes in the class of service. In common understanding, it will 'stand alone' from any other BRT routes, and may come to be referred to as a 'Line'. This does not preclude having a 'short-turn' provision as part of the service plan for a BRT route (as Metro's G Line does, with some buses only operating as far as Canoga Station).

b. Key Considerations

In laying out the length of a route, BRT service planners should consider:

> Economies of scale – short routes may not justify the capital investments required to build and operate a high-quality BRT

> The nature of the market – a key hallmark of BRT service is speed, and this feature tends to cater to travelers with longer trip lengths; a short route may not realize significant travel time advantages compared to a local bus or shuttle

> Serving a high number of destinations and attractions – a BRT typically serves corridors with a high number of activity centers, dense residential and employment areas, and regional and multimodal transportation hubs; a short route may simply not serve a sufficient number of these to be effective

> Reliability – long routes can suffer reliability issues, as there are more chances to hit pockets of congestion, and schedule-recovery times on long routes may be compromised by congestion or incidents

> Segments of thinner demand – long routes can be more prone to segments where demand is lower, particularly if a route is extended into less densely-developed suburban areas

c. Guidelines for Implementation

Minimum Length

For both Full BRT and BRT-Lite, It is recommended that:

> free-standing BRT routes in dense urban areas be not less than 6 miles in length;

> Routes should be no shorter than 10 miles for other urban and suburban areas, and 20 miles for regional routes.

For shorter corridor lengths, serious location-specific consideration should be given to the nature of the passenger demand to determine whether alternative treatments (e.g. a branch of another BRT route, a change to existing local services, a point-to-point shuttle, or improvements to 'first mile/last mile' accessibility) would be more effective and/or more cost-effective. This guidance should not be interpreted to apply to branches of a trunk BRT route, or to possible extensions of a BRT route operating in a local mode.

The rationale for the above recommendations starts with a consideration of economies-of-scale. The investment required for BRT is generally understood as being less than that required for rail systems. However any route with more infrastructure than that required for local bus service will incur a certain 'overhead' that may lead to diseconomies of scale for shorter routes. Further, the travel time benefits of BRT will be difficult to achieve if route lengths, and therefore trips, are short.

Even local bus services will exhibit operating cost diseconomies at short lengths, as layover time becomes a higher fraction of total revenue service hours.

Anecdotally, the shortest free-standing route of more than 80 on greater Boston's MBTA bus network in 2014 was 2.45 miles long, and the shortest route of Spokane Transit Authority's 36 routes in 2017 was 1.19 miles long.

BRT routes worldwide are more difficult to categorize as free-standing or not based on available data. Table 2 lists instances which are believed to be the shortest such routes in North America, Europe, and Australasia. All 3 operate in dense urban downtown environments, where the high ridership levels would tend to counteract the lost economies-of-scale of short lines. Since these densities are generally not present in Los Angeles Counties, short lines like these would likely not be cost-effective here.

Moving beyond the anecdotal, Luigi Moccia of the Consiglio Nazionale delle Ricerche in Italy has explored the economics of BRT versus route length for a service scenario similar to those envisioned for LA County, using the most recent formulation of a model[12] to which IBI Group staff have contributed. Moccia's results suggest that significant diseconomies of scale will be present at a route length of 2 km (1.25 miles) and that these will have substantially abated as route lengths approach 8 km (5 miles). The principal reasons for this are the need for schedule recovery and layover time, which decrease as a fraction of total cycle time as route length increases.

Route	length in miles	Opening Year
Hampshire County Council Eclipse (Gosport - Fareham)	2.8	2012
Nîmes T1 (Centre-ville - Caissargues)	2.8	2012
Strasbourg ligne G (Gare Centrale -Espace européen de l'entreprise)	3.2	2013

Table 2. Short Free-Standing BRT Routes

12 L. Moccia, D. W. Allen, and E. C. Bruun. "A technology selection and design model of a semi-rapid transit line", Public Transport, 10:455–497, 2018.

Maximum Length

Table 3 shows the ranges of recommended maximum BRT route lengths, depending on the likely portions of the route in different operating contexts, and for three general classes of BRT treatment of highway crossings. The guidance in this document is focused on the latter two classes, operating at grade in arterial roadways.

Predominant Highway Crossing Treatment	'Lean' Mix of Contexts (5% dense urban, 20% other urban, 75% suburban)	'Rich' Mix of Contexts (30% dense urban, 65% other urban, 5% suburban)
Full BRT - extensive pre-emption or grade separation (generally comparable to LACMTA light rail) – 75-minute travel time budget	27 miles	21 miles
Full BRT - Exclusive lanes with traffic signal control – 60-minute travel time budget	25 miles	20 miles
Full BRT and BRT-Lite - Primarily dedicated lanes, with traffic signal control - 60-minute travel time budget	20 miles	18 miles

Table 3. Guidance for Maximum BRT Route Lengths

If information on the corridor's demand is known, some additional guidance can be offered. The required information would be an estimated projected load profile for the corridor, from which the overall average trip length could be estimated, as well as the passenger traffic density (PTD) along the route. It is recommended that:

> The ratio of the average trip length should not be less than 30 percent of a free-standing route's end-to-end length. Lower ratios (for instance a 2.5-mile average trip on a 10-mile route) may indicate that the route would have more of a local nature than is well suited for a BRT route operating in conjunction with a parallel local service.

> A route should not be extended so that PTD falls below 600,000 for much of its length, a level below which the investment in BRT may well not be warranted. Overall, PTD for the entire route should be at least 1.25 million.

Absent corridor-specific demand characteristics, the guidance on this topic which can be offered is relatively limited. Anecdotally, Metro's light rail services and free-standing BRT route (G Line) range in length between 15 and 31 miles, and the 'VelociRFTA' exurban BRT in Colorado extends for 40 miles.

Without demand information, operational factors become the primary consideration, and these are better expressed in terms of running time than distance. One-way trip times on the aforementioned LACMTA services are 75 minutes or less, more or less in line with rapid transit nationwide. To maintain reliable operations, a specific route should have an allowance for 'schedule recovery' and a reasonable break allowance. This 75-minute budget is appropriate for a very high-performance BRT at ten-minute headways with highway crossing treatments comparable to LACMTA's LRT and some busways: many crossings are pre-empted or physically separated. For a surface-running BRT route on a ten-minute headway, where most major highway crossings are controlled by traffic signals, the one-way travel time should not exceed 60 minutes in order to be confident of reliable operation.

In the regional context, a travel time budget typical of Metrolink trips might be applicable, perhaps 90 minutes from a terminus at which much of the travel is concentrated. At a 30 mph design average speed, this would correspond to 45 miles.

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5 Station Spacing

a. Description
b. Key Considerations
c. Guidelines for Implementation

a. Description

The average distance between BRT stations is strongly linked to both a passenger's access time to or from the BRT service, and her or his in-vehicle travel time. For any particular route section, there is a range of minimum and maximum average inter- station distances that can represent a good balance between these considerations. Minimum and maximum averages are used to account for cases where strong, closely-spaced trip generators may warrant closer spacing. Generally, these ranges can be established by operating context as previously defined.

b. Key Considerations

In assessing locations for BRT stations, a BRT designer should consider:

> The layout of the underlying street grid, looking for locations at key intersections to support transit transfers and first/last mile connections

> Access to major concentrations of residential, employment, educational, health, shopping, cultural or recreational uses or centers

> General topography, locating stations in areas that are not arduous for pedestrians and bicyclists to reach

> The presence of concentrations of mobility-challenged populations, such as seniors' centers, or centers serving those with mobility impairments

> The presence of a good supporting network of first/last mile amenities, or the potential to add them (Chapter 7.6 provides further first/last mile guidelines)

> Adequate space to accommodate a BRT station footprint (Chapter 7.2 provides further station site layout guidelines)

> Potential to support nearby community and economic activity (Chapter 7.6 discusses this in more detail in the context of transit-oriented communities)

> The overall spacing of stations, as further discussed below

Operational Context	Minimum Average Stop Spacing (miles)	Maximum Average Stop Spacing (miles)	Minimum Distance Between Adjacent Stops (miles)
Dense Urban	0.5	0.75	0.2
Other Urban	0.75	1.0	0.25
Suburban	1.0	1.25	0.35
Regional	1.25	Based on market	1.0

Table 4. Station Spacing Guidelines

c. Guidelines for Implementation

For a Full or Lite BRT service in LA County, the overall recommendation for station spacing ranges between 0.5 and 1.25 miles, depending on the nature of the surrounding development and street grid. Since much of the county features a grid with major arterials spaced 1 mile apart, an average station spacing of 1 mile across a full BRT rule may be considered a good rule-of-thumb for the county.

Nevertheless, the 1-mile guide is not a one-size-fits-all recommendation. In any given BRT route segment, the average spacing should vary according to conditions. It is recommended that the minimum and maximum station spacings in Table 4 be established for BRT route sections in their respective operating contexts.

For the regional context, the minimum spacing is a value below which even an ideal application (online stations on a freeway with a speed limit of 65 mph) would be unlikely to attain an average operating speed of 30 mph. The recommended minimum distance between stations for the regional context is based on the shortest observed inter-station spacings on North American commuter rail systems, the functional equivalent of a regional BRT service.

For the urban and suburban contexts, these recommendations are informed by the observed station spacings from implemented rapid transit routes worldwide, ranging from local services in dedicated lanes to fully grade-separated rapid transit. These can be considered to be representative of how the interplay of the underlying considerations of speed and access has been resolved in practice.

The above recommendations were informed by consideration of local conditions and practice in LA County, as well as national and international experience with similar high-capacity services.

Figure 5 shows the cumulative distributions of average station spacing for 209 urban transit routes classified as follows:

> *'Urban Rapid Transit'*, 65 fully grade-separated rail rapid transit routes, within the two urban contexts defined herein. These are relatively tightly clustered around 0.5 miles

> *'Urban Semirapid Transit'*, 12 LRT or BRT routes in the dense or other urban contexts, clustered around 0.4 miles

> *'Urban LocalPlus'*, 16 streetcar or 'BRT Lite' bus routes which do not have a parallel local service, clustered around 0.35 miles

> *'Suburban Rapid and Semirapid Transit'*, 14 routes in the suburban context, centered around 0.9 miles

> *'Blended Rapid Transit'*, 48 fully grade-separated routes which cover both the urban and suburban contexts; centered around 1.1 miles, and

> *'Blended Semirapid Transit'*, 54 LRT and BRT services covering both the urban and suburban contexts, centered around 0.8 miles.

The distinction between 'rapid transit' (on an exclusive right-of-way entirely separated from highway crossings) and 'semirapid transit' (not separated from highway crossings and not necessarily entirely in an exclusive right-of-way) was introduced by Prof. Vukan Vuchic[13], and has been built upon by others. In the urban and suburban operational contexts defined above, the BRT vision is expected to fall into the 'semirapid transit' class. The inclusion of data for rail-based systems greatly expands the number of observations, and it has been shown[14] that the underlying relationship between station spacing and average speed does not differ substantially between rail and bus technologies.

A further recommendation for locating individual stations and for adding stations after the corridor is operating, adapted from one developed for the VIVA BRT system in York Region, Ontario,

[13] Vuchic, Vukan R. 2007. "Transit System Performance: Capacity, Productivity, Efficiency and Utilization." Chapter 4 in Urban Transit: Systems and Technology. Hoboken, N.J.: Wiley, 149-201.

[14] Allen, D., Bruun, E.C, and Givoni, M., "Choosing the Right Public Transport Solution Based on Performance of Components" Transport, 33(4): 1017-1029

is considered appropriate for the urban and suburban operating contexts:

"In terms of spacing, an additional vivastation on an existing Viva route should only be considered if:

> the additional vivastation is located at least 750 metres (about 2,500 feet) from the nearest adjacent vivastation on any Viva route serving the proposed additional station;

> It will not reduce the average route-wide distance between vivastations on any route the additional vivastation serves to less than 1,000 metres (about 3,300 feet);

> In terms of ridership, a new 'infill' vivastation on an existing route should attract more new riders than it discourages as a result of the additional travel time, and should be expected to attract at least 300 new boardings per weekday (i.e. the estimate of new boardings must not include shifts from adjacent vivastations)".

The principle of establishing a target increase in ridership to support addition of a new station, adapted to Los Angeles experience, is suggested for future adoption.

Based on the characteristics of the observed systems with the shortest average spacings, corresponding values for the urban and suburban contexts have been included in Table 4. Metro's 2016 Transit Service Policies and Standards identifies a maximum average spacing of 6,600 feet (or 1.25 miles), citing the need to both 'achieve the highest bus speeds' and to 'provide access to major activity centers and

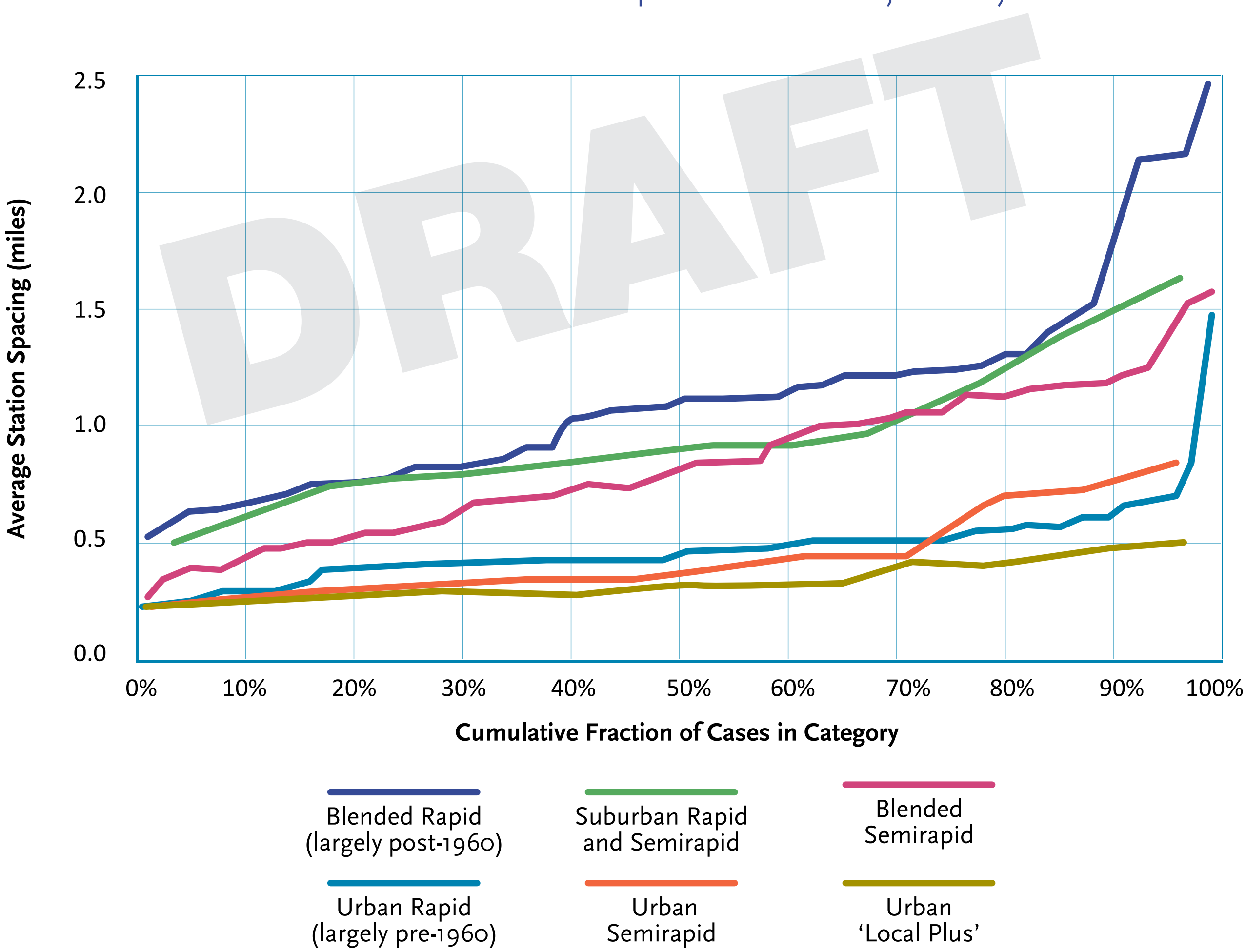

Figure 5. Distributions of Average Station Spacing
Source: IBI Group research based on transit agency published information, the National Transit Database, and direct observations

transfer points'. Based on the suburban systems observed, a slightly closer maximum spacing that corresponds to about the 80th percentile of these observations will accomplish this more effectively for the suburban context. Similarly, it is appropriate to establish different guidance for the urban contexts.

In the regional context, the absence of continuity in development patterns precludes setting a meaningful maximum average station spacing. Placement of stations in the regional context will be strongly determined by the specific locations to be served, but may also depend on the role of park-and-ride (P&R) in accessing the stations. Many commuter rail systems have substantial P&R access, and this is also true of the Roaring Fork Transportation Authority's 'VelociRFTA' regional/exurban BRT in Colorado.

6 Frequency of Service

a. Description
b. Key Considerations
c. Guidelines for Implementation

a. Description

LACMTA's 2016 Transit Service Policies & Standards document establishes 'policy' headways (scheduled intervals between vehicles on a route in the same direction). These establish a maximum headway (or minimum frequency) for service during the weekday peak periods and for all other times and days of service. Adherence to passenger loading standards, and the Metro Vision 2028 goal of providing high-quality mobility options that enable people to spend less time traveling, will often result in a service of any type offering more frequent service at various times of day on specific routes, depending on passenger traffic volume. This will be particularly true of a BRT route operating at a passenger traffic density appropriate for BRT. The distinction between the maximum 'policy' standard (grounded in the need to balance passenger convenience and cost-effectiveness) and the service levels that might be considered likely or appropriate for a branded BRT service for planning purposes is important to bear in mind.

b. Key Considerations

When determining the frequency or headway of a BRT service, a service planner must strike a balance between the following considerations:

> Shorter headways are more expensive to operate than longer headways

> Shorter headways provide shorter wait times for passengers and higher capacity on the route

> During peak periods, or potentially for a good part of the day on high-demand routes, longer headways can cause a route to exceed its passenger loading standards (see Section 7 below) – headways should always be adjusted to avoid this outcome

> In off-peak periods or on BRT routes with lower demand, the passenger demand may not justify a high headway; however too-long of a headway may deter riders, and is not in keeping with the image of BRT as a premium, rail-like transit service. Therefore maximum or "policy" headways should be established, as discussed below

c. Guidelines for Implementation

The recommended peak-period maximum headways for BRT are:

> 10 minutes for Full BRT

> 12 minutes for BRT-Lite

Off-peak headways should not exceed 15 minutes except on all-night ("owl") service.

[15] Especially Nantes and Strasbourg in France, where BRT routes have been added to a light rail network with comparable status in terms of branding and mapping.

Transit Service Type	Weekday Peak	Off-Peak
Light Rail	12 minutes	20 minutes
BRT	12 minutes	30 minutes

Table 5. Maximum ('Policy') Headways from 2016 Transit Service Policies and Standards

The recommendations track with both existing Metro policy and national BRT experience. LACMTA's 2016 Transit Service Policies & Policies document establishes the maximum headways shown in Table 5. For stand-alone BRT services as defined under 'Demand Density', it would be reasonable to expect a BRT service to at least match these standards for light rail transit. Based on comparisons with other cities in the US and overseas[15], BRT services appear to be offered at 20-25 percent higher frequencies than LRT in peak periods, which would point towards a 10-minute standard for the peak hours, and 15 minutes for off-peak. Perhaps not coincidentally, 10 minutes is the US Federal Transit Administration's guidance for considering a project to be 'BRT' in the agency's 'New Starts' funding process.

Therefore, it is recommended that for a stand-alone BRT route, the maximum headways are 10 minutes in the peak, and 15 minutes in the off-peak. Rather than try to prescribe a standard for branched routes, which may have different levels of demand, it is recommended that an off-peak headway of 15 minutes is established for any route section carrying two or more services identified or branded as BRT. It is further recommended that if a BRT route divides into two or more branches, the peak period maximum headway for any such branch is established as 20 minutes, and the maximum off-peak headway for such a branch be 30 minutes.

7 Passenger Loading

a. Description
b. Key Considerations
c. Guidelines for Implementation

a. Description

Passenger loading standards seek to strike a balance between system cost-effectiveness, passenger comfort , safety and dwell times. LACMTA's 2016 Transit Service Policies & Standards document establishes passenger loading standards to express "the maximum average ratio of passengers to vehicle size and frequency by direction for a one-hour period [which] should not be exceeded for at least 95% of all hourly periods."

b. Key Considerations

Since passenger loading is essentially a function of passenger demand and frequency of service, similar considerations as discussed for frequency must be balanced:

> Shorter headways are more expensive to operate than longer headways

> Shorter headways will reduce passenger loading, leading to a more comfortable and safer passenger experience, particularly for passengers making longer trips, which is a target market for BRT

> Shorter headways will also help to reduce dwell time at stations, since a heavily loaded bus will need more time for passenger boarding and alighting.

c. Guidelines for Implementation

The above standards from Metro's 2016 document are based on studies of LACMTA's peers, and are appropriate for both Full BRT and BRT-Lite in the frequency ranges defined. One change to the standard (shown in Table 6) is recommended for BRT:

> That the standards for a frequency of 1-10 minutes (1.4 passengers per seat in the peak, 1.3 off-peak) be applied to BRT in peak periods even in cases where it may be scheduled to operate less frequently than every 10 minutes

Research into passenger comfort suggests that passengers are willing to accept more crowded conditions for very short trips, as likely happens more often in the most congested parts of a BRT corridor. With very frequent service, customers who are averse to the most crowded conditions may also have better opportunities to wait for

Standard	Basis	Weekday AM and PM Peaks	Other Times
Current	Frequency 1-10 minutes	1.40	1.30
Recommended BRT	All frequencies	1.40	1.30

Table 6. Existing and Recommended Passenger Loading Standards

a less crowded bus. In the future, any available new research and guidelines regarding passenger comfort with regard to safe physical distancing practices also should be considered here.

8 Span of Service

a. Description
b. Key Considerations
c. Guidelines for Implementation

a. Description

LACMTA's 2016 Transit Service Policies & Standards document sets out standards for span of service (time span over which trips will be operating on a route) for various service types both weekdays and weekends.

b. Key Considerations

When laying out the hours of operation for a BRT, the service planner will need to consider:

- > Passenger convenience – a service which operates over an extended period will be more attractive to riders as it offers more trip flexibility and can accommodate more shift-workers
- > Cost-effectiveness – if the demand profile does not warrant late-night or early morning service, BRT will not operate cost-effectively during those periods
- > Transfers with other lines – consistent spans of service reduce the chance that a passenger will be "stranded" in the middle of their trip

c. Guidelines for Implementation

For both Full BRT and BRT-Lite, it is recommended that for stand-alone BRT services service spans in the urban and suburban contexts be established to be at least the same as the present standard for LRT, namely 4:00 am to 2:00 am on both weekdays and weekends.

This would assure that stand-alone BRT routes shown on a 'rapid'-class route map will create consistent expectations for all such routes, and would also maintain continuity with the adopted standard for the 'Metro Liner' service sub-type. An exception is made in the case of suburban routes that will not connect with the rail network - in this case a window of 4:00am to 12:00am is generally recommended; a later start-time may be used if there is a demonstrated lack of demand for 4:00am service.

If a decision is made to operate branched BRT routes, it is recommend that:

- > the trunk portion of the route have the same span of service as a free-standing BRT route, and
- > the span of service on any branch be no less than the present standard for the 'Metro Rapid' service type, i.e. 5:00 am to 9:00 pm on weekdays, and 6:00 am to 8:00 pm on weekends. Spans applicable to a branch are also appropriate for extended BRT routes operating in local mode and scheduled at half or less of the frequency of the trunk BRT route in the peak periods.

Given that the purpose of BRT services in the regional context can vary greatly from corridor to corridor, and that these likely would not be paralleled by local bus service, it is not possible to suggest a span of service for them. The span of service for a new regional BRT should be based on the intended market for the service.

Peak-Period Bus Lanes. If a BRT corridor uses peak-period dedicated lanes, their hours of operations should be set based on congestion levels in the corridor, generally 7:00 am to 9:00 am and 4:00 pm to 7:00 pm.

9 Service Reliability

a. Description
b. Guidelines for Implementation

a. Description

As articulated in the *Transit Capacity and Quality of Service Manual (TCQSM)* framework, service reliability is a distinct service attribute from travel time reliability. Service reliability, in the sense that buses run regularly, is an important part of how customers evaluate transit service. In contrast to travel time reliability, service reliability relates to the reliability of the service at a station in comparison to scheduled times, or for frequent services to the variability of headways. Service reliability is associated directly with customer waiting time at stations.

b. Guidelines for Implementation

For both Full BRT and BRT-Lite, it is recommended that service reliability is measured in two complementary ways – Metro's existing In-Service On-Time Performance (ISOTP) and Transport for London's (TfL) Excess Wait Time (EWT) LACMTA's 2016 Transit Service Policies & Standards establishes ISOTP based on considering a bus to be on time if it departs no more than one minute early or five minutes late at all time-points along a route. If a route uses headway-based scheduling (where buses are operated to keep a consistent headway rather than adhering to fixed timepoints), then the measurement will be early or late relative to the target headway rather than a fixed schedule.

The present ISOTP target is set at 80%, and there is an overall expectation that ninety percent of lines should achieve this standard at least ninety percent of the time. This aggregate measure cannot readily be assessed for a single route, percent on-time is not readily interpretable by customers, and particularly for frequent services, ISOTP may not represent the passenger experience so much as the operator's. For instance, if every bus on a ten- minute service is exactly ten minutes late, on-time performance is zero, but passengers will likely not notice the difference. An assessment based on on-time performance may be subject to change over time if the definition of 'on time' or the target levels change.

It is therefore recommended that in addition to ISOTP, BRT routes are evaluated in terms of Excess Wait Time a measure employed by TfL for high-frequency bus routes. EWT is recommended as a representative statistic because it has an intuitively understandable definition: how much time the average passenger has to wait for a bus in excess of the waiting time she or he would experience if the buses were perfectly regular in their arrivals.

The EWT is determined by the formula

$$EWT = 0.5\ H\ C^2$$

Where

> EWT is the excess wait time in minutes;

> H is the scheduled service headway in minutes; and

> C is the coefficient of variation of the headway, the ratio of the standard deviation of the headway to the average headway value.

The initial recommended standard for EWT is one (1) minute, the same as TfL's own standard for high-frequency bus services. As experience with this measure is accumulated, the standard may be adjusted, perhaps taking the form of a fraction of the scheduled headway.

EWT can be evaluated at any station or combination of stations, over any day or time period available.

It is recommended that the EWT is evaluated quarterly for each operational BRT route, on the basis of all stations on the route weighted by the number of passenger boardings, formed on the basis of each block of time which has a specific scheduled headway.

EWT can be evaluated at any stop or combination of stops, over any day or time period available. It is recommended that the EWT is evaluated quarterly for each operational BRT route, on the basis of all stops on the route weighted by the number of passenger boardings, formed on the basis of each block of time which has a specific scheduled headway.

10 Travel Time Reliability

a. Description
b. Guidelines for Implementation

a. Description

Travel time reliability assesses how confident a customer can be of traveling within the average (or scheduled) time required for his or her trip. If travel times are more variable, the customer will experience more schedule inconvenience time, having to accept arrival (on average) at the destination earlier than required, in order to provide a margin of safety against being late. LACMTA's service standards, like those for many other transit systems, do not include one for travel time reliability.

b. Guidelines for Implementation

It is recommended to measure travel time reliability according to the 3rd Edition of the *TCQSM*, which uses the coefficient of variation of travel time - that is, the ratio of the standard deviation (spread) of travel time to the average travel time along a route. The TCQSM does not establish a quality standard for this measure. However, the literature on travel demand[16,17,18] supports the notion that passengers see a minute of standard deviation of travel time as at least the same, if not higher, than the effect of an extra minute of travel time.

It is recommended that travel time variability is evaluated over a route, or even between timepoints, using the ratio of the standard deviation of the travel time over a route (in seconds) to a reference travel time variability TTRref given by:

$$TTR_{ref} = 0.0368\overline{TT} + 0.765\sqrt{\overline{TT}}$$

Where TT is the average travel time in seconds.

Over a calendar operating quarter, for each class of operating day (weekdays, Saturdays, Sunday/holidays) and major time period within those classes, this ratio should not exceed 2.70. Lower ratios, perhaps as low as 1.40, may occur if BRT routes have major portions of grade-separated exclusive right-of-way without traffic signals.

[16] Bates, J., J. Polak, P. Jones, and A. Cook, "The Valuation of Reliability for Personal Travel", Transportation Research Part E: Logistics and Transportation Review, Vol. 37, No. 2, 2001, pp. 191-229.

[17] Beaud, M, Blayak, T, and Stephan, M, "Value of Travel Time Reliability: Two Alternative Measures", 11th Meeting of the EURO Working Group on Transportation, 2012.

[18] Currie, G., Douglas, N', and Kearns, I., "An Assessment of Alternative Bus Reliability Indicators", Australasian Transport Research Forum (ATRF), Perth, WA 2012.

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11 Fare Collection and Boarding Protocols

a. Description
b. Guidelines for Implementation

a. Description

How a passenger boards the BRT vehicle and pays his/her fare is an important part of the user experience. Simplifying the procedure not only results in a better experience for the customer, it also speeds the boarding process, which reduces dwell times and boosts system speed.

All-door boarding is one of the most effective ways to reduce dwell times. In all-door boarding, non-cash customers may board using any door.

The LA County BRT Standards (2008-2014) call for all-door boarding at all stations. The sole exception is that up to 10% of Full BRT and 20% of BRT Lite stations can be exempted from all-door boarding if off-board fare payment is used. The Standards also call for dwell times of 2 seconds per boarding for Full BRT, and 2.5 seconds per boarding for BRT Lite; these thresholds are very difficult to achieve without all-door boarding, underscoring its importance to BRT performance.

b. Guidelines for Implementation

It is recommended that both Full BRT and BRT Lite offer all-door boarding for non-cash customers at all stations. Up to 10% of Full BRT stations and 20% of BRT-Lite stations may be exempted if they offer off-board fare collection.

While all-door boarding can be implemented on systems with on-board fare collection, off- board fare payment at high-volume stations is encouraged as another effective way to reduce dwell times.

There are two basic systems for collecting fares off the BRT vehicle – barrier and barrier-free. A barrier system is employed on Metro Rail, and has several advantages, including the creation of clear fare-paid zones, which enhances system security. However, it is anticipated that many BRTs in LA County will be implemented as predominately curb- or side-running systems where stations are adjacent to or integrated with sidewalks. At center-running stations, the fact that BRTs have low platforms - at or near curb heights - makes barriers ineffective since riders can easily bypass them. It is difficult to create fare-paid zones with such stations, therefore a barrier-free system is acceptable. These are also known as "proof-of- payment" systems where a customer is required to carry a fare card (e.g. a TAP card), ticket or other media that shows that a fare has been paid.

Use of the TAP card system is mandatory for Metro-implemented BRT and highly recommended for BRTs implemented by Municipal Transit Agencies, to allow for seamless transfers and a common BRT and Metro Rail rider experience.

Proof-of-payment systems rely on fare enforcement via random checks by roving inspectors. Therefore, it is recommended to implement a fare inspection system in accordance with overall agency policy.

If off-board fare collection is used, then a fare confirmation/activation/validation machine should be placed at each door.

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12 Other Services Sharing a BRT Corridor

a. Description
b. Guidelines for Implementation

a. Description

In the urban and suburban contexts, it is assumed that BRT services would usually be paralleled by local bus services making more frequent stops, and/or interface with other routes or patterns of service. This section suggests “rules of the road” for transit services sharing a corridor or interfacing with BRT services.

b. Guidelines for Implementation

Parallel Local Services

Where BRT services are in an exclusive median running way, parallel local services operating in the running way will interfere with, and cause delays to, the BRT service. Mitigation measures to preserve BRT speed and reliability include:

> Routing local buses in curb lanes in critical segments

> Reducing/rationalizing local bus stops

> Building passing lanes

> Lengthening stations to allow multiple buses

> Adding bays so that local buses can make way for BRT vehicles

> Adopting operating “rules of the road” to give BRT buses priority over local buses

Where BRT operates in a curbside dedicated lane (and service may therefore be adversely affected by right turning vehicles or other highway users) the local services can share the dedicated lane if provisions are made for them to pull into an offline position bus bay for the stop, so that BRT buses can pass them while they are stopped. In this situation, once local buses have completed their stop activities, they should be expected to yield to BRT buses. Transferring passengers would need to walk along the curb to move between the local stops and BRT stations in the same direction of travel.

In route segments where BRT services may need to operate in mixed traffic, BRT stations may be shared with local services when local circumstances warrant, such as when curb space is limited and/or total bus volumes are low.

Skip-Stop/Express Services

In the urban and suburban contexts, BRT services should be scheduled to make all stops. This maintains consistency with the other service types in the ‘rapid’ group (light rail and rapid transit).

The station spacing guidance in this document has been formed with a view to achieving goal average speeds with an ‘all stations’ service.

Express services have been operated on busways with two lanes in each direction (as on CTfastrak in Hartford, CT), or with passing provisions at stations (as on Pittsburgh’s West busway). Even in these wider busway configurations, TCRP 118 recommends that “a basic all-day ‘all stop' service" be provided. TCRP 118 further recommends that "BRT routes on city streets should have a single stopping pattern".

Skip-stopping (operating two or more service patterns on one corridor so that customers may need to transfer between services to make some trips) has been used to try to increase the effective speed and capacity of rapid transit services, most notably on the Chicago Transit Authority's (CTA) elevated rail lines, where the practice resulted in passenger confusion and burdensome wait times, causing a ridership decline - and a rebound when the practice was discontinued.

It has also been employed by local bus operations on downtown streets. For buses, skip-stopping requires buses to pass each other easily. Conditions most favorable to this include low general traffic volumes, and where there is a dedicated bus lane, provisions for bus stop 'pockets' for the use of general traffic lanes by buses.

The take-away is that skip-stop operations, whether BRT or rail, are complicated and confusing to passengers. They should be avoided unless there is a strong compelling reason in the density of demand patterns to warrant their use.

Feeders and Circulators

Feeder and circulator routes for which the routings are parallel to a BRT service and are on the same arterial should be treated in the same way as parallel local services. Transfers between BRT and feeders or circulators may be effected by moving along the curb or crossing arterial lanes. If the vehicles operated in feeder or circulator routes are interoperable with BRT vehicles, consideration may be given to sharing an exclusive BRT runningway, provided that the feeder or circulator route operation in the runningway does not extend farther than between two adjacent BRT stations, and it does not make any intermediate stops between the adjacent BRT stations.

For feeder or circulator routes, which operate across the BRT route, curbside stops for the feeder or circulators are appropriate, located so as to keep walking distances between these services and the BRT short. For instance, although 'farside' bus stops near intersections may be a preferred solution in most cases, a 'nearside' stop for a feeder or circulator might be considered if it would improve the average connection. Walking routes for the connections should be located in crosswalks or other protected locations.

13 Service Reviews

a. Description
b. Guidelines for Implementation

a. Description

Service Review refers to a regularly recurring formal performance review of a route against established benchmarks, so that corrective actions can be taken.

b. Guidelines for Implementation

The guidance on service reviews in Metro's 2016 Transit Service Policies and Standards is up-to- date relative to industry norms and remains appropriate for the BRT service type. No change is recommended to this guidance in terms of frequency of review, correction strategies, or the service change process. It is recommended that the key performance indicators (KPIs) for BRT are expanded to include:

> Annual operating and maintenance cost per person-mile traveled (PMT), to adjust out differences in average trip length between or among routes.

> Passenger traffic density (PTD), defined as the ratio of the annual PMT to the one-way route length. This 'dimensionless' measure is readily comparable among routes, modes, or even entire networks.

> Average vehicle occupancy per gross square-foot-mile of revenue operation. This is the ratio of PMT to the product of revenue vehicle miles operated times the gross square foot area (length times width) of the average vehicle operated in service.

> Productivity as measured by the ratio of PMT to the product of revenue vehicle hours operated times the gross square foot area (length times width) of the average vehicle operated in service. This both corrects for differences in average trip lengths (as compared to boardings per vehicle-hour) and adjusts for vehicle size, facilitating comparisons among modes and networks.

The advantages of adding these measures are: a) that they incorporate person-miles traveled rather than boardings, which is a more accurate way of measuring the amount of passenger transportation actually provided, and b) that they can be consistently determined on a route or network basis and used to objectively compare entire modes within a system or to make comparisons between systems. If these measures prove to be helpful, they could be added to measures compiled for other modes, or incorporated in the next update of the route performance index (RPI). By way of example, Figure 6 shows how an occupancy measure based on linear meters of vehicle (the range of vehicle widths is usually not very large) can be used to compare the results of multiple systems and support development of a performance benchmark.

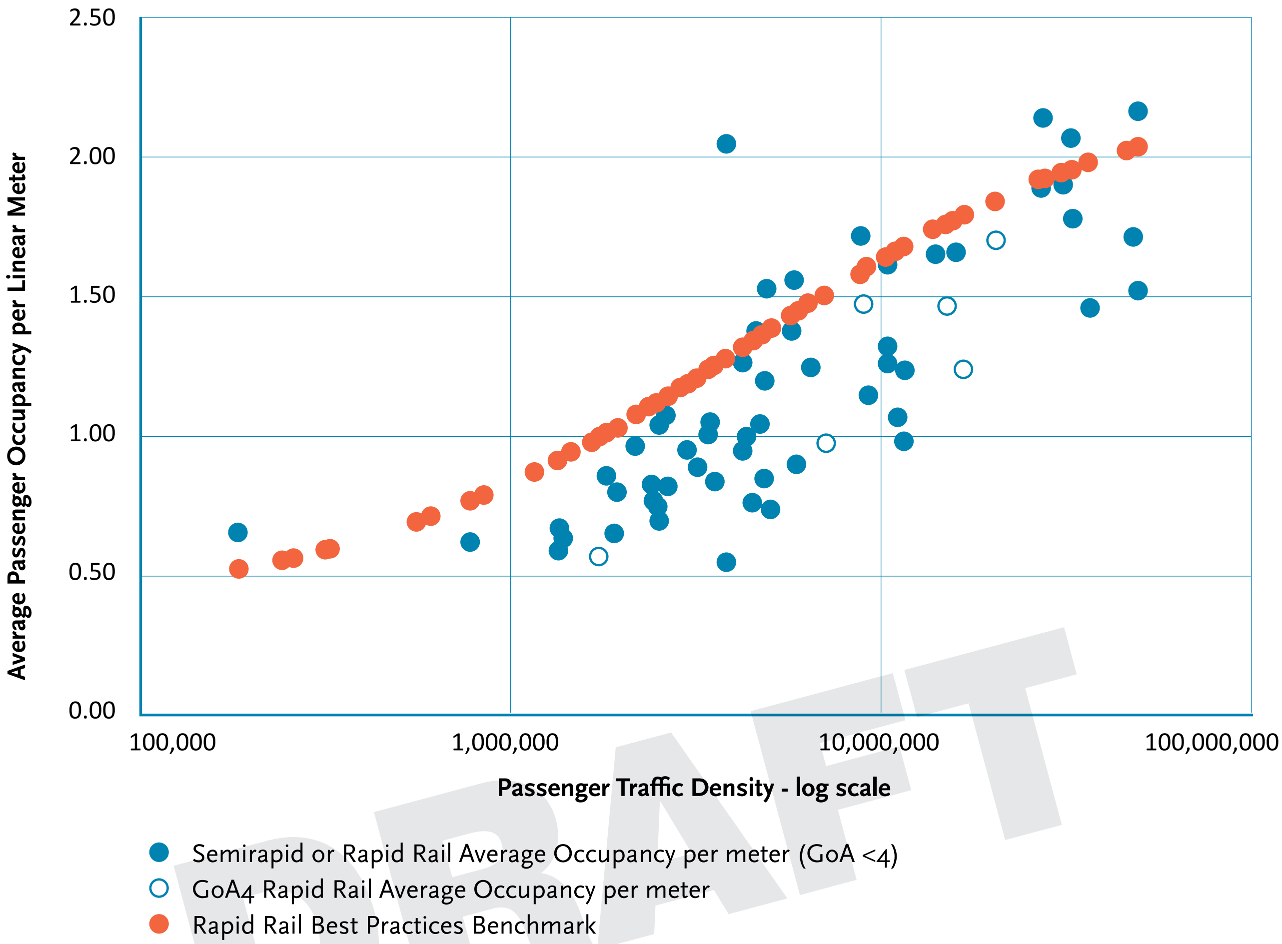

Figure 6. Example Cross-System Relationship between Performance Indicators

Table 7 summarizes the recommended BRT performance indicators, including both the new ones discussed above as well as existing measures that have been adapted to BRT. The pages following the table provide more detailed definitions and formulas tor the measures.

Category of KPI	Specific KPI	Description	Benchmark	Data Accumulation	Start KPI Measurement	Method of Measurement	BRT Goals: Our BRT will provide an attractive, convenient and reliable mode choice that is a safe, secure, inviting and comfortable experience for all users for the entire trip.	Our BRT will fulfill a distinct role that enhances and integrates with existing mobility services.	Our BRT will connect people to where they need and want to go.	Our BRT will consistently operate at high-performance levels allowing users to by-pass congestion	Our BRT will provide excellent infrastructure, vehicles, amenities and customer service	Our BRT will consider community needs and enhance quality of life	Our BRT will align design standards and service needs to maximize benefits
Ridership	2.1 Ridership	Daily Passenger Boardings by Route by Time Period (daily, peak, off-peak, weekend)	NA -route-specific - each route to be compared to itself over time	Continuous	Start monthly tracking within three months	APC Data/Fare System Data	●		●				
	2.2 Ridership Trends	% Change in Boardings by Average Day by Typical Day Year over Year		Periodic	Start quarterly tracking within six months	APC Data/Fare System Data	●		●				
	2.3 Passenger-Miles Traveled	Daily Passenger-Miles Traveled (PMT) by Route by Time Period (daily, peak, off-peak, weekend)		Continuous	Start monthly tracking within three months	APC Data/CAD/AVL Data	●		●				
Customer Satisfaction	2.4 Customer Satisfaction Ratings	Ordinal scale ratings (e.g. 1-5, 1-7) on service attributes	Existing agency standard	Periodic	Start at 18 months and update every two years	Periodic passenger survey		●			●		●
	2.5 Customer Service Feedback	Number of Positive & Negative Feedback Responses		Continuous	Start quarterly tracking within six months	Customer Call-Ins, emails, & App Responses		●			●		●
Service Reliability	2.6 On-Time Performance	% On-Time (1 min early/5 min late) by Timepoint By Period (daily, peak, off-peak, weekend)	"Full BRT - 80% or higher BRT Lite - 75% or higher"	Continuous	Start monthly tracking within three months	CAD/AVL Data	●						
	2.7 Excess Wait Time	Amount of Time a Passenger has to Wait Beyond what they should Expect to Wait if Buses Ran as Scheduled, by timepoint, weekday peaks by direction	1 minute or lower	Continuous	Start monthly tracking within three months	APC Data/CAD/AVL Data	●			●			●
Performance	2.8 Travel Time	Bus Travel Time Absolute (including dwell) by Segment (timepoint to timepoint) and Direction by Period (daily, peak, off-peak, weekend) Bus Travel Time Ratio to Baseline/Reference Time"	NA -route-specific - each route to be compared to itself over time 2.4 or lower	Continuous	Start monthly tracking within three months	CAD/AVL Data				●			
	2.9 Travel Time Reliability	Variability in Travel Time by Segment (timepoint-to-timepoint) and direction in weekday AM and PM peak periods	2.7 or lower	Continuous	Start monthly tracking within three months	CAD/AVL Data - Post Process				●			●
	2.10 Productivity	PMT per revenue vehicle hour-square-foot	"Full BRT - 0.5 or higher BRT Lite - 0.4 or higher"	Continuous	Annually on a calendar year basis	APC Data and CAD/AVL Data - Post Process with NTD reporting							●
Access	2.11 Mode of Access	% of Access by Mode to BRT Stations by Station	NA	Static	Start at 18 months and update every two years	Customer Survey		●			●	●	●

Table 7. BRT Performance Measures

Ridership

Ridership – defined here as total daily passenger boardings – is a fundamental measure of the success of a new BRT line. This data is routinely collected and is required to be reported to the FTA's National Transit Database (NTD).

Ridership should be collected and reported on a quarterly basis. Ridership should be reported for each route in each direction for the following as averaged over the quarter: weekdays total, weekdays peak, weekdays off-peak, Saturdays, Sundays/holidays. The classification into peak and off peak should align with regional planning and reporting practices. Additionally, ridership data should be collected at a station level periodically.

Ridership Trends

This Key Performance Indicator (KPI) uses the same data as Ridership above, however the focus when reporting is the percentage change since the last reporting period, to focus on trends.

Passenger-miles Traveled

Passenger-miles traveled (PMT) is a key statistic for assessing the amount of transportation provided by a facility of service. It is required to be reported to the FTA's NTD in addition to passenger boardings, in part because powerful indicators of efficiency or productivity can be derived from it, such as average bus occupancy (PMT per revenue vehicle-mile), passenger traffic density (PMT per mile of route) and operating costs per PMT.

With Automated Passenger Counter (APC) technology, PMT can be established at a basic unit of station-to-station, and as desired be compiled: by segments (e.g. timepoint-to-timepoint[1]); by routes, systemwide by mode; or in the aggregate across all modes operated. APC technology also enables the separation of the results by day or week or time of day. PMT has the same meaning and interpretation in all these contexts.

PMT should be collected and reported on a quarterly basis. PMT should be reported for each route in each direction for the following as averaged over the quarter: weekdays total, weekdays peak, weekdays off-peak, Saturdays, Sundays/holidays. The classification into peak and off peak should be align with regional planning and reporting practices.

Customer Satisfaction Ratings

BRT offers a blend of performance characteristics and passenger amenities that together make for a distinctive passenger experience. Periodic rider satisfaction surveys should be conducted to assess the overall popularity of the service as well as passenger feedback on distinct performance and amenities – e.g. system speed or station comfort.

At a minimum, this should be done at the time of an "after" study, to understand the effects of the new BRT service relative to baseline "before" conditions. Preferably, the BRT survey is also periodically conducted as part of larger passenger satisfaction survey efforts.

Customer Service Feedback

Another indicator of passenger satisfaction is a tally of both positive and negative comments received by the agency on the BRT service. Since this data is continuously collected as comments are received, it can serve to supplement relatively infrequent passenger surveys.

On-time Performance (OTP)

OTP should be reported on a monthly basis beginning with a BRT route's second full calendar quarter of operations. On-time percentages should be compiled for each BRT route in both directions for the following as averaged over the month: weekdays total, weekdays peak, weekdays off-peak, Saturdays, Sundays/holidays. The classification of trips into peak and off peak should be made in the same way as for the travel time KPI (see below). It is recommended that OTP be recorded both for each departure from each timepoint (except as noted below) in each direction and on a route-wide basis (by

1 Timepoints are designated timed waypoints along a route, used to aid in schedule adherence.

direction) using the arithmetic mean of the OTP percentages of each timepoint in each direction.

It is recommended that the definition of 'on time' be no more than one minute in advance of scheduled departure (or arrival for the terminal) and less than five minutes late relative to timetable schedule. If a route uses headway-based scheduling (where buses are operated to keep a consistent headway rather than adhering to fixed timepoints), then the measurement will be early or late relative to the target headway rather than a fixed schedule.

Excess Wait Time

Excess wait time (EWT) is a passenger-centric measure of the difference between the average wait time which passengers experience with the service as operated, and the wait time they would experience if the route operated exactly on schedule. The *Transit Capacity and Quality of Service Manual (TCQSM)* (3rd edition, Transportation Research Board) recognizes this measure in addition to OTP as a measure of service reliability, stating that: "when departures are not perfectly reliable, the average waiting time is longer than the average headway and is related to the spread in the headway distribution". For very frequent service, as would be characteristic of peak-period BRT route service, it is reasonable to assume that passengers arrive at a relatively constant rate independent of the timetable times, so that the EWT measure at a point I along the route for a given time period when the headway H is constant can be expressed as:

$EWT_i = (H/2)\,(1 + (\sigma/\mu)^2)$ where

μ is the average headway operated over the time period at point *i*

and

σ is the standard deviation of the observed headways operated over the period at point *i*.

Because the BRT demand will be heaviest in peak hours, when the headways will be shortest, EWT should be evaluated by direction for the weekday AM and PM peak periods on a monthly basis[2]. It is further recommended that EWT be evaluated at each timepoint to compile a route-wide statistic. The identification of the peak periods should align with regional planning and reporting practices in the same way as for PMT. Peak period operations may be constituted of one or more 'time slices' *j* in which a specific headway H_{ij} is scheduled at a timepoint *i*. The EWT value for an entire peak period for one operating weekday would be averaged across all timepoints and time slices.

The monthly reported value of EWT would be the average for all the normal operating weekdays (i.e. excluding holidays) in a calendar month. As reported by TCQSM, industry operating experience with EWT has shown that meaningful seasonality may be observed, which may be helpful for service planning purposes. Visibility of the underlying data by timepoint may also aid in identifying spatial 'hot spots' along a route where discontinuities in EWT occur and could be targets for remedial treatments. While the focus on consistent measurement should be the peak periods, as they are the highest-ridership times and most likely to suffer reliability issues due to congestion, periodic measurement of excess wait time in off-peak periods may be used to identify and remediate temporal 'hot-spots' too.

Travel Time (Absolute and Relative to a Baseline/Reference Travel Time)

Travel time is a principal measure for assessing the performance of a BRT route, because a fundamental motivation for bus rapid transit is to improve this attribute of service. APC technology enables accurate measurement of bus travel time for each bus trip between stations and can identify time spent at stations (dwell time). These times can be compiled: by segments (e.g. timepoint-to-timepoint) or along entire routes. The technology also enables the separation of the results by day or week or time of day.

Travel time should be reported on a monthly basis[2]. Travel times should be recorded for each trip on each BRT route, as measured from

2 Many transit operators have management 'dashboards' or other tools that can display these data on a daily or even near-real time basis. Such tools may be warranted for purposes other than assessing the overall performance of a route.

departure from the originating terminal (e.g. bus departure as determined by the APC) and arrival at the destination terminal (e.g. door opening at the terminal as determined by the APC). These times should be compiled for each BRT route in both directions for the following as averaged over the month: weekdays total, weekdays peak, weekdays off-peak, Saturdays, Sundays/holidays. The classification into peak and off peak should be made on the basis of the clock time at a user-specified mid-route timepoint, with the definitions of weekday peak and off-peak chosen to align with regional planning and reporting practices in the same way as for PMT.

The above is an absolute measure of the travel time in a corridor and is useful in a before and after study for comparing BRT performance to any previously-existing local services. It is also useful as an ongoing measure to spot and correct any negative trends in travel time along a route. However, since each route will be different in length, number of stations, underlying congestion and other factors, it does not provide information with which to compare corridors.

For this reason, it is also recommended to conduct periodic, recurring (monthly if practicable) evaluations of bus travel time relative to a fixed reference time that depends only on the number of timetable stations per mile along the route. Because the travel time will already be reported, forming this ratio is a simple matter of dividing by a fixed reference time for each route, that would only change if the route were modified or stations were added or deleted. The proposed reference time Tref in minutes takes the form:

$$T_{ref} = \frac{60}{55} + e^{(-0.763-0.011S-0.946\ln(S)-0.216S^{-1})}$$

where S is a station-to-station segment's length, or a timepoint-to-timepoint segment's average station spacing, or an entire route's average station spacing, all expressed in miles. In essence, the reference time establishes the shortest likely travel time over a straight and level route without traffic signals or other traffic and with a maximum speed limit of 55 mph.

The travel time ratio to the reference minimum should be reported on a quarterly basis (or monthly if practical) beginning with a BRT route's second quarter of operations. These ratios should be compiled for each BRT route in both directions for the following as averaged over the quarter or month: weekdays total, weekdays peak, weekdays off-peak, Saturdays, Sundays/holidays. The classification into peak and off peak should be made on the same basis as for travel time.

Travel Time Reliability

As articulated in the *TCQSM* framework, travel time reliability is a distinct service attribute from service reliability, which is covered by other proposed KPIs. Travel time reliability measures how certain a customer can be of traveling within the average or planned time required for his or her trip. If travel times are more variable, the customer will experience more schedule inconvenience time[3], where she or he accepts arrival (on average) at the destination earlier than required, in order to provide a margin of safety against being late.

Through accurate measurement of bus travel time, APC technology makes it possible to process these data to form the standard deviation of travel time for any set of N bus trips as:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

where μ is the average travel time KPI value for the same group of N trips; and x_i is the travel time of each trip *i* included in *N*.

These standard deviations can be compiled: by segments (e.g. timepoint-to-timepoint) or along entire routes. The APC technology for also enables the separation of the results by day or week or time of day.

Travel time variability should be reported on a monthly basis. Travel times should be as

3 Furth, Peter G., and Muller, Theo J., "Service Reliability and Hidden Waiting Time: Insights from AVL Data", Transportation Research Record, 2006, Aspects of this work have been brought into the TCQSM framework.

recorded for the travel time KPI, with standard deviations being processed after the travel times are captured. The standard deviations should be compiled for each BRT route in both directions for the following as averaged over the month: weekdays total, weekdays peak, weekdays off-peak, Saturdays, Sundays/holidays. The classification into peak and off peak should be made in exactly the same way as for the travel time KPI.

Productivity

Measuring route productivity is useful in assessing whether an agency's bus and BRT resources are being deployed effectively in the network, and may indicate where a BRT vehicle may be better redeployed on a more productive route.

The recommended measure of productivity is annual PMT per Revenue-square-foot-hour of service, or PMT/(VRH x A), where A is the floor-area in square feet of the average vehicle operating on the BRT route. This statistic should be reported annually on a calendar year basis. The underlying data VRH and PMT are already being compiled for the annual reports to FTA's National Transit Database (NTD). This KPI should be used to compare a route to itself over time, and can also be directly compared with results for other routes and other modes.

Modes of Access

The modes of access used by customers to reach the BRT route should be assessed bi-annually. Given the value of this information for general planning purposes, it is suggested that a fairly rich set of modes be defined, ideally a proven set in common use by the Southern California Association of Governments (SCAG), or already in use by Metro. It is recommended that this be obtained by an on-board survey of BRT passengers and that means be provided to also code or obtain the station at which each passenger boarded, the date, the time and the direction of travel.

Mode of access can be expected to be a relatively stable characteristic for each station beyond the first six months or so of operation and to vary among routes. In a sense, this is not so much a performance characteristic as an indicator of the route's nature and function. It may also prove useful in identifying First/Last Mile (FLM) improvements.

Significant changes are likely to be associated with changes to the transit and/or FLM network, such as a new connection with rapid transit, light rail, or other BRT services, or because of major changes in land use in station vicinities. Because a survey can be relatively expensive to administer, it is recommended that the survey be conducted every two years. Because there is effectively no way to establish a 'before' condition, it is suggested that the two-year cycle be common to all BRT routes and that the first such survey for each new route be conducted on the next two-year cycle following its sixth month of operation. This will enable system-wide trends to be tested across multiple routes.

There may be economies of scale to be achieved by combining this survey with others, such as for customer satisfaction.

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2

BRT Stations and Platforms

Stations are both the first and last impressions that customers have of a BRT system, and therefore set the tone for the entire rider experience. This section presents the LA County standard for BRT Stations, supporting a high-quality, consistent user experience while providing flexibility for space-constrained station areas.

1. Station Design Objectives
2. Station Footprint and Configuration
3. Materials and Finishes
4. Canopy Design
5. Systems Components
6. Lighting
7. Landscaping
8. Wayfinding Signage and Passenger Information
9. Passenger Amenities
10. Public Art
11. Parking
12. Outdoor Rooms/Open Space/Transit Plazas

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1 Station Design Objectives

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Opportunities and Challenges
e. Reference Documentation

a. Description

A key attribute to a Bus Rapid Transit system is that the passenger experience is "rail like". BRT stations fulfill several functions. They provide access to the transit service, create a comfortable and safe environment for passengers and provide transit information to customers.

The objective of the Metro BRT Stations Guidelines is to establish a baseline set of elements to be included in the design of BRT stations. The integration of the elements at station locations can facilitate an enhanced experience for passengers. It can do the following:

> Attract new riders
> Promote visibility and facilitate the branding of the system
> Provide protection from weather
> Ensure accessibility for all, including persons with limited mobility
> Provide route and wayfinding information
> Ensure that stations are integrated seamlessly into communities and contribute to urban design
> Facilitate convenient, safe transfers to other services, routes and modes

The BRT stations should be a substantial facility that shall include many of the following attributes:

> Shelter
> Opportunities for advance fare collection
> Distinctive architectural character
> Route and wayfinding information
> Lighting and security elements

Stations can also include facilities for additional functions listed below:

> Level boarding
> Seating
> Bike racks or storage
> Personal mobility device areas
> Additional shelters & canopies
> Leaning rails
> Enhanced plazas and landscaped areas

Factors to consider in determining additional amenities to provide at each station are:

> Existing and future passenger demand
> Ridership
> Transit service plans
> Capital cost
> Operating and maintenance cost
> Available right-of-way
> Compatibility of surrounding development plans and land use policies.

The guidelines in this section supplement and lay the groundwork for updating the Metro BRT Design Criteria (2008-2014) by providing guidelines for the implementation of BRT on future corridors in addition to outlining the goals and the vision of the BRT system as a whole.

b. Metro Standards

There are several guidelines that relate to transit facilities. These include:

> Metro BRT Design Criteria (2008-2014)
> Metro Transfers Design Guide
> Metro Signage Standards
> Metro Systemwide Station Design Standards Policy
> Metro Rail Design Criteria
> Metro Rail Architectural Standard/ Directive Drawings

c. Guidelines for Implementation

Iconic Design

An iconic station design fulfills both a functional and aesthetic need. In a diverse urban streetscape condition, it is important that the station design be distinguished from competing street elements, yet complementary to its surrounding environment so that it is clearly identifiable. The iconic design elements of BRT stations should respond to a diverse range of street front conditions, including mixed use commercial/ residential, public parks and plazas, undeveloped or low-density commercial sites, as well as areas of cultural or civic significance.

An easily recognizable design for BRT systems should distinguish the system from surrounding conditions within the built environment, as well as from other transportation service options along the corridor. This is accomplished by presenting a visually distinctive service, designed with the consideration of passenger amenities that go beyond standard bus stops.

Branding

The station shall utilize branded elements consistent with Metro's Brand Standards and Signage Standards, with the goal of optimizing clarity, legibility, and ease of use by the customer. These elements of consistency shall be designed and incorporated to complement the station architecture, while at the same time creating a distinctive and memorable visual impact that signifies the enhanced level of service. Partnering municipal transit agencies will require integrated branding that also clearly indicates their service, and the balance of these elements will require careful consideration from the standpoint of spatial hierarchy and visual logic. For this reason it is highly advisable that the project team enlist the services of a professional Environmental Graphic Design consulting firm to facilitate the creation of a cohesive graphic identity. Metro Arts & Design shall be provided opportunities for coordination and review of this design effort at all stages of the process.

Site Specific Context

BRT systems incorporate numerous station locations and, at times, multiple corridors or routes, all while typically utilizing one primary shelter typology. Concepts surrounding a site-specific design response should highlight the flexibility of the station design. Site specificity for BRT station design should include design elements which are apt to respond to varied site conditions, including but not limited to microclimate, shading conditions, site slope, existing utilities, driveways, local stakeholder concerns and the programmatic constraints of adjacent sites.

Passenger Experience

One of the key goals for future BRT transit corridors in LA County is to provide passengers with streamlined high quality transit service, and amenities on par with rail service where possible. There are many transportation options available to potential passengers. As one of those many transportation options, Bus Rapid Transit has to compete with the flexibility and personal comfort of travel in a single occupancy vehicle, the speed and capacity of rail service, and the ubiquity of local bus service. The role of station design in this endeavor is to create a high-quality user environment that can attract potential passengers who would otherwise travel via automobile.

Safety and Security

Safety and security are enhanced when associated with placemaking and openness. These components of Crime Prevention Through Environmental Design (CPTED) are the foundation of establishing a sense of 'place' at the stations. When passengers are provided an environment where they feel confident in their safety and their personal sense of security, it enhances the sense of ownership of their community station. This further enhances the station's placemaking potential within their community. Features such as enhanced lighting in the station areas, security cameras integrated into shelter design and high visibility at stations and at pedestrian crossings shall be incorporated into the design of stations.

Placemaking

In order to foster an environment where BRT passengers feel safe and have a sense of ownership, it is critical that the station design be responsive to placemaking. Consideration should be given to providing the necessary allowances and clearances for comfortable patron inhabitation. Clean, safe, and appropriately-sized space on platforms allow passengers, even for short durations, to establish personal space and to create a momentary link to the welfare of stations. Areas for design consideration should include seating (individual versus group), the various forms of station waiting areas (either planned or impromptu), ease and comfort of ticketing activities, and passenger orientation both to and from stations.

As an element of variability, artwork incorporated into the design of the station is an excellent way to create a unique and memorable environment within the more structure system identity. Artwork can be integrated into the shelter in a variety of ways, depending on the station typology, and will act as identifying landmarks.

Sustainability

Typical BRT station amenities do not include major mechanical systems to measure sustainable energy efficiencies, but several sustainable practices should be considered in the design of the stations.

Photovoltaics integrated into the design of canopies shall be considered. Considerations for the inclusion of photovoltaics at stations include:

- Station orientation
- Solar access
- Predesign Canopy roof for the inclusion of solar array

Additional sustainability components that shall be considered:

- Use of low albedo, durable materials
- Use of light colored and/or permeable paving
- Energy efficient LED light fixtures
- Heat-resilient systems
- Use of bio-swales as a low impact development feature.

Innovation

BRT is a flexible mode that can be used in a wide range of urban transport applications. As such the design of elements should be designed in a manner that allows for the integration of new technologies as they emerge.

Kit of Parts Approach

The station amenities will be designed using a kit of part approach. Stations elements as described below will be utilized at stations to establish a minimum requirement of Baseline of amenities for platforms. At locations where warranted by considerations such as higher ridership or where space allows, enhanced amenities shall be provided. Components of the kit of parts are design to be modular in nature. This allows for items such as the shelter to be utilized in different size configuration as side platforms and median platforms.

Baseline

> Marker
> Shelter/Canopy
> Integrated Lighting
> Litter Receptacle

Enhanced

> Bike Racks
> Windscreen
> Seating
> Leaning Rails

d. Opportunities and Challenges

Opportunities

> More people walking makes everyone safer.
> Going places on foot or by transit increases the opportunity for interactions between people.
> A visible transit system with highly visible stations creates a sense of neighborhood pride.
> More foot traffic creates marketing opportunities for existing businesses.
> More efficient transit service through improved boarding and wayfinding

Challenges

> Variations in site characteristics for stations: length and width of platforms.
> Variations in alignment types: side running or center median running.
> Station area vehicle requirements should be consistent.
> Variations in vehicle fleets from multiple operators: should be able to access any platform or layover facility.
> Space availability for side running.
> Turning movements conflicting with curb operations.

e. Reference Documentation

BRT transit facilities shall be designed in accordance with the most current applicable codes. Local codes shall have precedent over Standards and Guidelines that cannot be enforced by Authorities Having Jurisdiction. These include but are not limited to the following:

> California Building Code (2010 California Building Code title 24 Part 2),
> National Fire Protection Association (NFPA) 130,
> American Association of State Highway and Transportation (AASHTO),
> National Electric Code (NEC),
> International Fire Code (IFC),
> Americans with Disabilities Act Accessibility Guidelines (ADAAG),
> Transit Street Design Guide (NACTO)
> California Access Compliance (DSA),
> California Accessibility Reference Manual (CARM),
> California Transportation Department of Transportation (Caltrans) Standards,
> City Standards (Authority Having Jurisdiction), building and zoning permits
> Occupational Safety and Health standards (OSHA) 29FR Part 1910,
> California Public Utilities Commission (CPUC)

Where BRT facilities are not covered or found within a code, the best practice shall be implemented with approval from Metro.

Design Criteria and Guidelines

> Metro BRT Design Criteria, 2014
> LA Metro Transfer Design Guidelines- Improving Connections for a Seamless Trip, March 2018

2 Station Footprint and Configuration

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

Station Typologies

This section discusses the range of station typologies and presents guidelines for how they are to be configured along the running way. The configuration of the station types will be largely determined by the placement of the running way for the BRT systems within the roadway. Generally the running way will be placed adjacent to the curb or side running or may be located within a center median of the roadway. Considerations for placement of the guideway can be found in chapter 7.3 BRT Running Ways, section 2.

The type of running way will have a direct impact on the station typology that will be utilized. BRT Stations will be configured into two main types:

> **Side Running Station** will be utilized when the BRT operates in a curbside or side running guideway

> **Median Running Station** will be utilized when the running way is located within the center of the roadway.

Side Running

Platforms that are integrated into the side of roadways can have several configurations. Factors that impact the footprint of the platform area and placement of amenities include:

> The width of the existing boulevard available.

> An adjacent parking lane that can be utilized for the platform area

> A bike lane that is included in the roadway.

> Possible conflicts with adjacent building entrances or driveways.

Additional consideration on the placement of Stations can be found in chapter 7.6 BRT Planning and Integration Into transit-oriented communities.

In general, the platform footprint shall be 12ft by 75ft. This provides an area of 900 sq. ft. for utilization of station amenities. A platform length of 75 shall be considered as a minimum when the station is not shared with other services. Where operation needs are warranted a 100 ft long platform can be utilized. The platform height at the loading edge can range from curb- height to level-boarding, which is 14 inches above the busway surface.

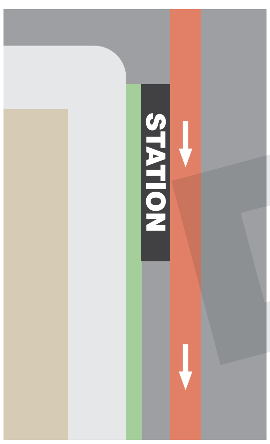
All station furnishing shall be placed to provide the maximum amount of unobstructed clear space at the platforms. The minimum clear space at platforms shall include:

> 96 inches (8ft) x 60 inches (5ft) at the accessible door for boarding

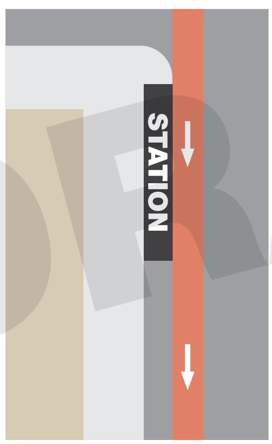
> 60 inches (5ft) x 60 inches (5ft) at all other doors

The typical configurations of stations for side running conditions shall be:

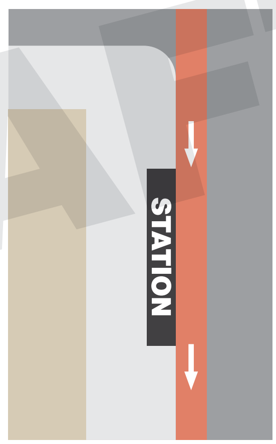
- **Type S1-Bulbout detached** - This configuration shall have a platform that is separated from the adjacent sidewalk boulevard with a bike lane (if present) that passes behind the platform.
- **Type S2-Bulbout attached** - This configuration shall have a platform that is 12ft wide by 75ft in length. This shall be achieved by projecting into a parking lane. This configuration shall be integrated into an adjacent sidewalk allowing for pedestrian flow through traffic behind the stations.
- **Type S3-Integrated** - This configuration of platform shall be used when a minimum width of 15ft is available including both sidewalk and landscaped area in an existing boulevard and placing the platform in a parking lane is not possible. Within the 15ft boulevard, the platform dimensions shall be 12ft x 75ft. This scenario is considered a constrained space and the placement of platform canopies shall be 8ft from the edge of the platform to allow for adequate clearance for boarding and alighting and for pedestrian flow through traffic behind the shelters.
- **Type S4** - Constrained - Similar to the 15ft integrated platform, this configuration is for constrained spaces. This configuration is expected to be utilized in very narrow right-of- way. The platform footprint shall be 8ft x 75 ft. The placement of the canopy and station amenities shall be at the back of the platform. Placement of the canopy and amenities can be adjusted to avoid any conflicts with building entrances or features.



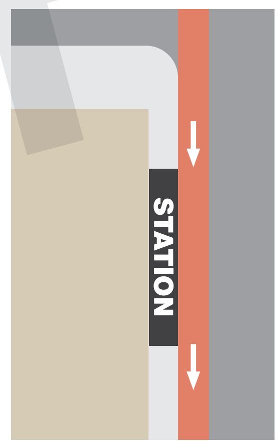
Side Running
Type S1-Bulbout detached



Side Running
Type S2-Bulbout attached



Side Running
Type S3-Integrated

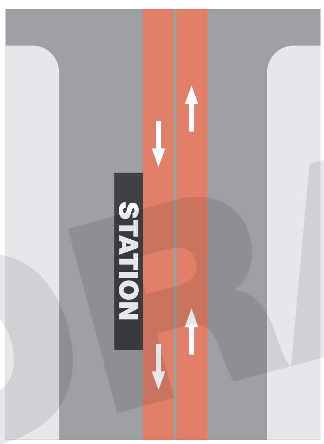


Side Running
Type S4

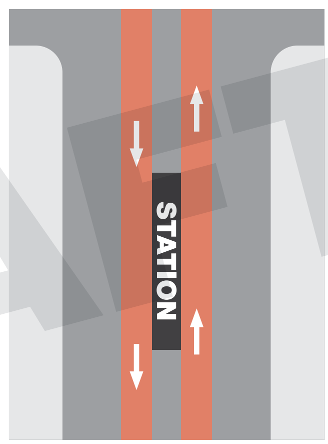
Median Running

Median running is when the station is located at the center of the roadway. There are two possible configurations. The first is side/side staggered, where two right-side platforms are placed on either side of the running way across the intersection from each other. The second is a center island configuration. Should a center island configuration platform be selected, a contraflow or crossover operation of buses is not acceptable. The preferred operation mode shall include a 5 door bus where boarding and alighting can occur on the left or right side of the buses.

- **Type M1-Side/Side Staggered** - A side/side staggered configuration of platforms with dimensions of 12ft x 150ft for a platform area of 1800 sq ft. Each platform shall be located on the far side of an intersection in the direction of travel. Access to the platform will be from the intersection crosswalk.
- **Type M2-Center Island** - The center island platform shall be 16ft x 150ft for a total area of 2400 sq ft. Platforms can be located on either side of an intersection, and will be evaluated based on physical constraints at each location or operational efficiency. Access to the platform shall be from the intersection crossing.



Median Running
Type M1-Side/Side Staggered



Median Running
Type M2-Center Island

b. Metro Standards

In general, stations shall be accessed at the ends of the platforms. Platform lengths shall be 75ft for side configuration stations. This shall allow for a single, 60ft, articulated bus. Median running stations shall have a platform length of 150ft. This shall allow for two 60ft articulated bus to berth at the platform edge.

Platform cross slopes shall be 1:48 maximum and shall be sloped towards the busway.

Platform width shall be a minimum of 12ft to allow for stations which include canopies, benches and passenger queueing areas, ADA clear floor space, and accessible routes.

Platforms in constrained spaces shall be a minimum of 8ft wide. Station amenities shall be placed on the platform to not encroach into a 5ft wide clear space from the platform edge.

c. Guidelines for Implementation

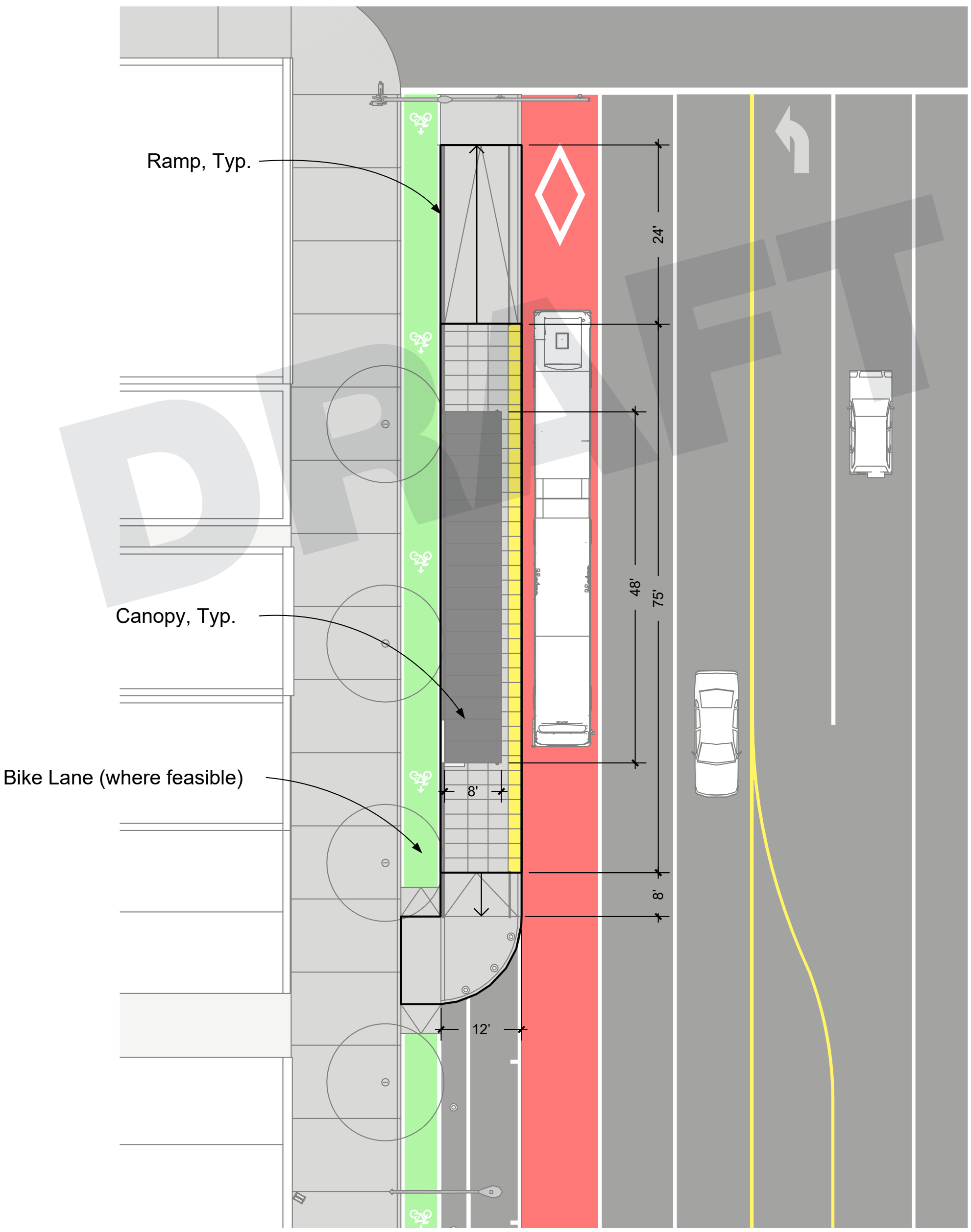
As a general guideline, the side running stations shall be integrated based on the Type S1-4 descriptions mentioned.

Approach walkways should be designed to have a slope of less than 5% slope. Main platform should be less than 2% slope.

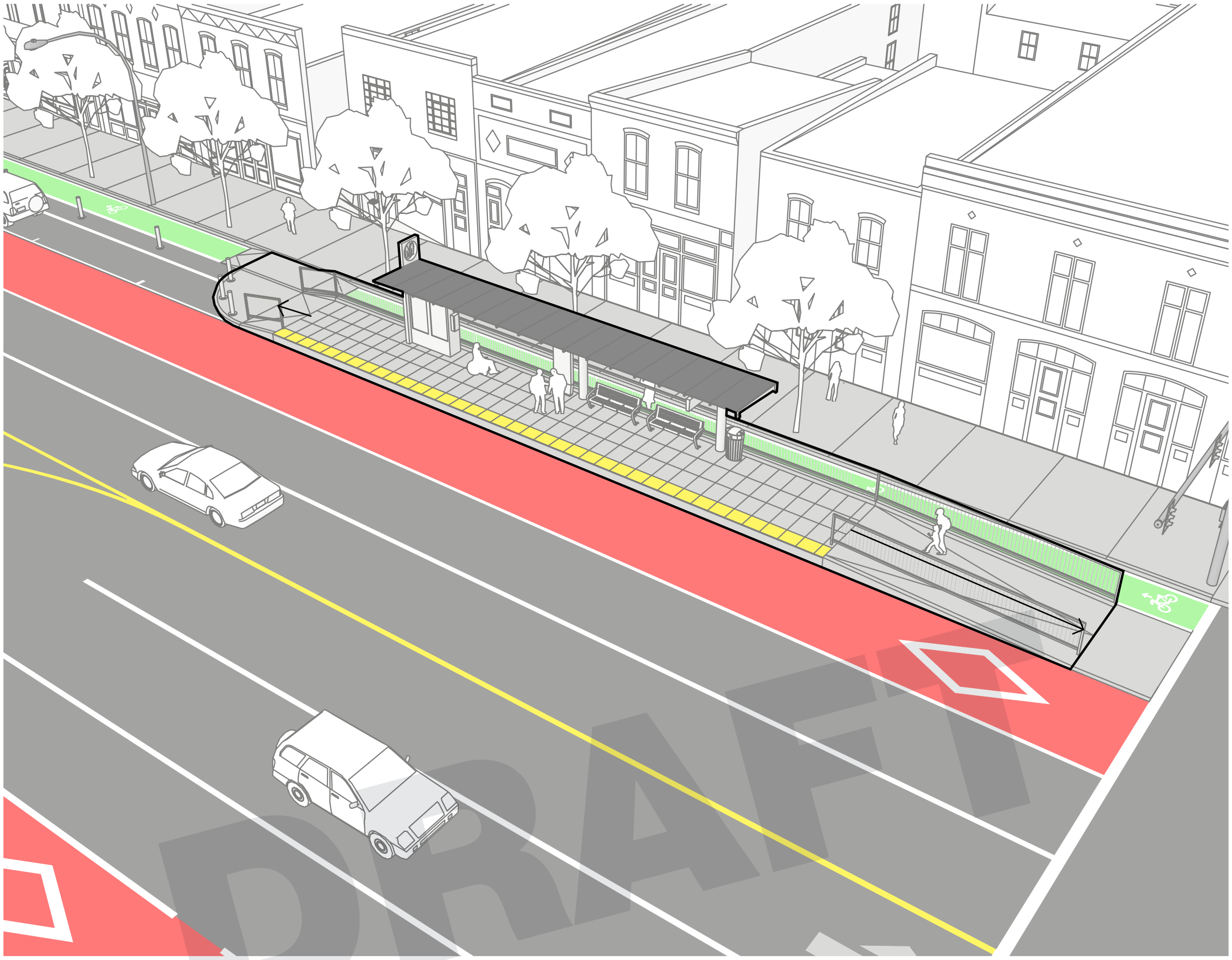
Key considerations for each station typology and variations are described in the following sections.

Type S1-Detached Bulb-Out with Bike Lane

- If present, a bike lane shall separate the sidewalk and platform
- 12ft wide X 75ft long platform for boarding and alighting
- Up to 125ft total length area when including approach walkways
- Canopy located to the back of the platform to maximize clear area from platform edge
- 150 sq.ft. coverage for canopy
- Baseline amenities as described in section 1, c at the platforms



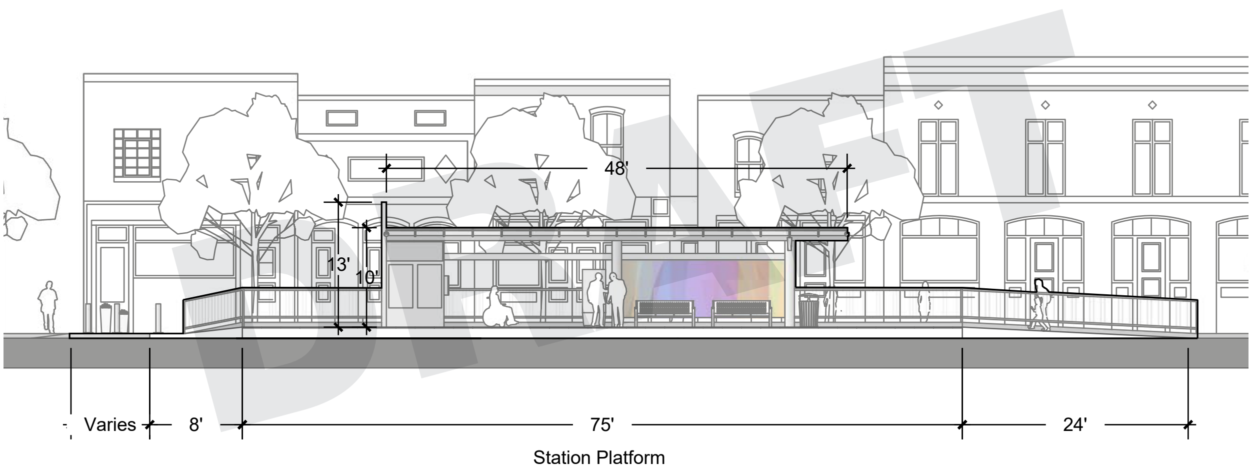
Plan of S1 / Bulbout Detached Station



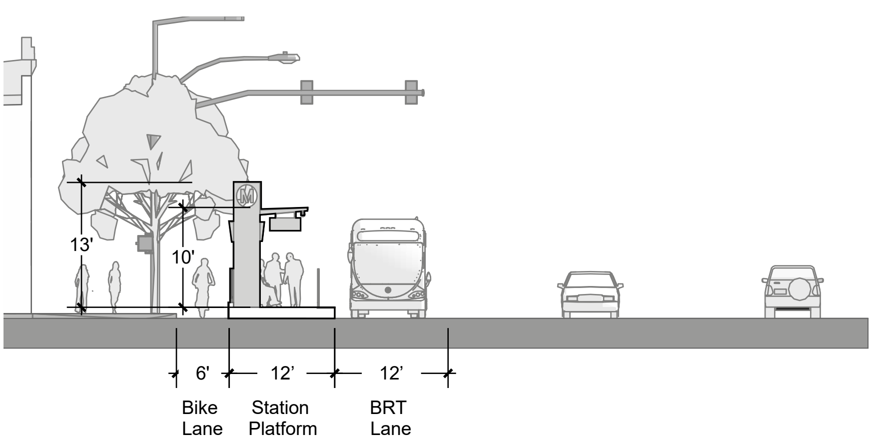
S1 / Aerial view

S1 / Ground-level view

S1 / Front Elevation - Art Panel Style 1



S1 / Front Elevation - Art Panel Style 2



S1 / Side Section

Type S2 Attached Bulb-Out

> The station projects into a roadway with existing parallel parking and is directly adjacent to the sidewalk

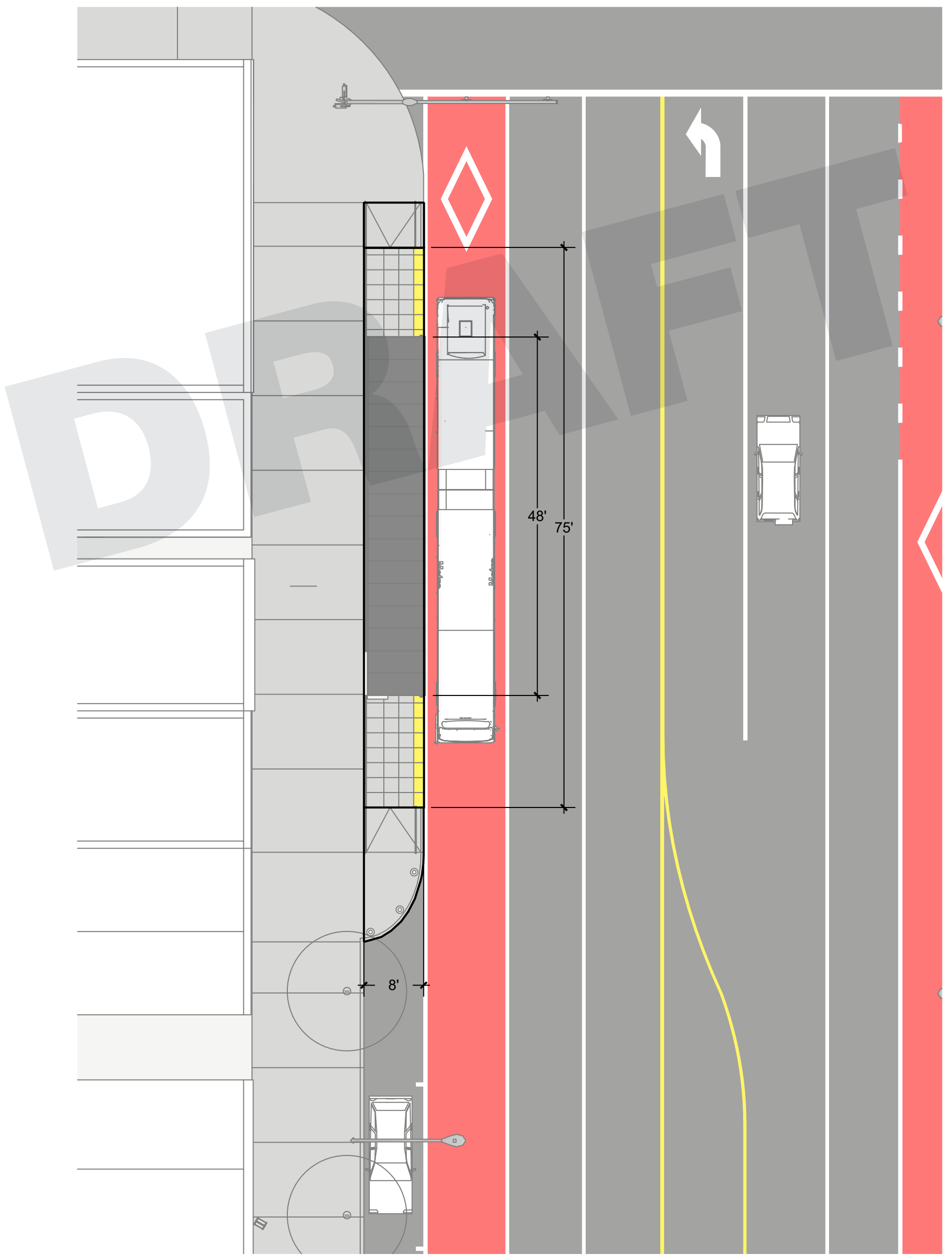
> 8ft wide X 75ft long platform for boarding and alighting

> Canopy columns placed at 8ft from the platform edge

> Up to 125ft total length when including approach walkways

> A protection railing may be needed at the back of the platform if the platform height is different than the adjacent sidewalk

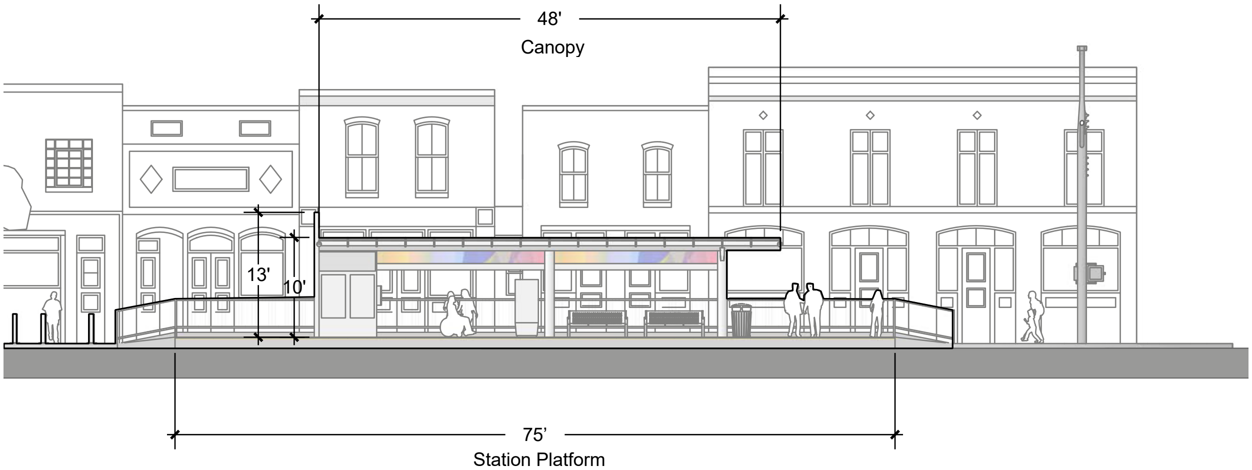
> Sloped walkways with slopes not exceeding 1:20 shall be used for the approach to the platform



Plan of S2 / Bulbout Attached Station

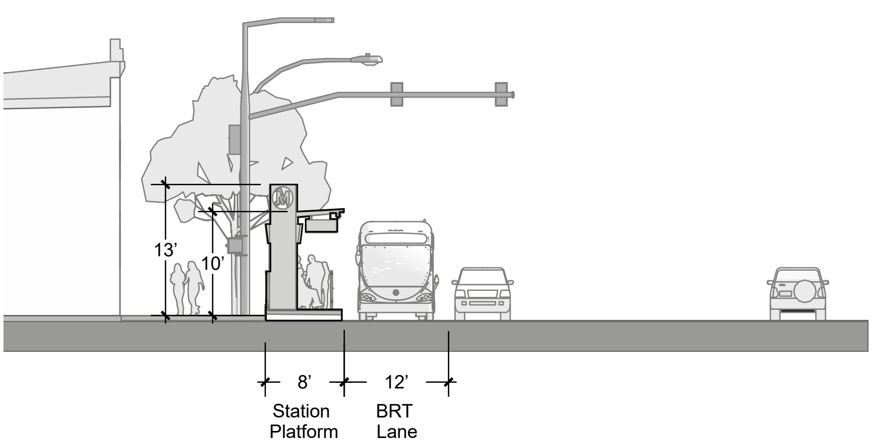
S2 / Aerial view

S2 / Ground-level view



S2 / Front Elevation - Art Panel Style 1

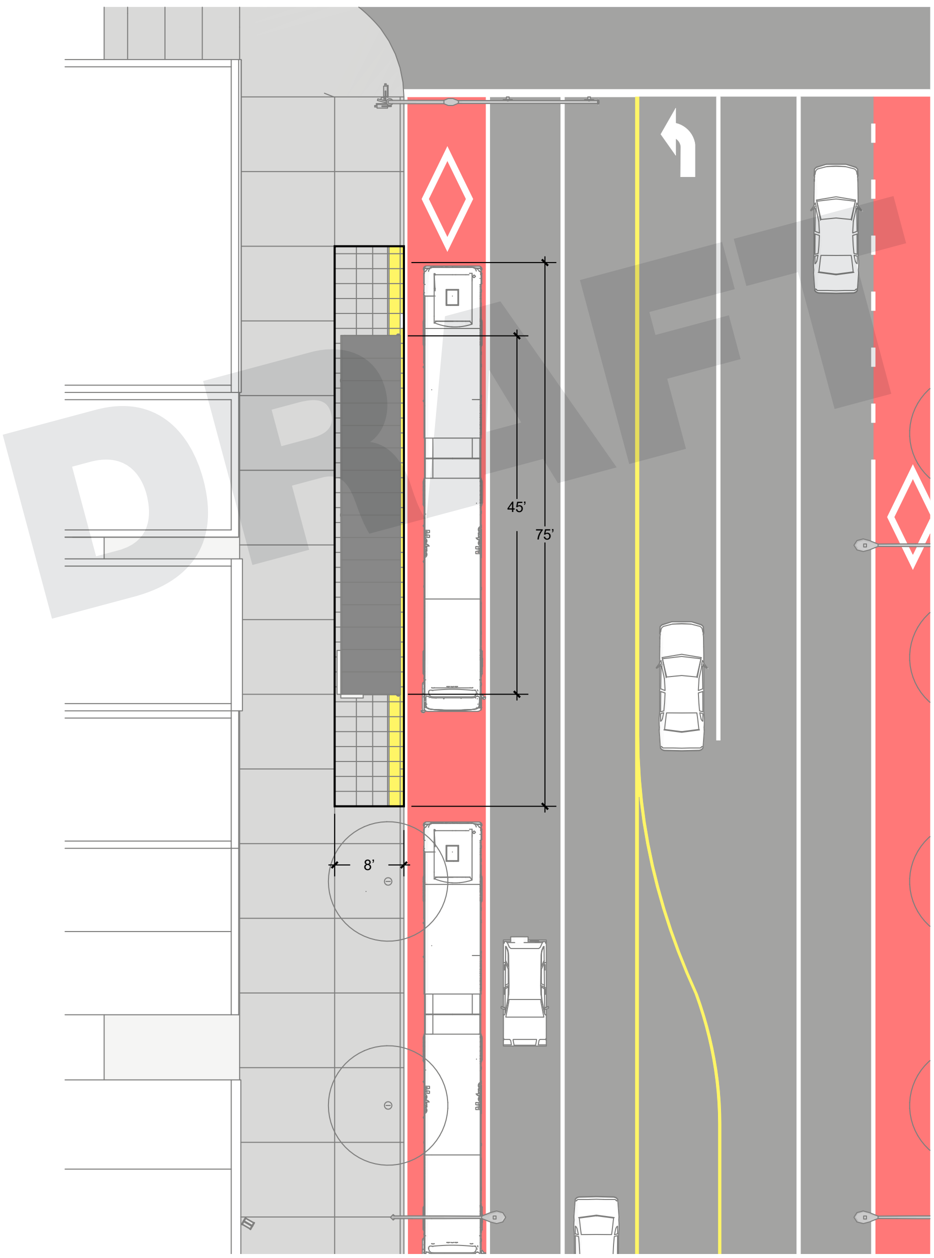
S2 / Front Elevation - Art Panel Style 2



S2 / Side Section

Type S3 Integrated within the Sidewalk

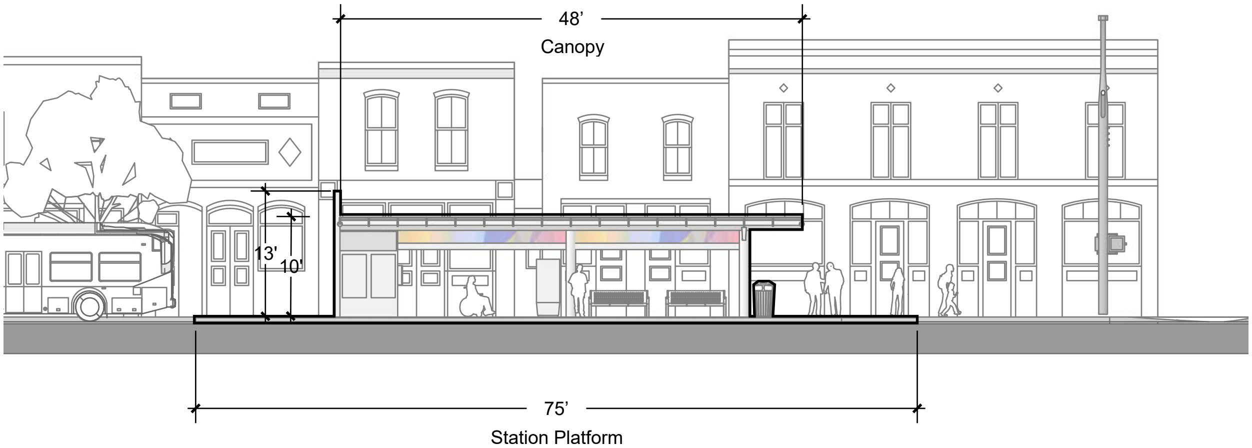
- The station is integrated into a boulevard where the available width is a minimum of 15ft or greater
- 8ft wide X 75ft long platform for boarding and alighting
- Canopy columns placed at 8ft from the platform edge
- Canopy roof cantilever will extend to within 2ft of the platform loading edge
- Station amenities placed to not encroach into pedestrian clear zones.
- Minimum of 5ft clear from the platform edge



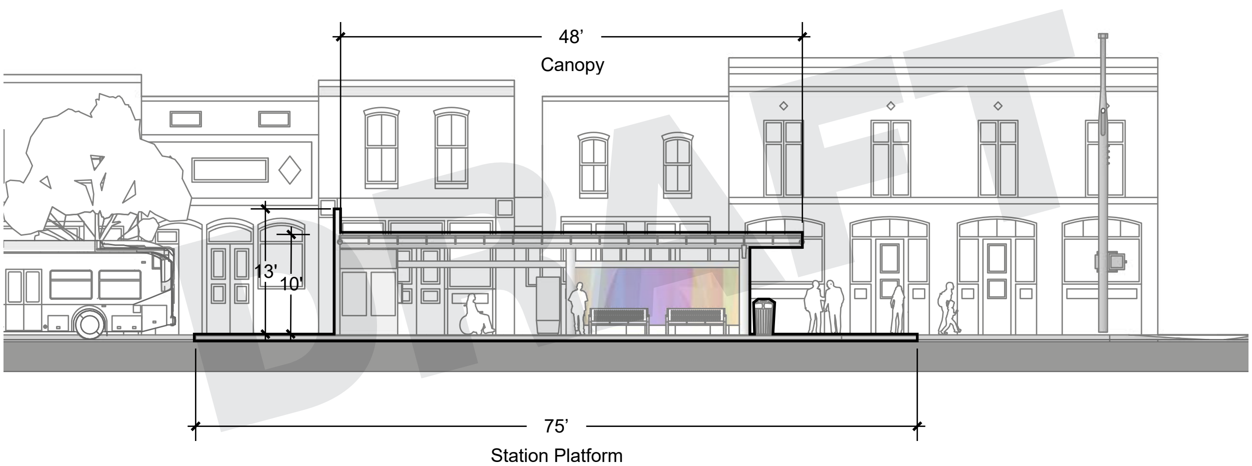
Plan of S3 / Integrated Station

S3 / Aerial view

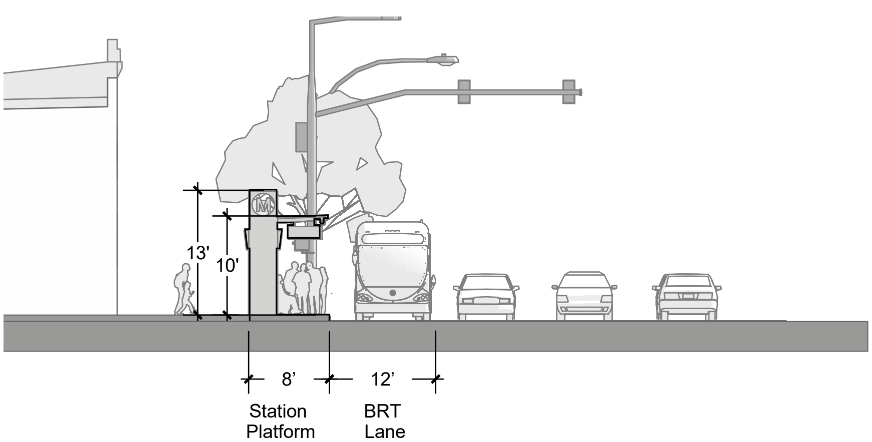
S3 / Ground-level view



S3 / Front Elevation - Art Panel Style 1



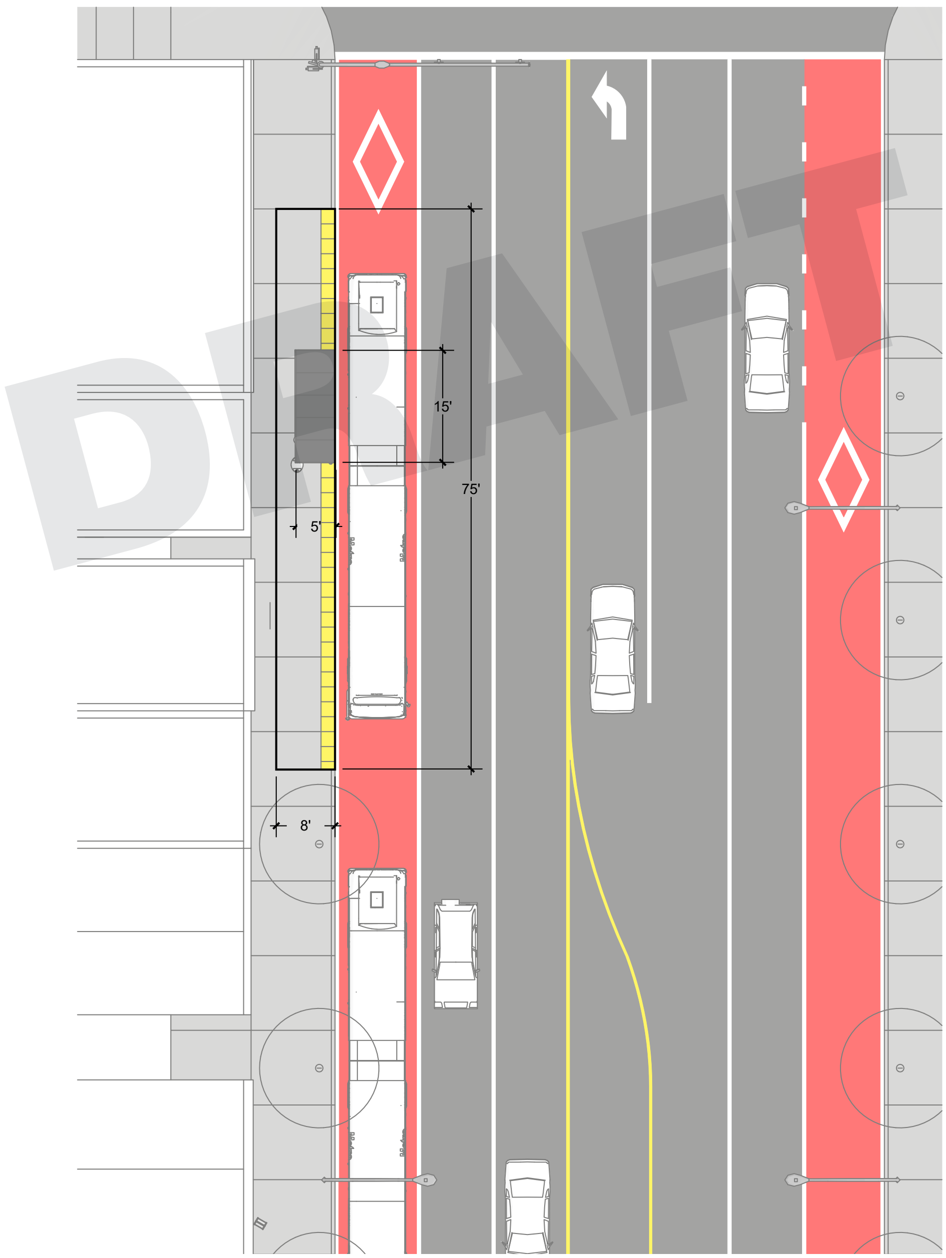
S3 / Front Elevation - Art Panel Style 2



S3 / Side Section

Type S4 Constrained

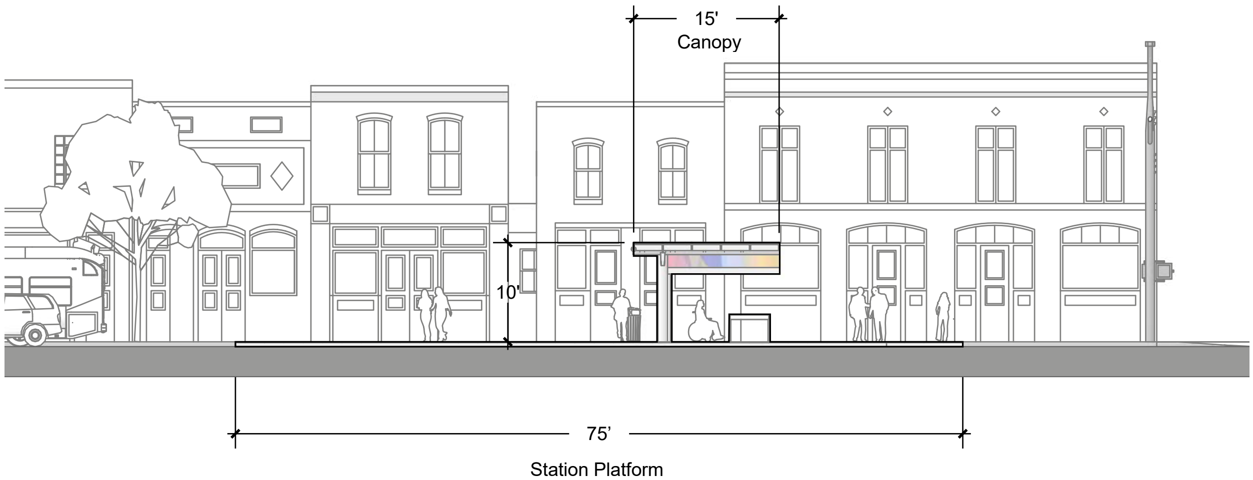
- The station is integrated into a boulevard in constrained conditions with the boulevard available width; minimum of 8ft and up to 15ft wide
- 8ft wide X 75ft long platform for boarding and alighting
- Canopy columns placed at 5ft from the platform edge
- Canopy roof cantilever will extend to within 2ft of the platform loading edge
- Station amenities placed to not encroach into pedestrian clear zones
- Minimum of 5ft clear from the platform edge
- Lean rail in lieu of seating areas
- Litter/recycling receptacle



Plan of S4 / Integrated Constrained Station

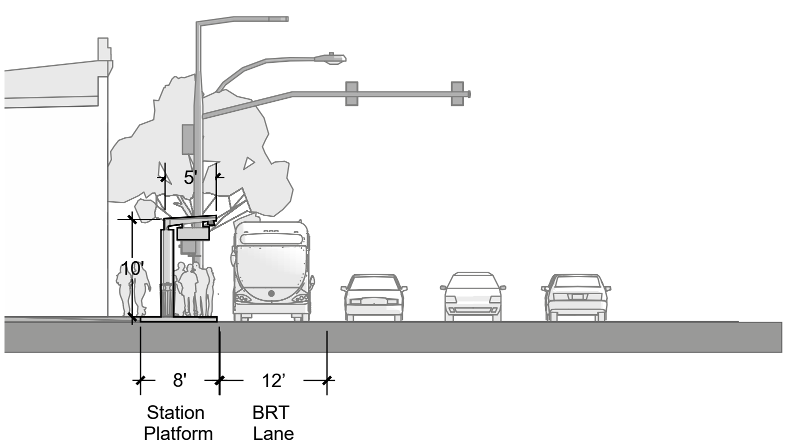
S4 / Aerial view

S4 / Ground-level view



S4 / Front Elevation - Art Panel Style 1

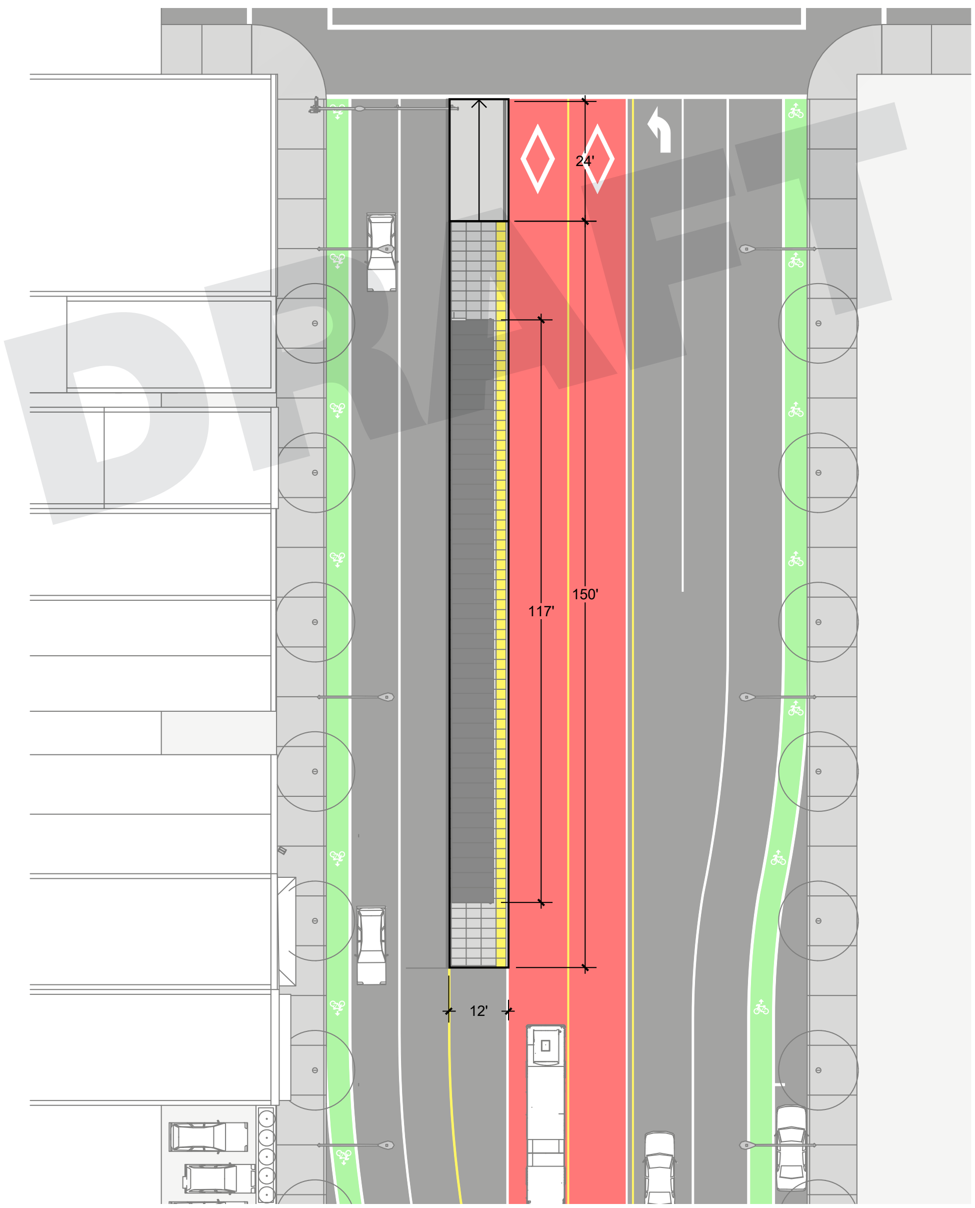
S4 / Front Elevation - Art Panel Style 2



S4 / Side Section

Type M1-Median Running Side/Side Staggered

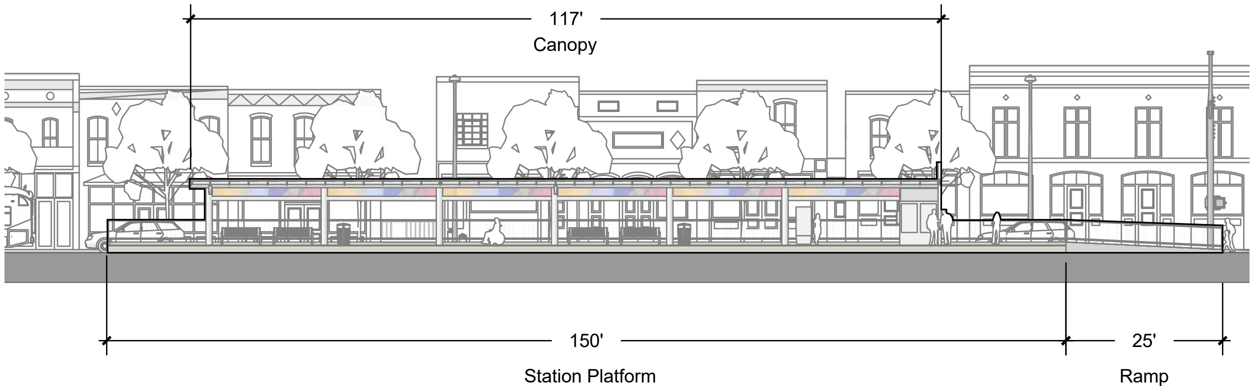
- The station is integrated into the center of a roadway when dedicated bus lanes are used and there is sufficient space within the roadway median to accommodate station
- 12ft wide X 150ft long platform for boarding and alighting is provided
- Up to 200ft total length of station when including approach walkways
- Sloped walkways not exceeding 1:20 shall be used for the approach to the platform
- Canopy columns placed at 11ft from the platform edge
- Provide a 42 inch tall continuous metal protection rail at the back edge of platform.
- A continuous overhead canopy shall be used to provide protection over 60% of the platform length
- Canopy roof cantilever will extend to within 2ft of the platform loading edge
- Station amenities placed to not encroach into pedestrian clear zones
- Minimum of 5ft clear from the platform loading edge



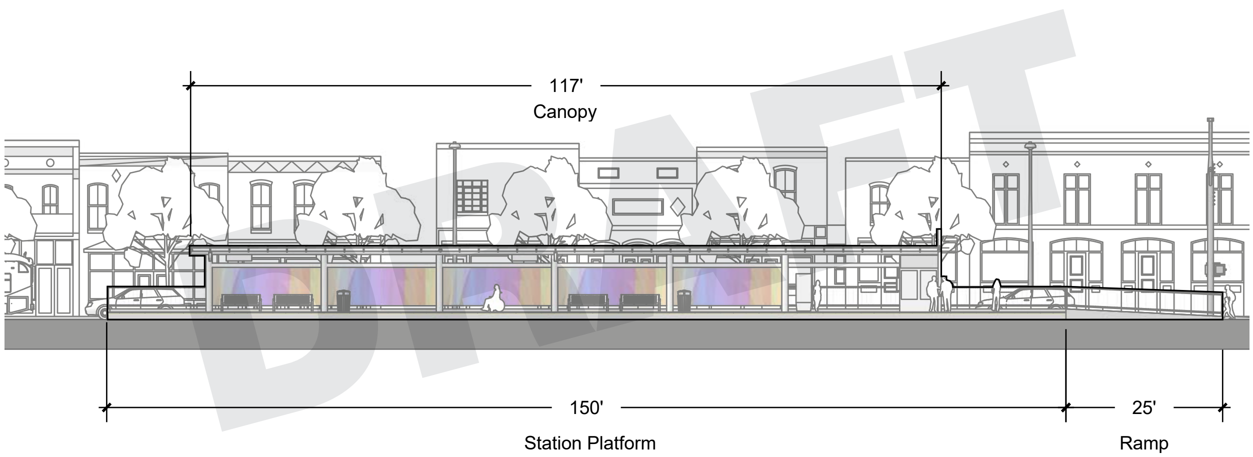
Plan of M1-Side/Side Staggered station

M1 / Aerial view

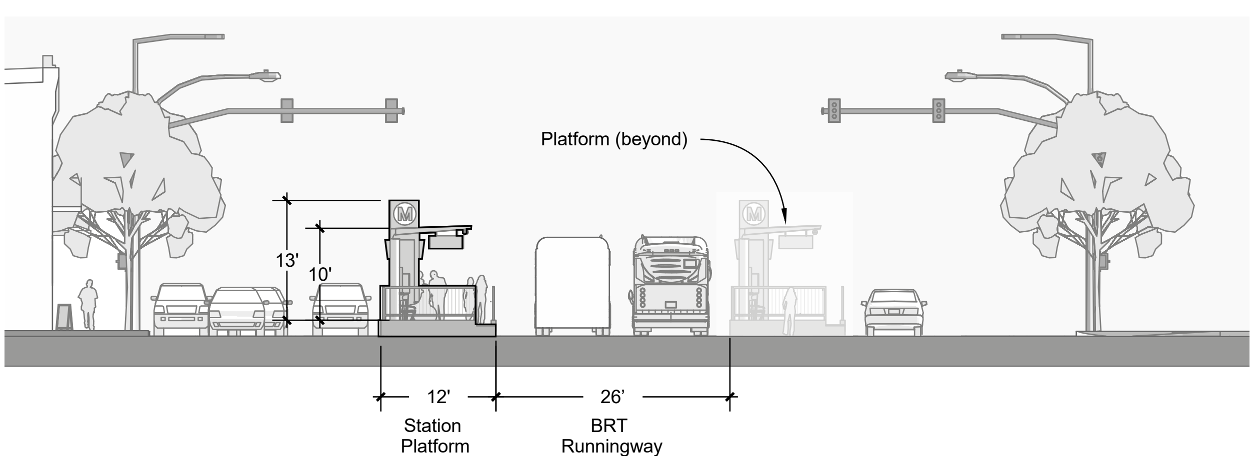
M1 / Ground-level view



M1 / Front Elevation - Art Panel Style 1



M1 / Front Elevation - Art Panel Style 2



M1 / Side Section

Type M2-Median Running Center Platform Configuration

> The station is integrated into the center of a roadway when dedicated bus lanes are used

> 16ft wide X 150ft long platform for boarding and alighting is provided

> Up to 200ft total length of station when including approach walkways

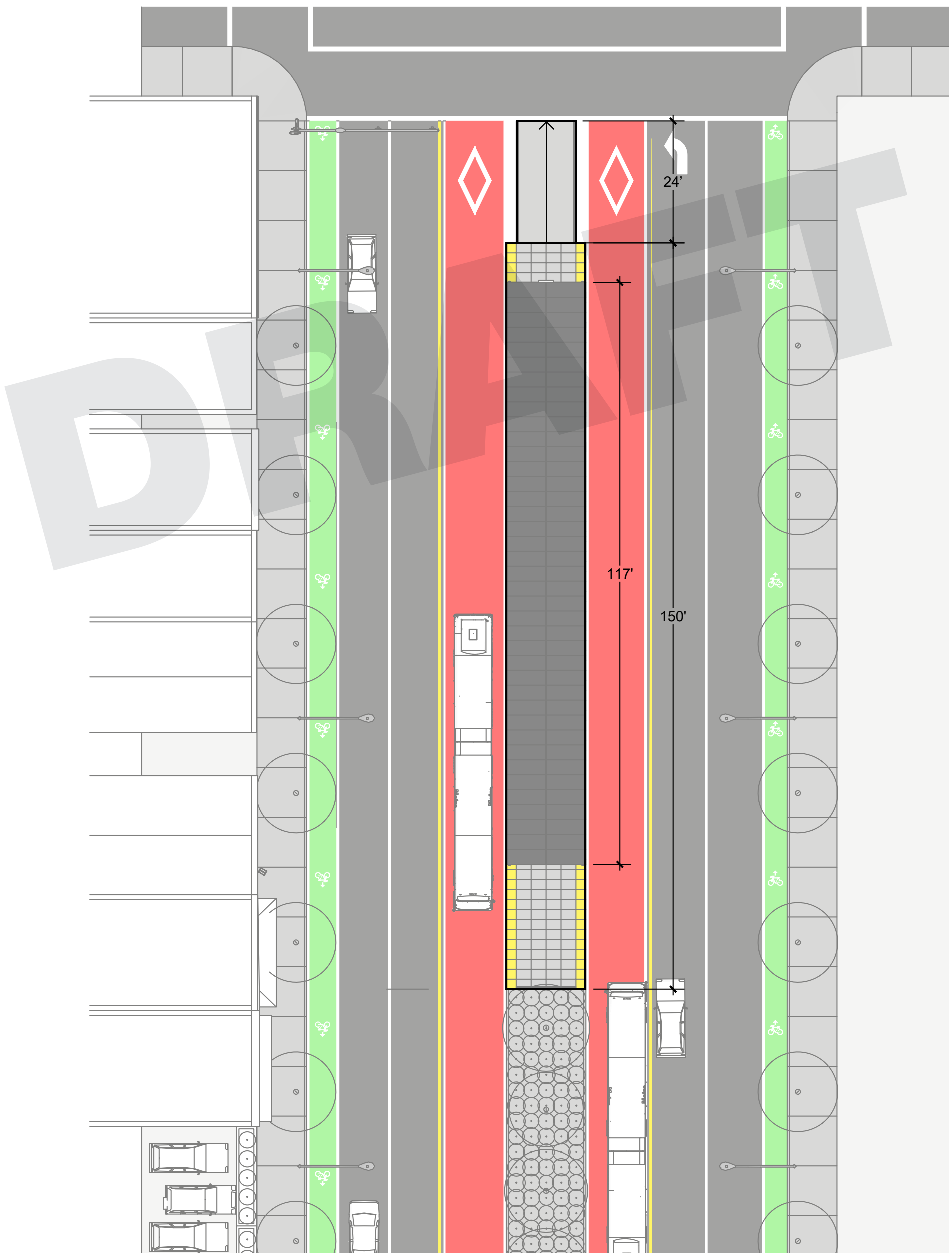
> Sloped walkways not exceeding 1:20 shall be used for the approach to the platform

> Canopy columns placed at 11ft from the platform edge

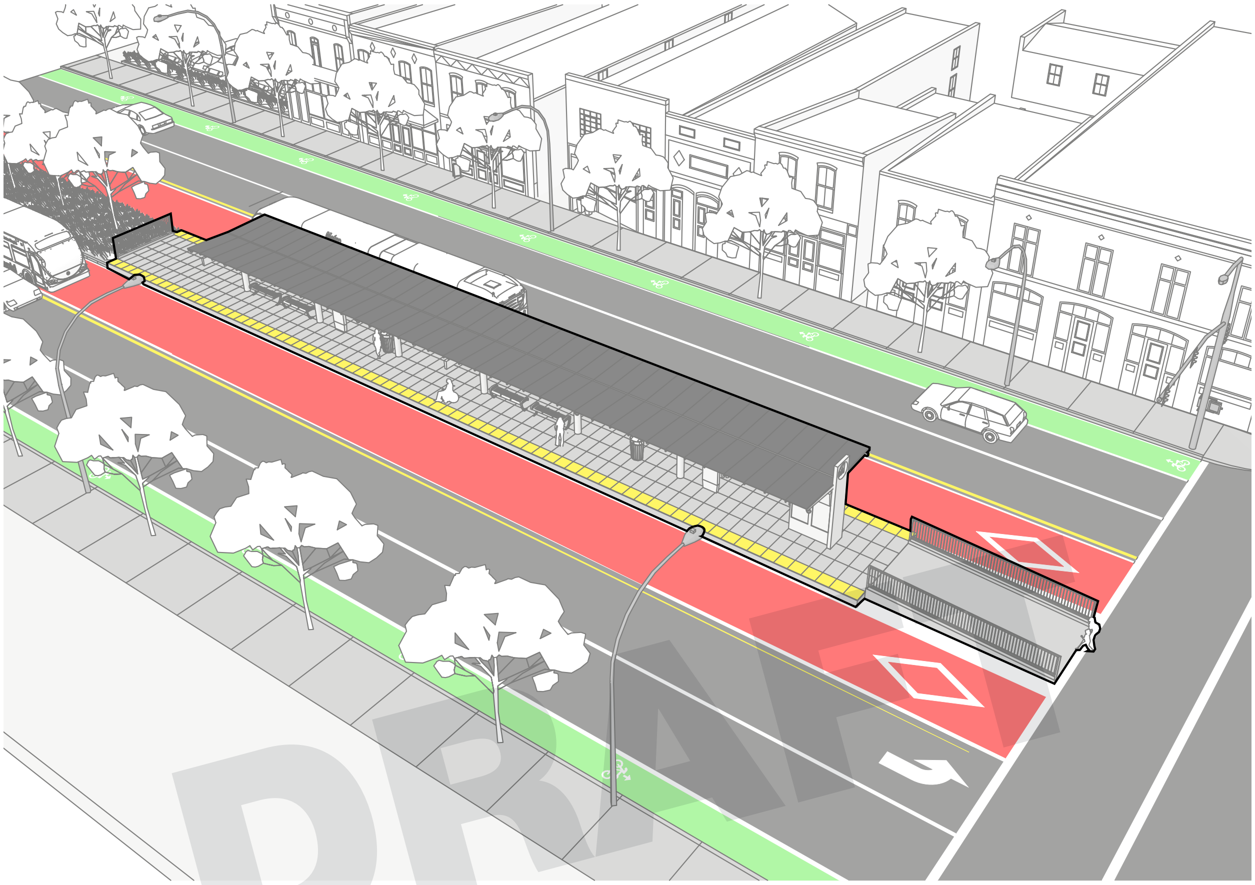
> Canopy roof cantilever will extend to within 2ft of the platform loading edge

> Station amenities placed to not encroach into pedestrian clear zones.

> Minimum of 5ft clear from the platform loading edge

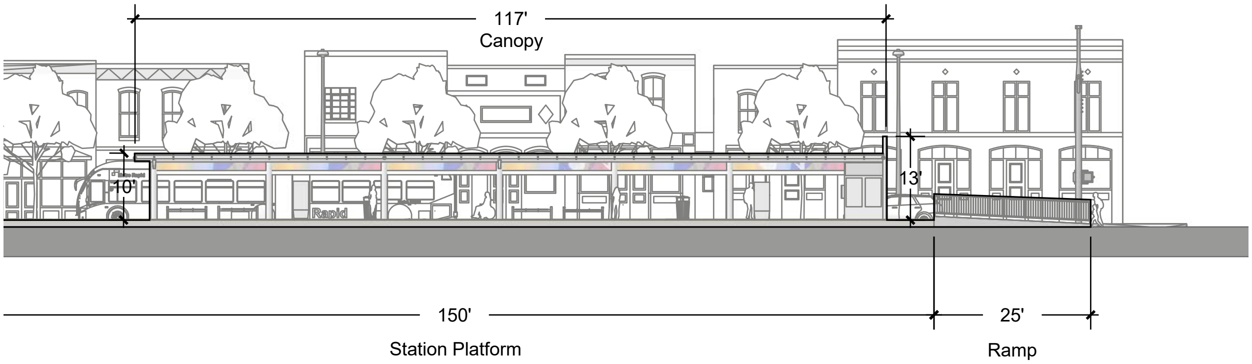


Plan of M2 / Center iIsland Station

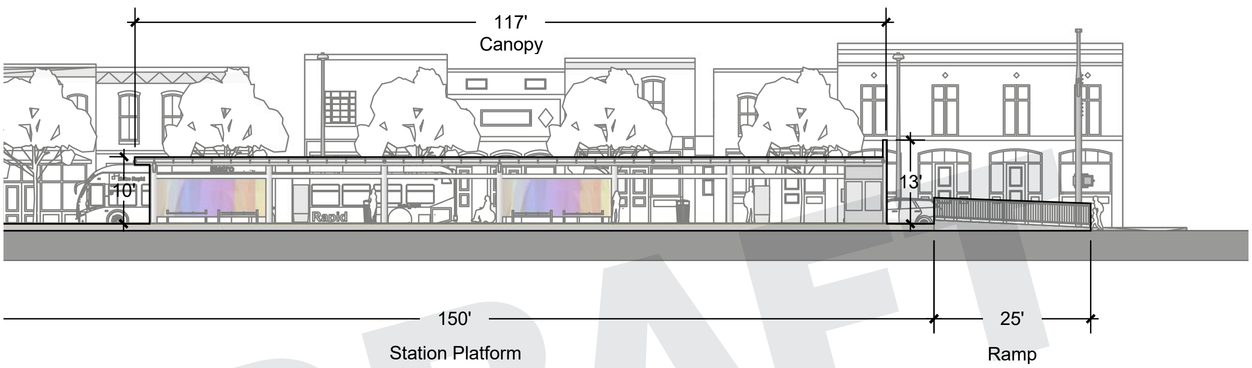


M2 / Aerial view

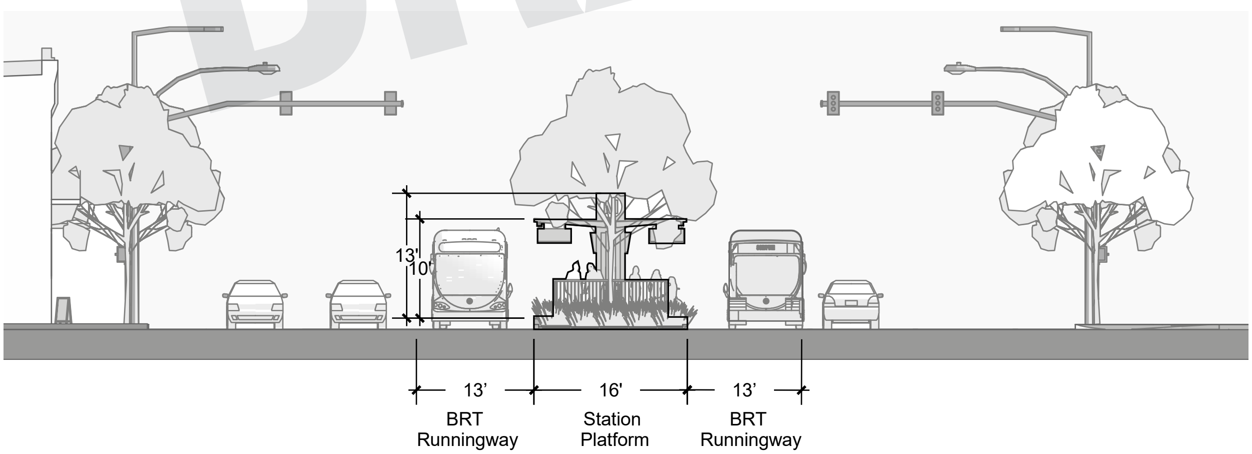
M2 / Ground-level view



M2 / Front Elevation - Art Panel Style 1



M2 / Front Elevation - Art Panel Style 2



M2 / Side Section

d. Reference Documentation

Design Criteria and Guidelines

- Metro BRT Design Criteria-Section 6 Architectural, December 09, 2014
- LA Metro Transfer Design Guidelines-Improving Connections for a Seamless Trip, March 201

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3 Materials and Finishes

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

Material finishes and the use of color are important components in the station design. They can simplify maintenance, increase the durability of station components, and reinforce the station architectural character and brand identity.

The material selection finishes and color shall be applied consistently to all the stations on an individual BRT corridor.

> Canopy Structural systems Stainless steel brushed finish.

> Glazing-Low iron, clear class with a linear ceramic fritting. Fritting shall provide 60%-80% opacity depending on the micro-climate of the region.

> Hand rails and protection guardrails shall be stainless steel.

> Station furnishings such as benches, litter receptacles and lean rails shall be stainless steel.

b. Metro Standards

Material selection and finishes shall be selected to provide for long service life. The materials must maintain their good appearance throughout the useful life and be colorfast.

c. Guidelines for Implementation

High Quality

Materials for station elements shall be selected based on performance over their life cycle. The materials shall reflect the design excellence conveyed by the architectural character of the stations.

Durable

Provide for long and economical service life by using materials with wear, strength and weathering qualities consistent with their initial and replacement cost. Materials shall be selected and used in a way that discourages vandalism, and that are difficult to deface, damage or remove.

Low Maintenance

Materials and components selected shall be resistant to vandalism. Reduce maintenance costs by using materials that, if damaged, are easily repaired or replaced with minimal interference with the operations of the BRT system.

Colors

The most important role for colors is to reinforce the system branding. Specific colors shall be selected to aid legibility in a variety of high illumination levels, with sufficient contrast to provide visual interest. The use of color at stations shall be applied consistently throughout the corridor to reinforce the identity of the BRT systems. Painted surfaces shall be avoided in the touch-zone.

Surface Treatments

Platforms and ramps shall be cast-in-place concrete. The platform area will be defined by the edge of the platform closest to the bus lane will have a 24 inch wide tactile warning edge in Federal Yellow, immediately behind the curb. Consideration shall be given to having a different color or texture at the loading locations to improve accessible wayfinding.

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d. Reference Documentation

> Metro BRT Design Criteria-Section 6-Architectural, December 09, 2014, Section 6.6 Materials

4 Canopy Design

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

An overhead canopy that provides weather protection adds to a comfortable customer environment. For the BRT system, weather protection will be provided by the use of an overhead canopy that shall shelter from the sun and rain. The overhead canopies consist of glass roof panels with a fritted pattern that provide 80% opacity. The structural framing system for the canopy shall be finished stainless steel.

Weather Protection

The area of coverage providing weather protection shall be 60% of the platform footprint. The canopy consists of stainless steel structural metal framing with tempered and laminated glazing as the roof material.

Perspective view of the shelter

b. Metro Standards

Metro is developing new guidelines related to LRT stations. BRT Stations shall be designed to provide an architectural character similar to the design of LRT Stations.

c. Guidelines for Implementation

Shelter Types

The standard configuration of shelter will include a canopy cantilevered in one direction for side running stations types S1-S4 and the median station type M1. The center island station, M2 will have a canopy that is cantilevered in both directions.

Roof area will provide approximately 60% of overhead weather protection relative to the platform area. The canopy will be arranged to provide a continuous roof area. The roof material will be fritted glass with 60%-80% opacity depending on the micro-climate of the region. Columns will be located on a center grid line and spaced at 20ft. The columns will be round in shape and approximately 12 inches in diameter. Conduit runs for lighting and other systems components will be concealed within the column and not visible to the public.

Modular Components

The canopy components, parts and systems should be standardized so that they may be applied across various station typologies. The use of a consistent palette of materials, structural framing, finishes and colors as elements of continuity will allow for the flexibility to adapt the canopy design to stations throughout the corridor while creating a consistent character of the station architecture. Standardization of components will also be a key to the maintainability of stations elements. Reduce the number of differing sizes or elements for:

- Glazing
- Metal guardrails or handrails
- Seating
- Litter receptacles
- Light fixtures

d. Reference Documentation

- Metro BRT Design Criteria-Section 6 Architectural, December 09, 2014

5 Systems Components

a. Description
b. Metro Standards
c. Guidelines for Implementation

a. Description

Safety and security equipment and passenger information systems are essential components to providing an enhanced passenger experience when using the BRT systems. Many components of these systems are located at passenger stations. This equipment shall be integrated into the design of the stations to appear as part of the station architecture.

> Reduce visual clutter

> Enhace the character of the station architecture

> Maximize free space on the platform

> Maintain clear sight-lines through the station

Consideration shall be given to locating system components on platforms and to integrating the equipment into the overall design of the canopy and marker structures. The approach shall be to integrate panels and control boxes into a designated cabinet that will form part of the canopy or marker design. Conduit runs for system components shall be integrated into the design and not be visible to the public.

Please review the stations section of Chapter 7.4 BRT ITS Systems chapter of this document for further guidance.

b. Metro Standards

Systems elements will be implemented following various relevant standards for BRT such as headway, lighting, on-time performance, etc. Please refer to the Chapter 7.4 BRT IT Systems of this document for further precision regarding relevant standards.

c. Guidelines for Implementation

Integration of Equipment within the Systems Cabinet

Systems equipment panels will be located within a systems cabinet enclosure that will form part of the canopy or marker design.

The following equipment shall be contained within an equipment enclosure:

> Platform electrical panel

> Communications panels

> Public address equipment

> Lighting control devices

> Lighting control panelboards

> CCTV control panelboard

On the exterior of the systems cabinet enclosure:

> Display frames for route maps and schedules if digital displays are not provided

> Validation equipment, if needed, mounted to the exterior surface

> Emergency call box

System control enclosures shall also be able to accommodate future equipment needs.

Traveler Information Systems

The Variable Message Signs (VMS) shall be integrated to the design of the canopy structure. The VMS shall be suspended from the canopy outriggers. They shall be double sided and placed in a location that is visible for the full extent of the platforms. Clearance from the top of the platform to the underside of the VMS shall be 9ft.

Spacing shall be as follow:

> 75ft platforms - Include one real-time sign per direction of travel.

> 150ft platform- Include two real-time signs per direction of travel. The distance between the VMS signs shall be a minimum of 80ft.

Security Devices

Security equipment that shall be included at the stations includes Closed Circuit Television (CCTV) Cameras and Emergency call boxes.

CCTV cameras shall be placed on the underside of the canopy. Two cameras shall be placed on each side of the canopy roof.

The Metro call point shall be integrated into the systems cabinet adjacent to the barrier free waiting area.

6 Lighting

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

Providing adequate illumination level at stations is essential to the attractiveness, safety and security of the BRT station. Lighting at stations should complement the canopy architectural character and surrounding station elements:

- > Provide lighting to all areas of the platform , including ramps and approaches.
- > Lighting levels shall be uniform and minimize glare.
- > Avoid light trespass which could negatively affect adjacent land uses.
- > Provide enhanced illumination levels at ticket vending machines and at the platform edge
- > Use lighting to enhance the architectural character of the shelter design including arworks.
- > A “standard” integrated approach to lighting layout within the canopy.

Also see security section in the Systems Chapter of this document for further guidance regarding lighting.

b. Metro Standards

Lighting shall be LED linear fixtures that are waterproof and vandal-resistant. Lighting fixtures shall be designed for ease of maintenance and be easily serviceable by system maintenance equipment.

MAX BRT shelter lighting and platform area lighting. Fort Collins, CO

c. Guidelines for Implementation

Integration of Canopy Lighting

> Lighting at the stations shall be integrated into the underside of the canopy roof and project down to the platform surface.

> Lighting levels at the stations shall be 5 foot candles.

Platform Lighting

> The platform area will be illuminated from the lighting that is integrated into the underside within the outrigger supports of the canopy.

> Should additional illumination be required in the station area, lower height light poles of a complementary character to the station architecture shall be located in the appropriate locations within the station area. These areas could include at the back of platform in line with canopy columns or adjacent to the platform along approaches to the station.

> The poles shall be placed at the back of platforms to not obstruct pedestrian flow.

d. Reference Documentation

> Metro BRT Design Criteria-Section 6 Architectural, December 09, 2014

7 Landscaping

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

Providing landscaping and streetscape improvements should be considered as an enhancement to the public realm along the corridor of the transitway. Special textured pavements and planting pockets shall be utilized to enhance the appearance of the corridor and to guide pedestrian movements to or around the boarding area. In parternship with city authorities, street trees can also be utilized to enhance the visual appearance in the corridor and to provide shade in the platform area.

In urban areas and areas with narrow sidewalks, landscaping options are limited due to constrained spaces. In these conditions, the station footprint shall be integrated into a sidewalk boulevard and have minimal amenities located at the platform.

The inclusion of landscaping as an enhancement to the streetscape will generally be in areas beyond the platform footprint. Consideration should be given to coordinating the platform design with streetscape improvement projects completed by others. This could include the inclusion of street trees that provide opportunities for shade adjacent to stations.

b. Metro Standards

Landscaping at stations shall be designed in conformance with local landscape ordinance or published standards of the agency having jurisdiction or with the criteria established in Metro BRT Design Criteria where the criteria exceed local or agency standards.

Perspective view of side running transitway showing streetscape

c. Guidelines for Implementation

The key objective to the integration of landscaping in the station area is to enhance the streetscape environment while maintaining compatibility with the BRT system:

> Maintain a clean busway to prevent contamination of debris ensuring positive drainage and safe bus operations.

> A cone of vision, as specified by the City of Los Angeles or local codes of jurisdiction shall be maintained so as to not obstruct the view of the bus operator.

> Low landscaping such as shrubs and ground cover shall not encroach into busways, walkways, bikeways or pedestrian circulation areas.

> Plant material shall be selected to minimize maintenance requirements.

> The landscape palette shall also be selected based on station specific microclimate and should consist of primarily drought tolerant native species.

d. Reference for Documentation

> Metro BRT Design Criteria-Section 6 Architectural 6.5 Landscaping and Irrigation, December 09, 2014

8

Wayfinding Signage and Customer Information

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

The primary function of signage at stations is to convey information regarding the BRT system, transit schedule information, and wayfinding information around station areas. Signage should also incorporate the system branding scheme to reinforce the BRT system identity. In addition to static wayfinding signage, the use of dynamic electronic signage is encouraged for such items as route maps, schedules, and arrivals information.

Wayfinding and station identification signs shall be located in the station area at frequent intervals and at visible locations to provide clear directions and information to patrons without additional assistance.

The key passenger information to be located at the stations includes:

> Marker sign with system logo and other branding elements
> Route maps and schedules
> Station identification
> Neighborhood wayfinding

Wayfinding and station identification signs can be internally illuminated as appropriate, but may also be illuminated by general area/station lighting. Reflective materials can be used for certain signs per Metro Signage Standards.

Regulatory and right-of-way signs may be necessary in addition to wayfinding information for safe bus operations.

b. Metro Standards

Graphic standards for signage and wayfinding is outlined in Metro Signage Standards. This includes the details regarding:

> Metro logo
> Signage types and sizes
> Typeface
> Color palette
> Use of pictograms

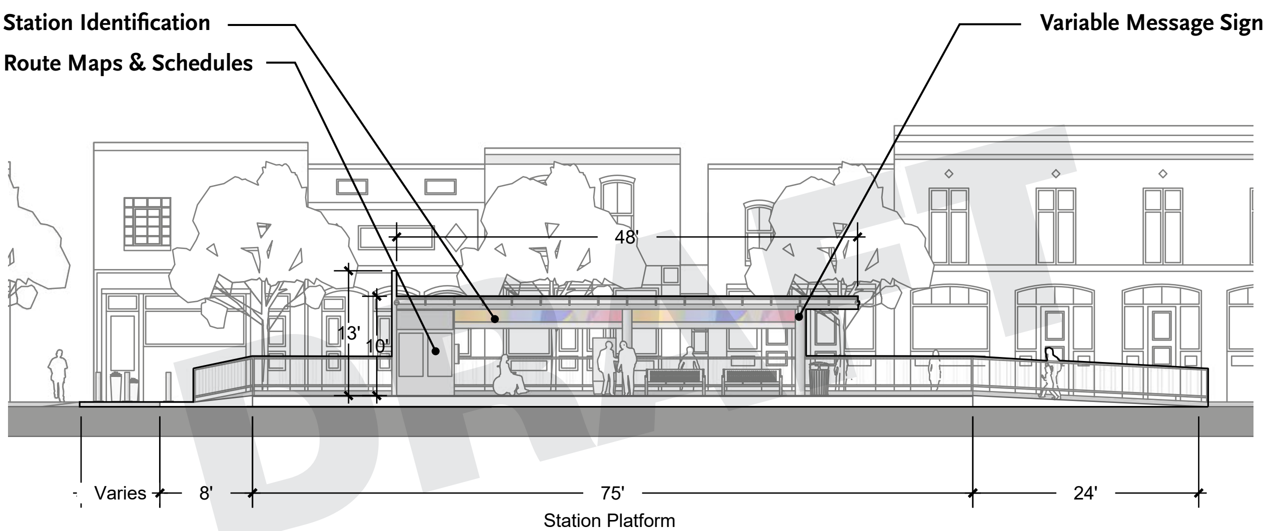
These standards will be the basis of the signage that will be integrated into the stations for future BRT systems. In addition, signs and graphics shall be consistent with ADA and AASHTO standards that include the use of braille as appropriate. Also refer to the Branding chapter of this document for further guidance on that specific matter.

c. Guidelines for Implementation

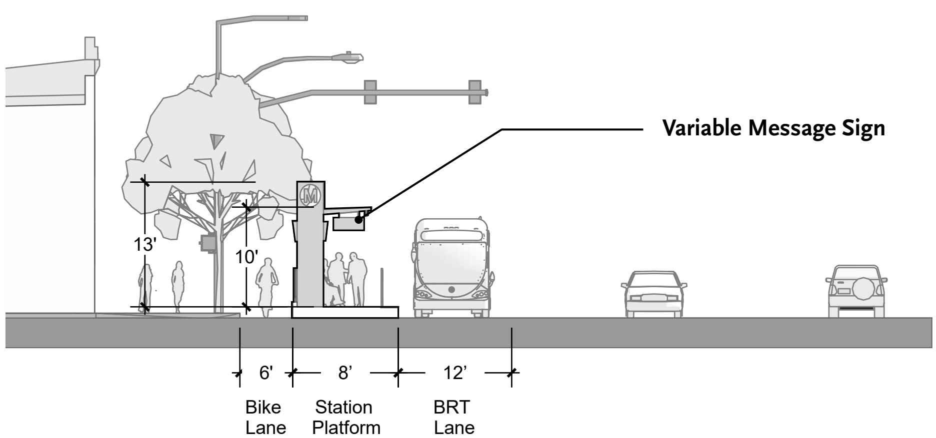
Locations of wayfinding signage and other customer information shall follow in general the exhibit below, however must be carefully considered and optimized for ergonomics, spatial composition, and sight lines – Metro Arts & Design shall review and approve all such placements as a component of an overall review of the signage and environmental graphic design program.

d. Reference Documentation

> Chapter 2.0 Graphic Standards
> Chapter 4.0 Bus Stops and Stations
> Chapter 10.0 Materials and Fabrication
> Chapter 13.0 Digital



S1 / Front Elevation, Location of signage



S1 / Side Elevation, Location of signage

9 Passenger Amenities

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

Passenger amenities are a key component and they include:

> Benches
> Litter & Recycling Receptacles
> Bike Accommodations
> Leaning Rails
> Passenger WiFi and Personal Device Charging Systems (on buses)

The amenities shall be placed at stations to not encroach into pedestrian clear zones.

b. Metro Standards

Refer to Metro design criteria and standards for items such as bench and litter receptacles.

c. Guidelines for Implementation

Enhanced

> Bike Racks
> Digital information Panel
> Landscaping

Baseline:

> Marker
> Shelter/Canopy
> Integrated LED Lighting
> Litter Receptacle
> Windscreen
> Seating
> Leaning Rails

Benches:

Seating shall be distributed to two or more locations along platform. At least one covered seating arrangement is desirable. Arrangement to optimize usage of space and not to interfere with:

> Travel way
> Queuing areas or emergency exits
> Pedestrian travel ways
> Movement for patrons with disabilities

Benches shall be provided within the canopy covered area:

> At the rear of canopy
> Adjacent to canopy columns

In areas where space is limited such as at side running constrained stations, benches can be located to leverage existing tree canopies to the extent possible to provide shade for passengers.

Litter & Recycling Receptacle:

Litter and recycling receptacles shall conform to Metro standard type and shall be bolted down to reduce vandalism. Liners shall conform with Metro standard liner sizes. Receptacles shall be provided at stations in locations that:

> Do not interfere with passenger travel ways
> Are easily accessible for patron use
> Are adjacent to canopy columns or seating areas

Bicycle Accommodations:

Bicycle accommodations on BRT systems can be a feature attracting ridership. Where space allows, bike racks shall be installed in close proximity to the platform areas. Bike racks shall not be placed on platforms where passenger boarding and alighting occurs. Special attention should be given to providing convenient and safe access to and through stations for passengers with bicycles. Bicycle parking should be provided at station areas since on-vehicle storage may be limited. Metro currently utilizes buses with exterior carrier racks. For this reason, when space is available, bicycle racks shall be provided within the area of the stops.

> Considerations for Location of Bicycle Racks:
- Located adjacent to the station but not in the fare paid area of the platform
- Direct access from bicycle lanes
- Placed not to impede access route for pedestrians
- Located in a well-lit area
- Designed with a 5 ft. of clearance from the rack to allow for easy access

Leaning Rails:

Leaning rails can be provided for the comfort of patrons. Leaning rails shall be encouraged where short headways are expected, or for stops with high volume and limited space. Leaning rails shall be stand-alone fixtures located on the platform to be in line with shelter columns.

WiFi:

Passenger convenience items such as WiFi and personal device charging systems shall be provided on buses in lieu of being provided at platforms or integrated into the canopy design.

d. Reference for Documentation

> Metro Rail Design Criteria
> Metro BRT Design Criteria-Section 6 Architectural, December 09, 2014

10 Public Art

a. Description
b. Metro Standards
c. Guidelines for Implementation
d. Reference Documentation

a. Description

The inclusion of public art is a key component of the station design that will have an impact on the image of the BRT system. As an element of variability, public art is a design feature that will define the look and feel of each station within the continuous kit-of-parts approach. Each artwork will be integrated, site-responsive and connect the transit station within the broader community context. Public art will enhance the customer experience, discourage vandalism, add to the perception of a clean and safe station environment and serve as local landmarks.

b. Metro Standards

Metro standards require integrated artwork to be high quality, site specific, require minimal maintenance and conform to Metro Art Guidelines for Materials and Finishes.

c. Guidelines for Implementation

Site-responsive artworks will be be incorporated into each BRT station. Locations will vary based on the station typologies and will be selected to maximize impact for passengers and the surrounding community. Integrated lighting will ensure artworks are visible during the day and at night.

d. Reference Documentation

> Metro BRT Design Criteria-Section 6 Architectural 6.2 Artwork, December 09, 2014

Art integrated into glazing at shelter

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11 Parking

a. Description
b. Guidelines for Implementation
c. Reference Documentation

a. Description

The goal of high-quality, reliable transit service is to provide an alternative to driving, and parking lots adjacent to transit stations are costly to build, operate, and maintain. The BRT lines currently in development by Metro will operate in built-up areas where the acquisition of land is prohibitively expensive and the cost of which is not supported by project budgets. Further, park-and-ride facilities can lead to community concerns regarding traffic and visual blight. Parking as a land use choice adjacent to transit is therefore generally discouraged.

Nevertheless, there may be cases, such as at end-of-line stations in outlying areas with minimal connecting or first-last mile services, where parking may support transit patrons.

b. Guidelines for Implementation

In general, building new dedicated transit parking should be avoided in built-up urban areas. If parking demand is identified in such areas, agencies may explore partnering with local jurisdictions, other agencies such as Caltrans, or private property owners to facilitate shared parking agreements.

In suburban areas or terminal stations, if there is a documented demand, parking should be integrated into larger mixed-use developments or strategic mobility hubs.

BRT lines that run sufficiently long distances between cities or major destinations or operate on freeways may warrant limited parking at terminal stations.

Where parking may be necessary, identify partnerships with nearby garage owners/ operators to reduce project costs and fully utilize existing infrastructure.

Price parking to ensure availability and use transit validation to reserve spaces for transit patrons.

Work with local authorities to remove parking minimums at new developments near BRT stations.

Parking minimums adjacent to BRT stations can increase the costs of housing and redirect budgets from uses that provide greater benefit to the public or that are more economically productive.

c. Reference Documentation

> Metro Parking Policies/Guidelines

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12 Outdoor Rooms/Open Space/ Transit Plazas

a. Description
b. Guidelines for Implementation
c. Reference Documentation

a. Description

Given that most transit riders begin and end their journey by walking or rolling to a station or stop, increased transit ridership can greatly enhance street life. A concept that can contribute to this is the consideration of BRT stations as “outdoor rooms,” where the station furniture can be looked upon as pieces of an expanded urban plaza that serves as a marker for community identity, hopefully producing a synergistic effect where combined Metro and city dollars are greater than the sum of their parts.

Transit plazas—especially those located at terminal/transfer stations or key activity centers—are also crucial spaces for integrating BRT projects into communities and other infrastructure.

Transit plazas can be catalytic for building community support, providing public space, and encouraging activity that makes transit adjacency inviting such as sidewalk café tables.

b. Guidelines for Implementation

Planners should seek designs that coordinate and balance the operational and safety needs of transit, collaborative projects with property owners and input and guidance from community based organizations.

Where space allows at terminal stations and major transfer locations, design transit plazas to support transit-oriented communities by creating a sense of place around transit.

On sidewalks that are either excessively narrow or excessively wide, the concept of an outdoor room can serve to integrate the bus station/ stop into the larger community fabric through thoughtful arrangement of station furniture.

Providing additional amenities can encourage local businesses to support street activation through pop-up events, sidewalk cafes, or discounts to transit riders.

Maintain clear and legible walking paths through the outdoor room to the boarding area. The concept of outdoor rooms, carried to extremes, can serve to detract from the BRT station to the detriment of its access and wayfinding objectives.

c. Reference Documentation

> Metro Systemwide Station Design Criteria
> Metro Transfers Design Guide

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3
BRT Running Ways

This chapter provides guidance for the evaluation and development of future BRT corridors, dependent on local conditions. The guidelines are meant to improve the transit experience, and to provide fast, dependable and safe movement of passengers.

1. General Guidelines
2. Running Way Placement Considerations
3. Roadway Geometrics
4. Intersection Geometrics
5. Gates
6. Pavement Sections
7. Street Signing and Striping
8. Green Streets and Landscaping
9. Traffic Operations
10. Utility Considerations
11. Betterments

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1 General Guidelines

a. Description
b. Goals and Issues Addressed
c. Standards
d. Guidelines for Implementation
e. Reference Documentation

Figure 1. BRT running way

a. Description

This chapter provides guidance on the design of running ways for Bus Rapid Transit (BRT) service. The characteristics of a BRT running way can vary considerably, from BRT vehicles operating on existing streets in mixed-flow to exclusive and grade separated structures. The design criteria presented in this chapter includes minimum requirements, which ensure a consistent baseline quality of service for a BRT route. It also includes recommendations to provide enhanced operations or better rider experience. Where practical, recommended design criteria values should be utilized. In constrained conditions, or where recommended values would result in unreasonable costs or impacts, minimum values may be used.

b. Goals and Issues Addressed

The goal of this document is to provide clear guidance on the design of BRT running ways, and ensure that BRT routes are distinguishable from regular bus service. BRT running ways should also strike a balance between achieving the highest quality service, efficient use of existing infrastructure, and lowest practical cost.

c. Metro Standards

Dedicated lanes are a key differentiating factor that allows Bus Rapid Transit to deliver a level of quality and reliability of service that is superior to standard bus service. Dedicated lanes should be implemented wherever feasible along a BRT route. If right-of-way is required or adjacent properties would be impacted, dedicated lanes may not be feasible and BRT vehicles may need to travel in mixed flow on those segments. In order to be classified as Full-BRT or BRT-Lite service, the following standards must be met:

- *BRT-Lite:* 10% of the corridor on dedicated lanes at all times, and 20% of the corridor on dedicated lanes during peak hours. If the 10% all-day standard cannot be met, then 40% of the corridor must have dedicated lanes during peak hours.
- *Full-BRT:* 50% of the corridor on dedicated lanes at all times.
- *Target:* Dedicated lanes 100% of the corridor, remove conflicting left turns and consolidate conflicting driveways.

d. Guidelines for Implementation

- The following guidelines are meant to present a menu of options for designers to consider in the unique context of each project.
- It may make sense to combine multiple running way alignment alternatives, or use modified versions of the running way elements to cater to the needs and goals of each individual project.

e. Reference Documentation

The following materials were consulted in the development of the guidelines for BRT running ways:

- Metro BRT Design Criteria (2008-2014)
- AASHTO A Policy on Geometric Design of Highways and Streets (The Green Book)
- AASHTO Guide for Geometric Design of Transit Facilities on Highways and Streets
- Manual on Uniform Traffic Control Design (MUTCD)
- Work Area Traffic Control Handbook (WATCH)
- National Association of City Transportation Officials (NACTO) Transit Street Design Guide
- "BRT: Bus Rapid Transit Service Design Guidelines" VTA Transit. Sustainability Policy 1-101, Santa Clara Valley Transportation Authority
- American Public Transportation Association (APTA) Bus Transit System Standards
- The Standard Specifications for Public Works Construction ("SSPWC")
- All applicable City Standard Plans
- Americans with Disabilities Act Accessibility Guidelines (ADAAG) Standards and Requirements

2 Running Way Placement Considerations

a. Curb Running
b. Side Running
c. Center Running
d. Grade Separations
e. Managed Lanes

A BRT running way is a travel lane dedicated for use by BRT vehicles. BRT running ways located within a roadway can be located along the curb, in the outside travel lane when on-street parking and/or bicycle lanes are located along the curb, or in the center of the street to the left of general traffic. BRT running ways can also be located on wide freeway shoulders or along a guideway that is completely separated from general traffic. These different types of running ways are described in this section, along with opportunities and challenges associated with the type of running way and guidelines for implementation.

a. Curb Running

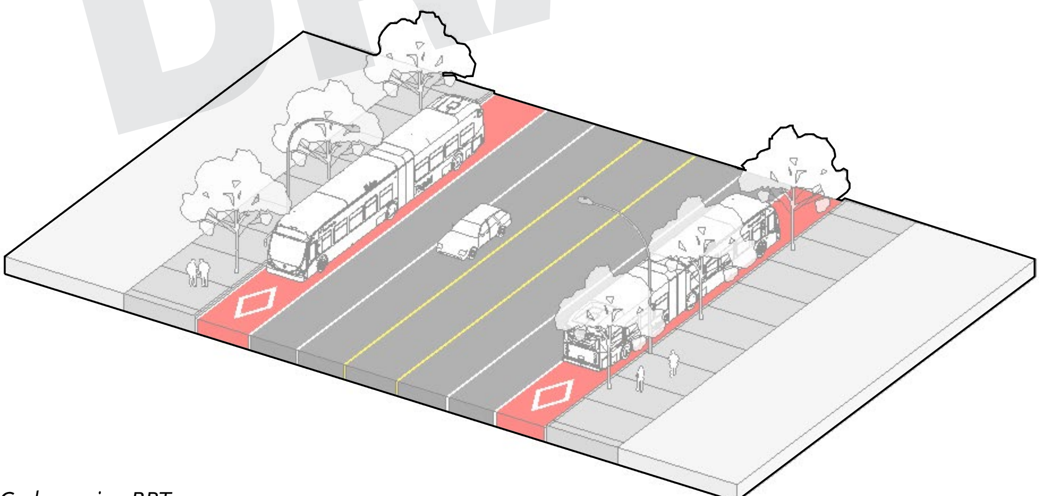

Figure 2. Curb running BRT

Description

This section discusses the curb running BRT alignment. In the curb running alignment, the bus lane is positioned on the far right, adjacent to the curb. Right turns for general traffic may be restricted, or limited to intersections only. To minimize the rerouting of right turning vehicles, non-transit vehicles may be permitted to enter the bus lane for short distances to make right turns, provided that they do not impede BRT vehicles. A curb running BRT lane can be restricted to bus traffic at all times, or during specified times of the day, depending on the frequency of transit service and underlying transit demand. Curb running bus lanes must be clearly signed and marked to communicate permitted and restricted uses.

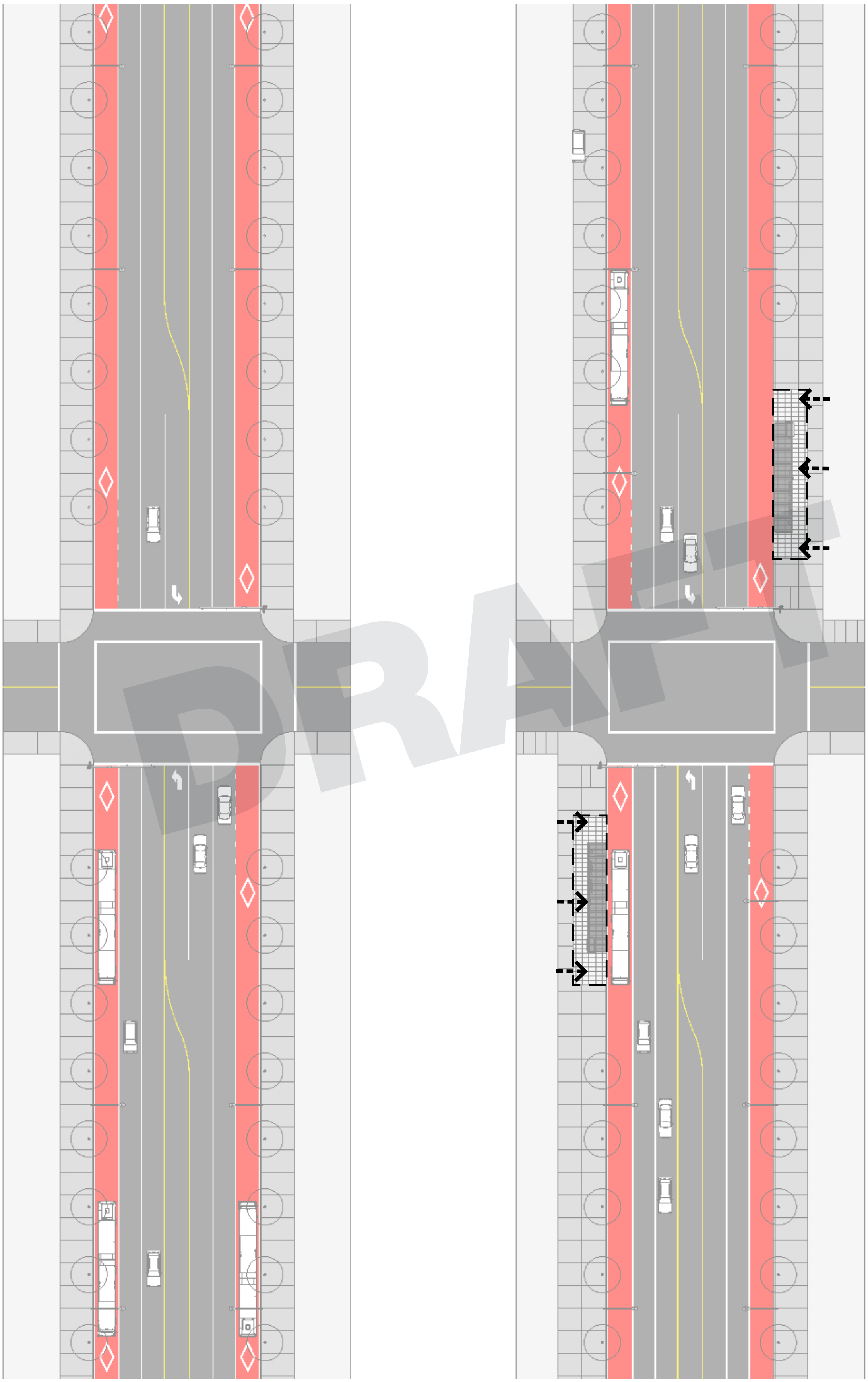

Figure 3. Curb running BRT cross section and intersection configuration with and without stations.

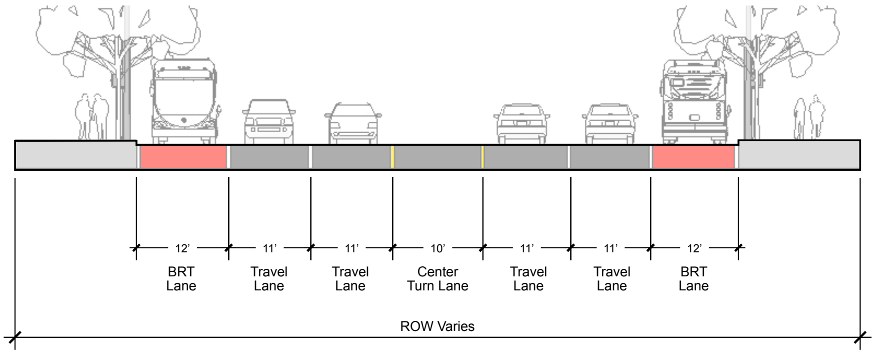

Figure 4. Typical lane widths for curb running BRT.

Guidelines for Implementation

- Curb running lanes are preferred where:
  - There is insufficient right-of-way to build median stations.
  - The bus lane may be limited to time of day use and used for parking, deliveries, bicycles or general traffic during off peak periods.
  - Diversion of left turning traffic may be prohibitively disruptive.
  - Opportunities to share the bus lane with taxis, HOVs, TNCs or bicycles are desirable.
- Curb running lanes may not be the best fit where:
  - There are a large number of private driveways along the corridor, such as where the primary land use along the street is single family residential.
  - There are high volumes of right turn movements at intersections with no right turn pocket and limited right-of-way available to install a right-turn pocket. The impact to intersection operations should be evaluated by a traffic engineer.
  - Driveways that provide access to commercial properties are in conflict with proposed station locations.
- By definition, the curb running BRT lane is against the curb, meaning there is no bike lane/parking/travel lane to the right of the BRT lane.
- The recommended minimum standard is that curb running BRT lanes are at least 12 feet wide, because they will experience less friction than narrower lanes, which will support higher travel speeds and faster travel times. Space within the roadway right-of-way must be balanced between transit, general vehicles, bicycles and pedestrians, and there may be instances where BRT may need to be less than 12 feet wide. Where BRT lanes less than 12 feet wide are proposed, design exceptions may be made for overriding considerations but every effort should be made to keep the length of these design exceptions to a minimum.

Opportunities and Challenges

Opportunities

- Where roadway widening is not required, curb running lanes involve the least amount of infrastructure modification, and cause the least disruption during construction.
- Stations can be accommodated outside of the roadway, taking up less roadway space, and can sometimes be combined with the sidewalk in constrained spaces.
- This is the typical alignment for most bus lines, so operationally it will be more familiar for drivers and pedestrians accessing stations.
- Curb running lanes can be used by NextGen and local buses, and provide an additional benefit to other bus transit services.
- There is no conflict between left turn vehicles and BRT.

> Curb running BRT does not preclude left turn movements at unsignalized locations like center or median running configurations.

Challenges

> The curb running BRT lane uses the curbside lane and is more prone to delays caused by other vehicles picking up/dropping off passengers, commercial vehicles unloading, vehicles parking or breaking down, other local bus lines, etc. The speed and safety of the BRT is sacrificed when the bus must avoid these obstacles. If high levels of activity along the curb can not be avoided, other BRT running way placements should be considered if feasible.

> Even vehicles that are not misusing the BRT lane will cross the BRT lane to enter/exit driveways, streets, and alleys, reducing the improvements to travel time for the BRT. Delays to the BRT are more significant in areas with high volumes of right turning vehicles, particularly when coupled with high volumes of pedestrian crossings.

> Enforcement may be required to ensure compliance with the BRT lane restrictions. Coordinate with local cities regarding their enforcement plans when selecting a running way configuration.

> Installation of curb running BRT in areas with on-street parking may require the removal of parking spaces. Parking lanes are not wide enough to be replaced by a BRT lane, and may require roadway widening and narrowing of sidewalks if the existing curb-to-curb width can not be reconfigured to meet capacity demands from all modes.

> Bicyclists typically travel in the outside lane. If a curb running BRT lane replaces a Class II bike lane with a shared bike and bus lane, potential changes to the bicycle network and connectivity should be considered.

b. Side Running

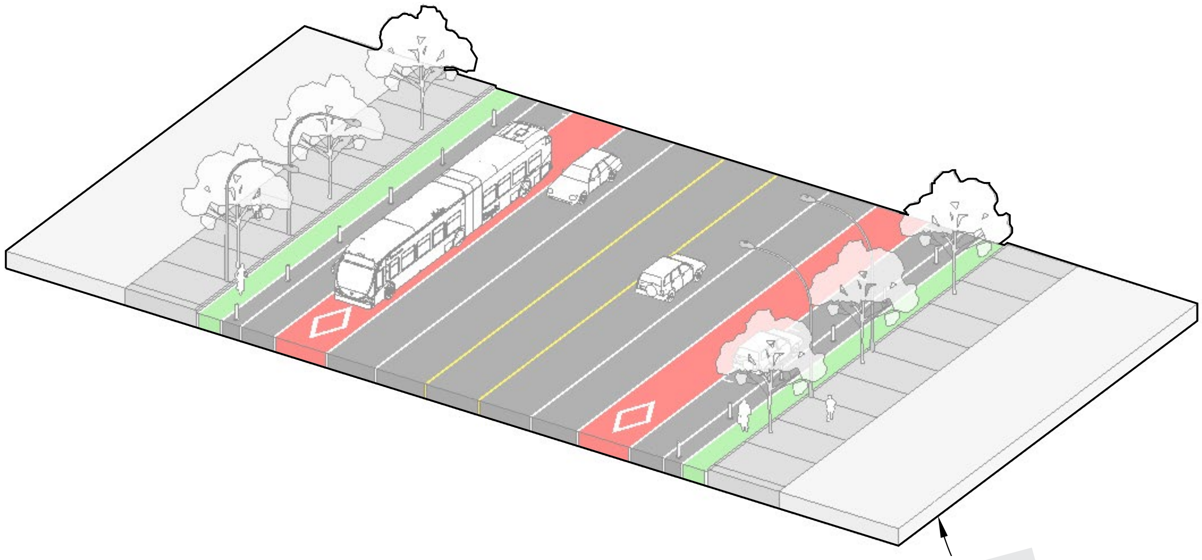

Figure 5. Side running BRT lanes with on-street parking and bike lanes.

Description

In the side running BRT alignment, the curb lane is used for on-street parking or right turns, and the bus lane is to the left of the curb lane. Unlike curb running bus lanes, side running allows on-street parking, delivery zones, and right turn lanes to remain in place. Side running configurations provide an opportunity for stations to be located on curb extensions, which is beneficial in areas where sidewalks are narrow and constrained.

Similar to curb running lanes, side running BRT provides different road users (taxis, ride share, HOV and bicycles) with better access to stations compared to median running lanes. However, general vehicle traffic will be able to regularly cross the BRT lane to access the parking and turn lanes, and the increase in weaving movements may affect transit operations. Most side running bus lane applications involve assigning an existing travel lane to bus use, which may result in impacts to traffic.

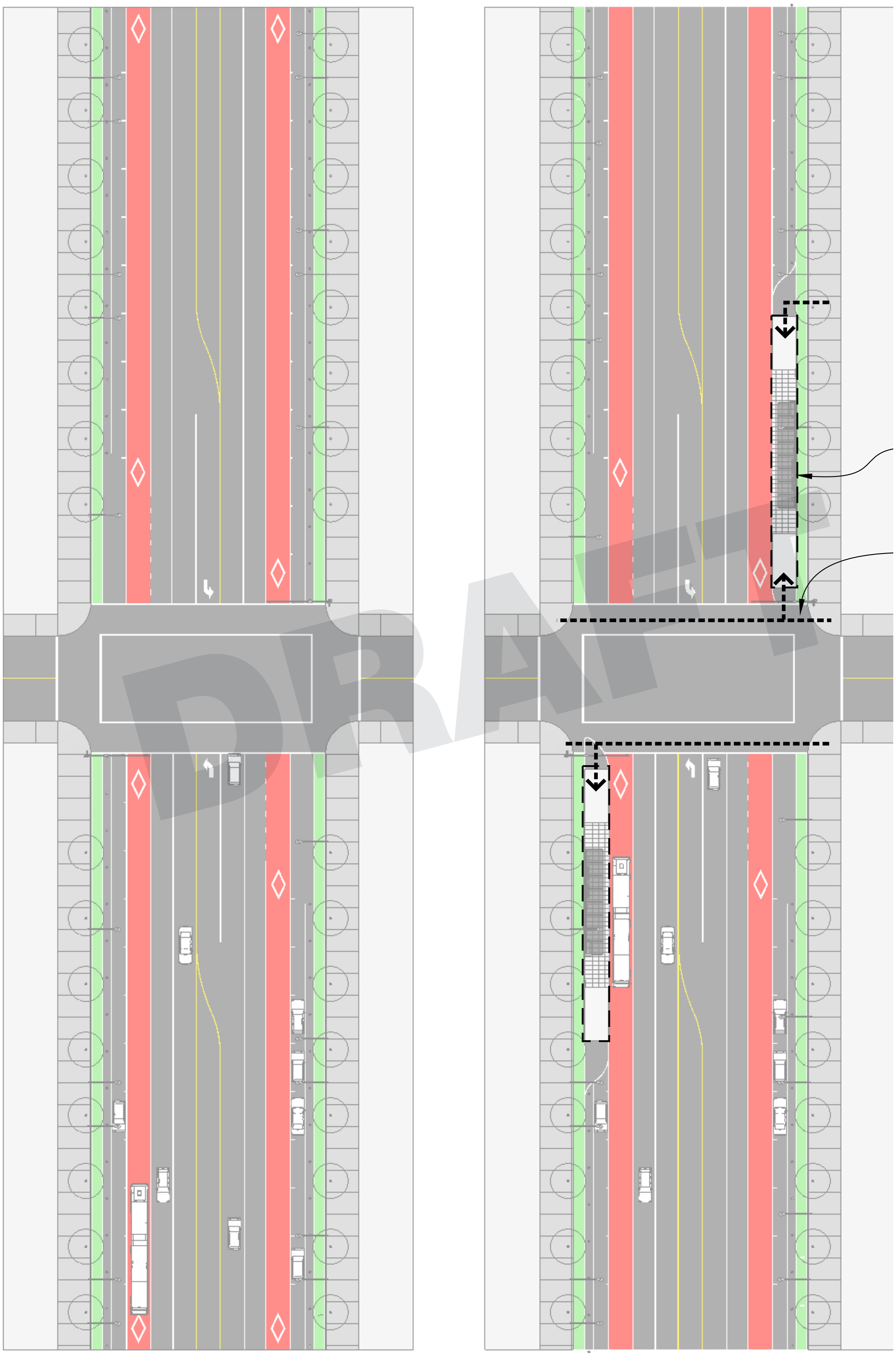

Figure 6. Side running BRT cross section and intersection configuration with and without stations.

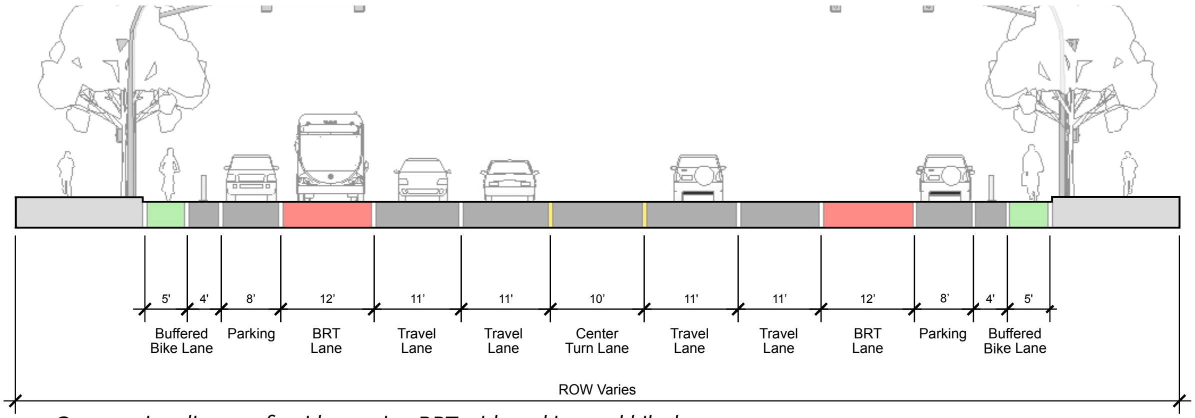

Figure 7. Cross section diagram for side running BRT with parking and bike lanes.

Guidelines for Implementation

- Side running lanes are preferred where:
  - There is insufficient right-of-way to build median stations and sidewalk space is also constrained.
  - Diversion of left turning traffic may be prohibitively disruptive.
  - There are large volumes of right turn movements.
  - Opportunities to share the bus lane with taxis, HOVs, or bicycles are desirable.
- Side running lanes may not be the best fit where:
  - There is insufficient roadway capacity to convert an existing traffic lane to BRT.
  - There are a large number of private driveways along the corridor, such as on a street where the primary land use is single family residential.
  - Driveways that provide access to commercial properties are in conflict with proposed station locations.
- Parking and or bike lanes may be between the curb and the BRT lane. The bike lane and parking lane positions in relation to one another can be switched depending on the situation.

Opportunities and Challenges

Opportunities

> If there is a bike lane and parking, this can provide width for a station with little offset through the intersection.

> Stations will be near the sidewalk, so transit riders do not have to cross the street to a center station.

> The side running BRT alignment is able to accommodate parking and/or bike lanes, if the right-of-way and roadway capacity is available.

> There is no left turn conflict with the buses.

> Side running BRT, similar to curb running BRT, does not preclude left turn movements at unsignalized locations like center or median running BRT.

> If funding is available, curb extensions can be installed to reduce crosswalk distances and enhance the pedestrian environment.

Challenges

> Vehicles will need to cross the BRT lane to turn right into driveways, parking lanes and right turn lanes.

> Pedestrian access to stations will need to be carefully planned to ensure ease of access. (See Chapter 7.2 BRT Station/Platform for further guidance.)

> Side running stations with a bike lane located between the sidewalk and the platform can be harder to maintain than other configurations. Coordinate with local cities regarding their maintenance and enforcement plans when selecting materials and running way configurations.

> If conversion of the BRT to rail is anticipated, center or median running BRT may be a better fit.

c. Center Running

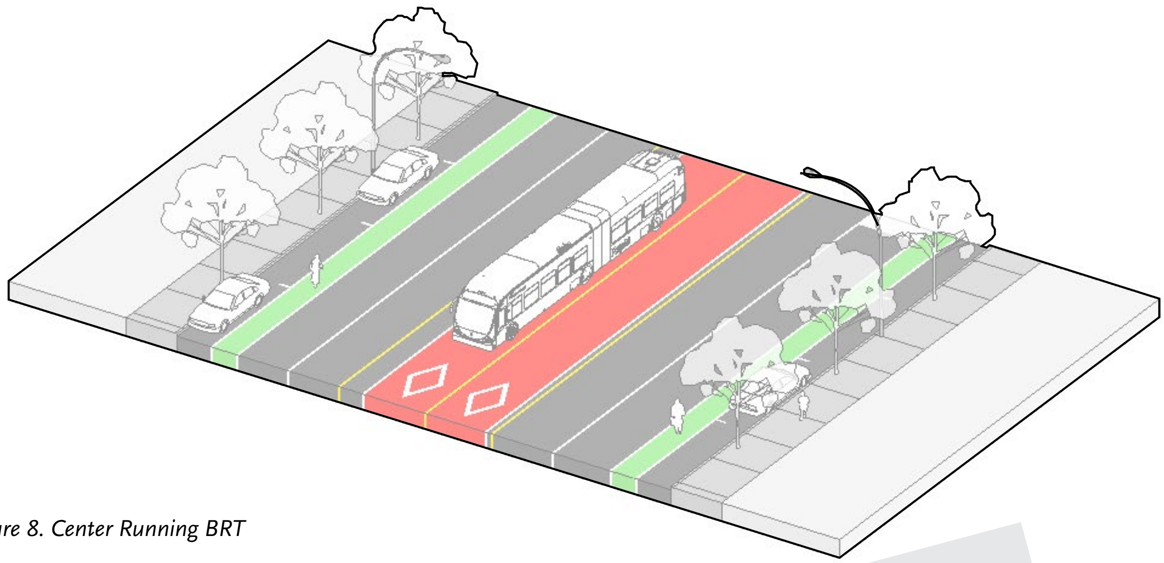

Figure 8. Center Running BRT

Description

This section discusses the center running BRT alignment. In the center running alignment, the bus lane is the left most lane in each direction. The center lane can be separated from general traffic by a physical median or lane markings. Left turn movements at unsignalized intersections would be prohibited, and a left turn lane can be provided at signalized locations. More complex signal phasing is required to facilitate transit movement for this configuration.

This configuration requires special consideration for vehicles turning left at signalized intersections. Left turn lanes could be located to the right or the left of the BRT lane, depending on conditions at each individual intersections.

If the left turn lane is on the left side of the BRT lane, left turning vehicles would need to cross the bus lane to get to the left turn lane, creating a left turn mixing zone (See Optibus BRT in Leon, Guanajuato, Mexico). Alternatively, the BRT lane could become a combined “Bus and turn lane” at the intersection (See IndyGo Red Line BRT in Indianapolis, Indiana).

Another option is to put the left turn lane on the right side of the BRT lane. This configuration avoids a mixing zone between buses and left turning vehicles. However, the left turn lanes are offset from each other (separated by the BRT lanes) which may require the left turn movements in each direction to occur in separate phases to avoid collisions between the left turning vehicles. The additional signal phases introduce delays to both general traffic and the BRT that can be poorly perceived by riders.

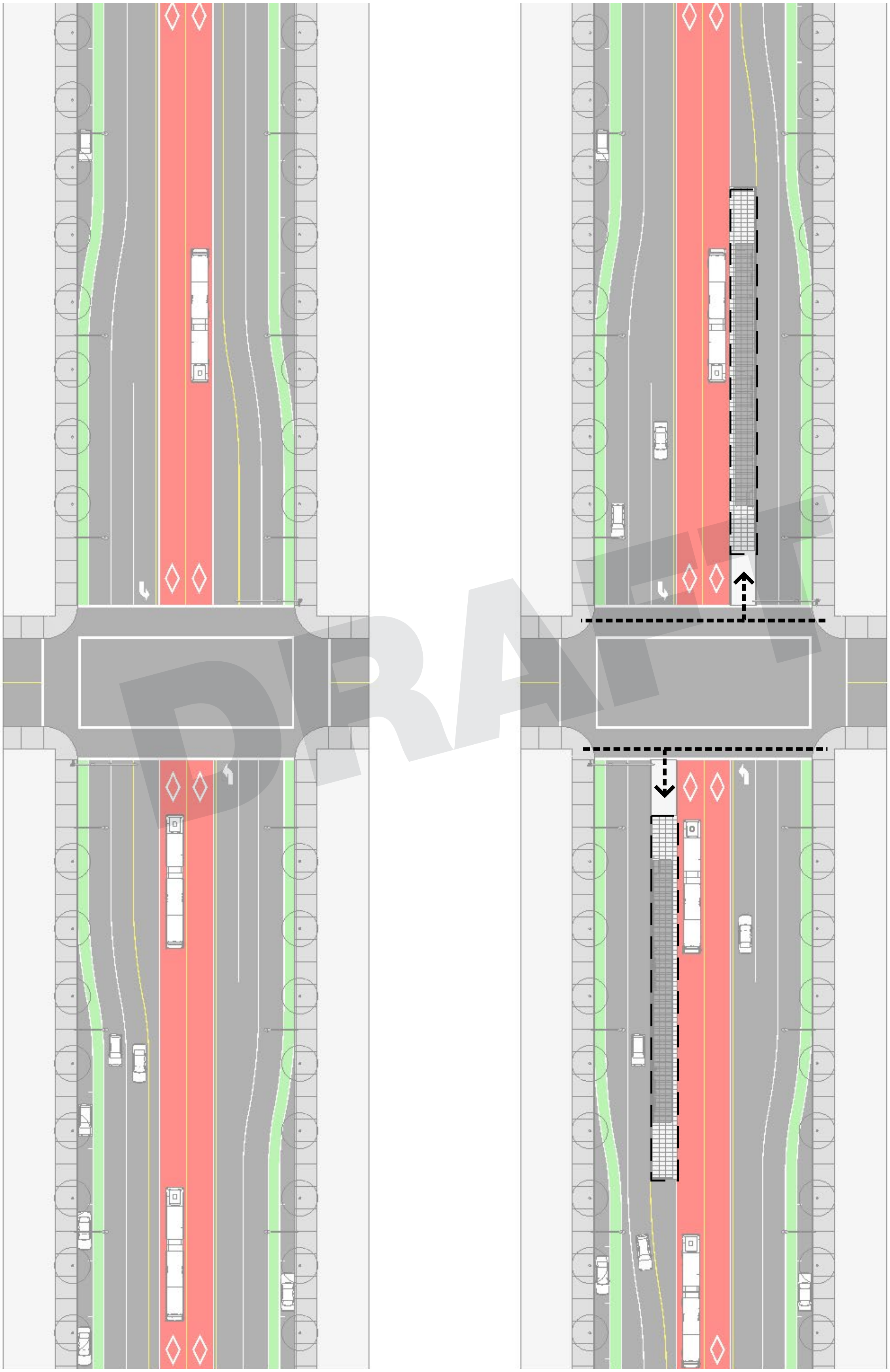

Figure 9. Center running BRT cross section and intersection configuration with and without stations.

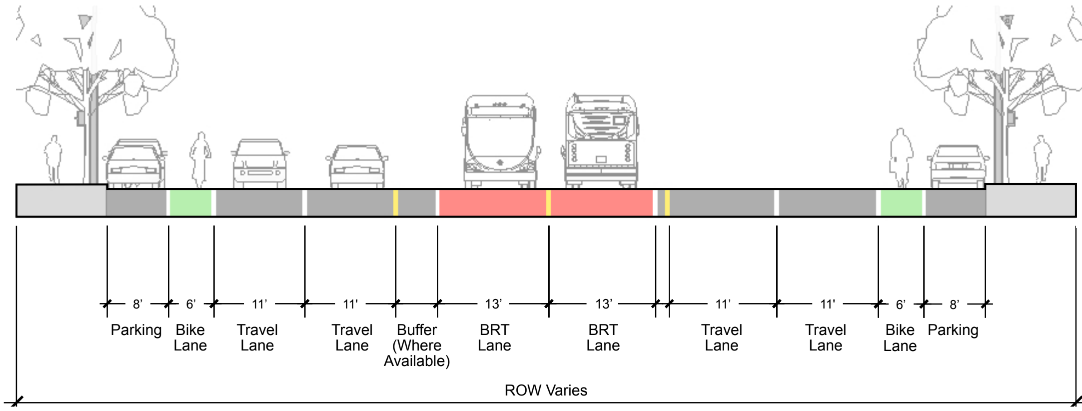

Figure 10. Cross-section of center running lane

Guidelines for Implementation

- Center running lanes are preferred where:
  - > Bus travel speed and reliability are a priority.
  - > There are a large number of private driveways along the corridor.
  - > There are commercial uses at proposed station locations with driveway access close to the intersection, which would preclude a curb or side station.
  - > There are large volumes of right turn movements.
- Center running lanes may not be the best fit where:
  - > Diversion of left turning traffic may be prohibitively disruptive.
  - > There is insufficient right of way to construct center stations.
- It will be important to restrict access to the lanes in the case where the lanes are essentially a center-running BRT guideway, by using clear striping and signage to ensure no turning vehicles mistakenly turn into the guideway.
- Center running bus lanes should be a minimum of 13 feet wide when bus lanes traveling in opposite directions are located adjacent to each other with no buffer in between.

Opportunities and Challenges

Opportunities

> The center running alternative has no conflict with right-turning vehicles at intersections or vehicles entering/exiting driveways or parking lanes.

> This alternative lends itself to conversion to rail.

> There is the possibility to activate TSP with loops in the case where the BRT lanes are essentially a center-running BRT guideway that other vehicles are not allowed to enter.

Challenges

> Center running ways are less likely to be shared by local bus services that will need to stop at intersections where no center running stations may be provided.

> At the stations, additional width will be needed.

> The left turning vehicles inherently have a conflict with the center running BRT.

> Riders have to cross part of the roadway to access center stations, unlike the convenience of having a station near the sidewalk.

> Center running ways may require more infrastructure to accommodate new medians, potential drainage modifications, protected left turn phasing, etc.

> Turning vehicles may mistakenly turn into the guideway.

> Transitions or certain procedures may be needed for buses to enter the guideway (special phasing), maybe in multiple places if one segment of the line begins operating before another.

d. Grade Separations

Description

This section discusses grade separated guideways, meaning a guideway that is tunneled or elevated. BRT vehicles on grade separated guideways do not experience delays from cross traffic or congestion.

Guidelines for Implementation

- Grade separated guideways provide optimal BRT operations and reliability. Provide the guideway as either an elevated or tunneled structure if dedicated lanes can not be accommodated within the roadway, and funding is available.
- Grade separated guideways should also be considered where collision rates are high and enhanced safety is a priority.

Opportunities and Challenges

Opportunities

> Tunneled guideways have less visual impacts.

> If the BRT route crosses an existing rail system, and the BRT route has a high potential to be converted to rail in the future, then grade separation may be worth the investment, since two rail lines cannot cross each other at grade.

> If there is not enough room on a certain segment to have the BRT lanes at-grade on the roadway, grade separation could be an alternative to right-of-way. Keep in mind however that if the BRT lanes are being elevated because there is no room for them at-grade, maintenance of traffic during construction will also be challenging due to the lack of roadway width.

> Removing at-grade crossings eliminates delay at intersections. After construction is complete, the BRT lane has little impact on general traffic.

> There is improved travel time with the full exclusivity and it is more obvious to drivers that they are not meant to enter the guideway and there are fewer opportunities to do so.

Challenges

> Grade separations can increase a BRT project's capital cost by 50% or more.

> An elevated guideway may require trees to be eliminated.

> Elevated guideways and tunnels have less access points for maintenance and supervisor vehicles.

> A disabled vehicle on a separated guideway can require BRT vehicles to travel along a detour route until the guideway lane is clear. Route deviations can result in longer travel times and unreliable service.

e. Managed Lanes

Figure 11. BRT managed lanes

Description

This section discusses BRT operation on managed lanes, which are dedicated lanes on a freeway for high-occupancy vehicles, or single-occupant vehicles who pay a toll. These lanes can be located on the shoulder, in the median, or by repurposing an existing travel lane; in LA County, they have been implemented in the median.

Guidelines for Implementation

- The managed lane should be clearly marked with signage and pavement markings. Transit-only segments (such as station entrances and exits) should be demarcated with additional signage, and colored pavement if feasible.
- By utilizing space on an existing freeway facility, a managed lane can be a low cost alternative to a new bus lane.
- The feasibility of installing a managed lane due to potential conflicts with on-ramps and offramps will need to be evaluated.
- If a freeway shoulder is used, the shoulder may need to be reinforced to accommodate regular bus traffic. Drainage, signage and lighting may need to be modified as well.
- Driver training is necessary for the use of shoulder lanes, due to potential conflicts at interchanges, with drivers stalled on the shoulder, or vehicles driving too close to the bus lane.

Opportunities and Challenges

Opportunities

> BRT managed lanes can be a low cost alternative to a new bus lane.

> Potential revenue source by allowing access to private shuttles and buses.

Challenges

> Unauthorized vehicles may enter the managed lane and/or an in-line station to avoid congestion or due to misunderstanding of the use restrictions.

> In-line stations in managed lanes may be constrained by limited right-of-way, and there may be challenges in establishing a pedestrian pathway between the station and the local street system. If in-line stations are not feasible, BRT vehicles would need to exit the freeway to access a station.

> If an inside or outside shoulder is converted to a managed lane, physical improvements such as reinforcement, drainage modification, and relocation of lighting and signage may be necessary.

> Specific regulation may be required to allow transit vehicles to run on shoulders.

> Shoulder lanes are subject to potential conflicts at freeway entrances and exits, with drivers stalled on the shoulder, or vehicles driving too close to the bus lane.

3 Roadway Geometrics

a. Mixed-flow
b. Queue Jumpers
c. Semi-exclusive Lanes
d. Exclusive Lanes
e. Exclusive Roadways
f. Transitions in Running Way Placement
g. Sidewalks
h. Pedestrian Crossings
i. Bike Facilities
j. Driveways

a. Mixed-flow

Figure 12. Mixed-flow traffic

Description

This section discusses the roadway geometric guidelines for mixed-flow BRT operation. The BRT operates as part of a standard traffic lane and allows for mixed-flow operation with motor vehicles or pedestrians, resulting in higher levels of operating conflicts and lower-speed operations. These alignments are often found in downtown areas where there is a willingness to forgo operating speeds in order to access areas with high population density and many potential riders.

Guidelines for Implementation

- Motor vehicles and bicycles operate with buses in traffic lanes on streets. Pedestrians cross this right-of-way at designated l ocations only.
- Mixed-flow lanes should be considered where congestion levels are low, and limited benefit would be achieved from a dedicated BRT lane.
- Standard placement for the mixed-flow lane shall be with the outside right traffic lane (side/ curb running). This will allow easier access to the stations on the sidewalk side as part of a standard BRT lite system. The bike lane and parking shall be placed to the right of the mixed-flow lane
- Minimum lane width for the mixed-flow lane shall be 12 feet and will contain both BRT and general traffic.

Opportunities and Challenges

Opportunities

> Requires less right-of-way and infrastructure to build, and thus has the lowest capital costs of any BRT option.

> Allows for incrementally implementing BRT and potentially investing in other elements for a BRT-Lite (TSP, etc).

> Intersection delay can be reduced when queue jumpers for TSP is used along the corridor.

> Less construction impacts than exclusive lane.

Challenges

> Mixed-flow lanes are impacted by traffic conditions and have the lowest travel time savings, level of safety, and reliability.

> Mixed-flow lanes have an increase in chances for collisions.

> Delay to buses may also result from turning, queuing, or double-parked vehicles and merging, turning, and/or loading/unloading buses may delay mixed-flow traffic.

> Mixed-flow lanes seem less permanent.

b. Queue Jumpers

Figure 13. Queue jumper

Description

Queue jumpers are used at intersections to allow the BRT to bypass queuing vehicles at intersections. Otherwise, the cumulative delay at intersections can hinder on-time performance and operating speed. Queue jumpers are typically installed at heavily congested intersections.

Guidelines for Implementation

- At intersections with relatively low right turn volumes, BRT vehicles can use an existing right turn lane along with a special signal phase to get a head start in advance of through traffic.
- To avoid getting caught behind right-turn vehicles, queue jumpers can replace a turning lane and allow only buses to move through, or as a dedicated lane between the turn lane and the parallel traffic lanes.
- Standard placement for the queue jumper shall be to the right of the outside through traffic lane. Queue jumpers are used as part of a mixed-flow operation. If there is a right turn lane, the queue jump lane will be placed between the outside through lane and the right turn lane. If there is a bike lane, the queue jump lane will be placed between the outside through lane and the bike lane.
- For a mixed-flow lane at the median, place the queue jumper to the left. If there is a left turn lane, the queue jump lane will be placed between the left turn lane and the inside through lane.
- The queue jumper will be designed to provide a transition between the mixed-flow lanes to the actual queue jumper.
- Minimum lane width for the queue jumper will be 12 feet and will contain only BRT and bus traffic.
- The queue jumper length shall be a minimum of 60 feet, the length of an articulated bus. The queue jumper shall extend up to the length of a right or left turn lane if it is adjacent.
- The signal timing will allow the BRT to enter the standard traffic lanes from the queue jumpers. (Refer to Section 9 Traffic Operations below and to Chapter 7.4 BRT ITS Systems for further guidance.)

Opportunities and Challenges

Opportunities

> Can reduce intersection delay for the BRT vehicles and shorten route travel time.

> Provides running way improvements at specific intersections in segments where the BRT operates in mixed-flow.

Challenges

> Potential right of way restrictions at intersection to place the queue jumper.

> Limited right-of-way may be available at locations where an existing right turn lane is not present.

> If a queue jump lane will displace a turn lane, there may be impacts to traffic operations.

c. Semi-exclusive Lanes

Description

Semi-exclusive lanes provide a dedicated travel lane for BRT vehicles that is subject to signal control at crossings. If a semi-exclusive lane is located within an existing roadway or runs parallel to an arterial, crossings occur at intersections from both perpendicular traffic and parallel traffic crossing the BRT lane to either make a right or left turn. If conflicts are able to be eliminated entirely, the guideway would be considered "exclusive" rather than "semi-exclusive."

Semi-exclusive BRT lanes located on an arterial can be located along the curb (curb running), in the outside travel lane if on-street parking and/or bicycle lanes are located along the curb (side running), or to the left of general traffic (center running). Semi-exclusive lanes can also be physically separated from general traffic by raised curb or located on a bus-only guideway.

Operating speeds in semi-exclusive lanes located on an arterial or highway are governed by speed limits for general vehicle traffic. For semi-exclusive lanes that are physically separated from general vehicles where the right-of-way is fenced and automatic gates have been installed at crossings, operating speeds are maximized. If the right-of-way is fenced but gates are not present, higher speeds can be maintained for shorter distances on segments between crossings.

Guidelines for Implementation

- Semi-exclusive lanes can be located within a street, or on a guideway that is physically separated from general traffic. For side or curb running placement, the right turn, bike, and parking lanes will be placed to the right of the BRT lane.
- For center or median running placement, the left turn lane can be placed to the left or the right of the BRT lane.
- Traffic may be allowed in the semi-exclusive lane for right and left turn crossings, where sufficient distance will be provided for crossing distance (Refer to Intersection Geometrics - Left/Right Turns). Traffic may also be allowed to cross the semi- exclusive lane to access driveways and/or on-street parking spaces for side and curb running placement. General vehicles are not permitted to travel in the BRT lane for through movements or to bypass congestion.
- Minimum lane width for a curb or side running semi-exclusive lane shall be 12 feet and the minimum lane width for center running BRT lanes shall be 13 feet.
- The semi-exclusive lane may be separated from parallel traffic between intersections by fencing, barrier (non-mountable) curbs, mountable curbs, striping, and/or lane designation.

Opportunities and Challenges

Opportunities

> Semi-exclusive lanes can improve BRT travel times, particularly in congested areas, making transit more competitive with the automobile.

> BRT in semi-exclusive lanes will operate faster and more reliably than in mixed-flow.

> Semi-exclusive BRT lanes that utilize existing infrastructure are more cost-efficient than new construction of exclusive lanes.

Challenges

> In order to redistribute arterial right-of-way more equitably between bicycles, transit and private vehicles, traffic lanes and/or on-street parking lanes may be converted to dedicated BRT lanes. This will result in less roadway capacity for general traffic or parking spaces.

> Traffic that crosses the semi-exclusive BRT lane to make right and left turn movements will introduce opportunities for conflict.

d. Exclusive Lanes

Description

Exclusive lanes provide a path of travel for BRT vehicles that is free of conflicts between buses and general vehicle traffic, and therefore also free of delay associated with signal control. Unlike semi-exclusive lanes, exclusive lanes do not have traffic from parallel adjacent streets crossing the bus lanes to make left or right turns.

Operating speeds in exclusive lanes are limited by the physical design of the roadway, such as horizontal curvature, vertical curvature, superelevation and sight distance.

Guidelines for Implementation

- Exclusive lanes are limited to BRT vehicles only. Generally traffic is not permitted to enter or cross exclusive lanes for any reason.
- Minimum lane width for an exclusive lane that is not directly adjacent to another exclusive lane shall be 12 feet.
- If two exclusive lanes are separated by lane markings only, the minimum width of each lane shall be 13 feet.
- The exclusive lane may be separated from parallel traffic by fencing, barrier (non-mountable) curbs, mountable curbs, striping, and/or lane designation.
- Specific signal timing is needed for the BRT to avoid the left turn conflict (Refer to Traffic Operations).

Opportunities and Challenges

Opportunities

- Exclusive lanes allow for the BRT to operate uninterrupted by traffic, and provide high travel time savings, level of safety, and reliability.
- Conflicts between BRT and general traffic are not present.
- Platooning of busses can maximize throughput while maintaining efficiency and reliability.

Challenges

- Right-of-way may not be available for exclusive lanes.
- Grade separation may be required to remove existing at-grade intersections between the BRT lane and the existing roadway network.

e. Exclusive Roadways

Figure 14. Exclusive BRT roadway

Description

This section discusses the roadway geometric guidelines for exclusive roadways. Exclusive roadways can be fully grade separated from both motor vehicle and pedestrian crossing facilities, or operate in an exclusive right-of-way with at-grade crossings at intersections.

Guidelines for Implementation

- Maximum operating speed for BRT is 55 MPH. Maximum operating speed through intersections is 45 MPH.
- Where the BRT project has the potential of being converted to a light rail facility, the horizontal alignment shall be designed using the latest edition of METRO's Rail Transit Design Criteria and Standards.
  - > Where light rail criteria is not practicable, or where the BRT project does not have the potential of being converted to a light rail facility, the latest edition of Caltrans' Highway Design Manual shall be used.
- Exclusive busways shall have two lanes, each with a width of 14 feet measured from the curb face to the centerline. Where curbs are not required, the lane width shall be 14 feet from edge of pavement to the centerline, with a 3 feet shoulder for an overall pavement width of 34 feet.
- For exclusive roadways on a bridge structure, the width of each lane shall be 15 feet measured from centerline to face of barrier. The distance from the right edge line to the barrier shall be 2 feet. The 4-inch wide white thermoplastic right edge line shall have raised and inverted profile.
- At intersections, exclusive roadways will either be separated from traffic by grade separation or gated crossings.
- Specific signal timing is needed for the intersections where the BRT uses gated crossings (Refer to Gates and Traffic Operations).

Opportunities and Challenges

Opportunities

> Exclusive roadways allow for the BRT to operate uninterrupted by traffic and provide the highest travel time savings, level of safety, and reliability.

> Exclusive roadways can accommodate the highest peak passenger flows.

> Exclusive roadways provide the best opportunity for conversion to light rail.

Challenges

> Exclusive roadways require significant right-of-way and infrastructure to build, and thus have the highest capital costs of any BRT option. In addition, the necessary right-of-way may not be attainable throughout the corridor.

> Construction impacts are similar to those for light rail transit.

> Require gated crossings at intersections.

f. Transitions in Running Way Placement

Description

This section discusses the roadway geometric guidelines for transitions in running way placement. There may be some corridor segments where the running way is in the center of the roadway due to applicable conditions and constraints, and other segments on the same line where the running way will serve stations on the sidewalk due to changes in land use, frequency of driveways, or other considerations. The primary consideration for transitions is when the running way location changes from side or curb running to center running and vice versa.

Guidelines for Implementation

- Mixed-flow segments can be used to transition between side or curb running BRT lanes and center running lanes for semi-exclusive and exclusive BRT lanes to allow the bus to navigate from one side of the roadway to the other.
  - The mixed-flow transition segment should be between two signalized intersections, and long enough to ensure that the bus can safely make the necessary lane changes required.
- If the roadway geometry permits, transitions can occur at a signalized intersection with a signal phase to allow the bus to transition across lanes.

Opportunities and Chellenges

Opportunities

- Transition segments provide greater flexibility in placing the running way in the optimal location based on local conditions.
- If a corridor includes varying land use types or right-of-way widths, there may be some segments where the BRT running way is preferred in the center and other segments where the running way is preferred on the side.
- Transitioning during an exclusive signal phase eliminates conflict points associated with lane changes.

Challenges

- Where a mixed-flow segment is provided for transitions, the bus will be required to make multiple lane changes. In congested conditions, the bus may have limited opportunities to change lanes.
- Each lane change required on a bus route introduces potential conflict points, and increases the risk of collision.
- Some intersections may not be configured to allow the bus to transition during an exclusive signal phase, depending on the lateral movement required, the width of the cross street, and the turning radius of the BRT vehicle.

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g. Sidewalks

Figure 15. Sidewalks and transit.

Description

This section discusses the roadway geometric guidelines for sidewalks that will serve BRT stations. In general, sidewalk modifications are not a part of the running way design, and may be considered as part of station design or first/last mile improvements.

If sidewalk modification is necessary to implement the BRT lanes or station areas, sustainable measures such as low impact development, use of recycled materials, and planted areas within curb extensions should be considered. Sustainability improvements are not required elements of a BRT project, and should be balanced with water conservation efforts, long term maintenance requirements, and compatibility with local goals and policies.

Guidelines for Implementation

- Minimum sidewalk width will be 5 feet, where there is no station. The preferred sidewalk width will be 10 feet or greater.
- ADA requirements must be met for sidewalk desirable widths, areas behind and adjoining driveways, alley openings, and pedestrian ramps.

Refer to Chapter 7.2 BRT Station/Platform for further guidance regarding sidewalk configuration at stations. Also refer to Transit-Oriented Communities chapter for guidance on streetscape and pedestrian infrastructures.

h. Pedestrian Crossings

Figure 16. Pedestrian crossing.

Description

This section discusses the roadway geometric guidelines for pedestrian crossings. Crosswalks are essential components of the path that pedestrians must travel to get to and from BRT stations. Implementation of dedicated BRT lanes typically involves restriping of the existing roadway, which can include pedestrian crossings.

Guidelines for Implementation

- Pedestrian crossing of the BRT right-of-way will typically be at-grade.
- Pedestrian crossings should be perpendicular to the traffic lanes and 15 feet in width.
- Street improvements that reduce the length of the pedestrian crossing are desirable, because they provide increased visibility of pedestrians, reduce pedestrian crossing time, and can result in better traffic operations.
- At intersections, standard pedestrian signals should be used.
- Where pedestrian crossing are anticipated to occur mid-block, the costs and benefits of a pedestrian signal to stop both traffic and the BRT should be evaluated.
- Sight lines at intersections should be assessed to ensure proper visibility of pedestrians at the intersection.

Opportunities and Challenges

Opportunities

> Can reduce the length of pedestrian crossings with bulbouts.

Challenges

> Pedestrian crossings can reduce the BRT travel times if they are too long or mid-block.

i. Bike Facilities

Figure 17. Bike facilities

Description

This section discusses the roadway geometric guidelines for bike facilities.

Guidelines for Implementation

- The bikeway facility width (Class I, II, and IV) shall be a minimum of 4 feet. The width of the bike lane shall be a minimum of 5 feet if adjacent to a general traffic lane or parking lane.
- The maximum bikeway facility width (Class I, II, and IV) shall be 6 feet, with any additional width being used for a buffer.
- A preferred Class IV facility will use a 6-foot bike lane width with a 4-foot wide buffer using a bollard.
- The bike facility can improve separation from the roadway by providing for a vertical element via a raised curb or raised bikeway.
- With minimal Class II bike facility width, the bike lane shall be placed to the left of parking or against the curb if there is no parking.
- With the preferred Class IV bike facility width, the bike facility shall be placed against the curb with parking and traffic lanes to the left.
- Sight lines at intersections should be assessed to ensure proper visibility of pedestrians at the intersection.
- If insufficient right-of-way exists to provide a dedicated bikeway or bike lane, a shared bike and bus lane may be used in side running and curb running alignments.

Refer to Station chapter for further guidance regarding interaction between bike facilities and stations. Also refer to Transit-Oriented Communities chapter for additional guidance on streetscape and pedestrian infrastructure.

Opportunities and Challenges

Opportunities

> Implementing BRT may provide an opportunity to provide new or enhanced bike facilities along new guideway or reconfigured lanes.

> Bicycle facilities provide a first/last mile option.

Challenges

> There may be limited curb to curb width to use a bike facility or protected bike facility.

> There are special treatments for the bike lane at station locations. See Chapter 7.2 BRT

j. Driveways

Description

This section discusses the interface and potential conflict between driveways and BRT lanes.

Guidelines for Implementation

- Driveways located within 100 feet of a signalized intersection could impact the location of side stations.
- Consolidate driveways that conflict with BRT stations or operations if possible.

Opportunities and Challenges

Opportunities

> Pursue opportunities to consolidate/limit the number of driveways and/or reduce driveway widths of driveway.

Challenges

> Driveways have an impact on side and curb running operation because of traffic crossing the BRT lane.

4 Intersection Geometrics

a. Left/Right Turns
b. Intersection Lane Offsets
c. Vertical Profiles (Crowns)
d. Concrete Bus Pads
e. Bus Turnouts
f. Contraflow Lanes
g. Ramps
h. Bulbouts
i. Exclusive Roadway and Managed Lanes Entry/Exit

a. Left/Right Turns

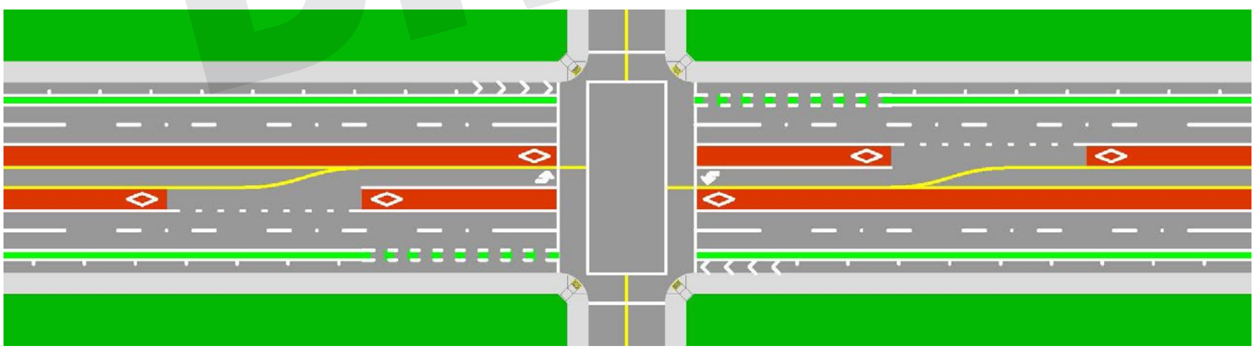

Figure 18. Left turn mixing zones along center running BRT

Description

This section discusses the intersection geometric guidelines for left/right turns for crossings of the BRT. The crossings for left turns occur for median or center running and crossings for right turns occur for side or curb running.

Guidelines for Implementation

- In general, left turns are prohibited to cross the BRT lane at unsignalized locations.
- The base configuration for left turns at signalized locations with center running BRT lanes places the left turn lane to the right of the BRT lane. This may create conflicts for the left turns, and require lead/lag phasing. Lead/lag phasing may also create additional delay for the bus vehicles.
- Left turn crossings are an option for center running lanes where the left turn lane is to the left of the BRT lane.
- A right turn pocket can be added by replacing the parking lane.
- When there is not sufficient space for a right turn pocket, vehicles can be allowed to enter the BRT lane in advance of the intersection to make right turns.
- The length of a dedicated left or right turn pocket is determined by the queue length as determined from the 95th percentile. The minimum length of the pocket shall be 60 feet, enough for an articulated bus in the BRT lane.
- The MUTCD Taper Length Formulas are recommended to be used to determine the length of the mixing zone prior to a left or right turn pocket. Where the speed limit is 40 miles per hour (MPH) or less, the taper length (L) in feet is equal to $WS^2/60$, where W = width of bus lane in feet and S = posted speed limit or anticipated operating speed in MPH. Where the speed is 45 miles per hour (MPH) or more, L=WS. For a segment where the operating speed is 30 MPH and the BRT lane is 12 feet wide, the mixing zone should be 180 feet long. The minimum length of the mixing zone should be 100 feet. In this mixing zone, left or right turning cars may cross the BRT lane to enter the left or right turn pocket.

Opportunities and Challenges

Opportunities

> Left turn crossings can be accomplished with less curb to curb width and can prevent lane offsets for the BRT lane.

Challenges

> The mixing zones are challenges for the BRT lane, as opposed to keeping the BRT separate.

b. Intersection Lane Offsets

Description

This section discusses the intersection geometric guidelines for intersection lane offsets. Lane offsets may be required to accommodate center running ways, particularly if the bus does not provide boarding from both sides of the vehicle.

Guidelines for Implementation

- *Lane offsets should be reduced through intersections as much as possible to provide contiguous lanes. Preferable offset should be kept at or below 2 feet. A maximum offset may be determined using the taper length formula based on speed.*
- *Caution should be used in designing a center running BRT, as significant lane offsets through the intersection may develop from left turn lanes. At a minimum, an additional buffer lane is needed when the left turn lane is not crossing. If the left turn lane is crossing, then an additional buffer lane is not needed and lane offsets are reduced.*

Opportunities and Challenges

Opportunities

> Lane offsets provide channelization and direction for drivers where non-standard lane configuration is required to accommodate BRT running ways.

Challenges

> The need for a lane offset depends on the BRT running way placement, left turn movements, and the available right-of-way. In some instances, lane offsets cannot be avoided.

> Lane offsets vary from standard roadway configuration, and can be confusing to drivers.

c. Vertical Profile (Crowns)

Description

This section discusses the intersection geometric guidelines for vertical profile (crowns). BRT vehicles that provide low-floor boarding sit low to the ground, and the bottom of the vehicle may come in contact with the roadway surface at changes in grade.

When selecting an alignment for BRT, or if roadway reconstruction through an intersection or along an existing or proposed BRT route is required, the following guidelines should be taken into consideration. If local design standards vary from the recommendations presented in this chapter, the more conservative standard should apply.

Opportunities and Challenges

Opportunities

> If roadway reconstruction is planned as part of a BRT project or for a new roadway, there is an opportunity to modify the vertical profile to accommodate all vehicles, including BRT.

Challenges

> For most instances where BRT vehicles will cross streets at grade, the budget may not include regrading of the street to provide a new vertical profile.

Guidelines for Implementation

- Longitudinal grades shall be a maximum of 5%, minimum of 0.3%, and desirable 1%
- Cross-slope shall be 2%
- Maximum grade differential shall be 9% for a crest vertical curve and 6.5% for a sag vertical curve. Crest and sag curves at top and bottom of ramps without parking may exceed these differentials, but must use a vertical curve 20ft in length or more.
- Vertical curves shall have the following minimum vertical curve length (Lmin) as determined by a factor and the algebraic difference in grades (A)
  - Crest Curves – Lmin = 28 A
  - Sag Curves – Lmin = 35 A
  - No vertical curves shall be less than 20 feet.

d. Concrete Bus Pads

Description

This section discusses the intersection geometric guidelines for concrete bus pads. Buses weigh considerably more than a standard passenger vehicle, and generate more wear and tear on asphalt surfaces. Concrete bus pads help prevent long-term damage (e.g. gaps, cracks, and ripples) to the roadway surface.

Guidelines for Implementation

- If construction of the BRT requires an existing bus stop to be relocated, a new concrete bus pad should be installed at the location of the relocated bus stop.
- If the construction of the BRT encroaches into an existing bus stop, a new concrete bus pad should be provided at the existing bus stop, in conformance with the local agency's standard.
- For existing bus pad or new bus pads outside of the busway, the thickness of the concrete bus pad shall be designed per geotechnical report recommendations, or per city of Los Angeles Standard Plan S-433-0, or per SPPWC Standard Plan 131 (latest revision), whichever is more stringent. The compressive strength of concrete (f'c) shall be 4,000 psi minimum.
- Bus pads should be designed with a minimum width of 12ft per pad and a minimum length of 90ft. See City of Los Angeles Bureau of Engineering Standard Plan S-433 for further detail.
- Bus pads may warrant a longer length to accommodate multiple bus lines and/or articulated buses.

Opportunities and Challenges

Opportunities

- Concrete bus pads help prevent long-term damage (e.g. gaps, cracks, and ripples) to the roadway surface.
- Where level boarding is required, concrete bus pads are sturdier than asphalt and less prone to changes in elevation due to wear and tear.

Challenges

- Installation of new concrete bus pads can be a significant cost.

e. Bus Turnouts

Figure 17. Bus turnout

Description

Bus turnouts are a common feature of local bus service, but are not recommended along BRT routes. A bus turnout is not aligned with the normal curb edge, but recessed so that the transit vehicle pulls out of the traffic lane to stop. Bus turnouts can allow through traffic to continue moving while the bus picks up and drops off passengers. However, if a bus must pull out of a turnout and into a general traffic lane, this may result in delays due to the time required for buses to re-enter the main stream of traffic. While the impacts are potentially small at each turnout, the cumulative effect on transit can be significant along the length of a corridor.

Guidelines for Implementation

- ✔ Bus turnouts are not recommended for BRT stops, even where the bus operates in mixed flow, due to the potential delays associated with pulling back into general traffic.
- ✔ If a bus turnout is necessary due to an unavoidable condition or impact, it should be constructed with a concrete bus pad with minimum width of 12 feet and minimum length of 90 feet.

Opportunities and Challenges

Opportunities

> Bus turnouts should be considered where buses will stop for extended periods of time, such as at route terminus locations.

Challenges

> Bus turnouts can negatively affect transit travel time due to the time required for buses to re-enter the main stream of traffic.

> Bus turnouts reduce the amount of space available to install passenger amenities such as shelters and sidewalks.

f. Contraflow Lanes

Description

This section discusses the intersection geometric guidelines for contraflow lanes. A contraflow lane travels in the opposite direction of adjacent traffic lanes. They are typically used on streets where general traffic is limited to one direction, but bus transit travels in both directions. Contraflow lanes can be used to create more efficient connections for transit.

Guidelines for Implementation

- Contraflow lanes should be a minimum of 12ft wide.
- Contraflow lanes can be designed similar to a standard bidirectional street, except that travel in one direction is limited to transit only.
- Contraflow lanes should be clearly marked through pavement markings and signage to distinguish them from general traffic lanes. At a minimum, BRT ONLY and directional arrow markings should be applied.
- A double-yellow centerline marking (MUTCD §3D-02) must be applied to separate contraflow traffic from opposing traffic.
- At signalized intersections, install transit-only signals facing the contraflow direction.
- Clearance intervals should be calculated using transit-specific speeds to provide safe movement across intersections.
- Intersection turn management should be designed to accommodate contraflow operation.

Opportunities and Challenges

Opportunities

> Contraflow operation can reduce the length of a transit route that would otherwise require additional turns to travel on conventional streets.

> Running transit in both directions on a one-way street can provide better connections for route transfer and stations easier to locate for passengers.

> Reconfiguration of a street to provide a contraflow lane may provide an opportunity to provide new or enhanced bicycle facilities.

Challenges

> There may be limited right-of-way available to introduce a contraflow lane.

g. Ramps

Figure 19. Curb ramp

Description

This section discusses the intersection geometric guidelines for ramps. Curb ramps and platform access ramps are a key component of pedestrian access to center or side BRT stations.

Guidelines for Implementation

- If BRT street improvements involve modifications that affect curb ramps, the curb ramps should be replaced in conformance with local City standards.
- Dual curb ramps should be considered at intersections where curb returns are modified as part of BRT Projects and provide direct access to stations. The design of curb cuts and ramps shall be in accordance with the applicable provisions of the Americans with Disabilities Act (ADA), Title 24, California Code of Regulations Part 2, "Regulations for the Accommodation of the Disabled in Public Accommodations" and City of Los Angeles standard plans. Location of ramps and curb cuts in public space shall be obtained from the local governing jurisdiction and shall be in accordance with the ADA and Title 24, Section 2-710(3)(a) and City Standard Plan No. S-442-3.

Opportunities and Challenges

Opportunities

> Provides a smooth surface for pedestrians pushing strollers, bicycles, wheelchairs or other wheeled devices.

> Detectable warning surfaces help to make curb ramps more visible, and also provide tactile feedback for sight-impaired pedestrians.

Challenges

> There may be limited right-of-way available to update older curb ramps to meet current code requirements.

h. Bulbouts

Figure 17. Bulbout

Description

This section discusses the intersection geometric guidelines for bulbouts. Bulbouts are extensions of curb into the roadway, which permits transit vehicles to dwell at a stop without pulling out of the main stream of traffic, as would be required for a bus bay. Transit vehicles are not required to merge back into traffic, which reduces delay to the bus. Bulbouts provide many benefits including reducing pedestrian crossing distance, slowing drivers at the corner, provides additional sidewalk space, and allows pedestrians and motorists to see each other more clearly.

Guidelines for Implementation

- Bulbouts can be applied at corners where on-street parking exists. If the full street width is utilized for through traffic, bulbouts would not be feasible.
- Bulbouts should also be considered near BRT stations to reduce crossing distance for pedestrians.
- Bulbouts should usually extend the full width of a parking lane, typically 8 feet from the curb. If a bike lane is present, however, the bulbout should be designed to accommodate drainage flows without affecting bicycle travel.
- When bulbouts conflict with the turning movements of trucks and transit vehicles, the width and/or length should be reduced rather than eliminating the bulbout.
- Sight distance and emergency access must be considered when planning to install landscaping elements, street furniture or other amenities on curb bulbouts.
- Bulbouts should be designed to allow stormwater to flow into drainage inlets without ponding.

Opportunities and Challenges

Opportunities

> Bulbouts allow on-street parking and right turn lanes to remain in place.

> Bulbouts establish a station footprint and can provide additional space for station amenities.

- Bulbouts provide more space for pedestrians and can reduce their crossing distance.
- Bulbout stations allow BRT vehicles to stay in the side lane rather than pulling to the curb for boarding and alighting.

Challenges

- Bulbouts must be designed to accommodate drainage and bicycle lanes (if present).
- Bulbouts can increase the capital cost of the BRT project.

i. Exclusive Roadway and Managed Lanes Entry/Exit

Description

This section discusses the intersection geometric guidelines for exclusive roadway and managed lanes entry/exit. Where right-of-way for an exclusive guideway is not available, the BRT may share a roadway that is used as a managed lane. Exclusive roadways use variable pricing to reduce traffic congestion, and users pay a toll to travel in the lane. Exclusive roadways are typically separated from general traffic by barriers, bollards, or pavement markings. In the context of this discussion, managed lanes are dedicated lanes on a freeway for exclusive BRT use. These lanes can be located on the shoulder, in the median, or by repurposing an existing travel lane. Taxis, high occupancy vehicles, or other designated vehicles could be permitted to share the managed lanes. Managed lanes in other contexts created by congestion pricing strategies or other methods could also be considered for BRT use as applicable.

Guidelines for Implementation

- BRT access to exclusive lanes or managed lanes will depend on the point of entry and the existing barriers to entry.
- For BRT access at an entry point utilized by other permitted vehicles, consider ways to reduce delays for BRT.
- For BRT access at an entry point not utilized by other permitted vehicles, consider sight distance to safely enter the exclusive or managed lane.
- Design enter and exit points to ensure that non-authorized vehicles do not attempt to follow the BRT vehicle into or out of the exclusive or managed lane.
- Managed lanes located on the shoulder of a freeway may cross entry ramps used by general traffic.
- Ramp meter interrupt technology can be used to create a gap in the entering traffic to allow a BRT vehicle to cross the entrance ramp lane.
- If stations are located on a managed lane, the bus will need adequate length to accelerate to the desired operational speed to merge back into freeway lanes. The AASHTO recommended minimum acceleration lengths for entrance ramps can be used to determine acceleration lengths required between BRT stops and merge areas.

Opportunities and Challenges

Opportunities

> If the conflicts at entry and exit points can be resolved, the use of managed lanes for BRT can provide an opportunity to provide quality service at a lower cost than building an exclusive, bus only lane.

Challenges

> Entry and exit between exclusive or managed lanes and a BRT running way can be complicated if the exclusive or managed lanes are controlled by physical barriers or gates.

> Transitioning from a perpendicular roadway to an exclusive or managed lane may require special lanes to speed up or slow down prior to or after entry, depending on traffic volumes and travel speeds on the exclusive or managed lane.

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5 Gates

a. Description
b. Guidelines for Implementation
c. Challenges and Opportunities

Figure 20. BRT gates

a. Description

This section discusses potential uses for gates for BRT operations and guidance for implementation. Also refer to the System chapter of this document for further guidance on access control.

b. Guidelines for Implementation

- Gates can be used to advise and restrict turning vehicles crossing exclusive BRT running ways that the BRT has right-of-way through an intersection. Typical examples would be in right turn lanes to supplement blank-out No Right Turn signage when the BRT phase is active at a traffic signal, or to block left turns in front of the BRT in center running designs.
- For roadway crossings of exclusive BRT running ways, full gates and flashers, similar to light rail crossings can be utilized.
- Gates can also be used to provide access control onto the exclusive BRT guideway lanes. These are used to block inadvertent or intentional movement of unauthorized vehicles onto the guideway lanes.

c. Opportunities and Challenges

Opportunities

> Gates provide improved safety for the BRT and crossing vehicles.

> Gates improve compliance with turn restrictions.

> Gates allow for higher operating speeds along the BRT running way.

> The use of gates can reduce traffic signal delay at crossings due to the gate systems providing preemption, as opposed to priority handling for the BRT.

> Gates reduce illegal use of the BRT guideway for shortcutting the local streets or to use as a raceway.

> Gates provide a clear indication to drivers that the BRT is not to be entered.

Challenges

> Gates require maintenance to ensure proper operation.

> Signal timing will need to be designed to account for gate activity.

> Gates can introduce delays and lost time into each signal cycle, which can negatively impact BRT operations.

> Right-of-way may be required to install gates and may be a challenge in constrained areas.

6 Pavement Sections

a. Description
b. Guidelines for Implementation
c. Opportunities and Challenges

a. Description

This section discusses pavement design for BRT projects. Many BRT project do not require new pavement design, but may be considered if roadway widening or rehabilitation is necessary.

b. Guidelines for Implementation

- BRT projects should consider the current in-place pavement along the proposed route as well as the future loads from BRT travel.
- An assessment of the current pavement condition along the route should be conducted with the local agency that operates the roadway. Particular attention should be given to the proposed location of the BRT lanes that will be placed on the existing roadway to determine if it will provide an adequately smooth surface for the BRT operation. Signs of pavement distress such as rutting, cracking, or potholes that may to be addressed prior to operation should be noted.
- During design, consideration should be given to the use of rigid (concrete) pavements in areas where buses will stop, or are likely to brake or begin acceleration due to the high stresses on the pavement due to bus action. Typical areas would be:
  - At and approaching station areas
  - At traffic signals or stop signs
    - 300 feet from the stop bar at major intersections
    - 200 feet from the stop bar at minor intersections
  - At any existing bus stops relocated due to the BRT design.
- Drainage issues should also be considered, both as it affects the longevity of the pavement life, and that the drainage should be designed to avoid large flows along the curb at stations to avoid splash conditions as the buses approach and leave the station.
- Exclusive busway pavement should be a different color than the cross street and adjoining pavements when possible. Generally, this pavement color difference can be accomplished by the busway being Portland cement concrete and the cross street being asphalt concrete. When both the busway and cross street are concrete or asphalt, a color difference can be accomplished by the use of colored concrete or asphalt for the busway, as accepted by Metro and the local jurisdiction.

c. Opportunities and Challenges

Opportunities

> Pavement rehabilitation can increase safety and reduce the number of subsequent traffic disruptions to make spot improvements.

Challenges

> Concrete bus pads can significantly increase project costs.

> Riding on a poorly paved surface deteriorates the asset and may result in an uncomfortable ride for passengers.

7 Street Signing and Striping

a. Description
b. Guidelines for Implementation
c. Opportunities and Challenges

a. Description

This section discusses pavement markings and signs to be used along a BRT running way.

b. Guidelines for Implementation

- After consultation with the appropriate local agency or Caltrans, street striping, markings and signage shall be designed to indicate BRT lane usage, turn restrictions, and others as needed for the operation of the BRT.
- Parking restrictions shall also be signed and/or marked with red curb where needed for turn lanes and for stations. All signs and pavement markings shall conform to the latest version of the California Manual of Uniform Traffic Control Devices (CA MUTCD).
- Temporary traffic control during construction in the City of Los Angeles shall conform to the Work Area Traffic Control Handbook (WATCH), and LADOT S-488.0 or site specific worksite traffic control plans as determined at the local agency.

c. Opportunities and Challenges

Opportunities

> Pavement markings and directional signage can help drivers to navigate streets with mixed- flow, semi-exclusive and exclusive BRT lanes.

Challenges

> Insufficient pavement markings and signage can make it unclear to drivers where they are permitted to travel or make turning movements.

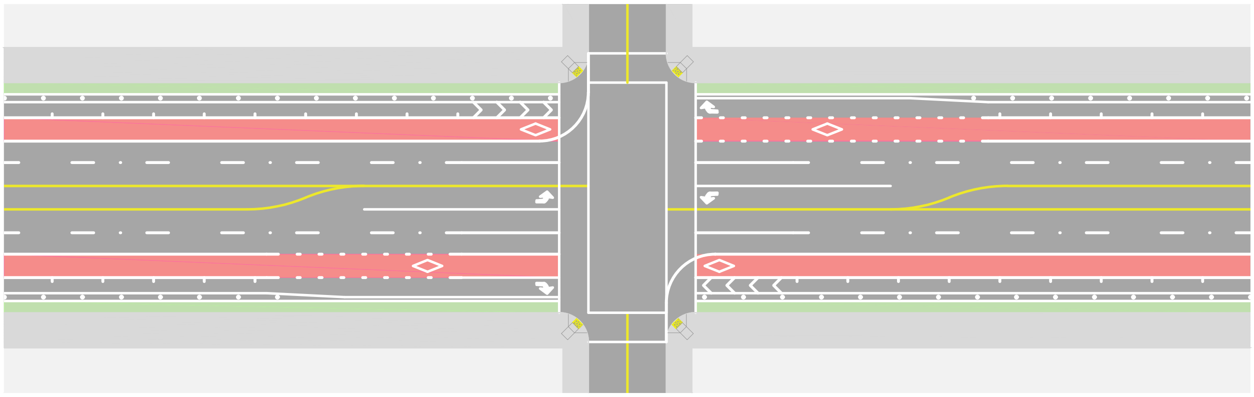

Figure 21. Side Running with Bike Lane

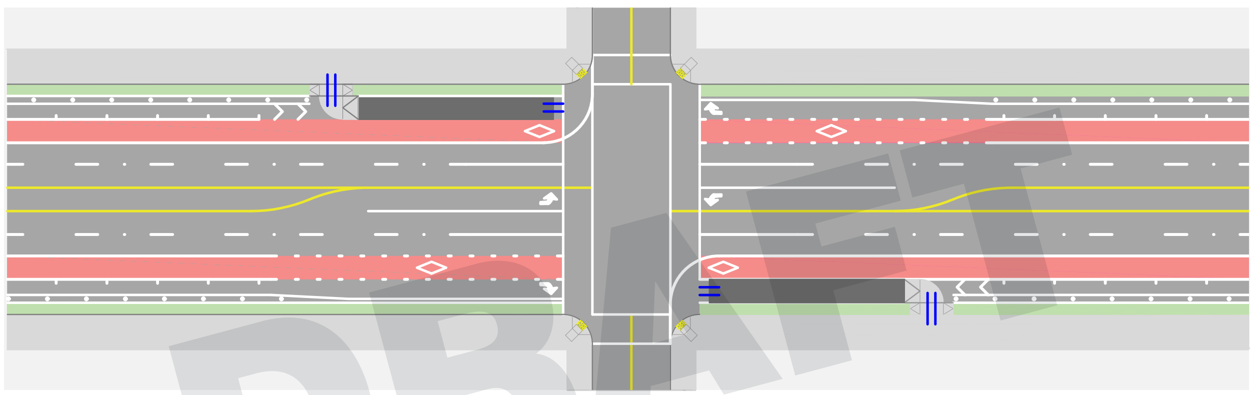

Figure 22. Side Running with Station and Bike Lane

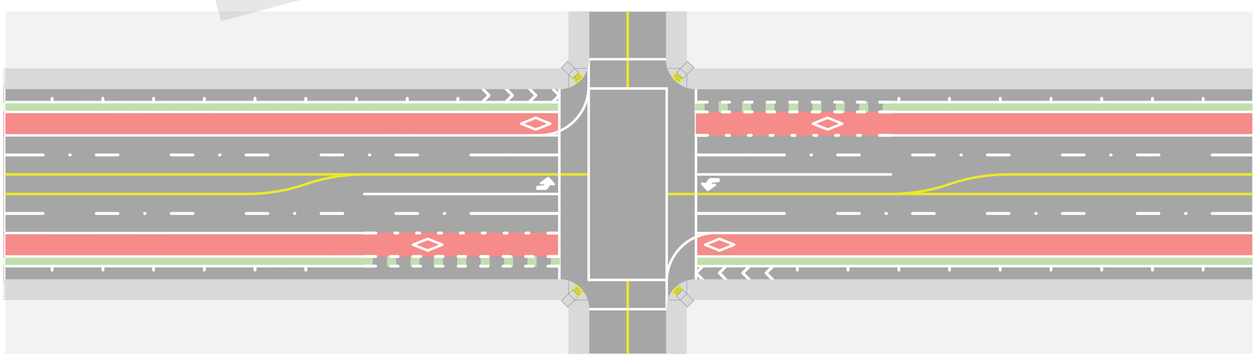

Figure 23. Side Running with Bike Lane – Constrained

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

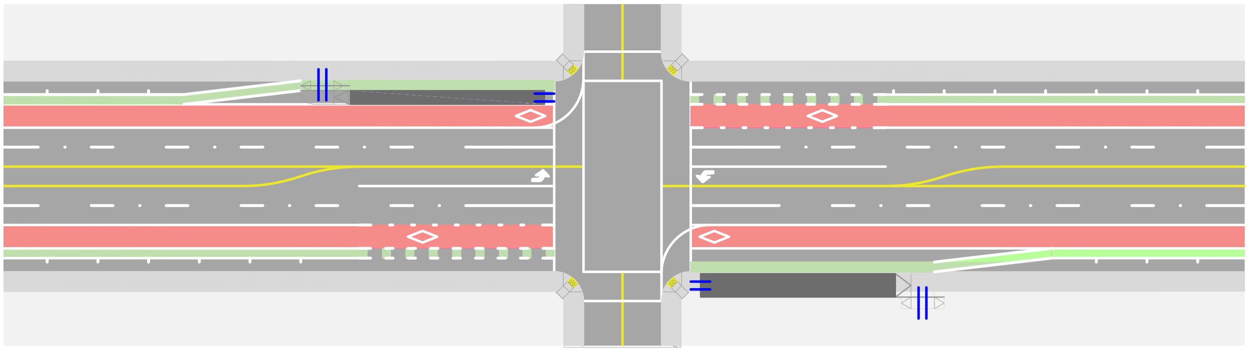

Figure 24. Side Running with Station and Bike Lane – Constrained

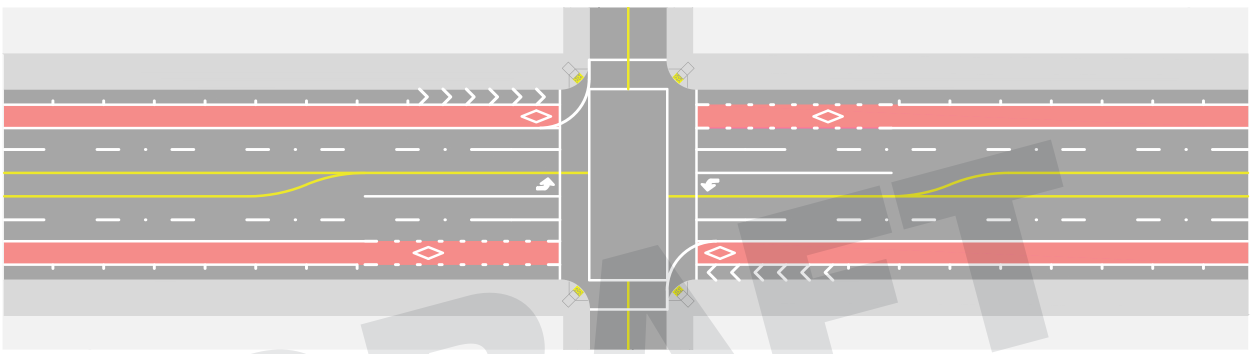

Figure 25. Side Running

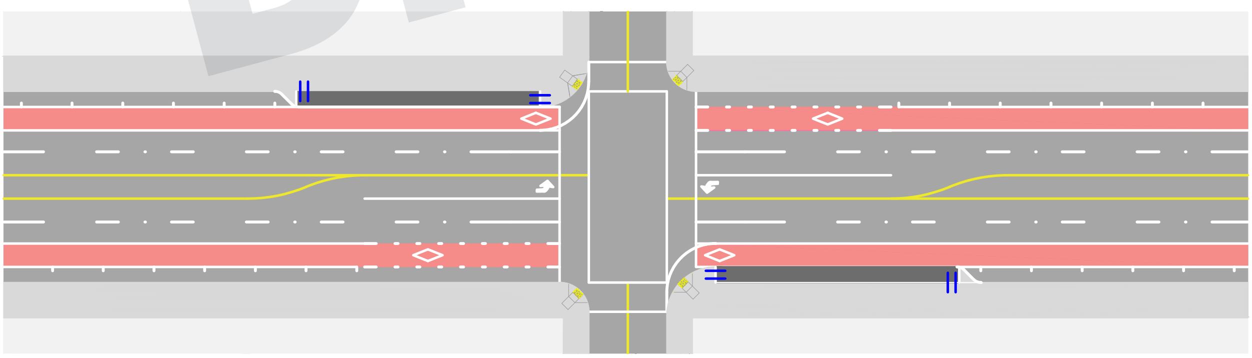

Figure 26. Side Running with Station

- Roadway
- Station
- BRT Lane
- Bike Lane
- Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

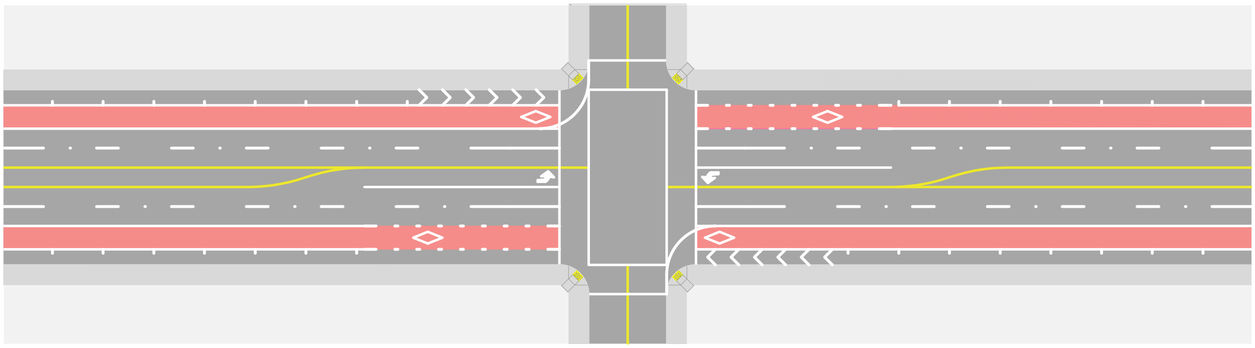

Figure 27. Side Running – Constrained

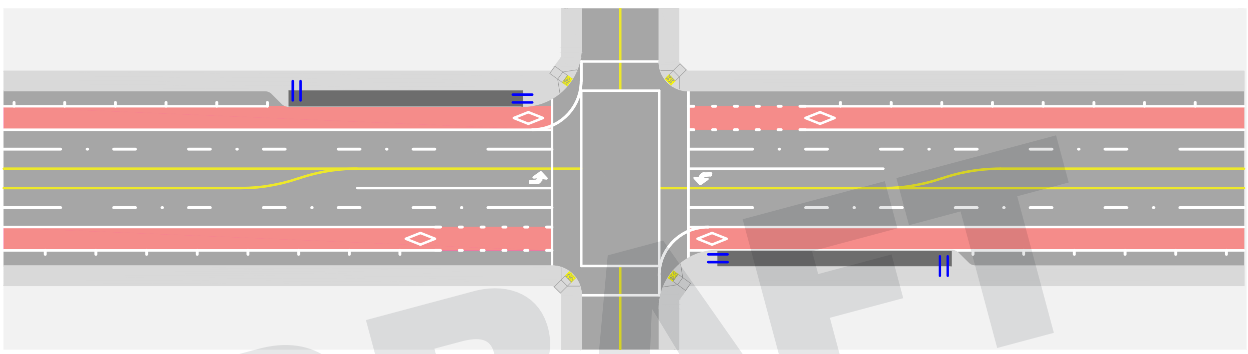

Figure 28. Side Running with Station – Constrained

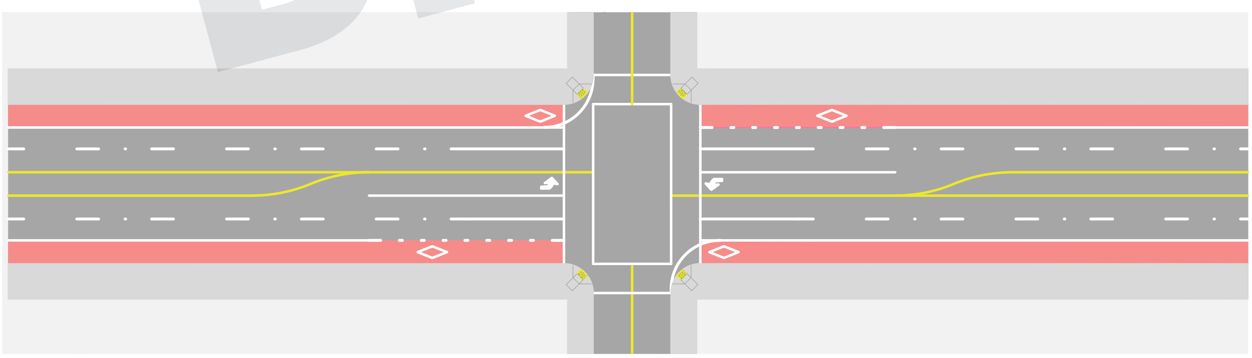

Figure 29. Curb Running

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

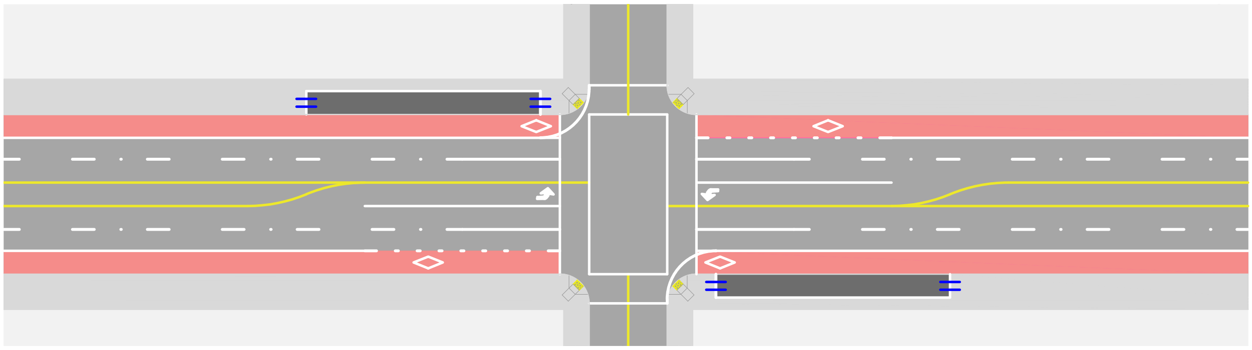

Figure 30. Curb Running with Station

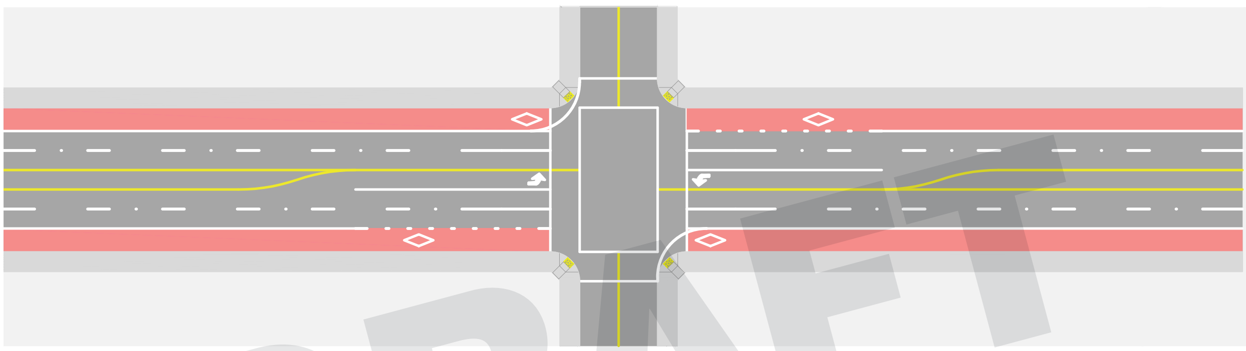

Figure 31. Curb Running – Constrained

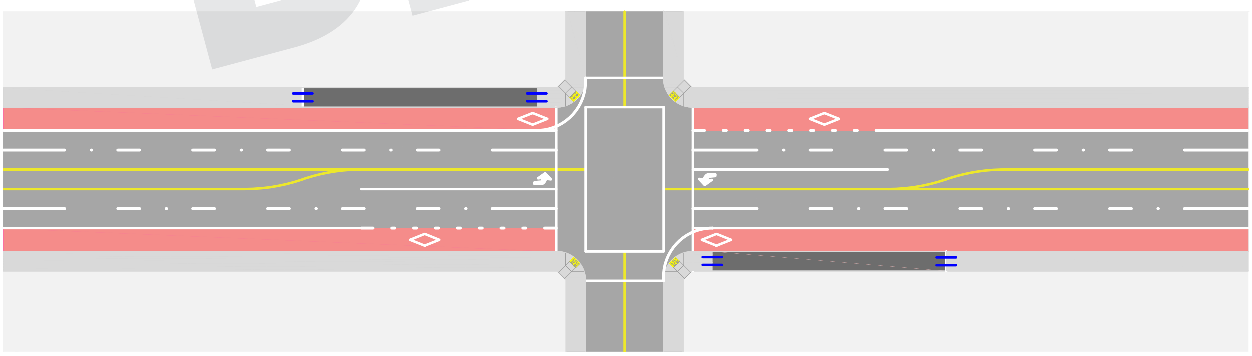

Figure 32. Curb Running with Station – Constrained

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section

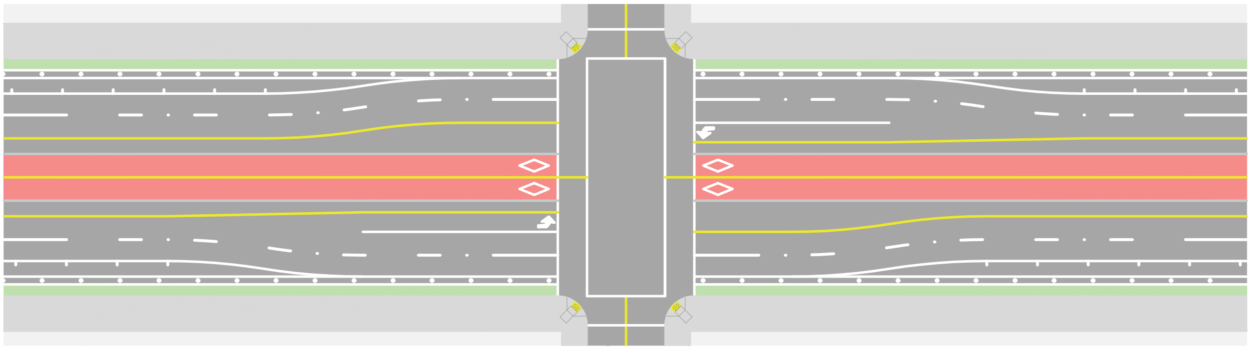

Figure 33. Center Running

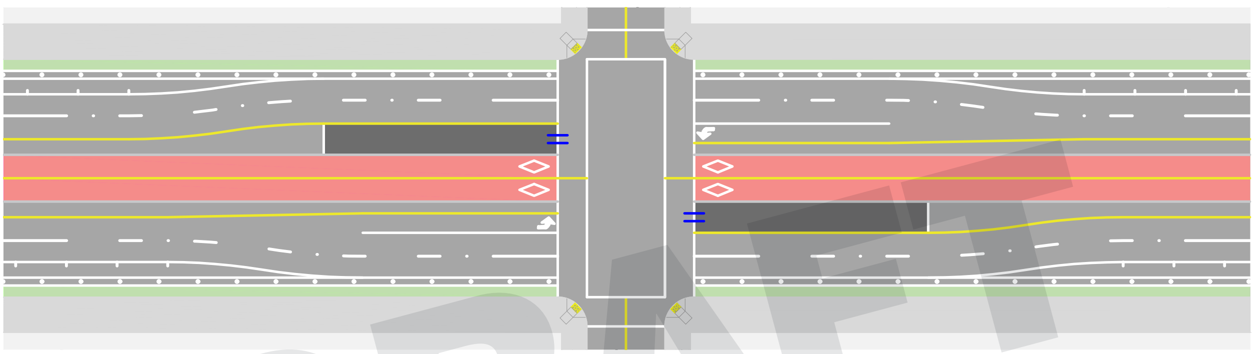

Figure 34. Center Running with Station

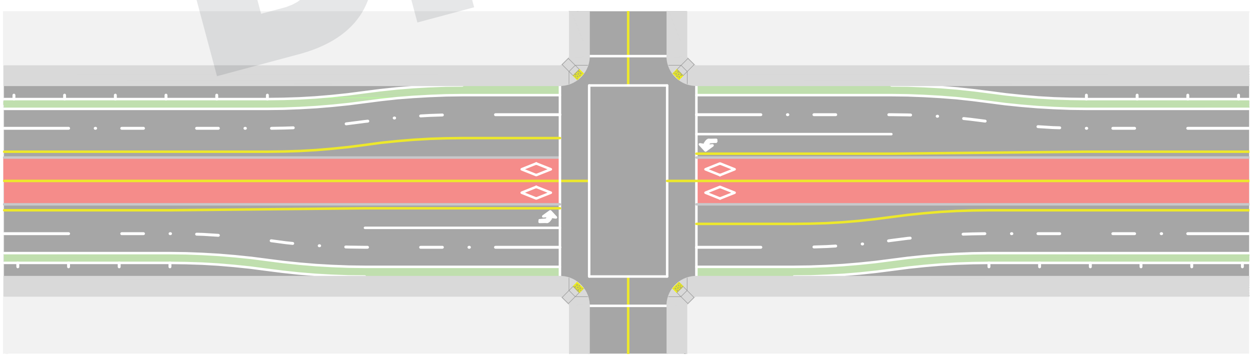

Figure 35. Center Running – Constrained

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

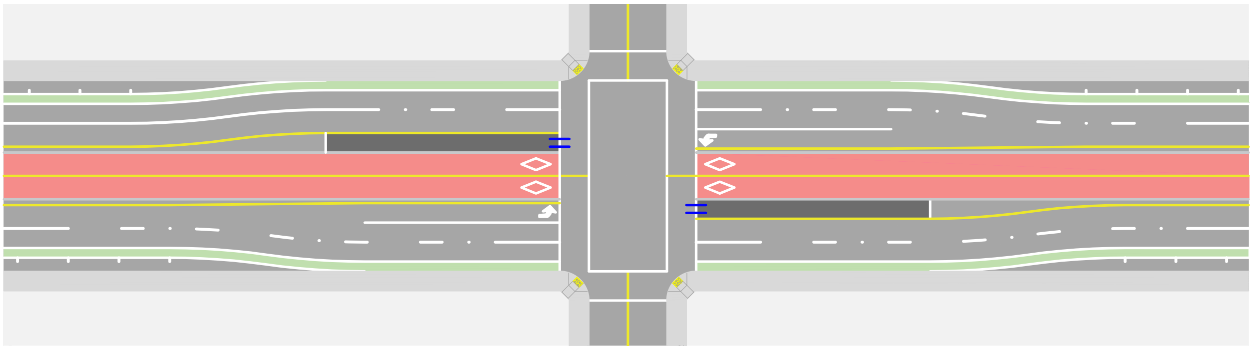

Figure 36. Center Running with Station – Constrained

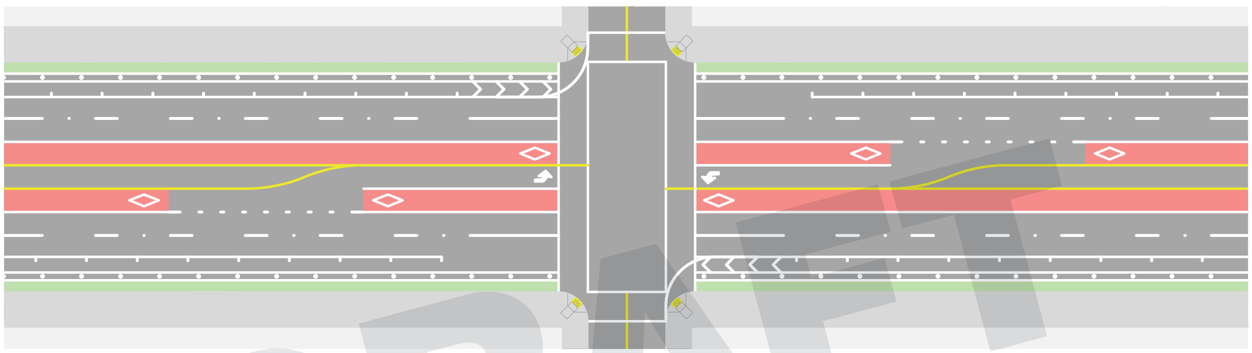

Figure 37. Median Running

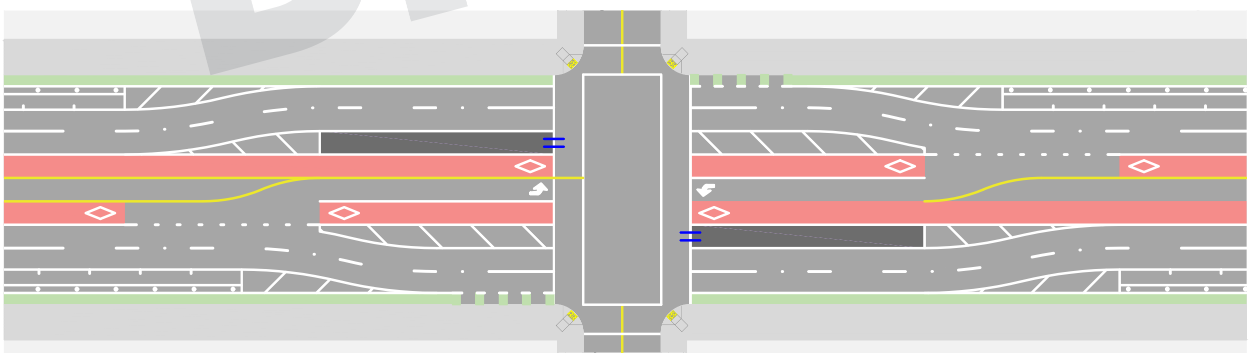

Figure 38. Median Running with Side/Side Staggered Station

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

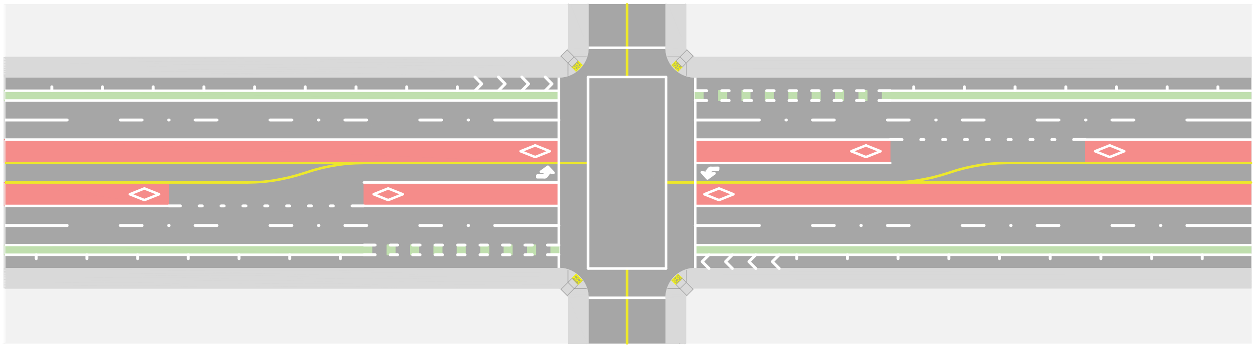

Figure 39. Median Running – Constrained

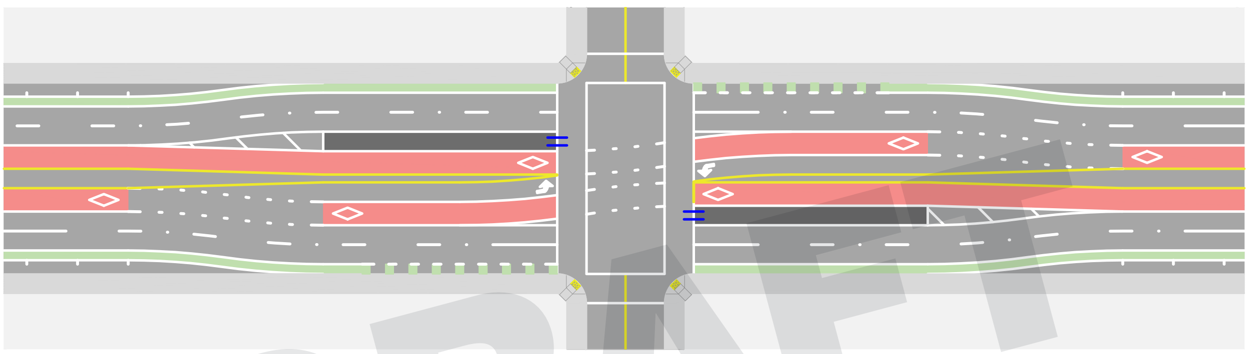

Figure 40. Median Running with Side/Side Staggered Station – Constrained

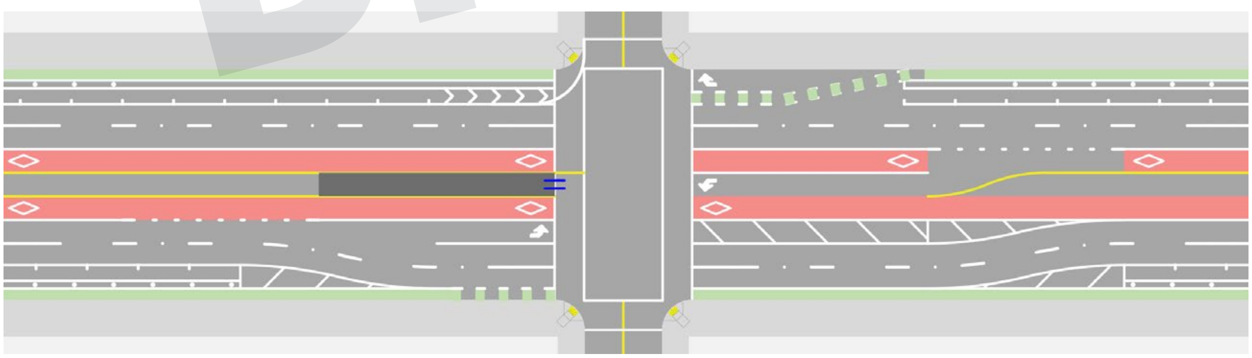

Figure 41. Median Running with Center Island Station

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

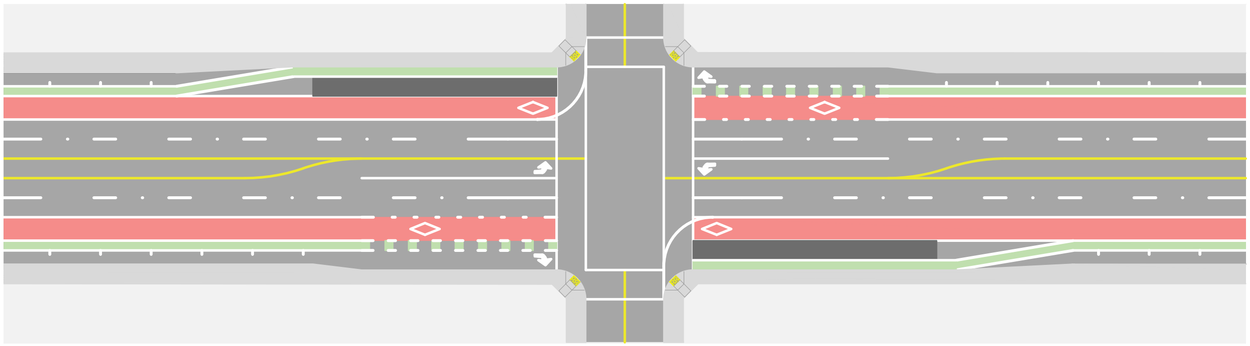

Figure 42. Right Turn Farside/General

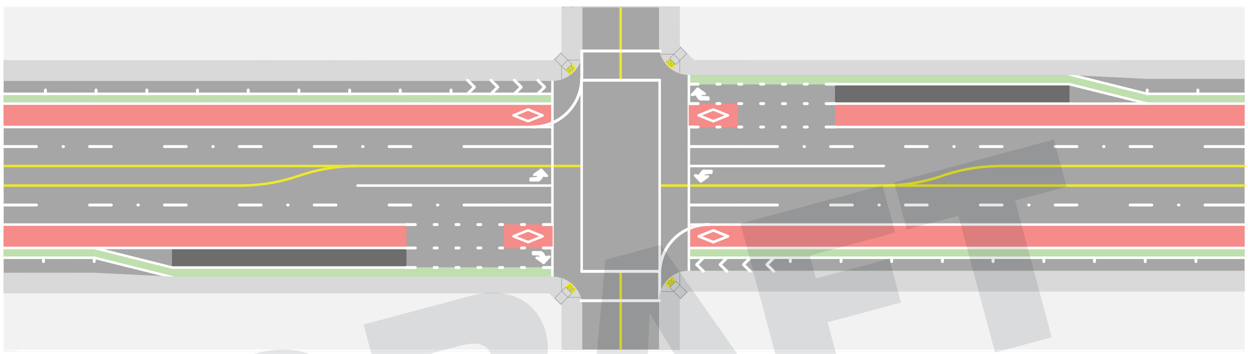

Figure 43. Right Turn Nearside

Roadway
Station
BRT Lane
Bike Lane
Ped Access to Station

-Dimensions based on Cross Section
-The positions of the parking lane and the bike lane can be switched and should be decided on a case-by-case basis.

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8 Green Streets and Landscaping

a. Description
b. Guidelines for Implementation
c. Opportunities and Challenges

a. Description

This section discusses Green Streets and landscaping elements that should be considered when designing BRT projects, if feasible. Roadway drainage systems are designed to remove water from the surface of the road and convey it into a stormwater management system. Roadway surface runoff typically contains pollutants such as trace metals, tire particulates, and hydrocarbon products from pavement and fuels. Green street elements are designed to capture and treat rainwater where it falls, removing up to 90% of pollutants, instead of moving it through drains and pipes to discharge into surface waters, rivers or streams.

b. Guidelines for Implementation

- Green streets and functional landscaping are not a required component of BRT projects, but can provide environmental and aesthetic benefits and should be implemented wherever feasible.
- Coordinate with the appropriate local jurisdiction to see where green measures may be compatible with local plans and goals for an area or corridor.
- Potential Green Streets and landscaping elements include:
  - > Street trees
  - > Drought-tolerant landscapes
  - > Green Stormwater Infrastructure
    - Biofiltration systems
    - Porous pavement
    - Rain gardens
    - Bio-swales
  - > Low Impact Development (LID) techniques
    - Materials and construction techniques that minimize life-cycle costs, greenhouse gas emissions and waste byproducts.

Also refer to Chapter 7.2 BRT Station/Platform for additional guidance about landscaping at and around stations.

c. Opportunities and Challenges

Opportunities

> Reduce peak surface runoff flows and reserve capacity in the stormwater conveyance system.

> Replenish groundwater supplies.

> Protect water quality by filtering pollutants.

> Increase the pedestrian environmental quality, aesthetics and livability of a community.

> Additional tree canopy coverage can supplement station shelters, offering transit patrons further shade protection from extreme heat.

Challenges

> Stormwater control measures located in the public right-of-way are subject to additional safety considerations and implementation constraints (tripping and falling hazards, etc.) compared to those located on private property.

> Landscaping plans should be reviewed to ensure tree trunks, limbs and shrubs do not interfere with vehicle driver sight distances.

> Turning radii may not be compatible with emergency response and fire access.

> Bioretention systems may require specialized maintenance.

> There may be conflicts with existing infrastructure or utilities.

Green Streets projects are consistent with Metro's sustainability goals and policies, and should be implemented where feasible within the BRT project footprint according to local jurisdictional requirements.

9 Traffic Operations

a. Transit Signal Priority
b. Bus Lane Enforcement

a. Transit Signal Priority

Description

This section discusses traffic signal priority (TSP) for BRT operations. There are two basic forms of TSP for BRT operations: passive and active TSP. Also refer to Chapter 7.4 BRT ITS Systems for further guidance about transit lane enforcement.

Guidelines for Implementation

- Passive TSP times the traffic signals to favor the movement of the BRT, rather than other traffic. Other traffic is often also served well by timing the signals to provide preference to the BRT.
  - This is done by timing the signal just past a station to turn green after the normal dwell time at the station.
  - The following signals are then timed based on the normal BRT travel time between intersections until the BRT reaches the next station.
  - The timing of the traffic signals is typically preset by time of day and day of week to adjust for typical station dwell times and traffic conditions along the route.
  - Depending on the spacing of intersections, and speed of the BRT, it may be difficult to provide good green times for BRT's in both directions at once, in those cases, the higher occupancy direction for the BRT operation should be favored.
- Active TSP provides adjustments to the traffic signal timing to either hold a green light until the BRT passes the signal, or to reduce the side street and left turn green lights to allow the BRT to get an early green. This function works best when the traffic signal are given as much time as possible to adjust the signal timing. This can be done through the use of central control systems, such as the City of LA's "ATSAC" system, or through use of peer to peer communications with Advanced Traffic Controllers.
- Active TSP, when used in conjunction with passive TSP provides the best result because with the signals already timed to provide green signals to the BRT, and thus the active adjustments are smaller and easier to achieve. This allows the BRT to get back into the timed passive TSP timing flow, and has lesser effects on the other traffic and pedestrians.

- Another approach to providing priority is to use the signal systems preemption functions of the traffic signal controller to either hold the BRT phase green signal, or to make the BRT phase the next phase served upon a request.
  > The main issue with this system is that in the case of BRT's arriving just a few minutes apart, and from both directions, the side street traffic may be skipped, and pedestrians not served for over 5 minutes or more longer, which would lead to the assumption that the signal is malfunctioning, and pedestrian as well as vehicles violating the signal indications. This may be considered if a time between preemption feature is activated to avoid these long delays.

Opportunities and Challenges

Opportunities

> TSP can reduce route travel time for BRT.

> TSP can be achieved without significant impacts to general traffic in some cases.

Challenges

> Active TSP may result in cycles where the side street signal is skipped, and pedestrians could wait over 5 minutes or longer for a walk sign. These scenarios could lead to drivers or pedestrians violating the signal indications.

b. Bus Lane Enforcement

Description

This section discusses bus lane enforcement, which includes measures to keep the bus only lane clear of parked or moving vehicles that are not permitted to share the lane. Enforcement can be challenging for a number of reasons. It can be difficult to identify vehicles that are using the bus lane inappropriately, since vehicles may be permitted to enter the lane for brief periods to access driveways, parking lanes, or to make right turns. Enforcement also requires cooperation between the local law enforcement agencies and the BRT operator. It will be essential to partner with the local jurisdiction regarding enforcement, and to ensure that the system is designed to compliment the available resources and priorities of local law enforcement.

Guidelines for Implementation

- It is important that the BRT operator makes enforcement as easy as possible through design and coordination.
- Design features include providing clearly marked running ways using standard signs and markings and that are understandable by the public. This will ensure that the citations issued are upheld in court.
- It may also be necessary to update the municipal code by ordinance to make certain regulations are enforceable.
- A design feature that aids enforcement is to provide a pull-out area along the guideway for offenders to be cited.

Opportunities and Challenges

Opportunities

> Clearly marked BRT exclusive lanes are easier to enforce and the citations are more likely to be held up in court.

> Providing space within a BRT to pull offenders over and issue citations can aid enforcement.

Challenges

> Enforcement of BRT exclusive lanes or guideway may be challenging if officer resources are limited or not prioritized.

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10 Utility Considerations

a. Description
b. Guidelines for Implementation
c. Opportunities and Challenges

a. Description

This section discusses utility interactions with BRT running ways.

b. Guidelines for Implementation

- During preliminary design of BRT routes, it is important to research and observe the location of utilities, with the aim of avoiding relocation as much as is feasible.
- Utilities typically run longitudinally along streets, which may create an impediment to the placement of stations or island in the roadway due to the need to be able to maintain and replace these longitudinal utility lines.
- Designs may require the relocation of these utilities, which may significantly affect the cost for construction of the BRT facility.
- Attention to the location of service access opening ("manholes") will avoid problems later in the need to adjust designs or the utilities, especially where islands will bisect the existing access point.
- All maintenance, support, relocation, restoration, construction or other utility work shall conform to the current design standards, criteria, specifications and practices of the agencies/owners having jurisdiction.
- Utilities to be relocated and/or protected shall be placed in locations according to policies, standards and requirements of the local agency.

c. Opportunities and Challenges

Opportunities

> Avoiding access openings ("manholes") when designing medians and curb extensions can prevent the need to redesign BRT elements or relocate utilities.

Challenges

> Existing utilities may restrict options for running way or station locations, if utility relocation is prohibitively expensive.

> Utility relocation can affect the critical path for project implementation.

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11 Betterments

a. Aesthetic
b. Functional/Operational
c. Sustainability

a. Aesthetic

Description

This section discusses aesthetic betterments for BRT systems, which can include design, art and architecture. Betterments are not part of the BRT project unless paid for by a third party. Betterments may be developed in partnership with the local city, and may be implemented if funding is available. Aesthetic betterments can increase the perceived quality for transit riders and the community, which can lead to additional benefits related to user behavior and ridership. Also refer to the Branding chapter for further guidance on branding and design.

Guidelines for Implementation

- Aesthetic betterments, by definition, are optional and not required for safety or basic operations.
- Aesthetic betterments should be developed in partnership with the local city.
- Aesthetic betterments should be coordinated with the built environment and the community.
- Art is commonly integrated into transit stations to provide a sense of place, to create quality spaces, and to influence how people perceive and connect with the system.
- Public art should provide clear sight lines between waiting transit passengers and transit vehicles.
- Public art installations should not create areas of concealment
- It may be appropriate for some betterments to be implemented by the local city.

Refer to Chapter 7.2, Section 10 for additional guidance on public art. Also refer to Station chapter for further guidance about art at stations.

Opportunities and Challenges

Opportunities

> Aesthetic betterments can clearly differentiate BRT from standard bus service, and contribute to the branding of the BRT system.

> Aesthetic betterments can increase customer loyalty, employee satisfaction and retention, and brand value.

> An attractive and compelling BRT system can help attract new economic development.

> An aesthetically pleasing BRT system may be better received by local residents and business owners.

Challenges

> Funding may not be available for initial capital costs and/or maintenance of aesthetic betterments.

b. Functional/Operational

Description

This section discusses functional and operational betterments for BRT systems. BRT covers a broad range of design options and can resemble standard bus service or light rail transit, and everything in between. Functional and operational betterments include any measures that reduce trip travel time, by removing friction during boardings and alightings or removing conflicts with vehicles and pedestrians between stations. Betterments can include technical enhancements to fare collection systems, control center management, upgrades to the computer aided dispatch and automated vehicle location (CAD/AVL) system, or signal timing, for example. It can also include physical improvements such as fare paid zones, dedicated lanes, exclusive guideways, Class I bike paths, or grade separated crossings. Betterments should be developed in partnership with the local city, and may be implemented if funding is available. Also refer to System chapter for further guidance on technology components that can support operational betterments of BRT services.

Guidelines for Implementation

- Functional/operational betterments, by definition, are optional and not required for safety or basic operations.
- The feasibility of functional/operational betterments will depend on the existing right of way, existing utilities, existing driveway locations, and potential impacts to traffic and parking.

Opportunities and Challenges

Opportunities

> Functional and operational betterments improve the efficiency of the BRT system.

> Functional and operational betterments may enhance the user experience on the system.

> Functional and operational betterments may have compounding benefits, such as increased safety, reduced total vehicle miles traveled, reduced emissions and reduced noise.

Challenges

> Funding may not be available for initial capital costs and/or maintenance of functional/operational betterments.

> Functional/operational improvements may require the removal of existing public features such as on-street parking, driveways, or sidewalk space.

c. Sustainability

Description

This section discusses sustainability betterments for BRT systems. In the context of BRT, sustainability refers to avoidance of the depletion of natural resources. Sustainability betterments can include the use of recycled materials during construction, reducing the amount of water and disposable items used by the system, reducing the urban heat island effect, low impact development, Green Streets elements, and enhancements to pedestrian and bicycle infrastructure. Betterments should be developed in partnership with the local city, and may be implemented if funding is available.

If pavement modifications are required as part of the BRT project, the use of cool pavement should be considered. The Green New Deal for Los Angeles includes reducing the urban/rural temperature differential by at least 3 degrees by 2035. Improvements such as planting of shade trees, installing new landscaped parkways, stormwater capture, shade structures and cool pavement can help to achieve this goal.

See Chapter 7.2 BRT Station/Platform for additional guidance on sustainable measures that can be implemented in station areas.

Guidelines for Implementation

- Sustainability betterments, by definition, are optional and not required for safety or basic operations.
- Sustainability betterments should be developed in partnership with the local city, and be consistent with local and regional standards and goals.
- It may be more appropriate for some sustainability betterments to be implemented and maintained by the local jurisdiction.

Opportunities and Challenges

Opportunities

> BRT sustainability betterments may provide an opportunity for cities to meet established sustainability goals and help reduce the urban heat island effect.

> Sustainability betterments typically provide cost savings over the long term.

Challenges

> Funding may not be available for initial capital costs and/or maintenance of sustainability betterments.

> Sustainability betterments may involve emerging micromobility options, and include an element of risk.

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4
BRT ITS Systems

Technologies and data play an increasing role in defining how, when, and why we interact with mobility options. The ITS design guidelines in this section discuss a wide range of technologies and systems that can be deployed for BRT. Some guidelines refer to traditional ITS elements that are already widely deployed and used for BRT, and others look at more emerging elements that are in planning, pilot, or initial deployment phases. ITS elements are grouped and discussed in this section following the categories below. Required elements must be deployed with a BRT system, while optional may be applied depending on the specific characteristics or needs of the BRT system under consideration. Some elements in this section are listed as optional but strongly encouraged and should be deployed if feasible.

1 General

REQUIRED

2R Roadside Elements

3R Stations

4R Vehicles

5R Control Center, Operations & Data

OPTIONAL

2O Roadside Elements

3O Stations

4O Vehicles

5O Control Center, Operations & Data

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1 General

a. Metro Standards
b. Roadside Elements
c. Stations
d. Vehicles
e. Control Center, Operations & Data

a. Metro Standards

Technologies and data play an increasing role in defining how, when, and why we interact with mobility options. For purposes of these guidelines, the collection of technologies and information systems are described as Intelligent Transportation Systems (ITS) elements. From the perspective of BRT, ITS supports all aspects of a transit trip from planning the trip in the first place, receiving timely and accurate information on the status of the bus system, promoting the progression of the bus in dedicated and shared rights-of-way, enhancing safety, and improving operational efficiency and performance monitoring. An effective BRT system will draw extensively from ITS to provide a distinctive and more convenient transit option when compared with regular fixed route service. In order to accomplish this, BRT systems need to leverage existing technologies deployed for the broader operating fleet, deploy new technologies that enhance customer perception and usefulness, as well as make extensive use of both existing and new technologies to operate more effectively. The ITS design guidelines in this section discuss a wide range of technologies and systems that can be deployed for BRT. Some guidelines refer to traditional ITS elements that are already widely deployed and used for BRT, and others look at more emerging elements that are in planning, pilot, or initial deployment phases.

Table 1 provides a summary of required and optional BRT elements. This table can be used as a shortcut to reference the more detailed guidelines sections. Users of this document not familiar with ITS applications for transit and BRT are recommended to review the general overview section first before proceeding to the more detailed descriptions.

Within Table 1, each element or related functionality is listed in rows and grouped under whether the element is: (a) focused on improving operations, travel times, and reliability; or (b) focused on improving customer information and experience for BRT. For each area a reference is provided for more detailed descriptions that can be reviewed. Each referenced description describes the element, prerequisites, roles and responsibilities, related BRT standards, and basic requirements. For some elements, references and required/optional status may be listed under one or more groupings to the right:

> Roadside/Station – Notes if the element has required or optional components that would be placed at a roadside (e.g. signalized intersection or along a guideway) or at a station.

> Vehicle – Indicates if the element has key functions or components located on the BRT vehicle.

> Central System – Applies if the element contains functions within the control center, operations, data analytics or non-station specific customer information areas.

Technology Functions Areas of Improvement	Section	Roadside / Station	Vehicles	Central System
IMPROVED OPERATIONS TRAVEL TIMES & RELIABILITY				
Transit Signal Priority (Bus Signal Priority)	2-R a)	Required	Required	Optional
CAD-AVL & Vehicle Tracking	4-R a) & 5-R a)		Required	Required
Fare Payment & Validation	4- R b) & 3-O a)	Optional	Required	Required
Schedule & Headways Management & Active Headway Management	4-R c) & 5-R b)		Required	Required
Voice & Data Communications	4-R d) & 5-R c)		Required	Required
Passenger Counters	4-R e)		Required	
Business Intelligence & Performance Metrics	5-R f)			Required
Guideway Control & Management	2-O b)	Optional	Optional	Optional
Access Control	2-O c)	Optional		
Ramp Meter Interrupt	2-O d)	Optional		
Transit Lane Enforcement	2-O a)		Optional but Strongly Encouraged	Optional but Strongly Encouraged
Connected Bus	2-O e) & 4-O a)	Optional	Optional	
Autonomous Vehicle Control/Driver Assist Systems	4-O b)		Required	
Vehicle Health	4-O c)		Optional but Strongly Encouraged	Optional but Strongly Encouraged
Video Live Look-In	5-O a)		Required	
Yard Management	5-O c)		Optional but Strongly Encouraged	Optional but Strongly Encouraged
IMPROVED CUSTOMER INFORMATION & EXPERIENCE				
Security Elements	3-R a)	Required		
Real-Time Customer & Wayfinding Information & Customer Information	3-R b) & 5-R e)	Required		Required
Help Points	3-R c)	Required		
On-Board WiFi	4-O d)		Optional but Strongly Encouraged	
Arrival Prediction	5-R d)		Required	Required
Active Lighting Control	3-O b)	Optional		
Customer WiFi & Charging	3-O c)	Optional		
Technology Support Elements	3-O d)	Optional		
Digital Advertising	3-O e)	Optional		
Supporting Mobility as a Service	5-O b)	Optional		Required

Required **Optional but Strongly Encouraged** **Optional**

Table 1. Summary of Required & Optional BRT ITS Elements

For some elements, it may be necessary to look-up references under separate categories based on interest. For example, some elements include vehicle and central system elements, and while there is some overlap in the individual descriptions, they consider the particular focus on the vehicle versus central systems. Sometimes the method of implementation may dictate whether or not an element has been indicated as optional or required. For example, Transit Signal Priority must include functions and components for the roadside and the vehicle, but it may also utilize a central system functionality to enhance capabilities. These details are discussed under the individual descriptions. Some elements are listed as options as they only apply when the physical infrastructure and BRT characteristics dictate it. For example, ramp meter interrupt is only applicable when the BRT will either use bypass lanes on freeway ramps or run in the outside shoulder/transit lane under certain operating conditions.

In some cases, the BRT ITS elements required have already been deployed for the broader transit bus fleet(s). However, BRT may recommend some additional or enhanced functions within those areas, so even areas where the agency has deployed systems should be reviewed.

It is crucial that ITS elements be integrated with the broader BRT concept including station design, runningways, and operational concepts in order to be fully effective. Figure 1 provides a high-level system architecture of the ITS elements that relate to BRT development and on-going operations. The full range of ITS design guidelines is discussed on the following pages based on the general area in which it is applied. For ITS elements, there is no distinction between full and lite BRT development levels as the development levels generally apply to both. A full BRT may make broader use of the same concepts and technologies, but this is independent of whether they are required or optional by the standards.

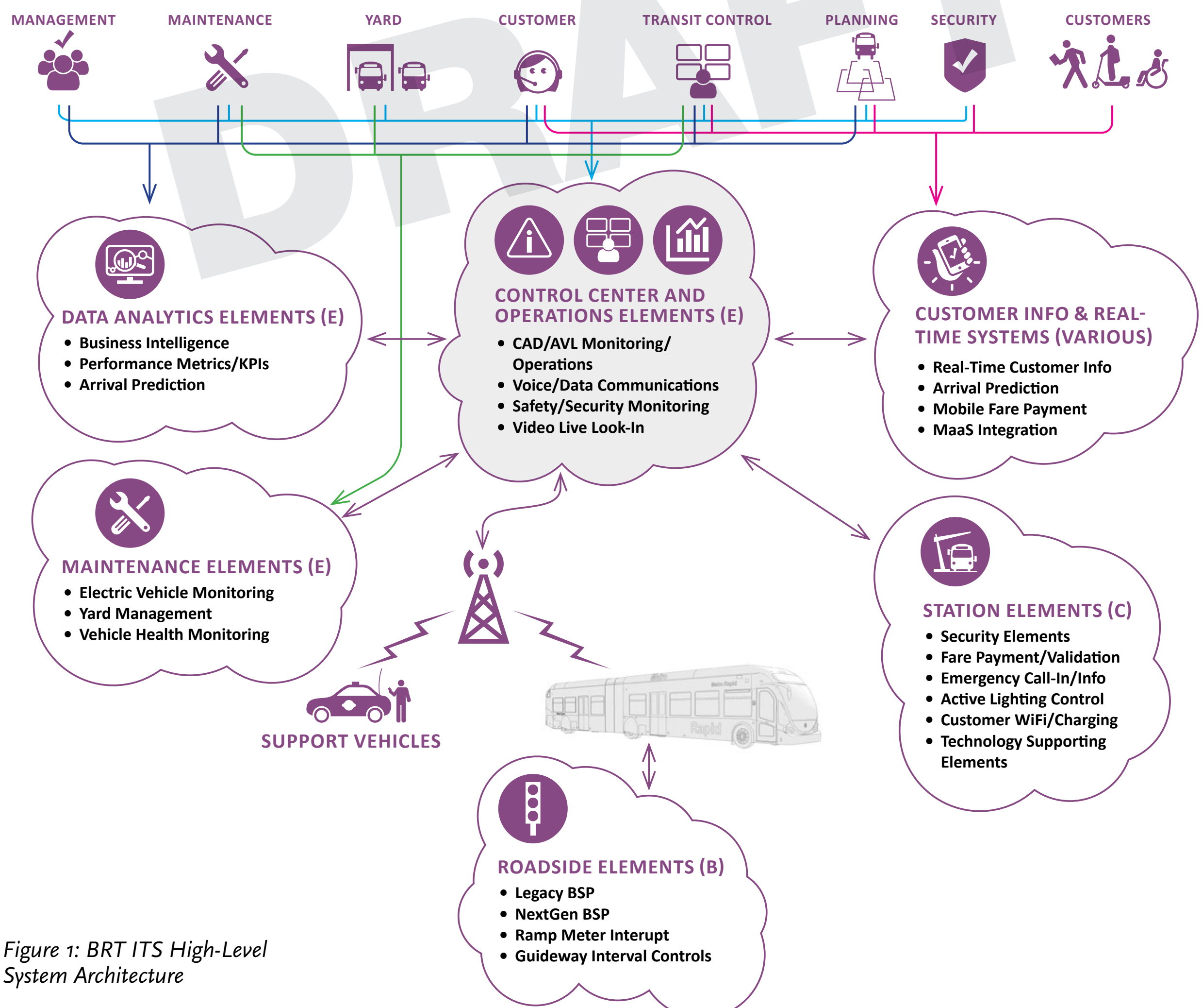


Figure 1: BRT ITS High-Level System Architecture

b. Roadside Elements

These ITS elements are used to enhance BRT operations and safety in mixed flow, freeways/ expressways, and dedicated runningways. These technologies allow BRT vehicles to communicate and integrate with roadway facilities across a broad range of functional areas.

- *Transit Signal Priority (TSP):* Also referred to as Bus Signal Priority (BSP) - Allows communications between BRT vehicles and traffic signals along the route to allow priority for transit vehicles over other non-emergency vehicular traffic.
- *Guideway Control & Management:* Provides operational guidance, restrictions and guideway flow management to runningways based on type of vehicle, time of day, priority rating, etc.
- *Access Control:* Process during which a transit vehicle gets granted access to a runningway, a transit lane, transit center, shared streets, or other specialized facility.
- *Ramp Meter Interrupt:* Similar to TSP but places a temporary hold on ramp meter lanes in order to allow priority access to transit vehicles either entering via an HOV/transit ramp lane or using an outside shoulder/ transit only lane.
- *Transit Lane Enforcement:* A combination of technology and in person monitoring processes that aim to ensure priority lanes are not being used or occupied by non-priority vehicles.
- *Connected Bus:* The ability of a vehicle to communicate and share information with surrounding roadway infrastructure and technologies using Connected Vehicle standards and protocols.

c. Stations

These ITS elements are deployed to support customers accessing station locations by enhancing available information, safety, and improving overall comfort and customer perceptions. BRT stations should utilize technologies and information that is integrated with the design and layout of stations to provide an enhanced experience beyond that of a typical bus stop. Figure 2 provides a high-level systems architecture and typical layout of ITS station elements and functions.

- *Security Elements:* A set of technology features and functions (such as video surveillance systems, video analytics, emergency blue light phones, smartphone security applications, etc.) that help enhance customer and operator safety, as well as the perception of safety.
- *Real-time Customer and Wayfinding Information:* The ability to provide instantaneous information to customers about schedule, service disruption, next bus arrival prediction, cost, etc. through on-site electronic signage of various types and supporting customer smartphone applications.
- *Active Lighting Control:* System that allows for various advanced lighting management and control, including adjusting lighting based on conditions and time of day, increasing lighting intensity and coverage when security concerns are present, actively changing lighting colors or activation sequences in emergency situations or to provide customer information (e.g. next bus is arriving).
- *Customer WiFi:* Amenity that allows transit customers to connect to the Internet with their mobile devices free of charge.
- *Technology Support Elements:* Allowances within the station design and equipment spaces to support emerging and future technology needs that enhance customer experience or provide for separate revenue generating opportunities (e.g. space for 5G microcell sites, USB power chargers, additional City or agency IT infrastructure, etc.).
- *Digital Advertising:* Multimedia advertising displays set up at transit stations to promote transit services and/or commercial ads.

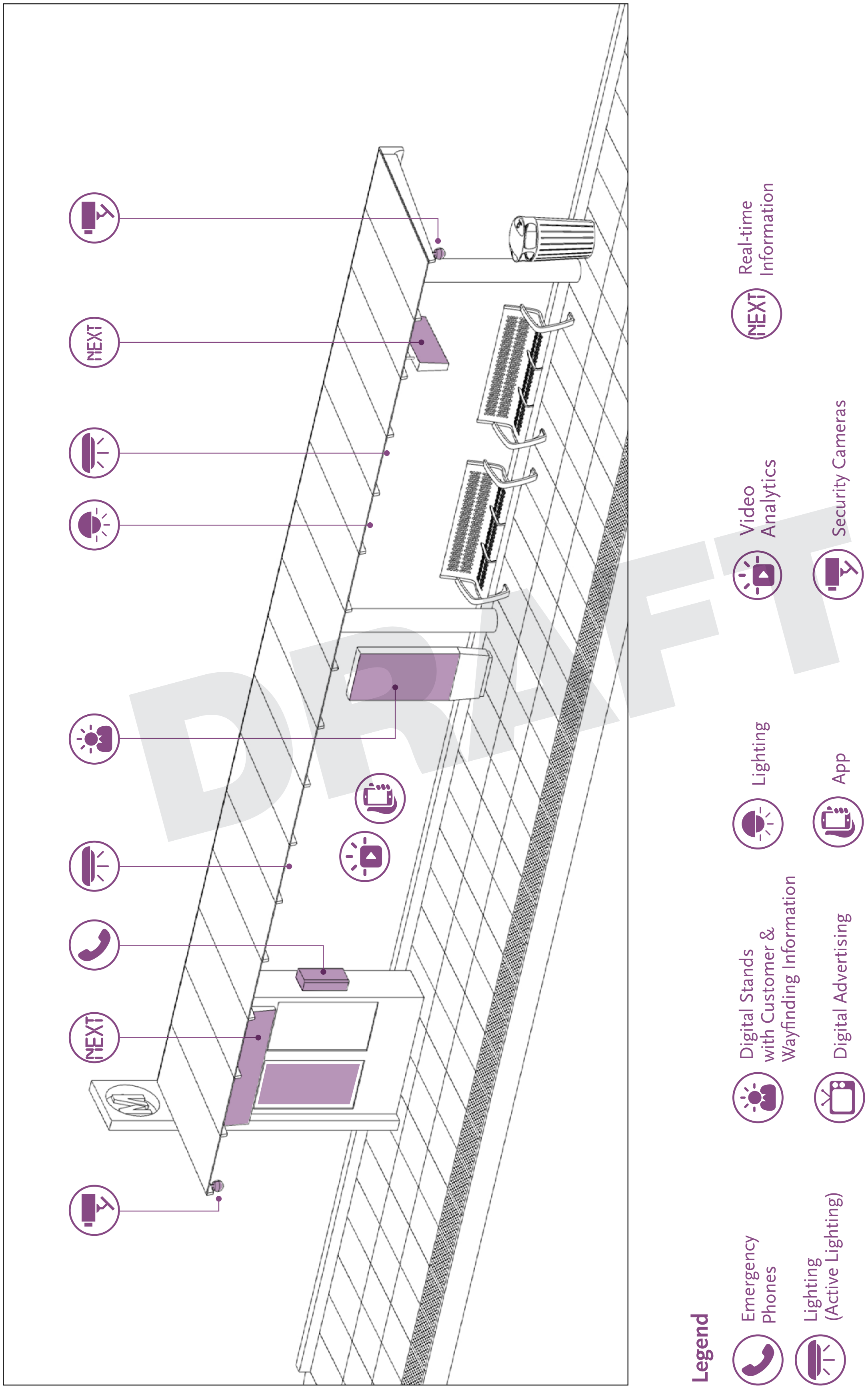


Figure 2: BRT ITS Architecture Overiview and Example Layout

d. Vehicles

BRT vehicles need to be able to both leverage fleetwide technologies deployed across an agency, as well as support the unique needs of BRT operations. Figure 3 provides a functional overview of various ITS elements that may be supported on a BRT vehicle. It should be noted that most ITS elements and functions must exist on the vehicle and as part of central operations in order to be effective. Some elements may appear as central, vehicle, and/or station-related elements.

> *On-Board Architecture:* Includes on-board systems architecture for the specific devices, programs, and parameters used in transit vehicles support operations, customer information, safety, Bus Signal Priority (BSP), and related needs.

> *Vehicle Tracking:* Functions that allow operators and customers to know where a transit vehicle is located.

> *Fare Payment & Validation:* In-vehicle system that collects fares and/or validate tickets. Includes the location of these devices, and the type of payment that can be processed.

> *Schedule & Headways Management:* Technologies and processes that tracks how transit vehicles arrive at stations on schedule and within target headway ranges, including feedback to operators on their current status relative to schedules or headway.

> *Voice & Data Communications:* On-board components of systems and technologies that support the quick and effective transfer of audio, video and data information between vehicles, operations centers, and customers.

> *Connected Bus:* The ability of a vehicle to communicate and share information with surrounding vehicles, infrastructure, and riders using Connected Vehicle standards and protocols.

> *Autonomous Vehicle Control/Driver-assist Systems:* Programs that assist drivers by supporting some vehicle control functions and providing supplemental warnings about surrounding traffic and safety concerns.

> *Vehicle Health:* Onboard feedback system that informs operations of vehicle status, health, and maintenance needs. This includes electric vehicle health and charge status monitoring.

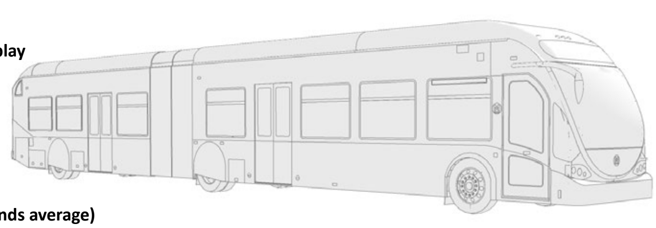
> *Passenger Counters:* Devices that allow to compile ridership information, and particularly how many board or leave a vehicle at a given station.

CUSTOMER FACING FUNCTIONS

- Internal/External Audio Visual Announcement
- Fare Validation/Payment
- Public WiFi
- Multimedia On-Board Display

VEHICLE FUNCTIONS

- Vehicle Tracking (<10 seconds average)
- Schedule Adherence
- Vehicle Health Monitoring
- BSP Legacy
- Electric Vehicle Monitoring
- Passenger Counts and Loads
- Video Surveillance System
- Video Live Look-In
- Connected Vehicle (V2I, V2V)
- Vehicle Safety Systems
- Video Analytics



COMMUNICATIONS FUNCTIONS

- Voice Communications
- Frequent/High Bandwidth Data Communications
- Ethernet/IP Architecture with Mobile Router
- Yard/WiFi Communications
- Connected Vehicle

BRT SPECIFIC FUNCTIONS

- Headway Management
- BSP Next Gen Ready
- Guideway Interval Controls
- Driver Support/Automation

Figure 3: BRT ITS Vehicle Elements and Functions Overview

Note: There is no distinction for ITS functions between Full BRT and BRT Lite.

- > *Bus Signal Priority (BSP):* Functions that support intersection signal priority for transit.

e. Control Center, Operations and Data

Like all fleet operations, BRT operations should be supported by effective dispatching, operations and control, and event/emergency response services. These are coordinated out of command and control center often known as the OCC (Operations and Communications Center) or BOC (Bus Operations Center). BRT services should receive a higher level of overall monitoring and supervision than typical fixed route bus services to accommodate higher performance expectations and recover more quickly from service interruptions.

- > *CAD/AVL:* Fleet management and tracking system that allows operators to monitor a vehicle's whereabouts and to properly take action in case of service interruption, delaying event or acute demand.
- > *Active Headway Management:* Processes that ensure service reliability and equal frequency of service along a route via diverse interventions limiting or increasing access to particular running ways in order to slow down or speed up travel flows.
- > *Voice & Data Communications:* The center based component of voice and data communications to support BRT operations; usually including communications between operators, dispatchers, maintenance, field supervisors, and sometimes security personnel or emergency services.
- > *Video Live Look-In:* Technologies and systems that allow direct streaming of video and audio content from transit stations and vehicles to an operations or security center.

BRT operations have many data analytics needs in common with typical fixed route services, but there are also unique needs based on specific BRT operations and the expectations of higher levels of service. A BRT operation should be able to use data to proactively respond to service issues and interruptions, and work towards resolving those issues as quickly as possible.

- > *Arrival Prediction:* Use of frequent vehicle location information paired with schedule and enhanced prediction algorithms to provide improved arrival prediction.
- > *Customer Information:* Catalogue of information available to current and prospective riders, including schedule planning information, status updates, delays and other mobility services available at a given location.
- > *Business Intelligence & Performance Metrics:* Analytics datasets that can be used for performance tracking and guide policy decisions.
- > *Supporting Mobility as a Service (MaaS):* Technologies and infrastructures that can integrate Mobility as a Service options into the overall offer of public transportation services.
- > *Yard Management:* Tools to allow for the management, assignment, pull-in/pull-out of BRT vehicles (particularly where BRT vehicle types are unique and yard space is constrained).

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2R Roadside Elements

a. Transit Signal Priority

a. Transit Signal Priority

Transit Signal Priority (TSP), also referred to as Bus Signal Priority (BSP), includes methods to provide signal timing preference to transit vehicles and/or movements at signalized intersections used by transit vehicles. The end result is fewer red lights for transit vehicles and/or reduced signal delays along TSP enabled corridors. Figure 4 below shows the main components of TSP systems. There are several different technical approaches to providing TSP along a BRT corridor, including: passive signal priority with signal coordination adjusted for bus movements and speeds, active signal priority where a single bus communicates with a single signal to request and process priority, and corridor-based active signal priority

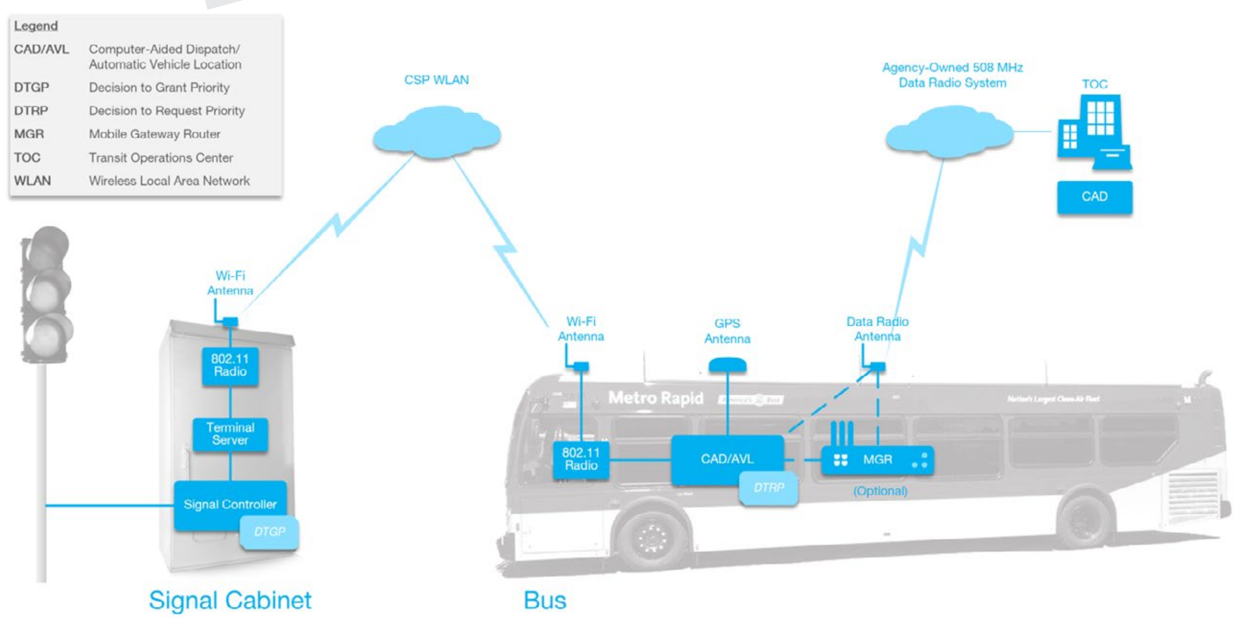


Figure 4: Transit Signal Priority Elements

REQUIRED

where multiple buses and multiple signals are communicating to determine priority requests and processing. TSP can be conditional based on a schedule adherence threshold, or simply configured to provide TSP based on headways and when the last priority request was granted. Various combinations of these approaches commonly exist within single corridors. Throughout the development of these guidelines, a wide range of transit and local agency stakeholders have reiterated the importance of signal priority in assisting BRT in reducing delays, increasing reliability, and establishing a higher level of service when compared with the rest of fixed route transit. Modern TSP approaches offer a broad range of configurability in terms of adjusting for levels of priority and avoiding specific impacts, and usually timing of individual signals can be adjusted to accommodate TSP without significant impacts to overall traffic.

Metro Standards

> *BRT-Lite:* Active signal priority should be implemented at 75% of signals.

> *Full-BRT:* Active signal priority should be implemented at 90% of signals.

> *Target:* Active signal priority should be established for all arriving buses.

Guidelines for Implementation

Pre-requisites

In order to be as effective as possible, there are several prerequisites for TSP, including:

- Reliable real-time communications from traffic signals to a central signal control or monitoring system for reporting and operations purposes.
- Frequent vehicle location updates from BRT vehicles to the TSP system; every second or less for BRT to signal communications, or every 7 seconds or less for cloud-based or corridor center-to-center systems.
- Agreements with the agencies managing signals to provide some level of reasonable priority to BRT vehicles along a corridor. Actual settings for TSP can vary from intersection to intersection but the maximum allowed extension or early green should generally be at minimum 10% or more of the typical signal cycle length.

Roles and Responsibilities

Most of the responsibilities for TSP will fall to the local agency controlling the signals and the transit operations agency. In some cases this may also include Caltrans, or involve partnerships between various transit operators (e.g. Metro and municipal partners). In general, responsibilities include:

- *Transit agency* – Providing for needed signal system and communications upgrades to BRT corridors, and on-going operational support budget for maintenance and monitoring. Also providing necessary equipment and supporting communications from the BRT vehicles to the TSP system, systems for placing TSP requests to the signals, and data analytics tools for managing TSP performance.
- *Local agency* – Typically, implementing or overseeing implementation of TSP improvements to signal systems and communications, supporting TSP configurations in signal timing, implementing timing adjustments, monitoring signal operations, and repairing signal related TSP equipment. In some cases, the transit agency takes on a larger more collaborative or supportive role (particularly if the local agency is small or resource constrained).
- *Contractor* – Often a consultant is hired to support the identification of TSP equipment and suggesting TSP configurations, as well as supporting initial implementation testing and oversight.

REQUIRED

Requirements

Functional

- Track BRT (every 1 to 7 seconds depending on system) vehicles to determine location, schedule status (if conditional TSP is used), and headways/bunching. Note: It is not recommended to use on-board passenger loads as part of the TSP request process, as vehicles may be approaching a heavy boarding or transfer location and arrival at that location is just as time critical as moving on-board passengers.
- Provide real-time communications from signals and between signals to a central signal management system for monitoring purposes.
- Enable the latest bench tested or proven TSP functionality within the signal controller logic. It is assumed that signal controllers will be upgraded to the latest standards possible to support TSP.
- Support a corridor-based or cloud-based TSP solution where possible as the latest emerging approach for TSP.
- Provide a TSP performance monitoring and metrics generation tool (will vary by specific solution) that can be accessed by the transit operators and signal agencies.

Physical

- Support each of the three current/emerging TSP architectures in the LA Region as appropriate to the BRT corridor in question:
    - *RFID – Legacy ATSAC based solution* – Largely utilized for legacy Rapid services this system uses a transponder on the bus paired with detection loops and specialized ATSAC signal controller logic to provide TSP. Schedules for the buses must be upload to the signal system in order for it to operate properly.
    - *WiFi – Legacy Countywide-based solution* – Currently in deployment and utilized for some BRT corridors, this approach uses 802.11b/g WiFi communications with a defined communications/data protocol to place the TSP requests to signals. This approach supports several signal controller types. It is important to ensure that the WiFi coverage is comprehensive along the TSP corridor and that interference is not an issue. It is assumed that upgrades will occur over time to this approach to support newer WiFi standards such as 802.11n or 802.11ac.
    - *Cloud-based TSP as a Service (sometimes referred to as BSPaaS)* – Recommend approach for LA Metro Next Gen BRT, this approach uses frequent vehicle location updates communicated to cloud-based logic that then sends requests and TSP processing communications to the signal system. This can take more of a center-to-center process approach, or it can be framed to support individual buses locating position to the cloud and communications to individual signals. Communications latency can be a concern. Also, connected vehicle applications can be overlaid to support TSP as well.
- Even where communications from the BRT vehicle is near-continuous, dedicated lanes and guideways will require backup detection methods to allow non-BRT vehicles (e.g. maintenance vehicles) to be detected and processed properly by signals.

Other Recommendations

The specifics of TSP will vary from location to location, but it should be part of any BRT deployment in the county. The level of potential signal delay on a corridor should be reviewed to consider what impacts TSP may have, and it should be anticipated that TSP functionality cannot reduce signal related delays by more than 20%. The concept of providing priority to BRT and vehicles carrying more people than SOVs is sound and will continue to improve over time. However, the time savings of TSP are frequently difficult to identify as they are rendered invisible under other factors that impact transit travel

REQUIRED

times and delays in a varying fashion. TSP should be generally monitored based on the number of red signals encountered by BRT vehicles with it enabled vs. disabled rather than the on-time performance results.

Where BRT operates in a dedicated median runningway, it is recommended that advanced signal controller logic, peer-to-peer logic, or signal interval control be used to reduce signal related delay. These approaches take advantage of the dedicated runningway conditions to provide estimated time of arrival to the signal system and adjust timing well in advance of the BRT arriving at an intersection (allowing more sophisticated TSP actions).

Opportunities and Challenges

The following concepts and trends promise to have a significant impact on TSP approaches and effectiveness:

Cloud-based Solutions

The power and flexibility of cloud based computing and communications solutions offers to simplify TSP implementation and lower costs. A cloud- based TSP computing algorithm can receive frequent BRT vehicle position updates and process signal information provided by the signal/signal systems. This allows for more sophisticated adjustments of signal timing and BRT vehicle speeds to increase effectiveness and lower impacts.

Bus Interval and Signal Control

Building on a cloud-based approach, bus interval and signal control seeks to manage bus headways through providing speed notifications to operators or controlling BRT speeds in dedicated runningways. Operators still maintain override and directional control of the vehicle. Intervals are placed within the signal timing of the corridor to provide optimal windows for BRT passage from station to station with lower chances of red lights, and active TSP functionality makes minor adjustments where vehicles are slightly off from the planned intervals.

Automated and Connected Vehicles

Automated and connected vehicle functionality will increase vehicle safety and provide a broader range of options for TSP. Ultimately, when a wide range of the vehicles on the roadways are connected and autonomous, then prioritization of BRT traffic over other traffic can be accomplished through virtual lanes and systemwide prioritization of traffic flows by types.

Other Related Elements

The following concepts and trends promise to have a significant impact on TSP approaches and effectiveness:

> Operating Characteristics - Service Parameters and Strategies

> Running Way Design - Traffic Operations

Reference Documentation

The following documents may prove useful as references for TSP consideration in the county:

> LA Metro Next Gen BSP Study

> Metro BRT Design Guidelines

REQUIRED

3R Stations

a. Security Elements
b. Real-time Customer & Wayfinding Information
c. Help Points

Typical BRT Station / Source: IBI Group

Security Camera / Source: IBI Group

a. Security Elements

Security elements at stations include equipment that supports individuals' safety from vehicles, and from criminal acts. It entails primarily the ability to see and be seen. It helps promote the perception of safety for transit customers, and can lower agency risks and liability. It includes lighting, surveillance cameras, and communication systems such as emergency phones. It also relates to the use of safety mobile applications such as the LA Metro Transit Watch application. The guidelines described below are applicable to other transit service infrastructures, and not only to Bus Rapid Transit.

REQUIRED

Metro Standards

> *BRT-Lite:* 75% of all stations should be equipped with security cameras and provide adequate lighting.

> *Full-BRT:* 90% of stations should be equipped with security cameras and provide adequate lighting.

> *Target:* 100% of stations should be equipped with security cameras and provide adequate lighting.

Guidelines for Implementation

Pre-requisites

- *Cameras:* Power and High-Speed/High-Bandwidth communication as well as a video monitoring system application. There needs to be on-site storage or supporting remote storage solution.
- *Lighting:* Refer to the Stations chapter for guidance about lighting design.
- *Emergency Phones:* Phone line or supporting communication system associated with a physical address. It also needs an ADA compliant mounting location. It also requires a call/dispatch center to receive communications. The system also requires either solar/battery or wired power.
- *Mobile Application:* Security/Customer response center to receive and process messages and requests.

Roles and Responsibilities

- *Cameras:* The transit agency needs to provide a security/surveillance operation center for monitoring video and alerts as well as supporting staff to review historical data and maintain camera equipment and systems.
- *Lighting:* On station and platform lighting monitoring and maintenance should be addressed by transit agency or subcontracted third party. Issues with surrounding public lighting should be monitored by the transit agency or subcontractor and handled by the appropriate local jurisdiction.
- *Emergency Phones:* Emergency phones should be maintained by the transit agency or subcontractor and calls from the phone should be directed to the agency transit safety/security operations center. Calls identified as an emergency should be relayed to the appropriate emergency dispatch center.
- *Mobile Application:* The mobile application should be maintained by the transit agency or subcontractor and messages from the application should be directed to the agency transit safety/security operations center. Messages identified as an emergency should be relayed to the appropriate emergency dispatch center. Customer issues and complaints can be directed to Customer Service.

Requirements

Functional

- *Cameras:*
  > *Coverage:* For platform, coverage should include the platform itself, the approaches to the platform, the boarding/alighting area. Continuous coverage should be applied to ticketing machines and emergency phone areas. Ideally, camera coverage would also include parking lots, walkways, dedicated guideways, and all right-of-way areas surrounding the stations.

  > *Resolution:* Resolution should be high definition 1080p or better.

  > *Storage:* General on-site or remote storage for all cameras should meet or exceed 30 days (after 30 days compressed).

  > *Video Analytics:* Consideration should be given for applying video analytics for camera views that cover the platform and boarding areas. Video analytics would be used to identify abnormal behavior or conditions to alert transit operations and security staff to focus on a particular camera feed or situation. Due to emergent privacy concerns, facial recognition is not recommended at this time.
- *Lighting:* Refer to Section 7.2 Stations/Platforms Lighting Design Guidelines.

REQUIRED

- *Emergency Phones:*
  - > *User-friendliness:* The emergency phones should support hands-free operations and may include direct connection to both information and emergency services.
- *Mobile Application:* The application should allow for easy and rapid access to security alerts, particularly if integrated with other transit information features. It should use symbols and language consistent with local transit communities. It should provide an accessible form to submit incident report, and the ability to receive alerts. Consideration should also be given to integrate geolocation.

Physical

- *Cameras:* Devices should be integrated with the shelter kit-of-parts and station design so they are visible but do not adversely impact the aesthetics of the site. Typical views and sight lines of cameras should be modeled for various station layouts. Individual cameras should be Ethernet/IP and POE. A mixture or PTZ and fixed-field view cameras may be utilized. Camera mounting locations and enclosures should consider glare throughout the day and device security and environmental protection needs.
- *Lighting:* Refer to Section 7.2 Stations/ Platforms Lighting Design Guidelines.
- *Emergency Phones:* Phones need to be mounted following ADA compliance requirements, and be wheelchair accessible. They can either be mounted separately or attached to other station elements. However, they need to be clearly visible and identifiable (such as the blue light system). See Figure 5 for installation details.
- *Mobile Application:* The application should be compatible on both Apple and Android devices.

Other Recommendations

In the case of pre-paid fare zones, designing secure pre-paid areas may be effective at limiting criminal activities and loitering.

Homelessness and loitering being a common issue at stations, security features are essential to make sure customers are safe and feel comfortable using BRT. Stations should be open and limit blind spots and opportunities for hiding. If motion-activated lighting is implemented, the system must be sensitive enough to detect most noises and movement.

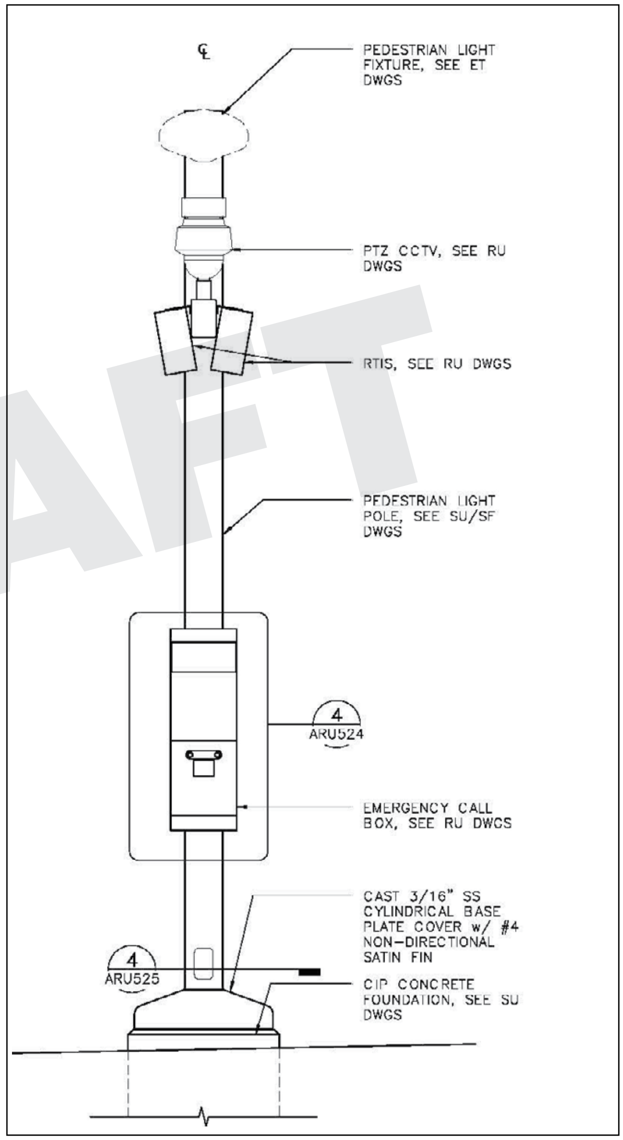


Figure 5: Installation Guidelines for Emergency Phones

REQUIRED

Opportunities and Challenges

Video Analytics

Recent improvements to video technology now allow for a wide range of data collection/analysis, safety/alerts, and operations monitoring, providing major advancement for safety and curbside management at stations. Video analytics can be a useful way to identify out-of-the-ordinary situations or incidents and make more efficient use of staff monitoring video feeds.

Security features should be context specific, be mindful of neighbors and take into consideration light pollution when planning for light installations.

Accessibility

Potential challenges exist in the accessibility of emergency phones and other hardware in instances where transit stations are busy and subsequently have high pedestrian volumes.

Other Related Elements

> Stations/Platforms - Lighting

> Stations/Platforms - Systems Components

> Stations/Platforms - Station Footprint and Placement

> Stations/Platforms - Shelter Design

> Integration of Transit-oriented Communities - Public Realm/Open Space

REQUIRED

Real-time Customer & Wayfinding Information / Source: IBI Group

b. Real-time Customer & Wayfinding Information

Real-time customer information refers to the ability to provide up-to-date information to riders regarding service, schedules, arrival predictions, and service alerts. Posted schedules cannot deliver critical information regarding transit delays, therefore real-time bus arrival information is critical. While most users carry mobile devices, real-time information dissemination provided by transportation agencies on fixed equipment at the station provide consistent and accurate information to customers, easily and with equity. Station displays can also provide wayfinding information to customers, supporting multi-modal trips and first/last mile connections. Customer information and wayfinding panels are a requirement at all BRT stations. The methods of providing real-time customer information can vary, but BRT stations will typically include some mix of the following:

> Basic LED displays showing routes, arrival predictions for the next few buses, information about other travel services available, digital id, and significant service alerts.

> Multimedia LCD displays that provide service information, arrival predictions, more detailed service alerts and pending changes or announcements, information about other travel services available, digital id, as well as potential advertising or other information of customer interest (e.g. local news, community info, etc.).

> Low power electronic displays with static schedule information, information about other travel services available, digital id, and service announcements replacing the static posted schedules.

Depending on the transit agency guidelines and approaches, audio announcements are usually triggered by hitting a button located in an accessible area. Some BRT lines also support public address systems for real-time updates from operations centers. Finally, all BRT systems should support external announcements from the vehicle indicating route, direction, and end destination.

Metro has instituted an agreement with the third party provider that will provide advertising on rail station multi-media LCD displays, as well as provide real-time service information and updates.

This display is in addition to the traditional LED displays indicating next train arrivals and updates. The multi-media display is managed and maintained by the third party with Metro provided transit data feeds mixed with other third party data feeds. A similar approach could be used for BRT stations, but consideration has to be given for the jurisdiction in which BRT stations reside and any current advertising agreements that could be impacted.

REQUIRED

Metro has deployed LCD multimedia displays at rail stations via an agreement with a third party that mixes real-time transit information with advertising and related information

Metro Standards

> *BRT-Lite:* 75% of all stations should provide real-time information.

> *Full-BRT:* 90% of stations should provide real-time information.

> *Target:* 100% of stations should provide real-time information.

Guidelines for Implementation

Pre-requisites

- Shelter and station designs that support high-visibility for customer information displays, provide vandal protection for equipment, and support relatively easy access to equipment for maintenance.
- Wired or wireless communications to the stations.
- Source systems providing the data feeds and management for real-time customer information.

Roles and Responsibilities

- *Transit Agency* - The transit agency is primarily responsible for providing accurate and timely data to customer information displays, monitoring systems, and maintaining systems and equipment.
- *Contractor* - Contractors may be used to monitor and maintain customer information displays through a simple contracting arrangement or an advertising agreement.

Requirements

Functional

- Provide static schedule or headway information.
- Provide real-time arrival prediction with updates every 30 seconds or less.
- Provide service alerts for detours, delays, service cancellations, special service, and other related items.
- Provide communications connectivity from source data systems to customer information displays at BRT stations.
- Information provided via station based customer information should be consistent with information provided through other outlets such as smartphone applications.
- A common back office or cloud-based solution should be implemented that supports the passing of customer information to a wide range of sign types that may evolve over time. This system should be a common source for supporting NTCIP compliant signs, and support templates that can be modified to support various types of electronic displays and information feeds. Interfaces to customer information signs should be vendor agnostic.

Physical

- Video screens or VMS must be mounted in a space visible and accessible to the greatest number of customers at any given time. Consideration must be given to impeding pedestrian circulation.
- Sufficient power to run variable message signs or screens as well as communications infrastructure.
- Adequate space to mount hardware and appropriate vandal protection for the mounting location. As a general rule, the enclosure should be able to survive a strike by a person swinging a baseball bat.

REQUIRED

- Communications WiFi or LAN infrastructure.
- Location of seating must be addressed in designing optimal placement of video screens.
- Where BRT platforms are integrated into larger transit stations, special BRT customer information displays should be provided at or near BRT platforms and BRT information integrated with broader information systems at the transit station.

Other Recommendations

As previously mentioned, Metro has initiated over the summer of 2019 the deployment of digital displays along the Blue Line.

Real-time customer information should be provided on similar displays at major BRT stops and transit stations. A consistent deployment of real time information infrastructure will serve to reinforce BRT branding; therefore the design of digital displays currently deployed along the Blue Line should be retained if possible. There should be minimal interruption to information display from advertising, or an integration of basic arrival updates onto the advertising slides. Displays should be visible and accessible from customer waiting areas. Consider developing displays using transit data; real-time arrival and departure, as well as schedule information, from LA SAFE's 511 system.

Real-time bus arrival times can be displayed using VMS signs; however the recommended approach is to invest in full screen digital displays where possible. VMS are character limited, while screen-based displays provide the flexibility for cross-purpose usage. With the use of digital displays, emergency information, PSAs, advertisements, and other content can be displayed when real-time information is not available or necessary. Care should be given that full screen displays (LCD or similar) comply with ADA requirements.

On site real-time customer information should be simple and concise. Unlike websites or mobile applications which can hold the user's attention for extended periods of time, the screen providing real-time information should provide only what the customer needs. Content may include a shortlist such as:

- Next three arrival times (in minutes from current time)
- Service disruption notifications
- Instructions for customers in case of emergency, such as a directive to call 911, or number for other emergency resources

For stops that do not include digital displays, information regarding ways to access information online should be provided. These may include vertical panels, or placards advertising the 511 telephone service as well as go511.com.

Opportunities and Challenges

Cloud Services, the Internet of Things, and 5G Technologies will improve Metro's ability to provide and update information with the least amount of delay possible. Cloud technology could furthermore reduce costs by avoiding storage, data management and other operational burdens. These technologies can also support the development of specialized applications that can provide a full range of information to transit users.

Opportunities can be realized in the cross-functional use of video screens. In case of emergency, real-time transit information may be replaced by content from emergency services.

Real-time information could be expanded to include *Mobility-as-a-Service (MaaS) and Transportation Network Cooperatives (TNCs)*, to offer fully integrated multi-modal services to commuters.

Connected and Automated Vehicles will also add to the agency's ability to provide real-time information to customers, by removing the "middle man", between vehicles and riders.

The threat of vandalism is a critical challenge to successful deployment of hardware such as digital display screens. Expensive equipment such as screens is susceptible to damage by the public, and may need to be housed in a protective container to ensure its safety.

REQUIRED

Other Related Elements

- > Stations/Platforms - Signage and Passenger Information
- > Stations/Platforms - Systems Components
- > Branding - Stations
- > Systems - Supporting Mobility as a Service
- > Systems - Vehicle Tracking
- > Systems - CAD/AVL
- > Integration of Transit-oriented Communities - First/Last Mile Connectivity

Reference Documentation

NTCIP standards for electronic signage

Local and State ADA codes and requirements

REQUIRED

Enhancing public safety through connectivity to NYC emergency and help points underground / Source: Transit Wireless

c. Help Points

Description

Help Points are stations being deployed throughout Metro's transit network. It allows direct communication between an individual and an operator in case of emergency. It may include emergency phone services, alarm buttons, or video alerts. It's imperative that access to emergency response is provided via a variety of methods, in case a single device is faulty or has been vandalized. There is overlap between this element and Security Elements; the efforts for both should be integrated and in alignment.

Guidelines for Implementation

Pre-requisites

- Emergency Phones: Phone line or supporting communication system associated with a physical address. It also needs an ADA compliant mounting location. It also requires a call/dispatch center to receive communications. The system also requires either solar/battery or wired power.
- There must be adequate accessible space dedicated to emergency phones, buttons, or other equipment.

Roles and Responsibilities

- Emergency Phones: Emergency phones should be maintained by the transit agency or subcontractor and calls from the phone should be directed to the agency transit safety/security operations center. Calls identified as an emergency should be relayed to the appropriate emergency dispatch center.
- Maintenance: Emergency phones must be quality checked for continued operation and maintained regularly.

Requirements

Physical

- Emergency Phones:
  - > User-friendliness: The emergency phones should support hands-free operations and may include direct connection to both information and emergency services.
- Signage in multiple languages should be posted at or near the communication device, easily visible by customers.

REQUIRED

Other Recommendations

Emergency call-in features should be prominent at stations and easy to access. There should be several Notification and call-in devices in the event that one of them is inaccessible or faulty.

Several transit agencies have implemented silent alarms system on vehicles, which allow anyone to promptly notify of an emergency, without letting the perpetrator know that law enforcement has been alerted. A similar system for stations could be considered to alert operators and increase video monitoring, and potentially alert the authorities and first responders.

Opportunities and Challenges

Video Analytics will play a pivotal role providing the ability to quickly alert operators or safety officers in case of emergency, giving them the ability to intervene quickly.

There have also been instances where devices using Artificial Intelligence (AI) Technologies have been implemented in public spaces such as transit stations to offer mobile surveillance system and emergency communication services with operators.

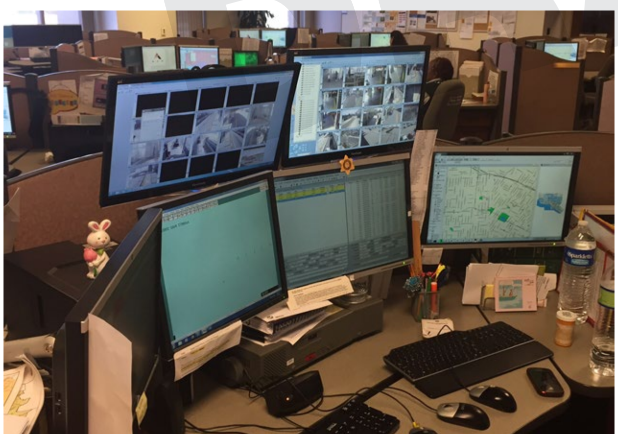
Potential challenges exist in the accessibility of emergency phones and other hardware in instances where transit stations are busy and subsequently have high pedestrian volumes.

REQUIRED

4R Vehicles

a. Vehicle Tracking
b. Fare Payment & Validation
c. Schedule & Headways Management
d. Voice & Data Communications
e. Passenger Counters

a. Vehicle Tracking



Vehicle Tracking

Vehicle Tracking

Description

Security elements at stations including equipment tracking BRT buses (usually via GPS-based automatic vehicle location-AVL solutions) is a fundamental requirement. Almost all transit operators in LA County utilize GPS-based solutions as part of a computer-aided dispatch-automatic vehicle location (CAD/AVL) system to track buses for operations, safety, customer information, performance monitoring, and schedule adherence purposes. Proper tracking can determine if buses are on-route, running hot, running late, or encountering other difficulties. Location updates are sent to the Bus Operations Center (BOC) where operations and communications with the fleet are managed. The most notable distinction between BRT and the

REQUIRED

rest of fixed route fleets is the necessity for very frequent location updates. This is particularly true of situations where BRT vehicles will use a Bus Signal Priority as a Service (BSPaaS) or improved arrival prediction systems. For example, whereas a normal CAD/AVL system using traditionally data radios may only support vehicle location updates of every 60 seconds or longer, newer systems using commercial cellular data or similar frequently support updates of every 10 seconds or less.

Metro Standards

While Metro BRT standards do not explicitly call out vehicle tracking, it is necessary to monitor and ensure that a service is meeting other standards established for BRT in LA County.

> *BRT-Lite:* Buses should be on time 75% of the time.

> *Full-BRT:* Buses should be on time 80% of the time.

> *Target:* Buses should be on time 90% of the time.

Guidelines for Implementation

Pre-requisites

All of the large and mid-sized transit operators in LA County utilize some version of a CAD/AVL system to support vehicle tracking and operations.

Roles and Responsibilities

The transit agency is fully responsible for providing and maintaining vehicle tracking functionality on BRT vehicles. Increasingly some Software as a Service options are emerging, but management and oversight would remain a transit agency responsibility.

Requirements

Functional

- All BRT vehicles must have vehicle tracking systems that at minimum include GPS/AVL that meets the following:
  - > +/- 10 feet accuracy
  - > 32+ channel GPS
  - > Built in gyro and/or dead-reckoning functionality
  - > Ability to track and record vehicle locations at least once every second
- All BRT vehicles that are deployed in service and use legacy TSP/BSP or (vehicle to intersection approaches to TSP) shall support vehicle location updates of every 1-2 seconds or less.
- All BRT vehicles deployed to support BSPaaS where the bus location is communicated to cloud-based TSP/BSP services shall support vehicle location updates and communications of those updates once every second.
- Where vehicle positioning is event driven, the collective events (e.g. stop arrival, stop departure, distance traveled, etc.) shall result in vehicle location updates of every 10 seconds or less.
- All vehicle location updates shall be timestamped and contain a recognizable vehicle ID.

Physical

- Transit agencies must deploy a CAD/AVL-based vehicle tracking solution on BRT buses.
- Should the agency desire to leverage existing fleetwide CAD/AVL solutions that cannot support the vehicle location update frequency noted above, then the agency should deploy supplemental vehicle location/tracking equipment on the BRT buses to support enhanced arrival prediction, TSP/BSP, and improved customer information. These more frequent updates are usually available through a Mobile Gateway Router (MGR) or another technology device on the bus (e.g. vehicle health tracking, etc.).

Other Recommendations

Vehicle tracking is a critical and required function for BRT, and should be deployed in such a way to allow frequent vehicle location updates to back-office/CAD/AVL solutions, as well as support frequent location updates for in-field communications and operations. As connected vehicle applications evolve, consideration should be given of what role vehicle location tracking plays in V2X functions, and which devices on the bus support the required vehicle location frequency and accuracy requirements. The guidelines above should be viewed as a starting point that is modified as necessary to support particular corridor cases.

Opportunities and Challenges

Service Coordination

The use of the same/compatible software by all transit agencies could lead to significant opportunities for service and transfer coordination. It could also create opportunities for transit agencies to share resources.

Connected/Automated Vehicles

The deployment of connected, and eventually automated bus fleets will allow for vehicles to be connected and tracked not only by operators but also by riders, infrastructure operators, and other users of the road. The progress done in those areas will further support Corridor Traffic Flow Prioritization, Bus Interval & Signal Control with Speed Management, the development of dynamic curbside and roadways, and the Reallocation of Roadway Cross-Section/ Complete Streets/Road Diets.

Other Related Elements

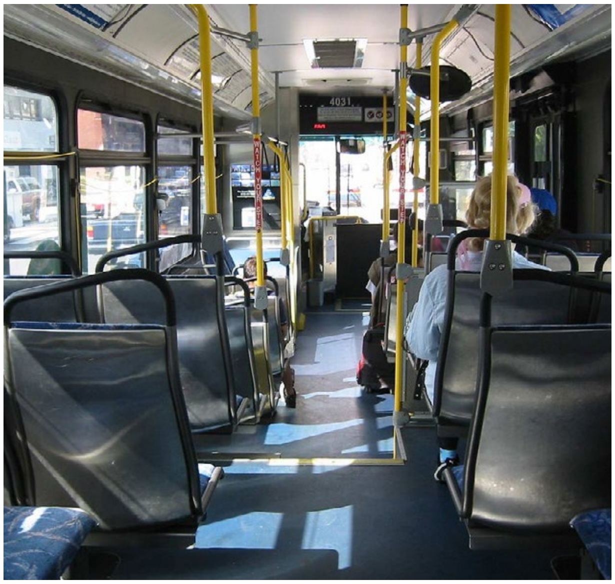
> Operating Characteristics - Service Parameters and Strategies

> Stations/Platforms - Systems Components

> Running Way - Traffic Operations

> Integration of Transit-oriented Communities - First/Last Mile Connectivity

REQUIRED



Fare Payment and Validation / Source: IBI Group

Fare Payment and Validation

b. Fare Payment and Validation

Fare payment and validation refers to the process of accepting and validating payment before and/or during boarding. It applies to the form of payment accepted as well as the location where payment is processed. LA County BRT standards call for all-door boarding for all station types. TAP is the regional smartcard transit fare system for LA County. This will generally imply one of the following:

> Ticket vending machines (TVMs) and smartcard validators at BRT stations

> Fareboxes supporting cash and TAP at the front door of BRT buses and TAP validators at all other doors

> No cash BRT router where riders must use mobile smartphone apps and/or TAP validation at any door

Any of the above would need to be supported by appropriate fare enforcement activities to ensure compliance with fare policies and payment. This usually includes fare enforcement personnel on the bus checking for valid forms of payment. The goal with BRT and all-door boarding is to reduce dwells and delays at stations involved in fare payment and processing, which can be a significant component in overall travel time for customers. It is likely that fare payment methods and processes will continue to evolve, as payment methods continue to develop in the broader payments processing industry, but roll-out of regional solutions usually occurs over several years, so region-wide upgrades may lag behind fare payment approaches that can be applied to individual agencies or corridors.

Metro Standards

> *BRT-Lite/Full-BRT/Target: All-door boarding for all stations.*

The standards do not require fare payment prior to boarding, and fare payment can occur either at the station and/or when boarding the bus. Paid fare zones may be designed at certain stations, which would require payment and validation to take place at specific entry points. There can also be in-person validation set up on board of vehicles by transit agency staff.

Guidelines for Implementation

Pre-requisites

If cashless operations is selected for a corridor, then other forms of obtaining electronic or smartcard fare payment methods must be in place. This could include placement of TVMs at all BRT stations or at some key locations. Transit operators may already have established fare box systems on board their broader fixed route fleet. These can be supplemented by smartcard validators and other means to support all door boarding.

Roles and Responsibilities

The transit agency maintains responsibility for installation, maintenance, and oversight of all fare systems both on- and off-vehicle. Maintenance functions and back-office are often contracted out or in the case of regional systems such as TAP, operated under agreement with partner agencies. Mobile smartphone fare payment apps are typically offered as a contracted service (such as SaaS) and can be set up with different arrangements for contractor reimbursement. The most common approach is for the contractor to "take" a certain percentage of the fare as part of the contracted arrangement.

Requirements

Functional

- BRT vehicles shall support TAP validation either prior to boarding or at all doors.
- BRT vehicles may support cash collection via a farebox at the front door only.
- Agencies must provide functionality to support fare enforcement and confirmation on BRT vehicles by transit enforcement of contracted enforcement personnel.
- BRT should support a mobile smart phone (e.g. either regional or local) for fare payment. Note: LA Metro rolled out a new smart phone app/TAP integration in 2019.
- BRT may support future fare payment options as a test case or consistent with fleetwide rollouts for the particular transit agency (e.g. NFC, QR code, etc.).

Physical

- If using prepaid zones at BRT stations, they should be clearly designated and represent a clearly enforceable prepaid fare zone.
- If TVMs are used, there should be redundant (min. of 2) TVMS within reasonable proximity of each other (e.g. two on the same platform or on paired platforms across the street, etc.) subject to cost and space constraints.
- If cash payment is allowed on the bus, then signage on the bus and at stations should clearly designate that cash payments board at the front door only.

Other Recommendations

BRT is an important regionally connected service and consistency across various agencies and services is important. BRT corridors must support the current and emerging approaches and processes of TAP, but may choose to support additional methods and approaches to fare payment. Ultimately, a situation can be foreseen within the timeframe of this BRT Vision where customers simply board the bus, and their presence on a bus in motion will generate a fare payment via mobile devices (e.g. smart phone or other). Until that time, fare payment options will likely continue to be an evolving mix of technologies and options.

REQUIRED

Opportunities and Challenges

Universal Fare Payment

The generalization of TAP and mobile fare payment could over time lead to the opportunity of integrating agencies payment systems into a regional fare payment system that would make transit and other Mobility-as-a-Service and Transportation Network Company services easier and more efficient. The use of a regional fare payment system would also support the implementation of a variable fee structure, where customers can pay a variable amount based on distance and the number of services used within one same trip.

Figure 6: Components of Fare Payment on Vehicles / Source: IBI Group

Distributed Ledger Technologies & Blockchain will support the development of secure mobile payments across a broad range of financial sectors and may eventually supplant the more traditional methods of payments and account management. It should be anticipated that DLT impacts to transit fare payment will likely be part of a larger transformation of the financial sector and processes.

Other Related Elements

> Operating Characteristics - Fare Collection and Boarding Protocols

> Stations/Platforms - System Components

> Branding - Stations

Source: Community Transit - IBI Group

Source: Community Transit - IBI Group

c. Schedule and Headways Management

Schedule and Headways Management refers to the technologies and processes that track how transit vehicles arrive at stations on schedule and within target headway ranges, including feedback to operators on their current status relative to schedules or headway. BRT is one of the service types that can benefit from considering different approaches to managing the distribution of buses along the corridor to try and provide more reliable service with less bunching or gapping of vehicles. Bunching or gapping of vehicles is a natural operations phenomena that occurs due to variations in traffic, dwell times, wheelchair ramp activations/tie-downs, driver behavior variability, and physical constraints in the roadway or station areas. Generally, there are two approaches to managing BRT spacing, timing, and operations along a corridor:

> *Traditional static scheduling* – Buses operate on a predetermined schedule (designated as a series of blocks and trips) where each station time point is assigned a specific arrival/departure time for each bus trip. Static schedules are utilized and adjusted to try and account for this variability between peak and off-peak periods, and to take into account operational experience. As a general rule, buses operating under static schedules are not allowed to run "hot" or early at time points to reduce customer frustration. The challenge with BRT operations is that efforts to help buses run faster or to save travel times can be defeated by an out-of-date or unadjusted schedule, and each bus/trip operates independently, making it difficult to gain overall efficiencies along the corridor (particularly where one bus may have the opportunity to gain greater efficiencies than others). Scheduled operations are typically applied where frequencies of buses are at 7.5 minutes or greater. The higher the frequency, the greater the opportunity for significant bunching under this approach.

> *Headway management* – Buses operate at set headways (e.g. every 5 minutes) regardless of the particular trip. Customers are provided information such as "between the times of 6AM and 7PM, buses for Route X arrive at this stop every five minutes." There are various approaches to controlling headways along a corridor, but buses are not held at time points based on schedule. Bunching of buses is instead monitored along the corridor, and buses are provided instructions to adjust speeds (within a safe range), or institute temporary holds at particular

REQUIRED

locations. Spacing of buses is frequently reset at layover or transit center locations. Traditionally, headway management was applied to service frequencies of 7.5 minutes or less, but trends and the availability of technology have been pushing this limit up to as high as 15 minutes. During off-peak/lower frequency periods, headway-based routes tend to convert to schedule-based approaches. The advantage for BRT corridors is that headway management can: enhance the feel/perception of BRT as a higher speed service with less stops, avoid stopping and waiting at time points, and allow individual vehicles to make the most out of BRT physical and signal priority opportunities. The challenge is that headway management has historically been more resource intensive, requiring additional operations and supervisory personnel to properly manage. The emergence of better vehicle tracking and headway management approaches and tools offers to reduce this burden.

Metro Standards

> *BRT-Lite:* 12-minute headway during peak periods.

> *Full-BRT:* 10-minute headway during peak periods.

> *Target:* five-minute headway during peak periods for BRT-Lite and Full-BRT.

> Off-peak headways cannot exceed 30 minutes, except on weekends and holidays.

Guidelines for Implementation

Pre-requisites

Actively managing headways requires a CAD/AVL system, vehicle tracking with location updates every 30 seconds or less, and a Bus Operations Center (BOC) with experienced staff proactively monitoring and managing the BRT corridor.

Roles and Responsibilities

The transit agency is responsible for all aspects of scheduling, setting headway policies and procedures, staffing, management and operations of the approach.

Requirements

Functional

- Headway management monitoring and alerting tool (either deployed separately or as part of a CAD/AVL system) – the tool needs to be configured to match the characteristics of the operating corridor and the headway policies set by the agency (e.g. what measures drivers can or should take, what situations should prompt active intervention, how are layovers and departures from layover addressed, etc.).
- Headway management and monitoring display for bus communications supervisors (BOC) – similar to a route ladder or display showing relative spacing of all buses along the BRT corridor.
- Headway management displays to the bus operator.
- If semi-autonomous functions are used, headway control could be tied into ACC or automated speed control for buses in exclusive dedicated guideways (drivers would always retain full steering control and control over the bus).
- Reporting and performance metrics based on headways at stops as opposed to schedule adherence, so that operations and policies can be adjusted.
- BSP functionality should be integrated with headway functionality to consider a balanced approach that alleviates bunching but still makes good use of BSP efficiencies.

Physical

- Some approaches to headway management require the bus to hold at specific locations when called for due to bunching, these locations need to allow for a safe extended dwell by the bus (usually less than 120 seconds).

REQUIRED

Other Recommendations

Transit agencies should review the potential application of active headway management to BRT corridors where peak frequencies are 12 minutes or more frequent. The approach should be strongly considered where the frequencies are 5 minutes or more frequent. The specific policies and procedures for headway management may vary based on the particular corridor characteristics and dedicated BRT infrastructure. Some approaches may seek to manage relative bus spacing by providing guidance directly to operators to target up/down on their speeds (within speed limits), whereas others may focus on hold points to alleviate bunching along with resets at turn-around terminal locations. Very frequent service might call for "leap-frogging" where a following bus overtakes a bus in front that is bogged down with heavy loads or dwells. Headway management has traditionally been viewed as resource intensive, but this need not be the case with the proper technologies and operational policies.

Opportunities and Challenges

The implementation of ITS and *Connected Vehicles* will provide further operations control and the ability to intervene quickly in instances where traffic disruptions could potentially lead to delays, as well as support improved headway management approaches. *Corridor Traffic Flow Prioritization & Autonomous Vehicles, and Bus Interval & Signal Control with Speed Management* is a specific example where headway management can be synchronized with signal operations to provide an optimized flow for BRT buses.

Other Related Elements

> Operating Characteristics - Service Parameters and Strategies

> Running Way - Traffic Operations

> Running Way - Roadway Geometrics

> Running Way - Intersection Geometrics

REQUIRED

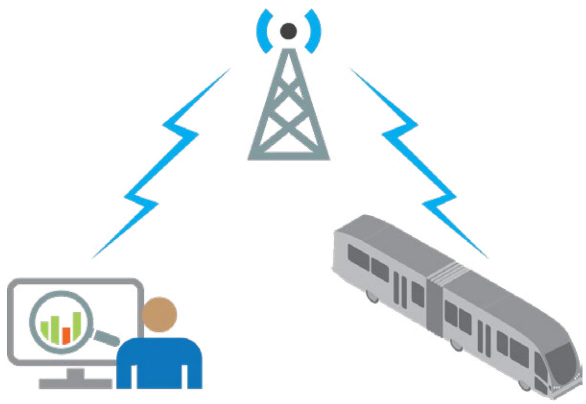


Figure 7: Voice and Data Communications / Source: IBI Group

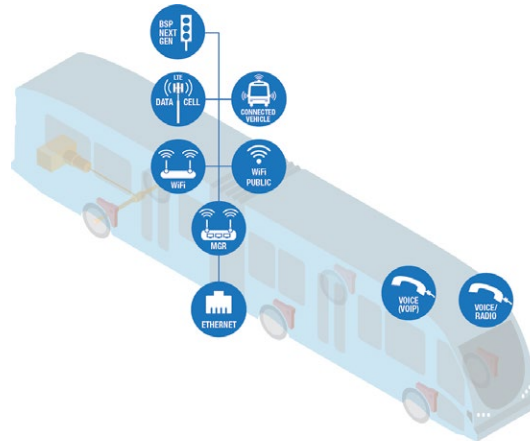


Figure 8: Components of Voice and Data Communications on Vehicles / Source: IBI Group

d. Voice & Data Communications

Voice and Data Communications refers to the technology used to share information between driver and operator, between vehicle and infrastructure, and between operator, vehicle and rider. It is a central component of CAD/AVL systems. Voice and data communications systems can be through a common device or separated out based on the needs of the agency and existing infrastructure. Voice communications are usually through a land mobile radio (LMR) solution or digital mobile radio system (DMR). Increasingly, some agencies are using data-based communications to support mobile Voice over IP (VoIP) which has parallels to the technologies for the voice communications used in many of today's office phone systems. Most transit voice systems utilize a Request to Talk/Priority Request to Talk (RTT/PRTT) approach where communications are set up privately between a communications supervisor at the operations center and a driver. Smaller systems sometimes operate on open talk groups where all operators and communications supervisors can hear all communications to/from vehicles.

Historically, data communications were through LMR or DMR systems, but these solutions limit bandwidth and vehicle location update frequency. Most agencies, including LA Metro, have been moving to data communications through a Mobile Gateway Router (MGR) that centralizes data communications on-board with support for commercial cellular, agency WiFi, and increasingly agency FirstNet cellular solutions. As noted in the on-board architecture overview, the MGR is a critical element for establishing and configuring communications to/from vehicles.

Metro Standards

> Reliable voice and data communications are essential to BRT and all fixed route operations and must be deployed.

Guidelines for Implementation

Pre-requisites

Agencies should establish a standardized on-board architecture for their transit and BRT vehicles, which includes a standard approach, equipment, and systems for voice and data communications. Voice communications systems should be common across agencies fixed route fleet and BRT vehicles, although data communications equipment may vary in order to meet requirements for BRT vehicle location update frequencies.

Roles and Responsibilities

- The transit agency should provide an operations center and staff to receive and process voice and data communication.
- BRT services and routes should have dedicated communications supervisory personnel during peak periods to monitor operations, manage communications, and proactively make service adjustments as needed.
- The transit agency or a subcontracted third party should install the communication system.
- The transit agency or a subcontracted third party should conduct regular checks and maintenance.
- The transit agency or a subcontracted third party should develop and maintain a mobile application that allow data communication. There should also be staff available to process information received by customers and respond appropriately.

Requirements

Functional

- Voice communications preferably should support RTT/PRTT approaches, or at minimum BRT services should be on a separate talk group from the rest of fixed route service.
- Voice communications from BRT should be directed and managed by communications supervisory personnel
- Voice communications should support a covert listen in function when an emergency or silent alarm is activated by the driver (unless this function is provided by another system).
- The need for a redundant or fallback voice communications solution should be reviewed and depending on the results of the assessment be provided.
- Data communications should support commercial cellular or FirstNet cellular communications that supports high-bandwidth/high-availability communications.
- The potential need for redundant data communications (e.g. through a secondary cellular carrier or fallback LMR/DMR data solution) should be reviewed. In many cases in LA County, redundant solutions will not be selected as the failure rate of primary systems and costs of redundancy does not frequently call for it.
- Data communications should be centralized through an MGR on board BRT vehicles that allows for configuration of data transfer priorities.
- Data communications should provide sufficient bandwidth to support: vehicle location updates (see vehicle tracking section), live video look-in for emergency situations (small subset of vehicles at any one time), system status, vehicle health, passenger loads, and related information.

Physical

- All voice and data equipment on the BRT buses should be robust and ruggedized to provide reliable service in a transit vehicle environment.
- All voice and data communications backhauls should be robust and constructed to quickly recover from major events/incidents.

Other Recommendations

As noted, voice communications should support an RTT/PRTT approach, and agencies should consider whether, for BRT operations, direct voice communications between drivers and field supervisors is needed. All BRT should route data communications through an on-board MGR.low Prioritization & Autonomous Vehicles, and Bus Interval & Signal Control with Speed Management is a specific example where headway management can be synchronized with signal operations to provide an optimized flow for BRT buses.

REQUIRED

Opportunities and Challenges

Voice and Data Communications technologies will determine the extent and level of sophistication that can potentially be used for transit signal priority system, guideway and headway control, on-board safety and customer service. Cloud Services and the innovation resulting from Connected/Automated Vehicle technologies represent tremendous opportunities to bring data communications to high performance levels at the vehicle to vehicle and vehicle to infrastructure level.

Other Related Elements

> Systems - Transit Signal Priority
> Systems - Guideway Control and Management
> Systems - Real-time Customer Information
> Systems - Vehicle Tracking
> Systems - Schedule & Headways Management
> Systems - CAD/AVL
> Systems - Video Live Look-in
> Systems - Arrival Prediction

Passenger Counters / Source: Flickr

e. Passenger Counters

Passenger counters are devices that serve three primary functions: (1) they can provide general on-board loads for BRT operations purposes; (2) they allow an agency to compile ridership information and trends by time of day/week/month/year and station; and (3) they allow an agency to fulfill its NTD reporting requirements. In addition, data from automated passenger counter (APC) systems can be used to determine boardings/alightings by station and provide a metric on dwell time per passenger boarding per station. APC systems often also provide supporting information at greater levels of detail on dwell times versus some CAD/AVL systems.

Metro Standards

Metro's dwell time standards provide guidance on how long it should take for passengers to board/alight at stations.

> *BRT-Lite:* 2.5 seconds per person/average 18 seconds at each stop

> *Full-BRT:* 2 seconds per person/average 15 seconds at each stop

> *Target:* 1.7 seconds per person/average of 12 seconds per stop

Guidelines for Implementation

Pre-requisites

All BRT vehicles shall be equipped with APCs sensors and supporting analyzers (preferably installed at the manufacturer if the bus is new). All APC sensors should be checked and calibrated as new BRT vehicles are received. APC systems should be integrated with data communications and CAD/AVL systems.

Roles and Responsibilities

The transit agency, vehicle OEM, or a subcontracted third party should install the APC devices on all vehicles, conduct performance assessments and service reviews on a regular basis, and perform checks and maintenance of the APC system.

Requirements

Functional

- APC system shall provide boarding and alighting data for each BRT vehicle at each station.
- APC system shall provide operations with an approximate comparison of on-board

REQUIRED

loads versus vehicle capacity (e.g. less than 50% full, 50% full, 75% full, 100% full+). Consideration of what constitutes capacity will be set by agency policy.

- APC system shall conduct balancing and post-processing of APC data for planning and reporting purposes.

Physical

- All BRT vehicles shall be equipped with APCs covering all doors.

Other Recommendations

APCs are an important technology for providing information on the performance of BRT services and making necessary adjustments. Full APC systems shall be required on all BRT vehicles. At some point in the future, APC equipment on the vehicles may become secondary to new systems where riders smartphones communicate directly with vehicle and transit systems for fare payment, etc.

Opportunities and Challenges

Location-Based Services (LBS) can now provide very specific origin-destination and demographic data that can also support counting and ridership monitoring efforts, and guide agencies in designing routes that better connect people to their destination.

As trends such as Gig-Based Economy and Remote Working become more common, there will be a disruption in typical travel patterns of LA County residents. Data collected from technologies such as passenger counters and LBS will be particularly critical to ensure a successful deployment of BRT services.

Other Related Elements

> Operating Characteristics - Service Conditions and Classifications

> Operating Characteristics - Service Parameters and Strategies

> Systems - Voice & Data Communication

> Systems - On-Board Architecture

> Systems - CAD/AVL

> Systems - Technology Support Elements

5R Control Center & Operations

a. CAD-AVL
b. Active Headway Management
c. Voice & Data Communications
d. Arrival Prediction
e. Customer Information
f. Business Intelligence and Performance Metrics

a. CAD-AVL

Figure 9: Components of CAD-AVL / Source: IBI Group

Description

Computer Aided Dispatch (CAD) and Automated Vehicle Location (AVL) (CAD/AVL) is the central core Intelligent Transportation Systems (ITS) element for BRT. It is the primary tool for providing operational situational awareness to the operations control center, a key source of customer information, a primary performance metrics monitoring tools, and the primary method of determining and tracking when service adjustments need to be made due to incidents, traffic conditions, heavy load conditions, etc. All large and mid-sized transit operators in the region utilize some form of CAD/AVL system.

LA Metro's CAD/AVL solution is called ATMS, and Metro is commencing efforts to scope the replacement of this system, which is nearing the end of its useful life. Core elements of a CAD/AVL system include an on-board computer for managing communications and operations related functions (e.g. stop announcements, visual displays, head sign integration, APCs, etc.), a mobile data terminal for interfacing with the driver, vehicle tracking that includes GPS and dead-reckoning functions, and sometimes integration with TSP/BSP devices.

REQUIRED

Metro Standards

While not specifically called out in the Metro BRT standards, a CAD/AVL system of some sort must be deployed for all BRT services.

Guidelines for Implementation

Pre-requisites

If an agency operates a CAD/AVL for fixed route operations, this system should be extended to the BRT vehicles for coordinated operational awareness. CAD/AVL assumes a robust voice and data communications system (see relevant guidelines section).

Roles and Responsibilities

The transit agency or a subcontracted third party must install CAD/AVL systems on vehicles, conduct regular checks and maintenance of the systems, and provide an operations center with staff to process and respond to information.

Requirements

Functional

- CAD/AVL shall provide operational situational awareness for all BRT buses including: vehicle position, schedule adherence, on/off route, block/trip/schedule, scheduled reliefs, emergency or covert alarm, approximate passenger loads, and snapshot of performance summaries
- CAD/AVL shall be able to separate out BRT from other services and routes, and support focused operations/dispatch personnel monitoring BRT service performance
- CAD/AVL shall support tracking service adjustments such as fills, short-turns, block/trip cancellation, detours and other typical service adjustments
- CAD/AVL or supporting system shall track when BRT vehicles or buses enter or leave a dedicated guideway (particularly median running or access controlled guideways)
- CAD/AVL shall support headway monitoring & management
- CAD/AVL shall provide basic performance metrics such as schedule or headway management performance, passenger counts, pull-out/pull-in performance, revenue and non-revenue miles and hours
- CAD/AVL may support conditional BSP/TSP
- CAD/AVL shall support communications between the operations center and BRT drivers, including voice, canned/freeform text messages, and service adjustment instructions
- CAD/AVL shall support feeds to customer information systems in an industry standard format (e.g. GTFS, GTFS-RT, etc.)

Physical

- CAD/AVL equipment (including a vehicle logic unit and mobile data terminal) shall be deployed on each BRT bus
- On-board CAD/AVL equipment shall be integrated with the MGR, video surveillance, radios (if applicable), head signs, and automated stop/visual announcement systems

Other Recommendations

CAD/AVL systems must be deployed on BRT vehicles. If an agency has an existing CAD/AVL solutions on the fixed route fleet, but it is lacking in specific BRT required functionality, then the agency should supplement the CAD/AVL functionality to fill these gaps.

Opportunities and Challenges

Bus Interval and Signal Control with Speed Management, and Corridor Traffic Flow Prioritization are two example of concepts that will rely heavily on CAD-AVL. The expansion of current communications technologies such as Cloud services and 5G, as well as the development of Automated and Connected Vehicles will make these ITS systems more sophisticated, and provide operators with the ability to play an even more active role in the

REQUIRED

monitoring, driver support functions, and headway and guideway management.

Other Related Elements

> Operating Characteristics - Service Parameters and Strategies

> Running Way - Traffic Operations

> Systems - Voice & Data Communication

> Systems - Video Live Look-in

> Systems - Passenger Counters

> Systems - On-board Architecture

> Systems - Schedule and Headway Management

Reference Documentation (Standards & Codes)

> LA Metro Fleet Management & Communications Systems Strategic Plan

> LA Metro IT Strategic Plan

Source: IBI Group

b. Active Headway Management

Active Headway Management refers to the various systems that can be used to ensure that services stay within headway targets. It can both ensure that buses do not get delayed, or do not bunch up one behind the other. Active headway management help determine how many buses are needed on a given route per hour in regular circumstances as well as during special events, or during congestion or other disruptive events. Under active headway management, vehicle locations tracking is combined with control center monitoring and supervision to make adjustments to bus positions, travel speeds, and turn-arounds at layover points to alleviate bunching or gapping through one of several means:

> Voice or text communications sent from the operations center to the driver to take action to hold at a predetermined point or adjust other behavior.

> Automated systems input asking operators to target up or down their travel times or to hold at a predetermined locations for a specific period of time (refer to Schedule & Headway Management in vehicles section).

> Authorizing following buses to bypass delayed buses in front of them on the same route.

> Other approaches set target speeds for vehicles based on relative vehicle spacing.

Headway operations work best where dedicated runningways are available and the route is not unduly long.

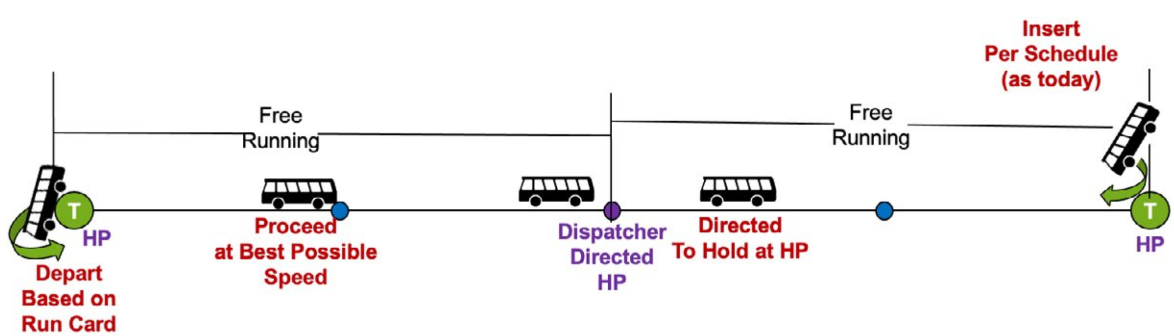


Figure 10: Example of hold & insert approach to active headway management

Metro Standards

> *BRT-Lite:* 12-minute headway during peak periods. Off-peak headways cannot exceed 30 minutes, except on weekends and holidays.

> *Full-BRT:* 10-minute headway during peak periods. Off-peak headways cannot exceed 30 minutes, except on weekends and holidays.

> *Target:* five-minute headway during peak periods for both services.

Guidelines for Implementation

Pre-requisites

CAD/AVL systems need to be in place to allow vehicle tracking and headway management. If the existing CAD/AVL system cannot support active headway management, the data from the CAD/AVL system can be used for supplemental applications/tools.

There must be an operations center with programs and staff to process information and respond accordingly.

There should be a fleet of standby buses that can be quickly sent along the route to respond to service needs and respect headway minimums.

Roles and Responsibilities

The transit agency must set policies, deploy appropriate supporting tools, and conduct training of operators and communications supervisors to support active headway management.

Requirements

Functional

- Active headway management should be supported by CAD/AVL and high frequency vehicle location tracking.
- Active headway management shall provide a headway focused display to control center operations personnel to enable them to easily view:
  > Bunching & gapping
  > Adjustment points for holds or bypasses
  > Instructions being provided to drivers by the system (if applicable)
  > Physical roadway configuration (e.g. median runningway, etc.)
- Active headway management should take into account segment-based run times (both scheduled and average historical by time of day) to be included in bunching & gapping calculations.
- Active headway management should be tracked and provide performance metrics based on the arrival and departure time of each bus at each station.
- Impacts and integration of BSP functionality with active headway management should be planned and considered so as to create complementary outcomes rather than potentially conflicting ones.

Physical

- Proper active headway management may require additional buses to be available for inserting trips during peak periods or ridership and congestion (depending on the specific headway management approach being used).
- Proper active headway management may require additional field supervisor personnel deployed at key turn-around or layover locations to help reinforce directions to drivers from the operations control center.

Recommendations

Transit agencies should review the potential application of active headway management to BRT corridors where peak frequencies are 12 minutes or more frequent. The approach should be strongly considered where the frequencies are 5 minutes or more frequent. The specific policies and procedures for headway management may vary based on the particular corridor characteristics and dedicated BRT infrastructure.

REQUIRED

Opportunities and Challenges

The implementation of ITS and Connected Vehicles will provide further operations control and the ability to intervene quickly in instances where traffic disruptions could potentially lead to delays, as well as support improved headway management approaches. Corridor Traffic Flow Prioritization & Autonomous Vehicles, and Bus Interval & Signal Control with Speed Management is a specific example where headway management can be synchronized with signal operations to provide an optimized flow for BRT buses.

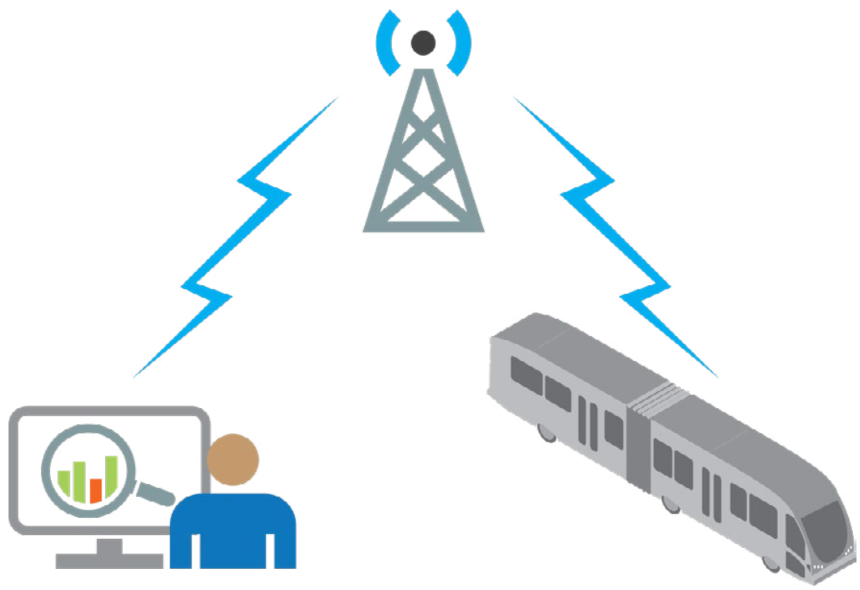


Figure 11: Voice & Data Communications / Source: IBI Group

c. Voice & Data Communications

Voice and Data Communications refer to the technology used to share information between driver and operation center, between vehicle and infrastructure, and between operator, vehicle and rider. It is a central component of CAD/AVL systems. Voice and data communications systems can be through a common device or separated out based on the needs of the agency and existing infrastructure. Voice communications are usually through a land mobile radio (LMR) solution or digital mobile radio system (DMR). Increasingly, some agencies are adopting data-based communications to support mobile Voice over IP (VoIP) which has parallels to the technologies for the voice communications used in many of today's office phone systems. Most transit voice systems utilize a Request to Talk/Priority Request to Talk (RTT/PRTT) approach where communications are set up privately between a communications supervisor at the operations center and a driver. Smaller systems sometimes operate on open talk groups where all operators and communications supervisors can hear all communications to/from vehicles.

Historically, data communications were through LMR or DMR systems, but these solutions limit bandwidth and vehicle location update frequency. Most agencies, including LA Metro, have been moving to data communications through a Mobile Gateway Router (MGR) that centralizes data communications on-board with support for commercial cellular, agency WiFi, and increasingly agency FirstNet cellular solutions. As noted in the on-board architecture overview, the MGR is a critical element for establishing and configuring communications to/from vehicles.

Metro Standards

Reliable voice and data communications are essential to BRT and all fixed route operations and must be deployed.

Guidelines for Implementation

Pre-requisites

Agencies should establish a standardized on-board architecture for their transit and BRT vehicles, which includes a standard approach, equipment, and systems for voice and data communications. Voice communications systems should be common across agencies fixed route fleet and BRT vehicles, and should allow operation staff to effectively manage multiple communication channels for drivers and field staff.

REQUIRED

Roles and Responsibilities

- The transit agency should provide an operations center and staff to receive and process voice and data communication.
- BRT services and routes should have dedicated communications supervisory personnel during peak periods to monitor operations, manage communications, and proactively make service adjustments as needed.
- The transit agency or a subcontracted third party should install the communication system.
- The transit agency or a subcontracted third party should conduct regular checks and maintenance.
- The transit agency or a subcontracted third party should develop and maintain a mobile application that allow data communication. There should also

Requirements

Functional

- Voice communications preferably should support RTT/PRTT approaches, or at minimum BRT services should be on a separate talk group from the rest of fixed route service.
- Voice communications should be directed and managed by communications supervisory personnel.
- Voice communications should be backed up and archived on a daily interval at a centralized location.
- Voice communications should support a covert listen in function when an emergency or silent alarm is activated by the driver (unless this function is provided by another system).
- The need for a redundant or fallback voice communications solution should be reviewed and depending on the results of the assessment be provided.
- Data communications should support commercial cellular or FirstNet cellular communications that supports high-bandwidth/high-availability communications.
- The potential need for redundant data communications (e.g. through a secondary cellular carrier or fallback LMR/DMR data solution) should be reviewed. In many cases in LA County, redundant solutions will not be selected as the failure rate of primary systems and costs of redundancy does not frequently call for it.
- Data communications should be centralized through an MGR on board BRT vehicles that allows for configuration of data transfer priorities.
- Data communications should provide sufficient bandwidth to support: vehicle location updates (see vehicle tracking section), live video look-in for emergency situations (small subset of vehicles at any one time), system status, vehicle health, passenger loads, and related information.

Physical

- All voice and data equipment on the BRT buses should be robust and ruggedized to provide reliable service in a transit vehicle environment.
- All voice and data communications backhauls should be robust such that communications can be maintained during higher data traffic events and constructed to quickly recover from major incidents.

Recommendations

As noted, voice communications should support an RTT/PRTT approach, and the system should support direct voice communications between operation staff and field supervisors. All BRT should route data communications through an on-board MGR.

Opportunities and Challenges

Voice and Data Communications technologies will determine the extent and level of sophistication that can potentially be used for transit signal priority system, guideway and headway control, on-board safety and customer service. Cloud Services and the innovation resulting from Connected/Automated Vehicle technologies represent tremendous opportunities to bring data communications to high performance levels at the vehicle to vehicle and vehicle to infrastructure level.

Other Related Elements

> Systems - Transit Signal Priority

> Systems - Guideway Control and Management

> Systems - Real-time Customer Information

> Systems - Vehicle Tracking

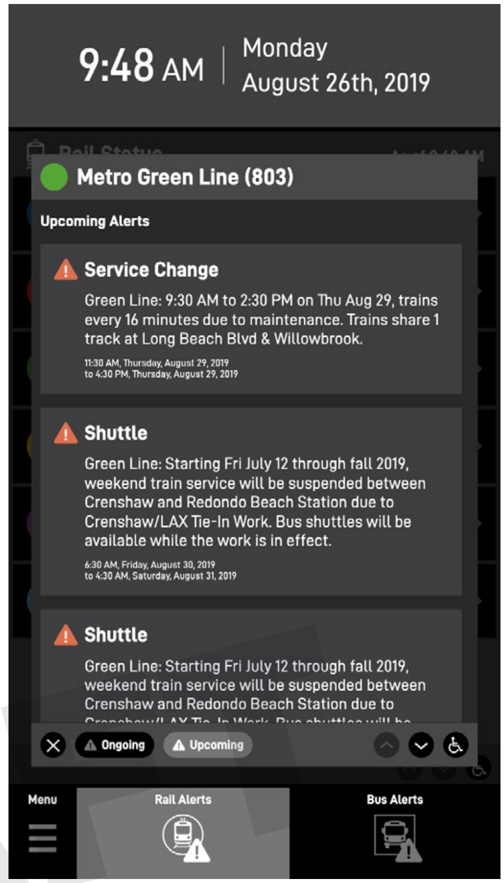
> Systems - Schedule & Headways Management

> Systems - CAD/AVL

> Systems - Video Live Look-in

> Systems - Arrival Prediction

Source: Metro BOC - IBI Group



Source: Metro BOC - IBI Group

d. Arrival Prediction

Arrival Prediction refers to the use of frequent vehicle location information paired with schedule and enhanced prediction algorithms to provide improved arrival prediction.

Tracking BRT buses (usually via GPS-based automatic vehicle location-AVL solutions) is a fundamental requirement. Almost all transit operators in LA County utilize GPS-based solutions as part of a computer-aided dispatch-automatic vehicle location (CAD/AVL) system to track buses for operations, safety, customer information, performance monitoring, and schedule adherence purposes. This also enables the calculation and provision of predicted arrival times based on scheduled adherence as the vehicle progresses throughout the trip and other criteria such as historic performance or other known issues or bottlenecks.

Providing predicted arrival times via mobile applications and other communications channels allows riders to plan around any delays before they arrive at their origin/stop. Riders may seek alternate modes of transportation, or simply plan to arrive at a stop later, effectively reducing wait time and the overall duration of their trip. When predicted arrival times are displayed at the stop for riders who are already there, having this information can reduce the perceived wait during delays. This is all contingent on the data being accurate.

REQUIRED

Metro Standards

- > *BRT-Lite:* Buses should be on time 75% of the time and should arrive within a 12 minute headway during peak periods. Off peak headways cannot exceed 30 minutes, except on weekends and holidays.
- > *Full-BRT:* Buses should be on time 80% of the time and should arrive within a 10 minute headway. Off peak headways cannot exceed 30 minutes, except on weekends and holidays.
- > *Target:* Buses should be on time 90% of the time and arrive within a 5 minute headway.

Guidelines for Implementation

Pre-requisites

- Vehicles should be equipped with tracking devices. Devices should be connected to a transmission system via WiFi or cloud-based program.
- There should be an operations center with available staff to review and process information.
- Arrival data should be shared with customers via displays at stations, mobile applications (incl. third party apps), and other channels.

Roles and Responsibilities

- The transit agency or a subcontracted third party should install tracking systems on vehicles.
- The transit agency or a subcontracted third party should conduct regular checks and maintenance on tracking devices and transmission systems.
- The transit agency should provide an operations center and staff to review and share updated arrival information.
- The transit agency should continuously monitor the quality of predicted arrival times.

Requirements

Functional

- The system should generate predicted arrival times at least 30 minutes prior to the trip starting.
- The system should provide the last vehicle location coordinates every 30-60 seconds.
- The system should reevaluate and generate new predictions for each stop arrival time as the vehicle progresses in the trip and conditions change.
- Predicted arrivals must be accurate based on predefined acceptable accuracy thresholds. This is done by comparing all predictions made against actual arrival times. Predicted arrival times for a given stop are expected to increase in accuracy as the vehicle gets closer to that stop.
- The agency should implement analytics and tools necessary to evaluate the accuracy of arrival times by stop.

Physical

- The system should produce a standard data feed that helps standardize the way downstream communication channels consume the data and can be consumed by third-party developers / mobile applications. The industry standard is GTFS-realtime; GTFS-realtime is a standard developed by Google for delivering transit real-time data. The data are generated in the Protocol Buffer format and must be integrated with General Transit Feed Specification (GTFS) schedule data to be meaningful to applications that consume the data. GTFS-realtime can include:
  - > *Trip Updates* – this feed provides real-time updates on the progress of a vehicle along a trip, including arrival predictions
  - > *Vehicle Positions* – this feed provides real-time positioning information for a given vehicle

REQUIRED

Recommendations

> Technology – All BRT vehicles should be equipped with a Mobile Gateway Router for communications with cloud-based applications as well as internal agency systems.

> Technology – Agencies should consider whether BRT systems are best deployed in an internal or cloud based/SaaS environment.

> The agency should consider developing a process independent of said systems to measure prediction data accuracy.

Opportunities and Challenges

Cloud Services will allow for the more rapid evolution of systems over time and deployment with less investment in fixed infrastructure. In the longer term, *Automated and Connected Vehicles* will bring on new technologies that will further increase communication from vehicles to operators, and from vehicle to vehicle. Deployment of AV and CV fleets will increase speed, safety and efficiency of communication, and of BRT systems overall, thanks to the ability to program more vehicles to make way for priority BRT. Coupled with *Corridor Traffic Flow Prioritization,* this means that virtual lanes or priority for BRT vehicles will be created and further support arrival prediction and service reliability.

Other Related Elements

> Stations/Platforms - Signage and Passenger Information

> Stations/Platforms - Systems Components

> Branding - Stations

> Integration of Transit-oriented Communities - First/Last Mile Connectivity

Reference Documentation (Standards & Codes)

The GTFS-real time specification is detailed at https://github.com/google/transit/tree/master/gtfs-realtime/spec/en. The Protocol Buffer format is detailed at https://github.com/google/transit/blob/master/gtfs-realtime/proto/gtfs-realtime.proto.

Source: IBI Group

e. Customer Information

Customer information refers to the ability to provide up-to-date information to riders regarding service and routes. Posted schedules cannot deliver critical information regarding transit delays, therefore real-time bus arrival information is critical. While most users carry mobile devices, real-time information dissemination provided by transportation agencies, on static equipment at the station will provide consistent and accurate information to customers, easily and with equity. Furthermore, given that riders at this point are already at the station and have planned their trip, having accurate real-time information may reduce the perception of delays should they occur.

Metro Standards

> *BRT-Lite:* 75% of all stations provide real-time information

> *Full-BRT:* 90 of all stations provide real-time information

> *Target:* 100% of all stations provide real-time information

Guidelines for Implementation

Pre-requisites

- Digital Display and/or Variable-Message Sign (VMS): Power and High-Speed/High-Bandwidth communication. Content: Source API or other data feed delivering real-time information to display
- The content management system must integrate with agency traveler information systems and ingest real-time data including data in GTFS-real time format

Roles and Responsibilities

- Operations and Maintenance of information – 511 operators at LA SAFE's TIC manage 511 content.
- Transit agency staff must perform regular physical checks of display, and communications infrastructure are necessary.
- The transit agency should continuously monitor the quality of predicted arrival times.

REQUIRED

Requirements

Functional

Video screens or VMS must be mounted in a space visible and accessible to the greatest number of customers at any given time. Consideration must be given to impeding pedestrian circulation.

Predicted arrivals must be accurate based on predefined acceptable accuracy thresholds. This is done by comparing all predictions made against actual arrival times. Predicted arrival times for a given stop are expected to increase in accuracy as the vehicle gets closer to that stop.

The agency should implement analytics and tools necessary to evaluate the accuracy of arrival times by stop.

- Predicted arrivals must be accurate based on predefined acceptable accuracy thresholds. This is done by comparing all predictions made against actual arrival times. Predicted arrival times for a given stop are expected to increase in accuracy as the vehicle gets closer to that stop.

Physical

Sufficient power to run variable message signs or screens as well as communications infrastructure

- Adequate space to mount hardware
- WiFi or LAN infrastructure
- Location of seating must be addressed in designing optimal placement of video screens
- The system content management system should accept a standard data feed for predicted arrival times. The industry standard is GTFS-real time:
- GTFS-real time is a standard developed by Google for delivering transit real-time data. The data are generated in the Protocol Buffer format and must be integrated with General Transit Feed Specification (GTFS) schedule data to be meaningful to applications that consume the data. GTFS-real time can include:
  - *Trip Updates* – this feed provides real-time updates on the progress of a vehicle along a trip, including arrival predictions
  - *Vehicle Positions* – this feed provides real-time positioning information for a given vehicle

Recommendations

Metro has initiated over the summer of 2019 the deployment of digital displays along the Blue line.

Real-time customer information should be provided on similar displays at major BRT stops and transit stations. A consistent deployment of real time information infrastructure will serve to reinforce Metro's brand; therefore the design of digital displays currently deployed along the Blue line should be retained if possible. There should be minimal interruption to information display from advertising, or an integration of basic arrival updates onto the advertising slides. Displays should be visible and accessible from customer waiting areas. Consider developing displays using transit data; real-time arrival and departure, as well as schedule information, from LA SAFE's 511 system.

Real-time bus arrival times can be displayed using VMS signs; however the recommended approach is to invest in full screen digital displays. VMS are significantly character limited, while screen-based displays provide the flexibility for cross-purpose usage. With the use of digital displays, emergency information, PSAs, advertisements, and other content can be displayed when real-time information is not available or necessary.

Onsite real-time customer information should be simple and concise. Unlike websites or mobile applications which can hold the user's attention for extended periods of time, the screen providing real time information should provide only what the customer needs. Content may include a shortlist such as:

- Next three arrival times (in minutes from current time)
- Service disruption notifications
- Instructions for customers in case of emergency, such as a directive to call 911, or number for other emergency resources

To address ADA considerations, audio messages can be disseminated in addition to video or visual messaging.

For stops that do not include digital displays, information regarding ways to access information online should be provided. These may include vertical panels, or placards advertising the 511 telephone service as well as go511.com.

Opportunities and Challenges

Cloud Services, the Internet of Things, and 5G technologies will improve Metro's ability to provide and update information with the least amount of delay possible. Cloud technology could furthermore reduce costs by avoiding storage, data management and other operational burdens. These technologies can also support the development of specialized applications that can provide a full range of information to transit users.

Opportunities can be realized in the cross-functional use of video screens. In case of emergency, real-time transit information may be replaced by content from emergency services.

Real-time information could also be expanded to include *Mobility-as-a-Service (MaaS) and Transportation Network Cooperatives (TNCs)*, to offer fully integrated multi-modal services to commuters.

Connected and Automated Vehicles will also add to the agency's ability to provide real-time information to customers, by removing the "middle man", between vehicles and riders.

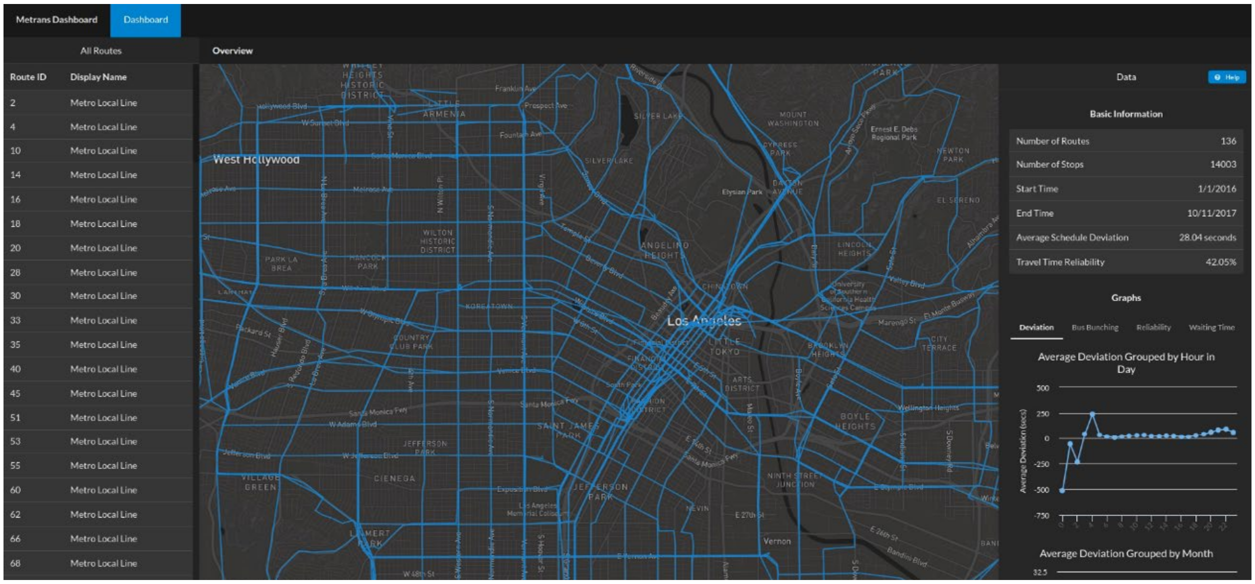
The threat of vandalism is a critical challenge to successful deployment of hardware such as digital display screens. Expensive equipment such as screens is susceptible to damage by the public, and may need to be housed in a protective container to ensure its safety.

Other Related Elements

> Stations/Platforms - Systems Components
> Stations/Platforms - Signage and Passenger Information
> Branding - Stations
> Integration of Transit-oriented Communities - First/Last Mile Connectivity

Reference Documentation (Standards & Codes)

The GTFS-real time specification is detailed at https://github.com/google/transit/tree/master/gtfs-realtime/spec/en . The Protocol Buffer format is detailed at https://github.com/google/transit/blob/master/gtfs-realtime/proto/gtfs-realtime.proto.



Source: *infolab.usc.edu*

f. Business Intelligence

Business Intelligence (BI) refers to a collection of technologies and techniques that are strategically applied by an agency to glean actionable insights from data. It is a tool that can be used to simplify performance tracking and evaluate policy impacts. This is done by integrating and cleansing operational data and presenting it in dashboards and reports that allow agency users to view metrics and key performance indicators and drill down to specific issues or questions. BI sets the foundation for a robust analytic environment starting with prescriptive analytics (what happened) and can enable analysts and data scientists to build predictive (what might happen) and prescriptive (what should we do) models.

Guidelines for Implementation

Pre-requisites

The transit agency should ensure that ownership of data is detained regardless of how operational systems are implemented, be it on premise or in the cloud. The agency should have access to business data under all circumstances with a direct database connection, web services (API), or another agreed upon method for live data access.

Roles and Responsibilities

- The transit agency should identify performance metrics for regular tracking.
- The transit agency or a subcontracted third party will run performance analysis and develop performance reports.

Requirements

Functional

- *Technology* – Using Metro or agency BI tools, BRT should develop specific dashboards and information elements that meet BRT needs. BRT data elements (e.g. ridership, TSP, headway/schedule adherence, service adjustments, pullouts, etc.) should be available in one place for integrated reporting and review.
- *Technology* – BI tools should support real-time (day-of) BRT operations, as well as regular operations review.
- *Operations* – BRT operations should be monitored on a regular basis to implement refinements and service adjustments as needed (e.g. schedule or headway adjustments, addition of trippers based on service needs, etc.)

Physical

Access to data and systems such as CAD/AVL must be established through a direct database connection, web services (API), or another agreed upon method.

Recommendations

The success of a Business Intelligence or performance monitoring solution often hinges on access to quality data. Before BI tools are licensed or built, the agency should attempt to answer critical questions or calculate performance metrics manually at first by analyzing all source data to identify potential issues early in the process. The agency should also assess the impact of querying production systems in real time and impact on system performance, which may necessitate the building of a data warehouse for more intensive analytics.

Opportunities and Challenges

> BRT can serve as an example for best practices for on-going policy and operations assessment and monitoring.

> Changes to schedules and operations can quickly be assessed to determine impacts to customers, operations, and costs to allow more rapid refinement and adjustment.

> KPI tracking and analytics tools, as well as easy access to this information at various levels within the agency should improve over time.

> Broad availability of high-level KPI and metrics data may make issues with baseline data (e.g. schedules, assignments, untracked service changes) more problematic.

> Availability of ready info for BRT services above and beyond regular service may make it more a target for those not supportive of transit.

Other Related Elements

> Operating Characteristics - Service Reviews and Shakeups

REQUIRED

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20 Roadside Elements

a. Transit Lane Enforcement
b. Guideway Control & Management
c. Access Control
d. Ramp Meter Interrupt
e. Connected Bus

a. Transit Lane Enforcement

Transit lane enforcement refers to the various technologies, policies, and institutional arrangements necessary to ensure dedicated or peak hour bus lanes are properly enforced. Although this element is not required, it is strongly encouraged, as the use of bus lanes by unauthorized vehicles can have considerable impacts on bus throughput, on-time performance and speed. Violations of bus only lanes are quite common, and in LA County agencies have noted concerns about TNC (e.g. Uber, Lyft, etc.) stopping to drop-off or pick-up passengers in bus only lane and/or station platform areas. It is generally easier to enforce median runningways or curbside bus lanes that don't allow right-in/right-out access. Enforcement can take the form of manual enforcement by law enforcement agencies, and/or automated camera enforcement. Automated enforcement of bus lanes is common in Europe, but could present some institutional, policy, and procedural challenges in LA County. NY MTA has instituted a bus lane enforcement program called ABLE that uses bus based cameras to capture lane violators and process warnings and ultimately violation fines through the NY DOT. A pilot of this concept is being considered by Metro.

Three basic approaches can be used to apply technology to the bus lane enforcement issue:

> *Video Feeds to Officers* - Provide a live video feed of high violation areas for access to law enforcement so that they can "enforce from around the corner" and then cite violators. This could be used across several locations to maintain visibility and unpredictability of the enforcement activities. This approach reduces institutional and violations processing issues and provides visible enforcement feedback while lowering the work level and exposure of officers.

> *Fixed Cameras in Lanes* - Use cameras at fixed locations with embedded video analytics to determine violators versus vehicles simply passing through the bus lane to access driveways. This can be combined with plate capture and appropriate enforcement processes to provide warning letters followed up by violations for repeat offenders. This approach provides for enforcement when officers are not available and regardless of whether buses are using that portion of the lane at the time.

- > *Camera on Buses* - Use cameras on buses that capture violators and license plates for processing similar to fixed cameras. The advantage of this approach is that field infrastructure is reduced and equipment can be maintained at the bus yard. Additionally, violators that are detected are actually preventing clear passage of a bus.

Metro Standards

While there are not specific Metro standards for bus lane enforcement, keeping bus lanes open for BRT use is crucial to ensuring performance standards can be met and maintained over time, including:

Headway:

- > *BRT-Lite:* Buses should arrive at 12-minute intervals.
- > *Full-BRT:* Buses should arrive at 10-minute intervals.
- > *Target:* Buses should arrive at five-minute intervals.

Speed:

- > *BRT-Lite:* Average speed should be 15 MPH.
- > *Full-BRT:* Average speed should be 18 MPH.
- > *Target:* Average speed should be 20 MPH.

On-time Performance/Reliability:

- > *BRT-Lite:* Buses should be on time 75% of the time.
- > *Full-BRT:* Buses should be on time 80% of the time.
- > *Target:* Buses should be on time 90% of the time.

Guidelines for Implementation

Pre-requisites

A bus lane needs to be in existence with supporting signage and striping that clearly designate the lanes and restrictions on any traffic entering or crossing the lanes. Zones where right turn lanes are allowed to cross or occur from the bus lane would be excluded from enforcement.

Bus lane enforcement cameras are frequently used in Europe / Source: IBI Group

Roles and Responsibilities

Bus lane enforcement requires close coordination between the transit agency, local law enforcement, and local traffic departments. It is likely that Memorandums of Understanding (MOUs) or even some legislative changes may be required, although enforcement options should be within the purview of the local agency councils. The following general responsibilities apply:

- *Transit Agency* – The transit agency would be responsible for budgeting and leading design modification efforts to support lane enforcement, including technologies to detect violators and capture the information necessary for processing warnings and violations. The agency would also need to install appropriate equipment on the buses or along the lanes, and establish operating rules and guidelines. Finally, the transit agency would need to monitor the status of systems and operations.
- *Local Agency DOT* – The local agency DOT would need to review signage and striping for enforcement and coordinate with local law enforcement.
- *Law Enforcement* – Depending on the jurisdiction in which the bus lanes operate, the local law enforcement will need to conduct enforcement activities.

It should be noted that fees from violations would likely not be provided to support transit agencies, but that enforcement activities would be beneficial to transit operations and performance.

Requirements

Functional

- Need video coverage of the bus lanes where enforcement issues exist with coverage sufficient to capture an image of the vehicle, operator and license plate.
- For fixed cameras in lanes, need video analytics to support identification of actual violators versus vehicles simply crossing the lanes to access driveways or not actually blocking the bus lane.
- Communications from field cameras to central or cloud-based processing system.
- For bus-based cameras, need video coverage forward facing with artificial intelligence to identify violators or support operating tagging. Coverage should be sufficient to capture an image of the vehicle and license plate.
- Method for cellular or yard-based communications to download video to a central or cloud-based solution.
- Video capture and processing system to review potential violators and process warnings or violations.
- Support systems to monitor and maintain video cameras and enforcement systems.

Physical

- Signage and striping to clearly designate bus lanes.
- Mounting structures for cameras to provide a clear view of vehicles in the bus lanes, as well as supporting equipment cabinets. It may be possible to integrate this equipment into BRT stations and equipment enclosures.
- Special signage to note transit lane usage violations and enforcement by cameras.

Other Recommendations

A successful enforcement strategy should plan for frequent enforcement, with high enough violation fees to be an effective deterrent. It should ideally include a mix of both police enforcement and, if allowed, automated camera enforcement. Metro should consider leading a pilot project as part of its BRT service program to assess the benefits of camera enforcement and sustain a dialogue between lawmakers and service providers in the region.

Education and monitoring are two other important components that should be integrated into Metro's enforcement program.

Opportunities and Challenges

Video Analytics can provide automated enforcement options, as well as activate notifications to warn violators. On the other hand, as roadways become more flexible and **dynamic**, lane enforcement might become more challenging, as it would require management systems that can adapt to time of day and demand-driven lane allocation.

Connected Vehicles

Connected vehicle functionality can inform drivers when they are in a transit lane, and ultimately support enforcement activities.

Other Related Elements

> Operating Characteristics - Multiple Services Sharing a Corridor

> Operating Characteristics - Service Reviews and Shakeups

> Runningways - Roadway Geometrics

> Runningways - Traffic Operations

> Systems - Autonomous and Connected Vehicles

Reference Documentation

California Vehicle Code – Specifically ARTICLE 3. Offenses Relating to Traffic Devices [21450 - 21468]

Single lane reversible median busway / Source: Skyscraper Page Forum

b. Guideway Control and Management

Guideways are dedicated runningways for transit or BRT. They can be median running down the middle of an arterial, separated runningway similar to reclaimed ex-railroad right-of-way for the Metro Orange Line, or they can be curbside running. They can have time restrictions and allow exclusively BRT, or other local services as well. In special circumstances, they can also allow use by other vehicle types (e.g. Circulator shuttle, rideshare, carpool). Guideway control and management provides operational guidance, restrictions and guideway flow management to specific runningways based on type of vehicle, time of day, priority rating, etc.

Given constrained right-of-way in many areas of the county where guideways would be implemented for BRT, guideway control and management can apply technologies and operational controls for transit and signals to support:

> *Reversible lanes* – This allows a single lane to be used either interchangeably by direction (e.g. as a median bus runningway in a constrained underpass or interchange environment) or by peak direction (e.g. where the bus runningway exists in a highly peak traffic directional environment).

> *Peak hour lanes* – This allows curbside lanes or other lanes to be adjusted to BRT or bus only lanes during peak periods or based on peaking traffic conditions.

> *Controlled access* – Controlled access can use a variety of signal indications, gates, and/or other technologies and barriers to limit access to a guideway. For example, local services may be integrated to access a BRT guideway at specific locations, but their access to the guideway could be managed based on relative BRT/bus spacing and headways. This can prevent bus bunching at shared stations.

> *Signal interval control for median guideways* – Combining guideway management and control with TSP and signal coordination/management approaches can provide for programmed intervals that help BRT vehicles move from station to station while hitting fewer red lights. Intervals are programmed and managed with the signal system based on the physical guideway layout and bus headways, then adjustments can be made to vehicle speeds to accommodate these intervals with active TSP measures supporting signal timing adjustments as needed. The overall goal is to develop a more smoothly operating guideway with fewer stops between stations rather than simply pushing a single bus through the guideway as quickly as possible.

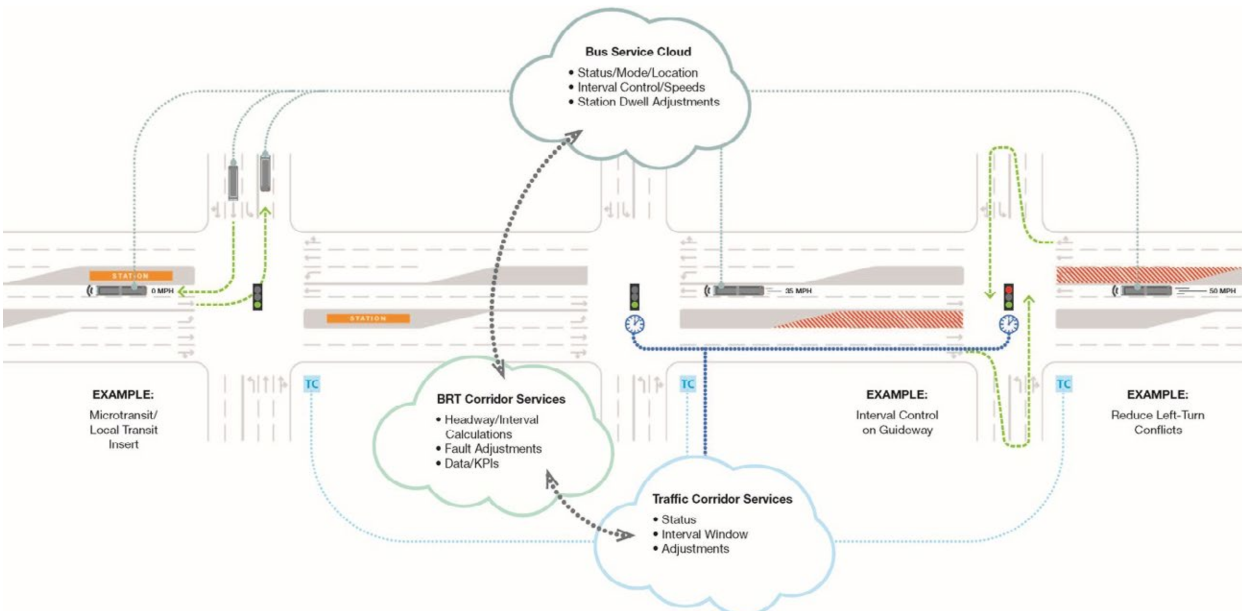


Figure 12: Example Concept of Guideway Interval Control - with the signal system working in conjunction with BRT speeds and managing intervals for vehicles to progress from station to station (local bus access control is also shown) / Source: IBI Group

While many of these can be implemented with static signage and striping, increasingly the expectation of drivers is that roadway lane designations will be clearly available in navigation apps, through electronic signage, and ultimately through connected vehicle technologies and in-vehicle displays.

Electronic signage can dynamically manage BRT Guideways in a variety of conditions / Source: ITVhub

Metro Standards

While there are not specific standards for guideway control for BRT, the use of guideway management and control approaches can be useful in achieving dedicated runningway and TSP standards.

> *BRT-Lite:* 20% of BRT-Lite corridors should have dedicated lanes during peak and 10% at all times. 75% of signals should have active priority (90% of signals on guideways).

> *Full-BRT:* 50% of the corridor should have dedicated lanes. 90% of signals should have active signal priority (100% of signals on guideways).

> *Target:* 100% of BRT corridors should have dedicated lanes. Conflicting left turns should be removed and conflicting driveways should be consolidated. 100% of signals along BRT corridors should have active signal priority focuses on achieving BRT performance metrics.

Guidelines for Implementation

Pre-requisites

In order to be as effective as possible, there are several prerequisites for guideway management and control, including:

- Reliable real-time communications from traffic signals to a central signal control or monitoring system for reporting and operations purposes.

OPTIONAL

- Frequent vehicle location updates from BRT vehicles to the guideway management system; every second or less for BRT to signal communications, or every 7 seconds or less for cloud based or corridor center-to-center systems.
- Agreements with the agencies managing signals to support programmed signal timing intervals focused on getting the bus from station with no to few stops at signals.
- Appropriate specialized indications for BRT vehicles and buses that will not be confusing to other traffic (e.g. MUTCD compliant).
- Sufficient curb-to-curb width and specialized designed striping and signage to support dynamic or flexible guideway management.

Roles and Responsibilities

The specific roles and responsibilities will vary based on the specifics of the guideway and the methods of control being utilized. In general responsibilities include:

- *Transit agency* – Providing for needed signal system, signage systems, corridor, and communications upgrades to BRT corridors, and on-going operational support budget for maintenance and monitoring. Also providing necessary equipment and supporting communications from the BRT vehicles to the signals and/or access management systems.
- *Local agency* – Implementing or overseeing implementation of guideway control and signal systems and communications, supporting signal configurations in signal timing, implementing timing adjustments to allow for special bus phases where appropriate, monitoring signal operations, and repairing signal related guideway electronics equipment.
- *Contractor* – A consultant is often hired to support the identification of guideway system equipment and suggesting configurations, as well as supporting initial implementation testing and oversight.
- *Specialty Roles* – Simple guideway control and access management can be carried out by typical design, construction, and engineering teams, however if more sophisticated interval control and speed management is desired, then the applications managing it must be specifically developed to meet the project needs. This may involve specialty software, vehicle system, and/or university research contractors.

Requirements

Functional

- Track BRT (every 1 to 3 seconds depending on system) vehicles to determine location and headways/bunching.
- Identify individual buses and vehicles by type to determine if they are "allowed" access to the guideway.
- Provide real-time communications from signals and between signals to a central signal management system for monitoring purposes.
- Supporting electronic signage depending on specific notifications needed to operators which might include:
    - Overhead or shoulder lane designation signage (noting to buses and other vehicles that a lane is currently a bus lane and/or directionality of that lane).
    - Bus signal indications to inform BRT and bus operators of when to enter/proceed along/or exit a guideway.
    - In-vehicle indications for speed or access available (where appropriate).
- For guideway interval control, need communications between bus tracking and signal interval functions to adjust TSP, as well as provide speed inputs to buses.
- Performance monitoring and reporting solution to provide feedback on equipment status, performance, and information for system fine-tuning.

Physical

- Appropriate signage and striping to make guideway access points clear and understandable to both bus operators and general drivers.

- Reduced conflicts (either cross streets or left turns) conflicting with the guideway where possible.
- Gantries or structures to support guideway signage and equipment.

Other Recommendations

The design of runningways must give careful consideration early on to operations, surrounding traffic conditions, physical design constraints, and passenger comfort when the BRT vehicle traverses the guideway at operating speeds. If guideways are not implemented with proper bus detection, signal priority, and management solutions, they can become a "physical trap" where buses are delayed while typical traffic signal operations are performed. The number of potential conflicting cross-street, and left-turn movements should be reduced to the minimum possible. Guideway design and systems should be focused on getting the greatest number of BRT vehicles between each station with little to no stops for signals or other forms of cross-street control. Pedestrian impacts and timing should be carefully considered as these can create significant delays for BRT vehicles, and it is best to board/alight on the far side of a controlled pedestrian crossings where possible with priority given to the BRT vehicle where safe to do so.

Opportunities and Challenges

The following trends and emerging technologies should be considered when designing the physical and technology elements of a guideway:

Dynamic Roadways

As advanced technologies such as **Connected Vehicles** and **Augmented Reality** become more accessible, dynamic roadways will allow the development of flexible road designation that can be adjusted based on demand and need at any given time. This may allow for a reduction in physical signage on the streets and increased use of in-vehicle indications and control.

Cloud-based Solutions

The power and flexibility of cloud based computing and communications solutions offers to simplify guideway management solutions. A cloud-based computing algorithm can receive frequent BRT vehicle position updates and process signal information provided by the signal/signal systems. This allows for more sophisticated adjustments of signal timing and BRT vehicle speeds to increase effectiveness and lower impacts.

Bus Interval and Signal Control

Building on a cloud-based approach, bus interval and signal control seek to manage bus headways through providing speed notifications to operators or controlling BRT speeds in dedicated runningways. Operators still maintain override and directional control of the vehicle. Intervals are placed within the signal timing of the corridor to provide optimal windows for BRT passage from station to station with lower chances of red lights, and active TSP functionality makes minor adjustments where vehicles are slightly off from the planned intervals.

Automated and Connected Vehicles

Automated and connected vehicle functionality should be planned for future implementation along any BRT guideway. It can be anticipated that vehicle to infrastructure connected vehicle functions will be implemented to manage vehicle access, speed control indications, enhance safety at guideway crossings, and ultimately support semi-autonomous or autonomous operations.

Other Related Elements

> Operating Characteristics - Multiple Services Sharing a Corridor
> Operating Characteristics - Service Parameters and Strategies
> Runningways - Traffic Operations
> Runningways - Roadway Geometrics
> Runningways - Intersection Geometrics
> Runningways - Runningway Placement Considerations
> Systems - Transit Signal Priority
> Systems - Access Control
> Systems - Access Control

Access Control / Source: IBI Group

c. Access Control

Access control describes the process during which a remote operator or program grants access to a bus to and from guideways, to special transit lanes, transit centers, or even shared streets where other vehicular traffic is restricted or prohibited. A LA County example of access control is the current effort to install railroad crossing like control gates at intersections along the Metro Orange Line. The implementation of quad-control gates along the Orange Line will be one of the first North American examples of using this approach to access control for BRT. There are several other applications where technology-based access control can be helpful. Increasingly, as our roadways face demands for broader and more equitable use across modes, the need for restricting or managing access increases. One common example in European cities is restricted access to shared street environments, where there is mixing of low-speed pedestrian, bicycle, bus, and sometimes local access auto/delivery traffic.

While it is possible to manage access to BRT facilities, lanes, transit centers, etc. using signage and striping, active access control can provide a higher level of control and separation. As technologies enhance over time, more dynamic use of roadway space will occur which may need to be combined with various forms of access management and control. In addition, access control may not always be physical in the future. As autonomous vehicles and shuttles proliferate, certain vehicle types may be "electronically" restricted from accessing certain guideways, lanes, shared street spaces, or transit centers.

Current example of moveable bollards for access control/ Photo Credit: National Signal

Shared street space with access control in Europe (examples exist where local access or bus is allowed / Photo Credit: ITVHub

Metro Standards

While there are not specific standards related to access control for BRT, it can be a useful tool in meeting standards for dedicate lanes.

> *BRT-Lite:* 20% of BRT-Lite corridors should have dedicated lanes during peak and 10% at all times.

> *Full-BRT:* 50% of the corridor should have dedicated lanes.

> *Target:* 100% of BRT corridors should have dedicated lanes. Conflicting left turns should be removed and conflicting driveways should be consolidated.

Guidelines for Implementation

Pre-requisites

The physical design of the BRT corridor or facility must be designed in such a way as to make efficient use of access control and management.

Roles and Responsibilities

Roles and responsibilities will vary on the specific application. In some situations where the access controls are for transit facilities only, the transit agency will be solely responsible for implementation, monitoring, and maintenance. In situations involving local agency right-of-way, the transit agency may support design, monitoring, and funding of operations and maintenance, but the local city or owning agency will likely be responsible for overall monitoring and maintenance. Specific roles and responsibilities should be defined during the planning and design stages.

Requirements

Functional

- Identify individual buses and vehicles by type to determine if they are "allowed" access to the controlled area. Access control is usually based on an RFID tag mounted to the vehicle, but video-based access control is also possible.
- Activation and status monitoring of the access control gates/barriers and systems to operate efficiently and alert when faults occur.
- Supporting communications from the access control systems to operations controls and safety management centers.
- Video feeds to operations or control centers for monitoring and enforcement by operations personnel.
- Clear signal indications to notify vehicles that access has been granted or denied and that the system is operational.

Physical

- Appropriate signage and striping to make guideway access points clear and understandable to both bus operators and general drivers.
- Physical barrier or gates where appropriate to enforce or clarify access points.

OPTIONAL

Other Recommendations

In an increasingly complex urban mobility environment, access control can be an essential ingredient of supporting an effective BRT system. It can allow BRT vehicles to access areas where other traffic should not be allowed for safety or other considerations. It can limit unwanted vehicle intrusions into dedicated guideways or transit facilities, and it can support a more dynamic use of roadway infrastructure where certain.

Opportunities and Challenges

The following trends and emerging technologies should be considered when designing the physical and technology elements of a guideway:

Dynamic Roadways

As advanced technologies such as **Connected Vehicles** and **Augmented Reality** become more accessible, dynamic roadways will allow the development of flexible road designation that can be adjusted based on demand and need at any given time. This may allow for a reduction in physical signage on the streets and increased use of in-vehicle indications and control.

Reallocation of Roadway Cross-Section/ Complete Streets/Road Diets

With the growing development of shared street concepts, bus services will have the opportunity to provide access and services to areas limited to vehicle circulation. Access control would allow for harmonious shared of the street between public transportation, cyclists, and pedestrians.

Automated, Connected Vehicles and Corridor Traffic Flow Prioritization will continue to play a central role in guideway configuration and access control, facilitating communication between vehicle, operators, and infrastructures.

Other Related Elements

> Operating Characteristics - Multiple Services Sharing a Corridor
> Runningways - Traffic Operations
> Runningways - Roadway Geometrics
> Runningways - Runningway Placement Considerations
> Systems - Guideway Control and Management

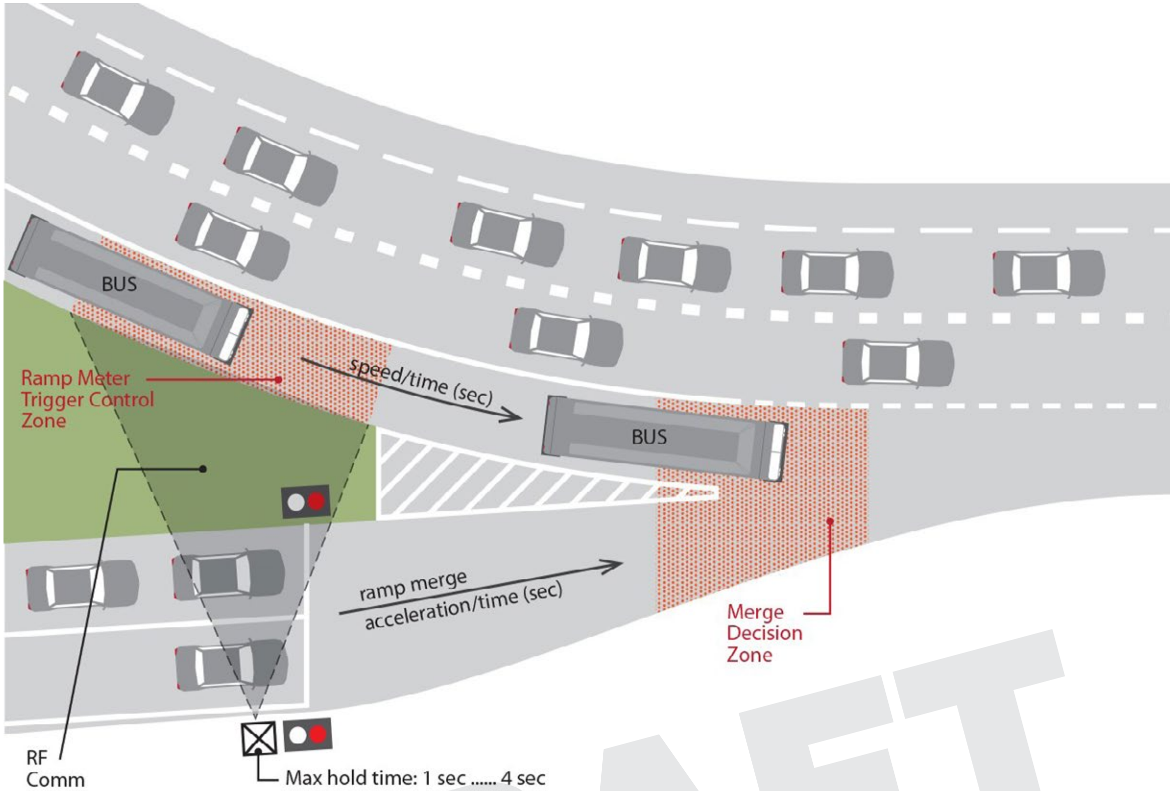


Figure 13: Ramp Meter Interrupt / Source: IBI Group

d. Ramp Meter Interrupt

BRT services that use freeways for a portion of the route frequently use ramps that are metered to merge onto the freeway. Ramp meters manage the flow rates onto freeways to reduce congestion and limit or delay flow breakdown on the facility. Where freeways are part of a BRT corridor, two types of ramp meter interrupt may prove useful to assist in giving the BRT priority: (1) where multiple on-ramp lanes exist along with an HOV or bus bypass ramp lane; and (2) where a bus on shoulder or transit only shoulder running lane is in use on the outside shoulder that crosses merge areas with on-ramps (see figure above).

In both cases, technologies can be applied to hold regular on-ramp lanes for a few extra seconds when a bus is present. In the case of a bypass on-ramp lane, this allows the bus to easily merge and progress down the ramp while other on-ramp lanes are held. In the case of the shoulder lane, the presence of the bus can trigger a hold of the on-ramp lanes that reduces the potential for conflicts at the merge or auxiliary lane area where the shoulder running bus and the on-ramp traffic has a conflict zone.

Ramp meter interrupt functionality exists in available Caltrans ramp meter software, and a transit only lane/outside shoulder demonstration project is underway in the San Diego region on I-805. Several technology options are available including use of TSP equipment, connected vehicle equipment, and/or video detection to determine the presence of a BRT vehicle. Operating BRT on the outside shoulder does have broader considerations involving physical conditions, operations guidelines and consideration, and typical peak traffic conditions that should be taken into account.

Pilot vehicle testing for the outside shoulder transit only lane running BRT with ramp meter interrupt - San Diego, Chula Vista / Photo Credit: IBI Group

Metro Standards

While there are not specific BRT standards for ramp meter interrupt and bypass lanes in the county, they can be part of achieving improved on-time performance and count towards dedicated lanes in some cases when in combination with transit only lane/shoulder lane implementation.

> *BRT-Lite*: Buses should be on time 75% of the time. 20% of BRT-Lite corridors should have dedicated lanes during peak and 10% at all times.

> *Full-BRT*: Buses should be on time 80% of the time. 50% of the corridor should have dedicated lanes.

> *Target:* Buses should be on time 90% of the time. 100% of BRT corridors should have dedicated lanes. Conflicting left turns should be removed and conflicting driveways should be consolidated.

Guidelines for Implementation

Pre-requisites

Ramp meter interrupt techniques assume the presence of an on-ramp with a ramp meter and either a bus bypass lane, HOV lane, or an outside shoulder transit only lane. It is important that the ramp meter operations be tied into and supported by the Caltrans ramp metering system for monitoring and management purposes.

If a shoulder transit only lane is used, then operational guidelines must be established for when the buses may operate in the lane. Usually, these guidelines assume that freeway speeds are 35mph or less and that the bus will not exceed 10 mph over the prevailing traffic flow. Adverse weather or lighting conditions may prevent use of the shoulder transit only lane. Improvements are often required to drainage, pavement, and signage to support these operations.

Roles and Responsibilities

Ramp meter interrupt implementation and operations requires close coordination with Caltrans and local agencies impacts by ramp modifications. The following general responsibilities apply:

- *Transit Agency* – The transit agency would be responsible for budgeting and leading design modification efforts to support ramp meter interrupt, including technologies necessary to detect the bus and communicate to the Caltrans ramp meter. Also, the agency would need to install appropriate equipment on the buses, and establish operating rules and guidelines. Finally, the transit agency would need to monitor the status of systems and operations and determine when bus operations using ramp meter interrupts would be allowed.
- *Caltrans* – Would review and approve designs, inspect construction efforts, update ramp meter controllers and software, and monitor ramp meter operations.
- *California Highway Patrol* – Is involved in pilot programming and ensuring safe use of the facility.

Requirements

<u>*Functional*</u>

- Need to be able to track and detect the position of the bus either on the outside shoulder or the ramp bypass lane (depending on the specific application). Usually this is accomplished through TSP or connected vehicle equipment (e.g. On-board Unit & Roadside Unit OBU/RSU).

- For outside shoulder transit only lanes, need to be able to determine if the bus is in the transit only lane or adjoining freeway lanes, as well as monitor and track speeds of the bus and general traffic flows.
- Need to be able to monitor status of the ramp meter and send a single to the ramp meter controller when an interrupt is required.
- Need to be able to set the maximum ramp meter interrupt by ramp meter location.
- Support the ability to track operations and equipment and communications status to monitor and maintain the system.

Physical

- Ramp bypass lane for bus or improved shoulder for transit only lanes.
- Mounting locations for communications equipment and video detection (if used).
- Static signage, electronic signage and signal indications for ramps to inform traffic when an interrupt is occurring.

Other Recommendations

Any mixed flow freeway ramp used by a BRT should have a bypass lane and ramp meter interrupt functionality. If a corridor is intending to utilize an outside shoulder transit only lane, then a ramp meter interrupt functionality is required for any on-ramp merge zones.

Opportunities and Challenges

Automated, Connected Vehicles and Corridor Traffic Flow Prioritization

Connected vehicle equipment and applications are especially well suited to ramp meter interrupt functionality, but are not required to implement it.

Institutional challenges can exist in implementing ramp meter interrupt, and it may be necessary to treat the effort as a pilot program, particularly with transit only lanes on shoulders.

Other Related Elements

> Operating Characteristics - Multiple Services Sharing a Corridor

> Operating Characteristics - Service Parameters and Strategies

> Systems - Transit Signal Priority

> Systems - Connected Vehicle

OPTIONAL

Transit Signal Priority / Source: www.ggwash.org

e. Connected Bus

Connected vehicles (CV) refer to the ability of a vehicle to communicate and share information with surrounding roadway infrastructure and technologies using CV standards and protocols. Connected vehicle applications are rapidly evolving, and their use in planning, implementing, and operating BRT corridors should be considered throughout the project development cycle. Connected vehicle functions are usually described as being based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) approaches. This design guidelines section specifically addresses bus to roadside infrastructure functions. These types of connected vehicle applications are most likely to apply to the following functional areas:

> *Transit signal priority* – Where a bus uses CV technologies and protocols to request and process signal priority with a signal controller or system.

> *Vehicle safety* – Where a bus receives feedback from roadside infrastructure on conflicting signal movements, lane closures, or other unsafe conditions.

> *Automatic Boarding* – Where presence of riders is detected and triggers the opening of the vehicle door.

> *Dynamic lane and guideway management control* – Where a bus uses CV technologies to identify lanes, status, directionality, and access points specific to BRT dedicated lanes, such as when it is ok to enter a median runningway, what directionality is set for a reversible lane, or what speed is most appropriate to match timed intervals for signals along a corridor.

> *Yard or transit center management* – Where a bus uses CV technologies in combination with CV roadside equipment to determine bay positions, layover status, and/or parking locations in a transit center or yard.

> *Mobility integration* – Where a bus communicates route, status, and other relevant information to roadside or station-based connected vehicle applications and protocols to support customer information and Mobility as a Service (MaaS) applications.

> *Future autonomous vehicle* – In the future autonomous vehicle functions may be supported by V2I communications and functions.

> *Intersection and roadway safety functions* - V2V and V2I based strategies can offer enhanced safety for transit vehicles and other traffic. This can include such items as red lighting runner warnings, collision warnings, proximity of pedestrians/cyclists, etc. Some bus based CV pilot test efforts are already underway in the LA region.

Vehicle specific connected vehicle functions are discussed in the vehicle section of the design guidelines.

Metro Standards

No specific Metro BRT standard exists related to connected vehicles and protocols. The technologies can however be helpful in supporting performance standards in a variety of areas.

Guidelines for Implementation

Pre-requisites

In order for connected vehicle applications to be effective, real-time communications should be in place from roadside CV equipment to central traffic and/or network monitoring systems. The end device needs to support the function required of the CV application. For example, TSP can be based on CV communications and protocols, but the end traffic signal controller must be capable of receiving the request and acting upon it.

Roles and Responsibilities

In order to implement CV-based approaches, close coordination between the transit agency and local agencies is required.

- *Transit agencies* – If CV roadside equipment is not already in place, it can be anticipated that the transit agency will need to budget for appropriate equipment along the BRT corridor, as well as ensure compatible equipment is deployed on the BRT vehicles. The transit agency may install, configure, monitor, and maintain vehicle-based CV equipment and applications
- *Local agencies* – Local agencies may install, configure, monitor, and maintain roadside CV equipment and applications.
- *Contractors* – Contractors will likely be needed to support design, implementation, and testing of CV applications along the BRT corridor.
- *Specialty Roles* – For the foreseeable future, CV applications will likely involve research, OEM, or university involvement to help develop and operationalize the applications.

Requirements

Functional

- Connected vehicles can support a wide range of functions, but typically provide location, direction, speed, and Basic Safety Message (BSM) information on a nearly continuous basis. The BSM includes data to support adaptive cruise control, speed harmonization, queue warnings, TSP, and incident/work zone alerts. BSM also includes information on vehicle actions, such as braking, throttle, steering wheel inputs, vehicle path prediction, and many other elements.
- Roadside CV equipment that can receive and process vehicle messages and information, as well as send out status, alerts, and information related to roadside infrastructure elements. For example, CV equipment connected to a traffic controller could be used to notify a bus that cross-street traffic has the "green."
- Roadside and vehicle CV equipment will communicate with vehicles via Dedicated Short Range Communications (DSRC) cellular V2X, and/or 5G.
- Mapping of the roadside infrastructure using CV protocols to identify transit lanes, runningways, other traffic lanes, and related attributes.
- Back office systems to support monitoring of equipment and applications.

Physical

- Physical space should be retained in shelters and in equipment cabinets along BRT corridors to support CV equipment and installations.

Other Recommendations

The exact path forward for CV technologies is not finalized, but it will play an increasing role in the sharing of information and functions between

OPTIONAL

vehicles, roadside infrastructure, and ultimately pedestrians and other forms of mobility. As each BRT corridor is assessed, it should be determined what near- and longer-term CV applications may be appropriate. BRT corridors are an excellent opportunity to test CV concepts, but not at the expense of near-term operational effectiveness. When available, OEM buses should be procured with on-board units (OBUs) using CV protocols.

Opportunities and Challenges

Automated and Connected Vehicles hold wide promises of increased safety on the road. They will provide for increased efficiency for many operational functions such as ramp meter interrupt for bus on shoulders, bus arrival at transit centers, routing to/from layover areas, automated accident notification, **Augmented Reality** for driver warnings, transit signal priority, etc. It will also support the development of **Corridor Traffic Flow Prioritization**, and other **Driver-Assist Technologies.**

Cloud Services will support the scaling and deployment of the technology needed to further develop connected vehicles. Paired with the **Internet of Things (IoT) and Mobility as a Service (MaaS)** services, it will allow the full integration of modes into a unified system, as well as the development of a platform where people can obtain immediate access to accurate data.

Artificial Intelligence (AI) Technologies is another core component that will bring further opportunities to develop connected vehicle technologies. If adequate customization can be achieved, it could play a significant role in analyzing systems' performance and adjusting service and mobility options in order to achieve increased ridership, among other things.

Other Related Elements

> Stations/Platforms - Systems Components
> Stations/Platforms - Signage and Passenger Information
> Runningways - Traffic Operations
> Integration of Transit-oriented Communities - First/Last Mile Connectivity
> Systems - Transit Signal Priority
> Systems - Vehicles

Reference Documentation

USDOT Intelligent Transportation Systems Joint Program Office – Connected Vehicle Website Info:

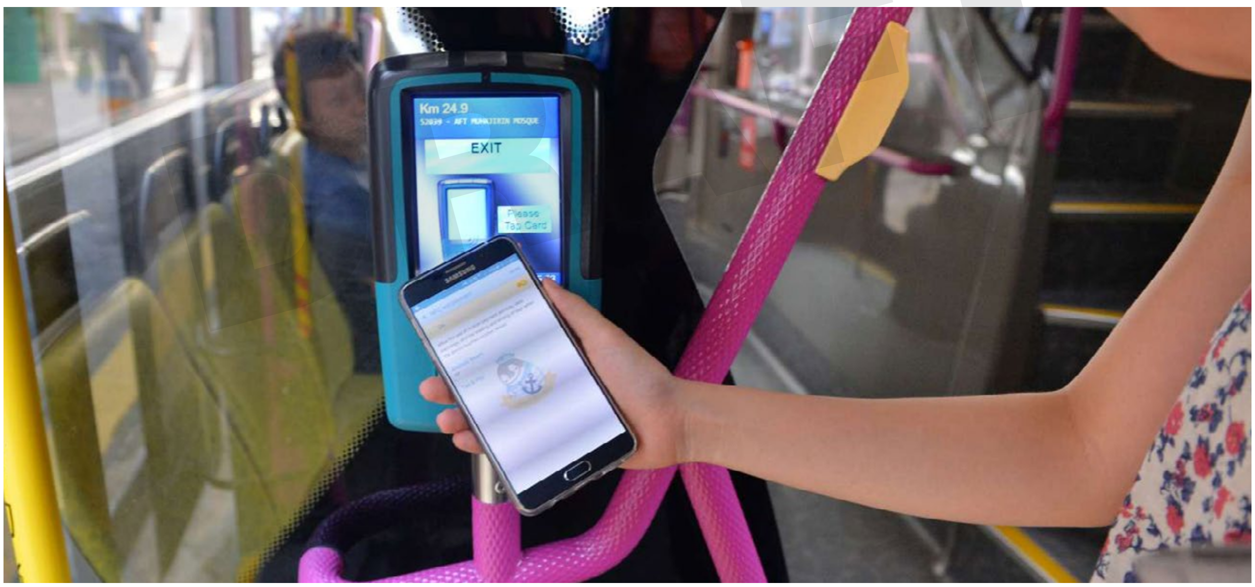
https://www.its.dot.gov/research_archives/safety/cv_safetypilot_progress.htm &

https://www.its.dot.gov/research_archives/safety/transit_v2v.htm

OPTIONAL

30 Stations

a. Fare Payment & Validation
b. Active Lighting Control
c. Customer WiFi and Charging
d. Technology Support Elements (e.g. 5G, etc.)
e. Digital Advertising



Fare Payment Validation / Source: The Straits Times

a. Fare Payment and Validation

Fare payment and validation options for BRT at stations currently include:

> *Ticket Vending Machines (TVMs)* – That can support cash, credit/debit card, smartcard/ pass validation.

> *Smartcard Validators* – That can be used to validate and deduct value or trips from a pre-paid smartcard device.

> *Mobile Fare Payment* – That allows riders to pay on their phone and either display a valid fare payment code or in some cases validate an on-phone smartcard option.

The LA County region has widely adopted the TAP system as a form of fare media, smartcard payment, and validation solution. This allows riders to buy, recharge, and use TAP for fare payment and validation with a variety of fare payment rates and programs.

OPTIONAL

Determining the best method of fare payment and validation depends on the specific characteristics of the anticipated riders for the new BRT service. Will a high percentage pay cash fares? This makes fare payment at a farebox at the front of the bus time consuming and generates extended dwells. TVMs may be the answer at locations with high-cash payment, but these systems can be expensive to deploy and maintain, particularly if the agency doesn't already have such as system for other services. If a high-percentage of riders will be TAP users, then it should be determined if validation can be accommodated by validators at each bus door or if prepaid fare zones may be most appropriate. Some agencies mix the two concepts depending on station types (particularly where rail and BRT services may be supported at the same transit station).

Metro Standards

TVMs at stations are not required in the BRT standards as many BRT stop/station locations may lack the space necessary for pre-paid fare zones. However, all-door boarding is required as part of the BRT standards, and this can be supported through a variety of fare payment approaches including using TVMs at stations. Transit Access Pass (TAP) is the regional standard for smartcard fare payment in the region, and any BRT service in the region must support TAP as an option.

Guidelines for Implementation

Pre-requisites

If TVMs and validators are to be deployed at stations, then appropriate power and communications must be designed and deployed for each station to support these elements. Also, security camera coverage of TVM payment areas where cash will be handled or vaults removed must be provided.

Roles and Responsibilities

The agency must specify and contract for the design and deployment of the fare payment equipment at stations. For larger agencies, these systems may be deployed by agency staff once appropriate communications and power are in place. The agency maintains the fare payment equipment at stations, or if multiple agencies use a station, then some form of interagency agreement may be required.

Usually agencies contract for removal of TVM cash vaults at regular intervals. Fare enforcement is conducted by the agency either on vehicle or at prepaid fare zones at stations using either agency or contracted staff.

Requirements

Functional

- Station-based TVMs shall be TAP compatible and allow the distribution, add value, and payment for TAP smartcards and related TAP fare payment devices.
- TVMs shall support all current agency fare programs (e.g. 1-trip, day-pass, monthly, reduced fare programs, etc.)
- If TVMs accept cash payment, then they shall make change.
- TVMs may be deployed without cash payment options (if the BRT line is expected to have very low levels of cash payment), and cash riders would pay at the bus farebox.
- TVMs shall be connected to a central fare system that monitors status of the TVMs, communications, and fare transactions.
- TVMs and validators shall send health alerts to support maintenance.

Physical

- If station prepaid fare zones are used, they shall be clearly marked.
- TVMs shall be placed to not obstruct the flow of pedestrian or station area traffic, as well as comply with ADA requirements.

- TVMs shall be deployed two per platform to provide redundancy unless the opposite platform TVMs or on-board payment options provide redundancy.

Other Recommendations

Fare payment options are evolving with LA Metro introducing the TAP wallet that allows an account based solution that can be used across multiple mobility options. TAP wallet allows even "unbanked" transit riders to replenish their accounts at designated outlets. Agencies should ensure any TVM and validators deployed can be easily updated to the latest TAP standards.

Opportunities and Challenges

The implementation of new TAP payment options and services, as well as account based solutions may make investments in expensive TVM equipment and infrastructure redundant. If riders can easily charge or pay for fare services and simply TAP validate as they enter any transit vehicle, the usefulness of TVMs is reduced significantly.

Other Related Elements

> Vehicles - Fare Payment and Validation

OPTIONAL

Active Lighting Control / Source: Franck Michel, Flickr

b. Active Lighting Control

Active Lighting can be added to regular lighting at stations to relay information and enhance safety features. Active lighting control uses technology and sensors to provide active monitoring and management of lighting elements at BRT stations. For example, active lighting control can be set up to:

> Change colors of particular lights or start a lighting sequence based on the approach of a BRT vehicle. Where multiple BRT routes intersect, the lighting color or conditions can be different for different routes. Another example is where a BRT station might be shared with local and BRT services. A lighting sequence or colored lights could be activated when a BRT vehicle approaches at the station, but not when local buses approach.

> Adjust lighting intensity and colors based on ambient lighting needs and presence of customers waiting for a bus. This could allow lighting to use less power when it is not needed.

> Adjust lighting to deter security or loitering concerns where lighting intensity can be increased to discourage extended loitering or reduce shadowed areas.

> Activate specific colors or lighted beacons based on emergency situations with control provided through activation of an emergency phone or operations control center actions. For example, a green light or beacon could be activated to help direct emergency services to the appropriate station platform or area.

Many cities are deploying smart streetlight systems that allow for lighting to adjust based on ambient conditions, presence of people, or specific situations. This simply extends that concept to BRT stations.

Metro Standards

Per the BRT standards, all BRT stations should be designed and implemented with lighting, including lighting in addition or in support of any street lighting that may be present in the corridor. However, active lighting control is a design and operations consideration and is not called for in the standards.

Guidelines for Implementation

Pre-requisites

The station and lighting elements should be designed with consideration of the possible use of active lighting control. Consideration needs to be given about whether the benefits of active lighting control outweigh the potential drawbacks (e.g. it may prove distracting for neighboring uses/businesses, etc.).

Roles and Responsibilities

The transit agency would typically retain responsibility for the design, implementation, monitoring and maintenance of active lighting control elements. Active lighting control can be driven by automated triggers (e.g. bus arrival), operations control center personnel, and/or safety/security center personnel.

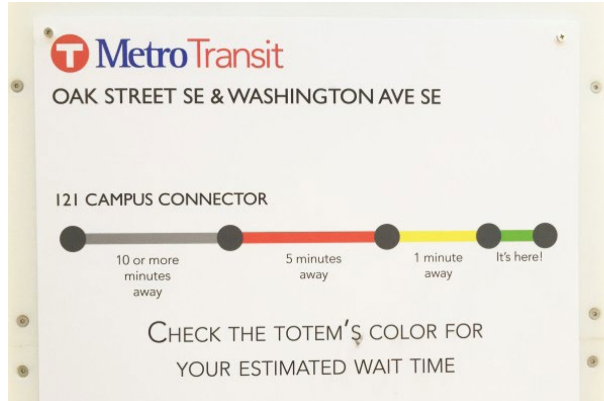
Requirements

Functional

- Ability to set up lighting actions based on various triggers.
- System to detect the pending arrival of a bus at the station (if this is the activation desired), usually triggered by GPS position updates through a cloud-based solution or through a TSP type device.
- Ability to remotely monitor and manage lighting controls and troubleshoot problems.

Physical

- Deployment of individual manageable lighting elements to support desired lighting controls/ actions.
- Deployment of a lighting control/ management device usually networked with communications to a central or cloud-based control system.
- Active lighting elements should clearly distinguish themselves from baseline lighting with the activation trigger and reasons being clearly discernable to customers waiting at the station.



Example of active lighting control at a bus station / Source: Rosco

Other Recommendations

Although motion-detection features are useful to alert customers and drivers of the presence of others, it can leave stations in the dark and provide uncomfortable environments for users. Active lighting control should be limited to areas where surrounding light is already present and where there are not substantial concerns about disturbing neighbors. Noise and movement detection systems should be sensitive enough to detect any human activity, and should light up a wide area to remove dark areas and blind spots. It should also include an alert system transmitted to operations center, to allow quick intervention as needed.

OPTIONAL

Opportunities and Challenges

Video Analytics will support the implementation of active lighting control technologies, providing the ability to interpret signals and movement, and communicate these signals as lighting needs.

Other Related Elements

> Stations/Platforms - Lighting

> Stations/Platforms - Systems Components

> Integration of Transit-oriented Communities - Public Realm/Open Space

Active Lighting Control / Photo Credit: Franck Michel, Flickr

c. Customer WiFi and Charging

Customer WiFi is an amenity that can enhance the attractivity of transit and make BRT a preferred mode. It refers to the ability to provide free WiFi services, easily accessible without login credentials, to riders waiting at transit stations. WiFi has other applications at stations, but this section pertains specifically to WiFi services as an amenity to enhance the rider experience and provide the ability for riders to access services that require a higher bandwidth than may be currently available through their selected data plan with their telecommunications service provider.

Metro Standards

Customer WiFi is not mentioned in the standard for Metro BRT-Lite and Full-BRT services.

Guidelines for Implementation

Pre-requisites

- *Service:* Continuous (24/7) access to the selected telecommunications digital network, or cable network through an internet service provider.
- *Power:* Electrical power supply for gateway, routers, access points.
- *Connecting Device (Ruggedized Mobile Gateway (Modem or Modem/Router)):* Supports 3G/LTE/5G or fiber optic connectivity and provides continuous (24/7) access through telecommunications service provider to internet backbone. (Recommended option)
- *Connecting Infrastructure:* Wired alternative to above WAN connectivity, such as fiber optic or DSL. (Secondary option)

Roles and Responsibilities

- Transit agency staff must perform regular physical checks of display and communications infrastructure.
- Transit agency technology managers must annually review and adjust agreements, acceptable standards and per passenger data usage policies (if any) to keep up with quickly evolving technology capabilities.

Requirements

Functional

- *WiFi standard:* All equipment should support IEEE Standard: 802.11n, ac, and ax, with backward compatibility to previous 802.11b and g standards.

OPTIONAL

- *WiFi Access Point (with the following capabilities):*
  - > Centralized management and provisioning capability
  - > Back-up power supply
  - > Unlimited In-network Roaming
  - > Limited Number of Uplink Requirements
  - > 2.4 Ghz 802.11 b/g/n Transceiver with Super-G, XRS, Mimo Technologies
  - > 5 Ghz 802.11 a/n/ac Transceiver with Turbo-G and Mimo Technology
  - > Centralized Access Control
  - > Fault-tolerant Infrastructure Implementation
  - > Real-time Client Scanning and Triangulation Services
  - > Advanced Authentication and Session Management
- > *WiFi Mesh Network System (Alternative for large footprint stations or multiple stations within 3000 ft proximity to one another):*
  - All of the above capabilities for the access point plus ability to serve as the backbone uplink for other client devices on the mesh network.

<u>*Physical*</u>

- *Service:* Service provider agreement
- *Power:* As specified for typical mobile gateways and access points
- *Connecting Device (Mobile Gateway):*
  - > Multi-carrier (3G/4GLTE/5G); dual SIM for carrier failover and flexibility
  - > Flexible 9-30 VDC power input
  - > Ruggedized (e.g., MIL-STD-810G certified for shock, vibration, temperature; IP5
  - > Interfaces (e.g., Ethernet port, DB9 or USB)
  - > WiFi AP support
- *Connecting Infrastructure:* Last mile fiber optic cable or DSL cable (secondary alternative)

Other Recommendations

Customer WiFi at stations and onboard the BRT vehicle is an important feature to ensure safety, allow transit riders to quickly communicate with operators or law enforcement, and improve the rider experience and perceptions of convenience. It is also a useful tool to access real-time information regarding routes, schedules, service disruption, TNCs, and other MaaS elements. Although most people currently have access to data via their mobile devices, customer WiFi should be made available at major transit stations in the short term.

Transit agencies should investigate possibilities for realizing economies of scale by using WiFi infrastructure deployed on BRT vehicles. Further economies of scale may be realized by the use of mesh network systems that provide WiFi coverage over a larger area and requiring a smaller number of uplinks to the internet backbone.

The availability of WiFi service should be advertised at stations on signage, as well as folded into the rotation of content on other screens or equipment being deployed for information dissemination.

Opportunities and Challenges

The Gig-based Economy implies that more and more people are working based on limited term contracts and changes in travel pattern. Customers may need to constantly stay connected and work in informal places. The ability to use WiFi while waiting at transit stations, as well as on the bus can support the need of this type of worker.

Opportunities for branding and customer service can be realized by using a WiFi portal. While the recommendation is to provide free WiFi, the agency should firewall the service with a page requiring users to agree to Terms and Conditions. This page can be used to advertise agency services, provide a method by which users can provide feedback, or connect with a mobile application providing customer service and emergency communication.

Internet technology is currently deployed using 4G networks; however, 5G is becoming available and the preferred option in some settings for service providers. 5G is still in the rollout stages in many cities, including Los Angeles. Agencies should take care to investigate the viability of deploying free WiFi in areas where 5G is available, but also ensure that 4G LTE services continue to be supported until the 5G network matures. Stations outfitted with WiFi running on 4G must also ensure that equipment deployed has cross-compatibility with 5G to accommodate this transition period between the two protocols.

Other Related Elements

> Operating Characteristics - Fare Collection and Boarding Protocols

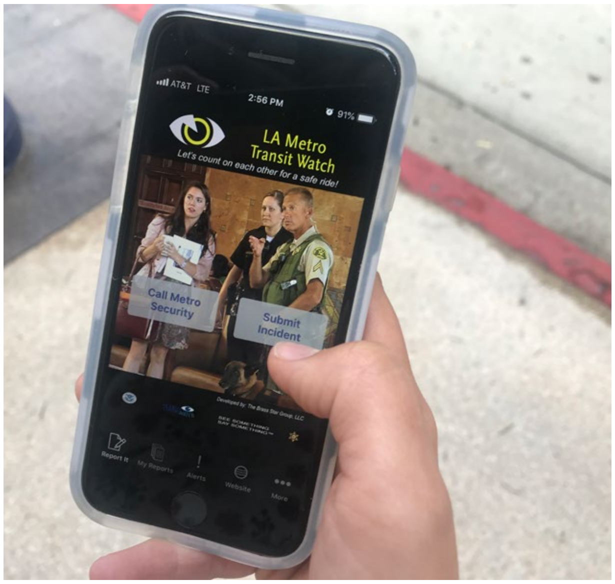
> Stations/Platforms - Signage and Passenger Information

> Branding - Stations

> Integration of Transit-oriented Communities - First/Last Mile Connectivity

> Integration of Transit-oriented Communities - Stations

OPTIONAL



Technology Support Elements / Source: IBI Group

Technology Support Elements / Source: San Diego Reader

d. Technology Support Elements

Technology Support Elements refer to upcoming technologies such as 5G and supporting data platforms, which will allow for quick sharing of data and information between individuals, vehicles, infrastructures, and operations. 5G in particular has upcoming releases that will provide enhancements in flexibility, scalability and efficiency, and will enable very high bandwidth transmissions for streaming video, supporting security cameras and WiFi access points, with low latency communications that will be needed for use with potential future remote communications capabilities for vehicle control, real-time passenger information, security/environmental sensors, or other Internet of Things (IoT) applications. 2019 is considered to be the initial deployment year for 5G, but it could be another few years before Los Angeles joins the cities who already have limited rollouts of this technology. Telecommunications service providers often start by rolling out the technology at specific sites and venues (such as stadiums or large event centers). Therefore, the extensive 4G LTE networks will continue to provide the underlying technology in the near term until 5G is fully deployed by various telecommunications service providers. Additionally, 5G has some limitations that telecommunications service providers must overcome with subsequent releases of the technology – namely poor wall penetration and short range of coverage. An alternative to fixed wireless solutions like 5G and its predecessors are wired solutions such as fiber optic, DSL and cable infrastructure, and their respective service providers. The various wired solutions would be considered a secondary alternative due to the high initial cost and inflexibility of installation.

Metro Standards

Metro does not have stated standards for Technology Support Elements.

Guidelines for Implementation

Pre-requisites

In order to be as effective as possible, there are several prerequisites for supporting technologies, including:

- Power supply
- Connectivity mechanisms, either wired (e.g., fiber-optic cable) or wireless (e.g., Wide-area Network (WAN)) access to the telecommunications service provider's network (i.e., 4G LTE or 5G digital cellular service).
- Continuous, reliable communications service (i.e., 4G LTE or 5G digital cellular service) will need to be active and available to stations and configured to allow agency remote or physical access to the router, access point, and service (for security equipment, fare payment applications) or to set up and enable customer WiFi access upon station activation.
- Implementation and verification of seamless interoperability between station communications equipment and BRT on-vehicle communications equipment to support technology-based amenities such as customer WiFi access points, and agency needs/capabilities such as passenger counting.
- Reliable, real-time communications from stations to an operations center or monitoring system for reporting and operations purposes.
- Agreements with telecommunications service providers will need to be in place between Metro and the service provider to accommodate any selected technologies that rely on cellular service or other wire-line services (if applicable).
- Agreements or memorandums of understanding may need to be in place between Metro and other municipalities where services, equipment or infrastructure will be shared or used cooperatively.

Roles and Responsibilities

- *Transit agency* – Provide needed connectivity to the digital cellular network (e.g., 5G, 4G LTE, etc.) by either wireless or wired communications infrastructure (or upgrades) to BRT corridors, including on-going operational support budget for maintenance and monitoring. Also provide necessary equipment and supporting communications services from the BRT stations or vehicles to the central operations and management centers, and data analytics tools for managing system performance or informing other systems such as passenger counting or fare payment systems.
- *Local agency* – Depending on division of responsibilities within each jurisdiction, local municipal agencies, may be responsible for some of the previously described transit agency responsibilities, and/or implementing or overseeing implementation of communications systems improvements, supporting communications equipment or system configurations, monitoring equipment operations and maintenance, or the administration of agreements with communications service providers.
- *Contractor* – Contractors may be responsible for the installation of communications systems, including supporting communications equipment or system configuration, providing communications system management tools or analytics.
- *Service Provider* – Service providers, such as telecommunications service providers or internet service providers (ISPs), will be responsible for providing either the commercial digital cellular communications services or, fiber optic or DSL services respectively, required to support interactions between points of service (stations or buses or operations centers) and the service provider's communications network.

OPTIONAL

Requirements

Functional

- *Service:* Continuous (24/7) access to the selected telecommunications digital network, or cable network
- *Power:* Electrical power supply for routers, access points, and other integrated communications equipment
- *Connecting Device (Ruggedized Mobile Gateway):* Supports 3G/LTE/5G connectivity and provides continuous (24/7) access to telecommunications service. (Recommended option) or similar
- *Connecting Infrastructure:* Wired alternative to above WAN connectivity device, such as fiber optic or DSL. (Secondary option)

Physical

- *Service:* Service provider agreements
- *Power:* As specified for typical mobile gateways and access points
- *Connecting Device (Mobile Gateway):*
  - > Multi-carrier (3G/4G LTE/5G); dual SIM for carrier failover and flexibility
  - > Flexible 9-30 VDC power input
  - > Ruggedized (e.g., MIL-STD-810G certified for shock, vibration, temperature; IP5
  - > Interfaces (e.g., Ethernet port, DB9 or USB)
  - > WiFi AP support
- *Connecting Infrastructure:* Last mile fiber-optic cable or DSL cable (secondary alternative)

Other Recommendations

Stations should be designed to accommodate future technology support elements such as routers to connect to current digital cellular networks, and upcoming 5G. Interactive displays, fare payment infrastructures, passenger counting, security cameras and supporting mobile applications will all be transformed by and dependent on these new technologies. Therefore, stations should include space within the cabinet enclosure to support gateway routers for digital cellular service connections for WANs and customer WiFi. Cabinet infrastructure and housings should be an integrated yet modular design that accommodates easy connections to power and communications infrastructures and allows items, such as routers or access points, to be easily replaced as technology changes. When specifying technologies, robust and flexible equipment would be most cost effective. For example, when selecting routers, especially during this period of transition from 4G to 5G, a multi-carrier/multi-service capability is recommended where one router can switch between carriers and services as conditions dictate.

While wireless technology is the preferred trend, fiber-optic infrastructure may be available along certain BRT corridors. Running ways near stations should be designed to also allow for connections to fiber-optic communications infrastructure to support selected technologies (if needed).

A review should be conducted prior to and during the detailed design for a BRT station's communications infrastructure and the development of other supporting technology equipment specifications to determine what capabilities and services are currently available from the telecommunications service provider, router/modem technology providers, and trends in consumer technology capabilities. Additionally, it will be necessary to determine if service agreements and existing infrastructure support the design and specifications, or if upgrades or updates will be needed.

Opportunities and Challenges

Technology support elements will play a pivotal role in enhancing stations amenities such as customer WiFi, security devices, customer information displays, increasing the quality and speed of Video Analytics, or enabling the implementation of Artificial Intelligence Technologies.

Mobile Communications Standards

Internet technology is currently deployed using 4G networks; however, 5G is becoming available and will become the preferred option for providers over the next few years. Stations outfitted with systems and technologies running on 4G LTE may find the service reaches end of life in a short period of time (5-7 years). Low latency, high bandwidth, and connection density (more devices) are some of the primary advantages of 5G as the new standard for cellular-based broadband, thus creating a direct benefit over WiFi nodes that are connected to a fiber-optic network and require a more significant investment in physical infrastructure. An interim Gigabit-Class LTE is a higher-performance expansion of 4G LTE and is touted to be a pathway to 5G; additionally, 5G is not anticipated to replace 4G in the very near term, but will work in concert with 4G during the transition. Selection of routers and other broadband infrastructure will require an examination of current standards and anticipated near term changes in technologies at the time of deployment.

Some example use cases and opportunities for the currently available and emerging standards may include:

Mobility Data Specifications

Connectivity and interoperability with other mobility modes and services is a desired characteristic of BRT. Connectivity among modes requires data sharing and governance of the data. The capabilities in this realm are evolving quickly, so there will be a need to re-examine the available technologies and tools every few years. Currently, for example, the City of Los Angeles has developed a Mobility Data Specification (MDS), a publicly available data and API standard (for agencies and providers) that allows an agency to collect, analyze, and compare real-time data from Mobility-as-a-Service (MaaS) companies. Originally intended for visibility into dockless mobility devices, MDS has potential to facilitate the exchange of data for a much broader set of mobility services, including private mobility and car sharing that would help agencies gain visibility into regulatory compliance challenges (such as curb management) and would help make connections and trip planning more seamless for customers. Metro's back-office connections to this tool and/or similar tools will be important as part of the support technology suite for BRT. A challenge accompanying this data specification includes privacy concerns and competitive sensitivities associated with the private companies that are requested or required to share data.

5G Small Cell Tower Range and Penetration

The benefits of 5G are dependent upon a denser network of smaller cells due to current range and penetration limitations for 5G. The implementation and installation of the "small cell" towers needed for 5G will require local municipality/government authorization. A clear understanding of existing infrastructure around the proposed station will be key in determining how to best support the proposed technology devices and applications proposed for BRT stations.

Use Case	4G LTE	Gigabit-Class LTE	5G
Video for Surveillance	Visual recognition	HD visual recognition	Machine recognition & automatic triggers
Video for Public Safety	Video capture for analysis after event	Real-time HD video monitoring	Machine recognition and response
Wireless WAN	No wired/fiber infrastructure needed; accommodates low bandwidth requirements	No wired/fiber infrastructure needed; may accommodate higher bandwidth requirements	No wired/fiber infrastructure required; accommodates fiber-like requirements
Transit Vehicles	Tracking and telemetry applications (AVL)	Multi-media applications	Real-time driver assist and autonomous applications

Table 2. Summary of Short Urban Rail Routes

OPTIONAL

Other Related Elements

> Operating Characteristics - Fare Collection and Boarding Protocols

> Stations/Platforms - Systems Components

> Stations/Platforms - Signage and Passenger Information

> Branding - Stations

> Branding - Stations

Digital Advertising Example/ Source: JCDecaux Singapore

e. Digital Advertising

Digital advertising represents an opportunity to integrate customer information needs, advertising opportunities, and even entertainment options for people waiting for a bus. Highly visible and ruggedized electronic displays are increasing being utilized to fulfill advertising contract needs/ opportunities, as well as customer information at rail and busy bus stops. Depending on the location and right-of-way considerations of the stops, digital advertising can be supported by agency deployed and managed systems and equipment or through contracted relationships with third party advertising companies.

LA Metro has been rolling out digital advertising mixed with customer information and service alerts through an arrangement with a third party at rail stations. Equipment is deployed and maintained by the third party which allows certain space and screen allocations for customer information needs. A similar approach could be utilized for other rail services and BRT corridors depending on institutional agreements and current advertising contact considerations.

Metro Standards

Metro has not established standards for digital advertising at BRT stations. However, deployment of digital advertising should be restricted to high-volume stations with good security, lighting, and vandal resistant enclosures. Also, the types of digital advertising and enclosures should enhance, support, or at least not conflict with the branding elements of the BRT.

> *BRT-Lite:* BRT designator on stations and vehicles.

> *Full-BRT:* Distinctive design and logo, coordinated colors, and art.

Guidelines for Implementation

Pre-requisites

Availability of power and communications to the location of the advertising display.

Roles and Responsibilities

The transit agency is responsible for incorporating the space, power, and communications drops to support near-term or future planned digital advertising displays. The transit agency may need to review and negotiate allowances for the displays with other agencies

OPTIONAL

if the station resides outside the transit agency right-of-way. In any event, the transit agency will need to negotiate advertising fees and requirements for content provision, maintenance and installation of the displays.

Advertising companies may take on the full roll of providing, installing, delivering content, and maintaining the display. Communications may utilize the transit agency backbone communications to stations or be provided separately.

Requirements

Functional

- Provide customer information feeds for inclusion into digital advertising content.
- Provide management tools for content management and framing (if not provided by contractors).
- Displays should be bright enough to be easily visible in direct and/or bright sunlight.

Physical

- Provide conduit and pullbox/cover for future potential digital advertising pylons.
- Provide power and communications for installed advertising pylons/displays.
- Enclosures should be vandal and weather resistant.
- Advertising pylons should not take up space under the shelter canopy that could be used for customers.

Other Recommendations

Although it can bring revenue, digital advertising should be secondary to service information and updates. Standards must be developed that allow for presentation of digital advertising only secondarily to critical information dissemination. Advertisements should be run only after real-time transit arrival information, emergency access instructions and information, and potentially PSAs have adequate time for display.

Interactive Adobe EchoSign Game / Source: Owen Jones

Opportunities and Challenges

Digital advertising provides benefits not available in static, printed panel advertising. The frequency and duration of advertising can be adjusted based on the importance of other information.

Other Related Elements

- > Stations/Platforms - Signage and Passenger Information
- > Stations/Platforms - Systems Components
- > Branding - Stations
- > Systems - Customer System Information
- > Integration of Transit-oriented Communities - First/Last Mile Connectivity

OPTIONAL

40 Vehicles

a. Connected Bus
b. Autonomous Vehicle Control/Driver-assist Systems
c. Vehicle Health
d. Onboard WiFi

a. Connected Bus

Connected vehicles (CV) refer to the ability of a vehicle to communicate and share information with surrounding roadway infrastructure and technologies using CV standards and protocols. Connected vehicle applications are rapidly evolving, and their use in planning, implementing, and operating BRT corridors should be considered throughout the project development cycle. Connected vehicle functions are usually described as being based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) approaches. This design guidelines section specifically addresses bus to roadside infrastructure functions. These types of connected vehicle applications are most likely to apply to the following functional areas:

> *Transit signal priority* – Where a bus uses CV technologies and protocols to request and process signal priority with a signal controller or system.

> *Vehicle safety* – Where a bus receives feedback from roadside infrastructure on conflicting signal movements, lane closures, or other unsafe conditions.

> *Automatic Boarding* – Where presence of riders is detected and triggers the opening of the vehicle door.

> *Dynamic lane and guideway management control* – Where a bus uses CV technologies to identify lanes, status, directionality, and access points specific to BRT dedicated lanes, such as when it is ok to enter a median runningway, what directionality is set for a reversible lane, or what speed is most appropriate to match timed intervals for signals along a corridor.

> *Yard or transit center management* – Where a bus uses CV technologies in combination with CV roadside equipment to determine bay positions, layover status, and/or parking locations in a transit center or yard.

> *Mobility integration* – Where a bus communicates route, status, and other relevant information to roadside or station-based connected vehicle applications and protocols to support customer information and Mobility as a Service (MaaS) applications.

> *Future autonomous vehicle* – Future autonomous and connected vehicle functions may be supported by V2X communications and functions for a variety of operational and safety features.

Vehicle specific connected vehicle functions are discussed in the vehicle section of the design guidelines.

Metro Standards

No specific Metro BRT standard exists related to connected vehicles and protocols. The technologies can however be helpful in supporting performance standards in a variety of areas.

Guidelines for Implementation

Pre-requisites

In order for connected vehicle applications to be effective, real-time communications should be in place from roadside CV equipment to central traffic and/or network monitoring systems. The end device needs to support the function required of the CV application. For example, TSP can be based on CV communications and protocols, but the end traffic signal controller must be capable of receiving the request and acting upon it.

Roles and Responsibilities

In order to implement CV-based approaches, close coordination between the transit agency and local agencies is required.

- *Transit agencies* – If CV roadside equipment is not already in place, it can be anticipated that the transit agency will need to budget for appropriate equipment along the BRT corridor, as well as ensure compatible equipment is deployed on the BRT vehicles. The transit agency may install, configure, monitor, and maintain vehicle-based CV equipment and applications.
- *Local agencies* – Local agencies may install, configure, monitor, and maintain roadside CV equipment and applications.
- *Contractors* – Contractors will likely be needed to support design, implementation, and testing of CV applications along the BRT corridor.
- *Specialty Roles* – For the foreseeable future, CV applications will likely involve research, OEM, or university involvement to help develop and operationalize the applications.

Requirements

Functional

- Connected vehicles can support a wide range of functions, but typically provide location, direction, speed, and Basic Safety Message (BSM) information on a nearly continuous basis. The BSM includes data to support adaptive cruise control, speed harmonization, queue warnings, TSP, and incident/work zone alerts. BSM also includes information on vehicle actions, such as braking, throttle, steering wheel inputs, vehicle path prediction, and many other elements.
- Roadside CV equipment that can receive and process vehicle messages and information, as well as send out status, alerts, and information related to roadside infrastructure elements. For example, CV equipment connected to a traffic controller could be used to notify a bus that cross-street traffic has the "green."
- Roadside and vehicle CV equipment will communicate with vehicles via Dedicated Short Range Communications (DSRC) and/or 5G.
- Mapping of the roadside infrastructure using CV protocols to identify transit lanes, runningways, other traffic lanes, and related attributes.
- Back office systems to support monitoring of equipment and applications.

Physical

- Physical space should be retained in shelters and in equipment cabinets along BRT corridors to support CV equipment and installations.

OPTIONAL

Other Recommendations

The exact path forward for CV technologies is not finalized, but it will play an increasing role in the sharing of information and functions between vehicles, roadside infrastructure, and ultimately pedestrians and other forms of mobility. As each BRT corridor is assessed, it should be determined what near- and longer-term CV applications may be appropriate. BRT corridors are an excellent opportunity to test CV concepts, but not at the expense of near-term operational effectiveness. When available, OEM buses should be procured with on-board units (OBUs) using CV protocols.

Opportunities and Challenges

Automated and Connected Vehicles hold wide promises of increased safety on the road. They will provide for increased efficiency for many operational functions such as ramp meter interrupt for bus on shoulders, bus arrival at transit centers, routing to/from layover areas, automated accident notification, **Augmented Reality** for driver warnings, transit signal priority, etc. It will also support the development of **Corridor Traffic Flow Prioritization**, and other **Driver-assist Technologies.**

Cloud Services will support the scaling and deployment of the technology needed to further develop connected vehicles. Paired with the **Internet of Things (IoT) and Mobility as a Service (MaaS)** services, it will allow the full integration of modes into a unified system, as well as the development of a platform where people can obtain immediate access to accurate data.

Artificial Intelligence (AI) Technologies is another core component that will bring further opportunities to develop connected vehicle technologies. If adequate customization can be achieved, it could play a significant role in analyzing systems' performance and adjusting service and mobility options in order to achieve increased ridership, among other things.

Other Related Elements

> Stations/Platforms - Systems Components
> Stations/Platforms - Signage and Passenger Information
> Runningways - Traffic Operations
> Integration of Transit-oriented Communities - First/Last Mile Connectivity
> Systems - Transit Signal Priority
> Systems - Vehicles

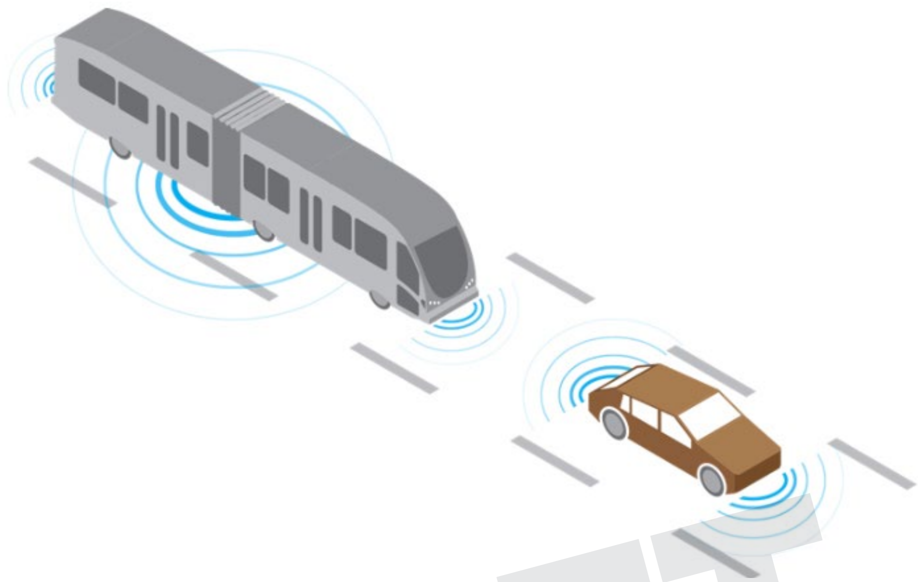
Reference Documentation

USDOT Intelligent Transportation Systems Joint Program Office – Connected Vehicle Website Info:

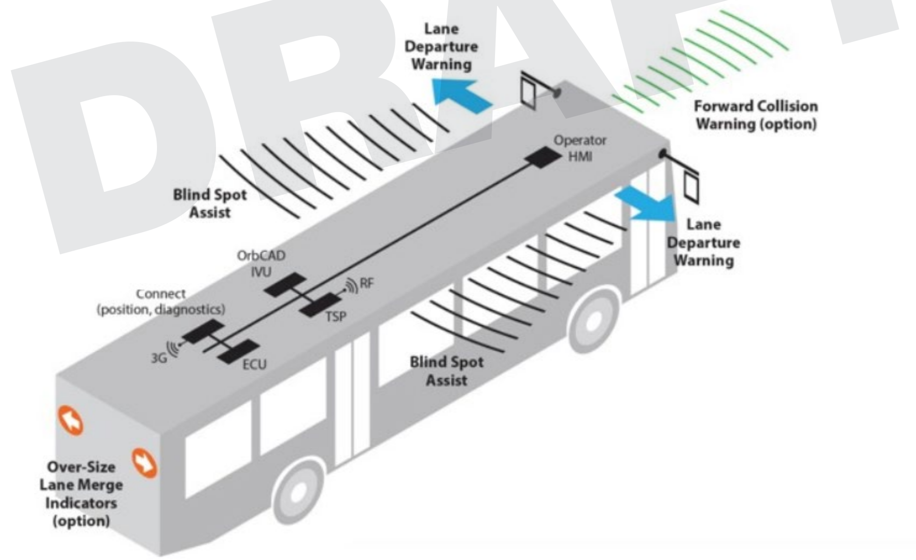
https://www.its.dot.gov/research_archives/safety/cv_safetypilot_progress.htm &

https://www.its.dot.gov/research_archives/safety/transit_v2v.htm

b. Autonomous Vehicle Control/ Driver-assist Systems



Source: IBI Group



Source: IBI Group

In the context of this study, Autonomous Vehicle Control & Driver-assist Systems refer to programs that assist drivers by supporting some vehicle control functions and providing supplemental warnings about surrounding traffic and safety concerns. On-board Driver Assistance Systems (DAS) include sensors, processors, and displays to continuously monitor traffic for safe operating conditions and can provide Forward Collision Warning (FCW), Lane Departure Warning (LDW), Pedestrian and Cyclists Collisions Warning (PCW), and Blind Spot Detection (BSD) alerts to bus operators during appropriate situations. Driver assist systems are best specified during the manufacture of the vehicle. Systems that combine the capabilities BSD and PCW are evolving and some are currently on the market, although the individual capabilities of the BSD do not replace the capabilities of the PCW, or vice versa. As driver assistance systems become more mature, many of the capabilities will likely continue to be packaged into more sophisticated multiple-capability systems using a variety of complementary technologies (e.g., radar, image processing, lidar, etc.) in a single integrated system versus the installation of individual systems with the aforementioned capabilities that must be integrated with one another upon installation on the bus.

Specific BRT applications can benefit from autonomous functions – such as bus speed controls (to meet signal control windows of opportunity) and median running (lane guidance), resulting in lower driver fatigue. These guidelines will be safety or speed related

Metro Standards

N/A

Guidelines for Implementation

Two types of Driver-assist Systems – 1. Warning systems that require the actions of a trained, skilled and alert driver to safely mitigate the conditions that caused a system alert; 2. Warning and mitigation systems that require a combination of actions of a trained, skilled and alert driver to determine if additional actions are required mitigate the conditions that caused a system alert or the automated system responses (e.g., automatic braking). This guideline focuses predominantly on the first, the warning systems, with the exception of speed controls that may also include throttle controls and possibly braking controls.

Pre-requisites

For all driver assist systems and autonomous functions, buses must be equipped with systems and technologies that include sensors, processors, and visual displays or audible alert devices required to inform the drivers' operational decisions. These systems are best specified by the transit agency before purchasing the vehicle and installed during manufacturing. Alternatively, these systems and technologies may also be procured and installed by subcontracted third party providers. Maintenance and operations training and schedules must be developed to support the system deployment and on-going operation. Driver education and training plans are also a requirement for these systems. Coordination and collaboration with labor representatives are an important pre-requisite to ensure accurate understanding of how driver assistance and autonomous vehicle control systems are intended to integrate into current and planned operations. The systems discussed in this guideline current do not take the place of a trained, skilled, alert driver exercising safe driving habits and using appropriate judgement when taking any action based on the current driving conditions. Based on the present day maturity of these technologies, the systems discussed in this guideline are largely warning systems with some low levels of automation.

An optional element of this system may also include an interface to communications equipment or an on-board unit (OBU) that permits the status of the driver assistance and autonomous vehicle control systems to be communicated and monitored remotely at a central operations center.

Roles and Responsibilities

For new BRT buses, the transit agency is responsible for specifying the equipment to be installed on the bus to the manufacturer.

For retrofitting of existing BRT buses, the transit agency will be responsible for specifying the equipment to be installed on the bus and the transit agency or a subcontracted third party must

OPTIONAL

install driver-assist technologies on vehicles and monitor the equipment performance and health and conduct regular maintenance and upgrades. Overall operational safety and the bus operator's ability to trust and rely on the proper operation of these technologies raises the criticality of monitoring and maintenance of the systems. The transit agency and/or the technology vendor or vehicle manufacturer must establish and implement appropriate education and training programs for the maintenance (and in some cases installation, replacement, or repair) for each type of drive assist technology deployed in the vehicle.

The transit agency or a designated sub-contracted driver training organization will be responsible for providing initial and ongoing education and training for drivers and operators who will interact with vehicles equipped with driver-assist technologies.

Requirements

Functional

Forward Collision Warning (FCW)

- All BRT vehicles must have forward collision warning systems that meet the minimum safety and performance standards set forth by the International Organization for Standardization standard ISO 17361:2017(en) and will be superseded by its current replacement standard (if any), at minimum.
- The system will not take any automatic action to prevent possible lane departures. Responsibility for the safe operation of the vehicle remains with the driver.
- All FCW systems must provide the capability to monitor and display the following distance between the BRT bus and a vehicle in front of the bus.
- The system must provide a visual, tactile (vibration) and/or audible warning alert for the bus operator when minimum safe following distance thresholds are reached.
- The system must provide an alert that indicates one of two states for the system: 1. The system is currently operable and functioning correctly, or 2. The system is not functioning correctly or in a non-operational state.

Lane Departure Warning (LDW)

- All BRT vehicles must have lane departure warning systems that meet the minimum safety and performance standards set forth by the International Organization for Standardization standard ISO 15623:2013(en) and will be superseded by its current replacement standard (if any), at minimum.
- The system will not take any automatic action to prevent possible lane departures. Responsibility for the safe operation of the vehicle remains with the driver.
- The system will disengage when the turn signal is on or when the driver is accelerating to overtake another vehicle.
- The system will be pro-active – warning the driver when the bus encroaches on the lane boundary based on system's ability to detect visible lane markings.
- The system must provide a visual, tactile (vibration) and/or audible warning alert for the bus operator.
- The system must provide an alert that indicates one of two states for the system: 1. The system is currently operable and functioning correctly, or 2. The system is not functioning correctly or in a non-operational state.
- LDW systems are monitoring systems that are dependent upon the visibility of lane markings. Consideration and training will be needed to ensure that drivers understand that in construction areas or during periods of bad weather that theses system may be non-operational.

Pedestrian and Cyclists Collisions Warning (PCW)

- All BRT buses must be equipped with a pedestrian or cyclist collision warning system with software that can distinguish and classify moving objects (i.e., is capable of discerning the difference between vehicles and pedestrians and cyclists). The system must be able to detect objects in the vehicle's path, track the bus's distance to the objects, calculates the time to impact taking into account the bus's current speed, and determine the type of object based on its movement pattern, height and size.

- The system will not take any automatic action to prevent possible lane departures. Responsibility for the safe operation of the vehicle remains with the driver.
- All BRT vehicles must have pedestrian and cyclist detection and collision warning systems that meet the minimum safety and performance standards set forth by the International Organization for Standardization following two standards: ISO 19237:2017(en) and ISO 22078:2020(en) and will be superseded by their current replacement standards (if any), at minimum.
- For BRT buses, and based on the ISO standards, the Bicycle Detection and Collision Mitigation System (BDCMS) must be of Class II and Type II that the size/ operation of the vehicle (Heavy vehicle), and different ambient illuminance conditions (Daytime, twilight and nighttime)
- For BRT buses, the Pedestrian Detection and Collision Mitigation Systems (PDCMS) described in the aforementioned ISO standard indicates that, at minimum, a warning of imminent collision will be provided to the driver, and depending on the capabilities of the system, the countermeasure included with this standard includes activation of the vehicles brakes. These countermeasures may be considered as part of the system at the time it is specified to determine if they fit within the requirements for and Metro's level of readiness for vehicle safety automation.
- The system must provide a visual, tactile (vibration) and/or audible warning alert for the bus operator.
- The system must provide an alert that indicates one of two states for the system: 1. The system is currently operable and functioning correctly, or 2. The system is not functioning correctly or in a non-operational state.

Blind Spot Detection (BSD)

- All BRT vehicles must have a blind spot detection system that meets the minimum safety and performance standards for Lane Change Decision Aid Systems set forth by the International Organization for Standardization standard ISO 17387:2008(en) and will be superseded by its current replacement standard (if any), at minimum.
- The BSD system must be capable of detecting objects alongside (laterally and to the immediate rear of) the bus and that provides a detection zones and coverage areas that are commensurate with the size, length, and configuration of the BRT bus. A typical coverage area will need to be large for the articulated BRT buses (e.g., 10 feet from the side of the bus and along a 15-20 foot parallel section of the side of the bus).
- The BSD system or the parent system, should be capable of connection to the bus through the J1939 CAN BUS.
- The BSD system must filter out stationary objects to reduce false alerts.
- The system must provide a visual, tactile (vibration) and/or audible warning alert for the bus operator.
- The system must provide an alert that indicates one of two states for the system: 1. The system is currently operable and functioning correctly, or 2. The system is not functioning correctly or in a non-operational state.

Speed Controls

- BRT buses should be equipped with an adaptive cruise control system and/ or collision mitigation braking system. Adaptive cruise control is an enhancement to conventional cruise control that will allow the bus driver to set a speed for the bus and follow a forward vehicle at a safe distance by controlling the power train or the engine or both; some systems may also employ the brake.

OPTIONAL

- Note: Traditionally the driver would use this system primarily during longer intervals between stations and on freeways using conventional cruise control (Limited Speed Range Adaptive (LSRA) Cruise Control) which can only assist the driver with speed adjustments to a certain minimum speed, but the systems and technologies (Full Speed Range Adaptive (FSRA) Cruise Control) have evolved to include collision mitigation braking capabilities that allow the system to assist the driver by bringing the vehicle to a standstill in full stop-and-go driving conditions or to assist in avoiding rear-end collisions).
- All BRT vehicles must have adaptive cruise control systems that meet the minimum safety and performance standards set forth by the International Organization for Standardization standard ISO 15622:2018(en) and will be superseded by its current replacement standard (if any), at minimum.
- The system must provide sensors (radar, or lidar, and/or cameras) that automatically adjust the bus speed based on the pace of a preceding vehicle traveling ahead in the same direction.
- The system must be able to dethrottle the bus and navigate full stop-and-go driving conditions, providing for a full stop in heavy traffic conditions or to avoid rear-end collisions.
- The system must provide a visual, tactile (vibration) and/or audible warning alert for the bus operator.
- The system must provide an alert that indicates one of two states for the system: 1. The system is currently operable and functioning correctly, or 2. The system is not functioning correctly or in a non-operational state.

Physical

Forward Collision Warning (FCW)

- Sensors mounted on the front of the bus (e.g., radar, lidar, and/or cameras)
- Driver interface mounted within range of the driver for visual and/or tactile (vibration), and/or audible alerts.
- On-board vehicle data processor and data storage
- Communications equipment (i.e., cellular modem or other device capable of transmitting data from the bus to a hosted environment with computer equipment capable of accepting and storing data.

Lane Departure Warning (LDW)

- Sensors mounted on the front and sides of the bus (e.g., optical, electromagnetic, GPS, or other technologies or combinations of technologies)
- Driver interface mounted within range of the driver for visual and/or tactile (vibration), and/or audible alerts.
- On-board vehicle data processor and data storage
- Communications equipment (i.e., cellular modem or other device capable of transmitting data from the bus to a hosted environment with computer equipment capable of accepting and storing data).

Pedestrian and Cyclists Collisions Warning (PCW)

- Sensors mounted on the front, sides and rear of the bus (e.g., radar, lidar, and/or cameras)
- Driver interface mounted within range of the driver for visual and/or tactile (vibration), and/or audible alerts.
- On-board vehicle data processor and data storage
- Communications equipment (i.e., cellular modem or other device capable of transmitting data from the bus to a hosted environment with computer equipment capable of accepting and storing data.

Blind Spot Detection (BSD)

- Sensors mounted on the sides of the bus (e.g., radar, lidar, and/or cameras)

- Driver interface mounted within range of the driver for visual and/or tactile (vibration), and/or audible alerts.
- On-board vehicle data processor and data storage
- Communications equipment (i.e., cellular modem or other device capable of transmitting data from the bus to a hosted environment with computer equipment capable of accepting and storing data.

Speed Controls

- Sensors mounted on the front of the bus (e.g., radar, lidar, and/or cameras)
- Driver interface mounted within range of the driver for visual and/or tactile (vibration), and/or audible alerts.
- On-board vehicle data processor and data storage
- Communications equipment (i.e., cellular modem or other device capable of transmitting data from the bus to a hosted environment with computer equipment capable of accepting and storing data.

Other Recommendations

Technologies that assist drivers with awareness and safe operational decisions are becoming more readily available in configurations that are suitable for transit and commercial vehicles. The maturity of driver assistance system technologies and their integration with OEM vehicles will continue to evolve rapidly beyond the capabilities and standards described in this section. Therefore, as Metro considers fleet vehicle replenishment and acquisition, it is recommended that Metro includes consideration, examination, and discussions with manufacturers about their offerings of driver assist technologies. Third party, after-market integrations of driver assist technologies are improving, but must be assessed on a case by case basis to determine if the retrofit of existing vehicles is worthwhile taking into consideration the useful life of the vehicle and Metro's vehicle replacement cycle.

Opportunities and Challenges

Technology Maturity

Automated Vehicles and Driver-Assist technologies are still being tested in controlled environments and not all are ready for deployment on public transit systems yet. As technologies are ready for deployment, Metro will need to determine from a policy standpoint, how long a technology must be in successful operation prior to integration into the Metro fleet.

Operator Education and Adoption

Close coordination and education of vehicle operators is paramount in developing understanding and comfort around the information that can be provided to the driver and how the system improves safety and reduces risks of collisions due to inherent operating difficulties (e.g., blind spots). Drivers will need to understand basic levels of automation and understand that initially these technologies provide alerts/warnings and can gradually add in automation (such as braking assistance in FCW systems). These levels of automation likely will be gradual in adoption and education will be essential in gaining driver confidence in the technologies.

Other Related Elements

> Operating Characteristics - Service Parameters and Strategies

> Running Way - Roadway Geometrics

> Running Way - Intersection Geometrics

> Running Way - Running Way Placement Consideration

Reference Documentation (Standards & Codes)

> International Organization for Standardization (iso.org) standard ISO 15623:2013(en) Intelligent transport systems — Forward vehicle collision warning systems —

Performance requirements and test procedures

> International Organization for Standardization (iso.org) standard ISO 19237:2017(en) Intelligent transport systems — Pedestrian detection and collision mitigation systems

(PDCMS) — Performance requirements and test procedures

> International Organization for Standardization (iso.org) standard ISO 22078:2020(en) Intelligent transport systems — Bicyclist detection and collision mitigation systems (BDCMS) — Performance requirements and test procedures International Organization for Standardization (iso.org) standard ISO 17387:2008(en) (BSD)

> International Organization for Standardization (iso.org) standard ISO 17361:2017(en) Intelligent transport systems — Lane departure warning systems — Performance requirements and test procedures

> International Organization for Standardization (iso.org) standard ISO 15622:2018(en) Intelligent transport systems — Adaptive cruise control systems — Performance requirements and test procedures)

> ISO/TR 16352:2005(en) Road vehicles — Ergonomic aspects of in-vehicle presentation for transport information and control systems — Warning systems

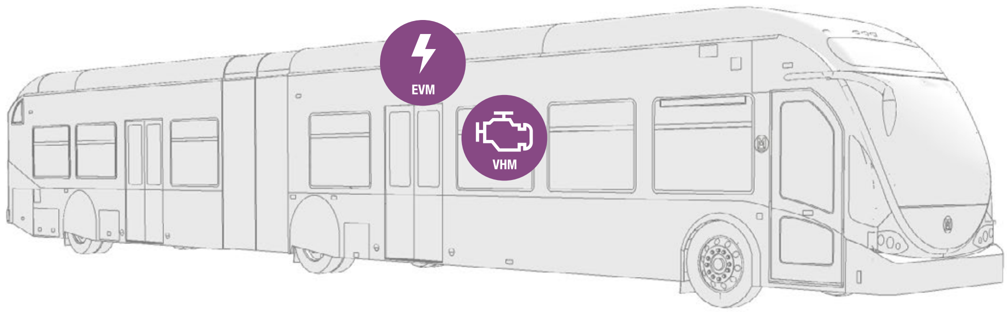


Figure 13: Vehicle Health Components on Vehicles / Source: IBI Group

c. Vehicle Health

(Although this element is not required, it is strongly encouraged.)

Vehicle health (sometimes referred to as VHM systems) refers to the on-board feedback from electrical and mechanical systems. These systems can provide information such as engine temperature, oil pressure, electrical faults, failing equipment charge status, etc. It also collects miles in revenue and non-revenue service, which determines preventative maintenance cycles. VHM systems' typical uses include:

> Notifying bus operations of vehicle health issues that require immediate attention or prevent the BRT vehicle from continuing service. This might include critical systems on-board BRT vehicles that support necessary guidance, access control, and/or TSP/BSP functions.

> Providing maintenance staff the ability to quickly identify or troubleshoot issues on buses in operations.

> Collecting background information on bus health and performance trends to assist with near term and longer term maintenance activities.

As BRT fleets increasingly include all-electric vehicles, specialized VHM systems focused on electric battery status, charge levels, usage, range, etc. become more critical. With electric vehicles, this information can be part of operational decision making. For example, a BRT vehicle is needed for an additional trip, but do the batteries have sufficient charge to support the additional trip and range, or should some recharging be conducted first? If recharging is required, how long will it take and what additional range will it provide?

Metro Standards

> VHM systems are not required by Metro BRT standards, but in the case of all-electric BRT buses, they are strongly recommended.

Guidelines for Implementation

Pre-requisites

VHM systems on-board buses are usually integrated into the agencies maintenance management system and/or asset management system.

Roles and Responsibilities

The transit agency maintains full responsibility for VHM and resulting maintenance from the information the system collects, as well as oversight of any subcontracted party conducting the maintenance or using the VHM system. Some VHM systems are provided by OEM bus manufacturers that are available for transit agencies to use as VHM tools.

Requirements

Functional

- VHM system shall identify and provide near-real time alerts to operations and maintenance on critical vehicle health elements that would require a BRT vehicle to be removed or replaced in service.
- VHM system shall collect on-board vehicle health status and diagnostics information for longer term trends analysis and adjustment of preventative maintenance schedules based on real-world BRT operations and use.
- VHM shall support remote access by authorized maintenance personnel to remotely collect and diagnosis situations.
- Where hybrid buses are deployed, the VHM status information shall include data and diagnostics on the operations and status of the hybrid systems.
- Where all-electric vehicles are deployed on BRT routes, VHM should provide both quick summary views and more detailed status on battery status, charge state, temperature, distance traveled since last charge, estimated remaining range, and estimated charge time to various battery charge levels.

Physical

- VHM systems and equipment can usually be procured with new vehicles, but sometimes VHM systems are different across different vehicle makes or models. It is recommended that key information be unified in a separate VHM system for maintenance and operations quick-view purposes.

Other Recommendations

Often BRT services are selected for deployment of new vehicle types including new on-board systems, mechanical systems, and drivetrains. Many agencies are selecting all electric buses for BRT services. When new buses (or at least new to the agency) are selected for BRT service, VHM systems become more critical as maintenance and operations learns more about the reliability and troubleshooting processes for many of the new systems and vehicle components. The BRT vehicles often have special characteristics that make it more difficult to simply swap them for other buses in the broader fleet, and this means that spare ratios may be lower than is typical for the rest of the fleet. This factor drives the need for VHM. In particular, agencies using all electric vehicles should have a VHM solution that provides details to maintenance on the information suggested in this section, and overview information to operations in order to make real-time operations decisions about vehicle swaps, service adjustments, recharging requirements, etc.

Opportunities and Challenges

The Internet of Things (IoT) and Metro's use of MGRs for its BRT buses can ultimately support maintenance checks and send diagnostics to maintenance teams at a fast pace, ensuring quick interventions and healthy vehicles.

Other Related Elements

> Systems - Voice & Data Communication
> Systems - On-board Architecture Overview

OPTIONAL (ENCOURAGED)

***Onboard WiFi** / Source: Des Moines Area Regional Transit Authority*

d. Onboard WiFi

Onboard WiFi (wireless connectivity) provides riders on BRT vehicles with free access to the Internet using the WiFi connectivity (e.g. 802.11ac) of their mobile device or smartphone. While most mobile devices support commercial cellular (e.g. 4g LTE or even 5G) communications, these have data limitations, caps, and costs for the user. Free onboard WiFi can be viewed as a benefit to riders as it allows them to access the Internet without using paid data services, and it allows them to conduct business or personal matters while riding the bus. The rules and guidelines for using free onboard WiFi vary from agency to agency, but all agencies require accepting a notification screen on usage guidelines. Onboard WiFi is offered without warranty or promises by the agency. Some agencies limit or restrict streaming of high-bandwidth video or similar services, and/or restrict access based on website blacklists (e.g. potentially offensive material). LA Metro has begun roll-out of onboard WiFi for fixed route bus services which would include BRT services with the network name "Free Metro WiFi" on labelled buses. In addition to accessing email, social media, web pages, etc., riders can access Metro customer service, alert Metro security, and/or view real time bus information. Plans are that this service will roll-out to the full Metro bus fleet.

Metro Standards

> Specific standards have not been set for onboard WiFi for BRT services in the LA County region, and while their implementation is option it is strongly encouraged.

Guidelines for Implementation

Pre-requisites

Onboard WiFi will require the agency to establish and configure network connectivity to the Internet through a commercial cellular provider. The setup can be separate from all other on-board communications equipment and systems, or it can be functionally placed within an existing on-board vehicle systems architecture. If the agency is using FirstNet for their data communications from the vehicle, then any on-board WiFi must be configured to run through a separate commercial cellular network.

Roles and Responsibilities

- The agency will need to establish guidelines for use, conduct appropriate marketing on the availability of the service, maintain contracts with commercial cellular providers, install (or contract to install) appropriate equipment on the vehicles, and monitor overall usage levels.

OPTIONAL (ENCOURAGED)

Agencies typically contract for unlimited data usage to avoid potential overage charges. If usage levels are very high and/or complaints about the service availability occur, the agency can expand the available bandwidth on each vehicle, but will incur additional equipment and cellular costs.

- Riders will be asked to agree to use the service consistent with the usage guidelines and usage terms.
- Commercial cellular carriers provide connectivity to the Internet from the WiFi access points on the vehicles.

Requirements

Functional

- Service shall provide potential users with upfront notification of the terms of usage of the service, including privacy, limits on use, lack of warranties, and security considerations and require their acknowledgement before proceeding.
- Service shall allow the agency to monitor WiFi access, bandwidth usage, and number of users by time of day, day-of-week, month, and type.
- Service shall allow a capped number of users accessing onboard WiFi per vehicle.
- Service shall allow the agency IT department to turn-off or suspend the connectivity at any time.
- Service shall allow the agency to restrict or filter certain websites or types of sites (at agency discretion).
- Appropriate network security measures shall be in-place to prevent any cross-over of breach of on-vehicle system communications with available on-board customer WiFi.
- Service shall not interfere with other on-board vehicle system communications as indicated by on-board pilot tests.

Physical

- Onboard WiFi shall allow 802.11ac capable or newer devices to access the service.
- Each BRT vehicle shall include a WiFi access point, antenna, and appropriate cellular modem to access 4G LTE or newer service.
- Installation and use of a Mobile Access Router (MAR) or Mobile Gateway Router (MGR) to manage on-board WiFi configurations and monitoring is preferred.
- No direct connectivity between the onboard WiFi access point and devices shall be allowed with the on-board vehicle Controller Area Network (CAN) bus.

Other Recommendations

It is popular for riders to try and stream video (e.g. Netflix, Hulu) over the onboard WiFi. Agencies should determine how restrictive they will be in terms of allowing access to popular services. Too many restrictions tend to make on-board WiFi of limited use to riders and result in poor use of the amenity. Unlimited restrictions may lead to very slow or unusable connectivity for riders unless the systems are designed to support higher data bandwidths. Usually large file downloads and HD video streaming are

Opportunities and Challenges

Communications technologies are evolving rapidly with 5G systems already being rolled out on some commercial cellular networks. The equipment deployed on vehicles should allow for upgrades to 5G technology (e.g. modem swap) without requiring full replacement of the system. As commercially available data options increase, the value of On-board WiFi may decrease over time, however cost and data usage considerations are likely to remain in effect for transit riders.

Other Related Elements

> Vehicle - Voice & Data Communications

> Systems - Technology Support Elements

OPTIONAL

50 Control Center & Operations

a. Video Live Look-in
b. Supporting Mobility as a Service (MaaS)
c. Yard Management

a. Video Live Look-in

Video Live Look-In refers to telecommunications technologies that allow direct streaming of video and audio content to operations center. The video and audio live streaming may be combined or separate components. Traditionally, vehicles have onboard microphones to provide audio live streaming when a covert alarm (CA) is triggered by the operator. More recently, with the increased adoption of data-based communications and the advances in video technology, video live look-in has become increasingly common onboard transit vehicles, as it provides an increased level of situational awareness for operations and control center staff during onboard incidents. Aside from the data communication components, the system consists of multiple video cameras on both the interior and exterior of the vehicle, as well as an onboard computer to process recorded footage, and a Digital Video Recorder (DVR) to store recorded footage.

The technology and components required for video surveillance at BRT stations is largely similar to on-vehicle systems. The difference is that the BRT station video systems will likely have a wired data communication system that is not reliant on wireless data. This will provide a more consistent video live stream as well as the opportunity to provide a high quality video live stream.

Metro Standards

Reliable data communication channel to enable live look-in in the event of an incident onboard and at BRT stations.

Guidelines for Implementation

Pre-requisites

Agencies should establish a standardized plan for an on-board video system for their transit and BRT vehicles, as well as BRT stations. This includes the number and positioning of video cameras needed to allow for all areas to be monitored. Minimum data bandwidth requirements should be established to enable consistent video live look-in quality. There should be an operations center, established standard operating procedures, and available staff to monitor video, review alerts and respond as needed. There should be a single operation center to monitor both vehicle and BRT station video footage.

OPTIONAL

Roles and Responsibilities

- The transit agency or a subcontracted third party should install cameras at stations and on vehicles.
- The transit agency or a subcontracted third party should conduct regular checks and maintenance of video equipment.
- The transit agency should establish an operations center, create standard operating procedures, and make available staff to monitor video, review alerts and respond as needed.

Requirements

Functional

- Communications from camera systems along dedicated lanes and BRT stations should allow for reliable high-speed communications to/ from cloud-based services.
- Communications from camera systems on-board transit and BRT vehicles should allow for reliable and high quality video live streaming.
- Camera systems should be setup to support high definition and glare-free operations (but do not need to support facial recognition for BRT purposes).
- Camera systems should support operator input to allow for tagging, such that agency staff can review the specific segment of the recording at another time.
- Camera systems should support input from operational staff to enter live look-in.
- The BOC positions for BRT and related safety/ security positions should be arranged to support automatic activation of screens with video analytics based alerts and alarms.
- Video analytics skill sets should be developed and maintained among operation staff to understand and support fine tuning of operations.

Physical

- Video camera equipment should be robust and ruggedized to provide reliable service in a transit vehicle environment.
- On-board video camera processing and storage equipment shall be robust and ruggedized to ensure video files are securely stored on-board until the files are transferred to the central system.
- Examples and typicals should be determined for placement of camera feeds/video analytics covering key access and station platform areas.
- Locations for video analytics/camera placement should allow view of dedicated lanes, particularly in areas close to entry/exit and/or station areas.

Recommendations

Video camera and data communication equipment should enable a high quality video live look-in feed as well a high quality recording. Operation staff should be trained to utilize the live look-in functionalities.

Opportunities and Challenges

Video Analytics can lead to major advancement for security on vehicles and at stations. However, widespread deployment could have on-going costs (analysis as a service). Future advancements in communication technologies such as 5G, will further enable high quality on-board video streams.

Other Related Elements

> Systems - Guideway Control and Management
> Systems - CAD/AVL
> Systems - Voice & Data Communications
> Systems - Video Live Look-in

OPTIONAL

Metro MicroTransit Pilot

DRAFT

b. Supporting Mobility as a Service (MaaS)

Mobility as a Service (MaaS) refers to the technologies and infrastructures that can integrate services into the overall offer of public transportation services. This element specifically refers to the technologies/systems that can be put in place to integrate BRT services in order to make public transit more convenient and effective. MaaS provides end-to-end trip planning, with services such as ride hailing, bikeshares, scooters, on-demand shuttle services, etc.

The customer facing aspect of a MaaS platform is a single user interface where users may receive trip planning recommendations based on input, they can then select the trip choice, and purchase fare or pay for the trip. This is enabled through a single platform by utilizing open data standards and interfaces where service and payment providers can integrate their respective services. This means users can access all of these services via a single account without having to register and provide payment information for each of these services.

Metro Standards

> Metro should create or develop open data standards and interfaces for service providers to intergrade with.

Guidelines for Implementation

Pre-requisites

- A platform combining all mobility services available, which can be accessed through any widely user platforms, such as a mobile application.
- There needs to be an agreement between the local jurisdiction, the transit agency, payment processors and service providers.
- Open API and data standards that facilitate data sources for developers and data providers to add to the digital platform.
- Customer WiFi should be offered at stations and on vehicles to facilitate the use of the digital platform and support trip planning "on-the-go".

OPTIONAL

Roles and Responsibilities

- The transit agency should allocate sufficient right-of-way and curb space for mobility services.
- The transit agency should work with mobility service providers in offering services complementary to BRT services.
- The transit agency or a service provider should maintain and manage the mobile application.
- The transit agency or a service provider should continue to develop the mobile application and open data standards such that it continues to be compatible and to keep up with advancements in technology and mobility services.
- The transit company should provide up to date service data to the coordinating entity.

Requirements

Functional

- *Technology* – Any MaaS app and functions should distinctly identify BRT as a special level of service (e.g. separate from local bus).
- *Technology* – Any MaaS payment options (mobile app, near field communication (NFC), etc.) should be supported by BRT once regional adoption occurs.
- *Technology* – Information on MaaS services and availability should be readily apparent to BRT users (e.g. via app, on-the bus, customer information at stations, etc.), including any defined microtransit or Mobility on Demand (MoD) service area restrictions.

Physical

- Ensure all major BRT stations support the full suite of MaaS needs (e.g. bike lockers, shared bikes, shared scooters, local micro-transit PUDO, etc.). Spaces should be separate from loading/alighting zones to avoid conflicts between users.
- Provide customer WiFi and customer information displays at BRT stations to enable efficient information access for users in transit.

Recommendations

The platform should utilize open data standards and be open to any service provider interested in sharing information and payment structure, and willing to comply with the terms and agreement defined within the agreement. The platform should be user friendly, offer reliable trip recommendations to users and provide seamless transitions between services.

Opportunities and Challenges

> Excellent opportunity to support first/last mile connectivity to BRT.

> Attracts new potential users to BRT.

> Provides one stop shop for trip planning, payment, customer info – including for BRT.

> Promotes new options to meet personal mobility needs (e.g. all options under one roof)

> Can be integrated regionally to support Muni and Metro needs.

> In some cases could compete with BRT, possibly using higher subsidized services.

> It is unclear what MoD and MaaS services will be most successful and many are provided by private parties which means that allowances need to be made as the types of services may change over time.

> There are opportunities to obtain corporate sponsors to support the cost of maintenance and management of the mobility platform. While corporate sponsors would gain visibility at large, these agreements could also benefit customers through discounted fares and rewards.

> 5G technologies will offer accrued opportunities for the integration of services and the development of service repositories.

OPTIONAL

Other Related Elements

> Operating Characteristics - Multiple Services Sharing a Corridor

> Stations/Platforms - Signage and Passenger Information

> Branding - Running Ways

> Integration of Transit-oriented Communities - First/Last Mile Connectivity

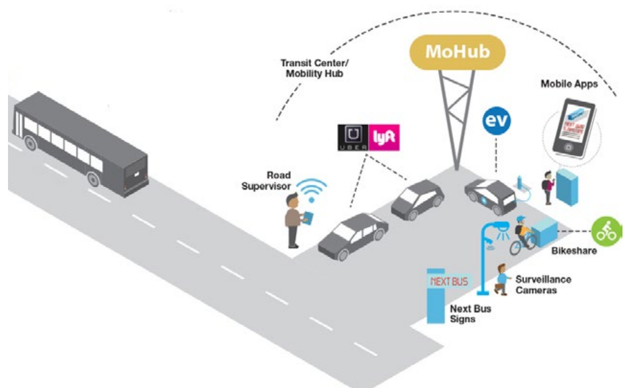


Figure 14: Example of Mobility Hub / Source: IBI Group

Yard Management / Source: IBI Group

c. Yard Management

Yard management systems include the software and hardware components that allow for the tracking, assignment, and pull-in/pull-out of BRT vehicles (particularly where BRT vehicle types are unique and yard space is constrained). The yard map display is a primary component of a yard management system, where a detailed base map is configured to show the layout of parking lanes, maintenance locations, and the locations of other typical yard features. This allow operations staff to keep track of where the BRT vehicles are within the yard at all times and to identify when a vehicle departs or arrives at the yard. Should a driver notify operations staff of an issue on-board during the pre-trip inspection, the system will allow staff to quickly reassign the operator to another available vehicle in the yard. It is important that the system only allow assignment of specific vehicles to BRT routes.

There are different types of technologies that allow for precision location tracking of vehicles in the yard, these include: transponders, GPS, and triangulation using wireless routers between the yard and on-board units. Aside from vehicle location tracking, it is important for the yard management system to include or integrate with other transit management systems. Integrating with a maintenance system will enable operations staff to notify drivers as they return to the yard should they park they vehicle in a maintenance facility or at a parking spot located close to such facility. This will also provide maintenance staff with insights on where the vehicle is located and when preventative maintenance is due for a particular vehicle.

Metro Standards

While not specifically called out in the Metro BRT standards, a yard management system of some sort must be deployed for all bus yards that operate BRT services.

Guidelines for Implementation

Pre-requisites

The yard management system should operation in conjunction with the CAD/AVL system. The latter keeps track of vehicles that are outside of the yard and are in service, whilst the former keeps track of vehicles within the yard. Agencies should also consider other systems such as HR, payroll, and vehicle scheduling, which may be integrated with the yard management system.

OPTIONAL

Roles and Responsibilities

- The transit agency should provide an operations center and staff at each yard to manage vehicles.
- The transit agency or a subcontracted third party should install the yard management system software.
- The transit agency or a subcontracted third party should install the yard hardware that may be needed for tracking vehicles in the yard.
- The transit agency or a subcontracted third party should develop and maintain system interfaces that allow data transfer between other management systems.

Requirements

Functional

- The yard management system should receive updated vehicle yard positions on a regular basis.
- The yard management system should identify regular transit and BRT vehicles separately within the yard.
- The yard management system should track when vehicles enter or leave the yard, utilizing either existing on-board positioning systems or a yard based vehicle tracking system.
- The yard management system should allow operations and supervisory staff to modify operator and vehicle assignments.
- The yard management system should either allow yard maps to be imported or provide tools to configure and modify yard maps.
- The yard management system should be managed by yard operations personnel.
- The yard management system should interface with the agencies' other systems, such as maintenance, CAD/AVL, and vehicle/operator scheduling system.

Physical

- All vehicle tracking equipment and positioning should provide good coverage such that tracking is consistent regardless of yard configuration.
- All data communications backhauls should be robust such that near real-time position tracking can be provided within the yard.

Recommendations

As noted, the yard management system should support accurate vehicle tracking within the yard, and the system should support operator and vehicle reassignment capabilities for yard operations staff. The system should be integrated with other systems that the agency uses to support BRT operations management.

Opportunities and Challenges

Innovation resulting from *Connected/Automated Vehicle* technologies could standardize small scale vehicle location technologies by utilizing vehicle to infrastructure communication hardware.

Other Related Elements

> Control Center & Operations - CAD/AVL

> Control Center & Operations - Voice & Data Communications

> Vehicles - Vehicle Tracking

> Vehicles - Connected Bus

DRAFT

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5
BRT Branding Design Elements

There is an adage in the marketing world that suggests "you are not who you think you are, you are who your customer thinks you are." As a result, transit agencies are increasingly interested in understanding what actions can be taken to define and improve their brands as a way of improving the customer experience. This chapter covers those efforts within the context of BRT.

1. Standards and Goals
2. Metro Literature/Policy Review
3. Running Ways
4. Stations
5. Vehicles
6. Other Considerations

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1 Standards and Goals

a. Brand Consistency and Awareness
b. System Integration
c. Attracting New Ridership
d. Establishing a Branding Approach

Metro has worked consistently over the past decade to pull the various components of its transportation services into a combined program of branding awareness, to benefit the user public in its understanding of service availability and product differentiation. Well-conceived branding portrays Metro as a transportation agency that strives to be relevant from the standpoint of mobility, service efficiency, customer satisfaction and, importantly, social equity.

a. Brand Consistency and Awareness

Consistent application of graphics, tone, and images creates a readily identifiable image of Metro as an agency that is continuing its long history of public service while pursuing new and expanded transit and innovative transportation-related technology. The expansion of BRT services provides an exciting opportunity to employ a highly beneficial countywide BRT service.

This branding section of the BRT Design Guidelines seeks to apply Metro's current design and branding standards to new BRT infrastructure while highlighting examples of successful and innovative solutions from other agencies and cities. It can also serve to inform branding decisions by other cities and agencies in LA County who seek to implement a BRT system or coordinate their existing service with Metro.

b. System Integration

The branding guidelines in this report are designed to provide consistency of approach where necessary (elements of continuity), while identifying where one-off, unique items of design and delivery (elements of variability) could be deployed in support of individual route character.

Elements of Continuity

> Vehicle branding and stations across a BRT line.

Elements of Distinction (Variability)

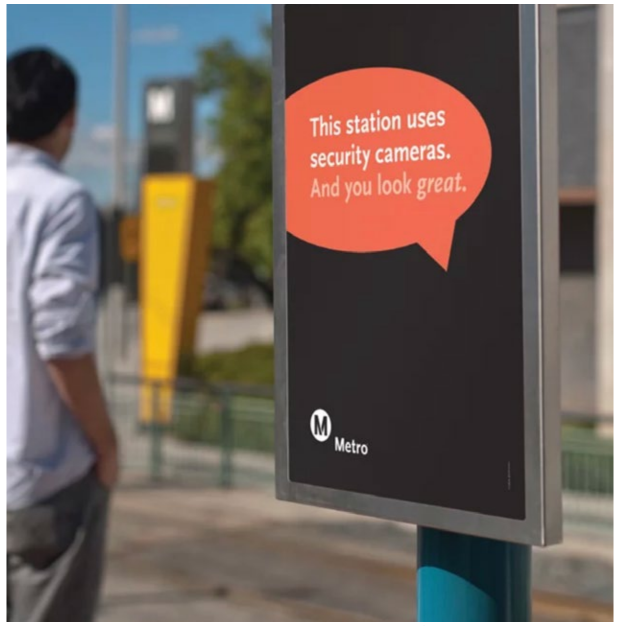
> Where another transit or planning authority is the primary provider or funder of the station.

> Agencies might explore unique branding in special circumstances, such as a location adjacent to a university or historic/culturally significant area.

c. Attracting New Ridership

Positive public perception of transit is important for retaining existing riders while attracting new ones. Although branding is not directly related to overall system design, it can contribute to legibility and ease of use of the system.

Clear and consistent branding reinforces a message that other aspects of the system are thoughtfully designed and that the public can rely on the services provided. As a public resource, transit can also instill an intangible sense of civic pride and, when done well, form a core component of daily life. This core component is ever more relevant as Metro seeks to complement the overall effort to combat climate change.



Text kept to a minimum while tone remains upbeat and friendly.

Metro brand identity example in station rendering.

d. Establishing a Branding Approach

Essential to developing and executing a successful BRT line is developing a distinguishable brand for the service. Clearly denoted branding elements and distinctive signifiers along BRT routes, vehicles and stations allows for riders to differentiate between lines and helps riders navigate the system.

Over the past fifteen years, Metro has redefined its approach to branding by combining its design studio, communications, marketing, business-to-business sales, print shop, and other related activities into a centralized department. This has led to greater consistency in the way that the Metro brand is communicated, not just through external advertising and marketing, but also within the Metro system and its vehicles.

For new BRT lines at Metro, the identity and branding will be guided by existing standards set by Metro Communications. For example, where new naming conventions across LRT and BRT lines were recently adopted, those conventions will be extended for a consistent brand identity.

Local jurisdictions or smaller transit agencies may not have the scale or flexibility in reallocating staff resources to be able to completely redefine branding, marketing, and communications services. However, long-range planning efforts may incorporate an agency branding audit that includes an analysis of types of service. Implementation of a BRT brand should in turn support the audit's recommendations, with the goal of reinforcing a brand image that one would expect from a high- quality transit service.

Agencies implementing BRT for the first time should consider future growth and whether or not branding of the line will accommodate expansion efforts or new routes. Once a graphic style for the BRT service has been determined, agencies should produce a graphic standards manual that clearly articulates its intended purpose, logo, and color specifications. The manual should also set standards for repetition and/or evolution of the branding program with regard to existing or future service.

Where possible, agencies may seek to coordinate or integrate branding with other municipal services or designs. The City of Hillsboro, OR, for example implemented a citywide wayfinding program and incorporated light rail station markers into its design package. Phased installation of signage helped spread costs over multiple budget years and were also partially paid for by outside grants.

The level of brand collateral will also vary between transit agencies. Nevertheless, the ability to clearly differentiate between a BRT line and a local or municipal line is crucial for the transit rider's route planning, expectation of service, and user experience.

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2 Metro Design Criteria and Policy

In reviewing these design guidelines, it may be necessary to refer to prior Metro documents to ensure consistency of effort moving forward.

a. Metro Bus Rapid Transit Design Criteria
b. Metro Transit Service Policy
c. Metro Systemwide Station Design Standards and Directive Drawings
d. Metro Systemwide Station Design Standard Policy
e. Metro Rail Design Criteria
f. Metro Writing & Style Guide
g. Metro Logo Guidelines

When embarking upon new branding initiatives associated with BRT planning and delivery, it is important to recognize and build upon the comprehensive work completed to date. A first step in appreciation of this prior effort is to methodically review it to avoid missteps moving forward. This section outlines the most significant take-aways from the literature review.

a. Metro Bus Rapid Transit Design Criteria (2008-2014)

This document provides design concept standards and guidance for the implementation of all BRT projects in LA County. Branding-related goals emphasize clarity, simplicity, and consistency. It also emphasizes BRT's role in bolstering positive perceptions of transit. The BRT Design Guidelines provide an initial basis for updating the 2008 BRTDC document.

b. Metro Transit Service Policy

The Transit Service Policy document sets forth the policies, principles, and requirements that Metro staff uses to design or modify the service network. It includes guidelines for items that may be considered for branding, such as passenger amenities at stations and line lettering conventions.

c. Metro Systemwide Station Design Standards and Directive Drawings

Metro Systemwide Station Standards are contained within Section 6 of the Metro Rail Design Criteria (MRDC) and the Design Architectural Standard and Directive Drawings provide guidance for Metro stations to ensure safe, state-of-the-art, maintainable and sustainable station environments in a consistent architectural language and brand identity. These standards inform the station design concepts that are developed under Section 7.2 Station Platform Design Criteria.

d. Metro Systemwide Station Design Standards Policy

This policy requires that all future BRT station designs conform to the Metro BRT Design Criteria and Standard Drawings that will be developed as part of the BRT Vision & Principles Study. It reaffirms a commitment to Metro's Systemwide Station Design Standards or "Kit-of-Parts" design toolkit, and emphasizes safety, state-of-the-art design, maintainability, sustainability, consistency, legibility, and accessibility of stations and related equipment. It also defines Metro departmental responsibilities related to Systemwide Station Design Standards implementation.

e. Metro Rail Design Criteria

Section 6 of the Rail Design Criteria pertains to the architectural design of all station types. Elements include area requirements, design of platforms, amenities, artwork, signage, advertising, landscaping, platform access, standards for the selection of materials, and general principles and standards for use in the design of bus access, Pick-up/Drop-off and Park and Ride facilities, stations and ancillary facilities. It includes space requirements; materials and finishes; standards for planning and construction, and area requirements.

f. Metro Writing & Style Guide

Metro's Writing & Style Guide encourages greater consistency in written communications. Key recommendations that can apply to branding include keeping the overall 'tone' of messaging conversational, friendly, and optimistic. Communications should keep Metro's target audiences in mind when writing and minimize the use of technical terms.

g. Metro Logo Guidelines

Taking cues from Metro's stationery and other printed materials, the BRT Design Guidelines should consider design and branding elements to be simple and direct, clean and uncluttered. The use of Metro's logo on station and bus elements should respect Metro's desire to maintain a positive relationship with its employees, customers and the public.

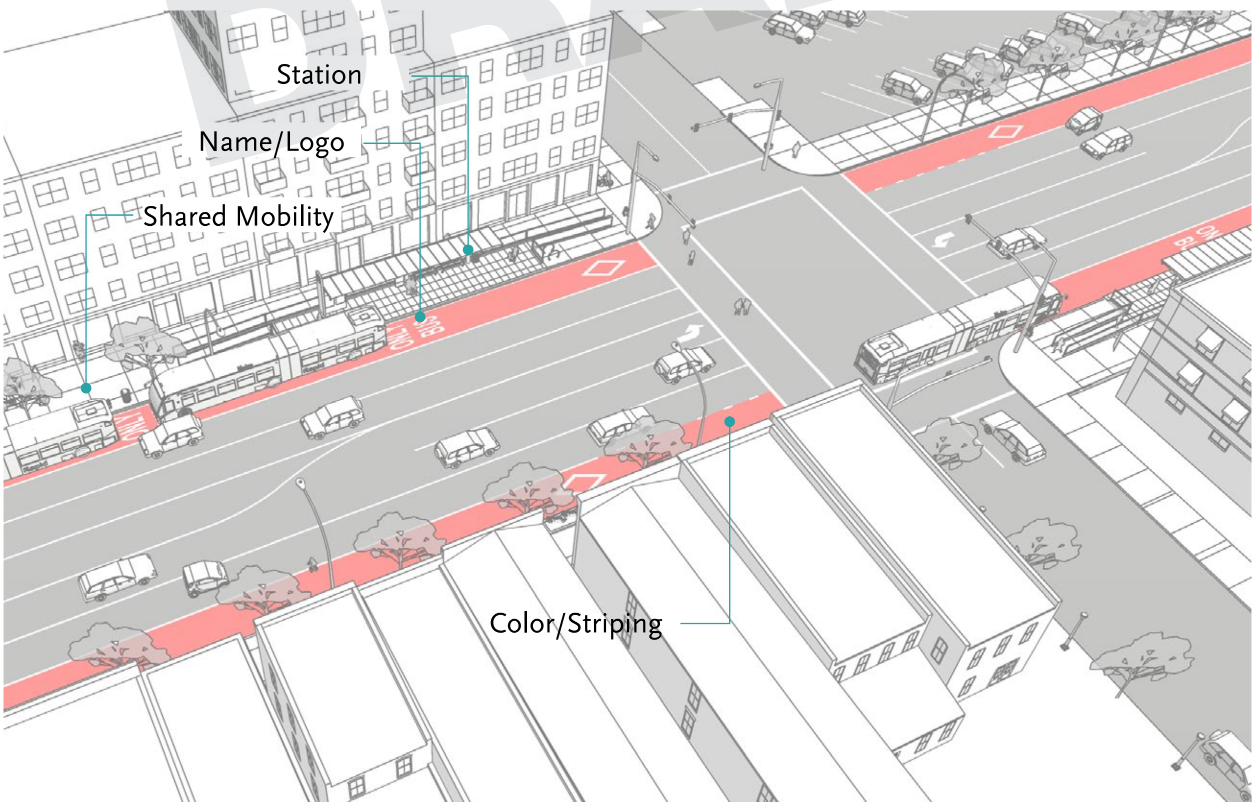
3 Running Ways

a. Components
b. Description
c. Metro Standards and Goals
d. Guidelines for Implementation

Running ways are relevant to the branding exercise in that they serve to advertise the existence of BRT service, either as a dedicated lane or in mixed traffic – a potential continuous or intermittent stripe of color running the length of the corridor. In the process, running ways also provide an ideal opportunity for BRT system wayfinding.

a. Components

Although engineering standards may supersede efforts to add more creative elements to running ways, the design of bus lanes and the elements that are adjacent to them can form a part of the BRT brand. These components and their placement are illustrated in the image below.



Running ways context diagram - see section 7.3 for more information

b. Description

Running ways can include both fully dedicated rights-of-way (e.g., Metro Orange Line), as well as exclusive lanes (e.g., Rapid 720 peak hour). A detailed discussion of bus running ways is covered in chapter 7.3 BRT Running Way Criteria. Recommendations from a branding standpoint relate primarily to color and striping.

c. Metro Standards and Goals

Metro must coordinate roadway treatments with local jurisdictions and as such does not have specific brand guidelines related to color and striping. The Federal Highway Administration's Manual on Uniform Traffic Control Devices recommends separating dedicated bus lanes from other traffic using solid single or double white stripes. The MUTCD states:

"A solid single white line conveys that crossing into the bus lane is discouraged, whereas a double solid white line means that encroachment is legally prohibited." *(MUTCD 3B.04)*

Existing peak period bus lanes in Los Angeles follow the single stripe convention and are unpainted. Elsewhere in the country, cities/agencies have deployed or are testing red paint, thermoplastic, or embedded color in asphalt to demarcate bus lanes. Bus lanes also require additional signage to inform other users of the street if and how they may use the lanes, such as for right turns or for off-peak parking.

d. Guidelines for Implementation

- **Consideration:** Clearly-marked, full-time, bus-only lanes throughout the corridor help to identify BRT service and clearly distinguish it from local bus service.
- **Recommendation:**
  > Use high-visibility paint wherever possible to clearly communicate transit prioritization.

Paint used to delineate shared station use between bikes and bus - Los Angeles, CA - Photo Credit: IBI Group

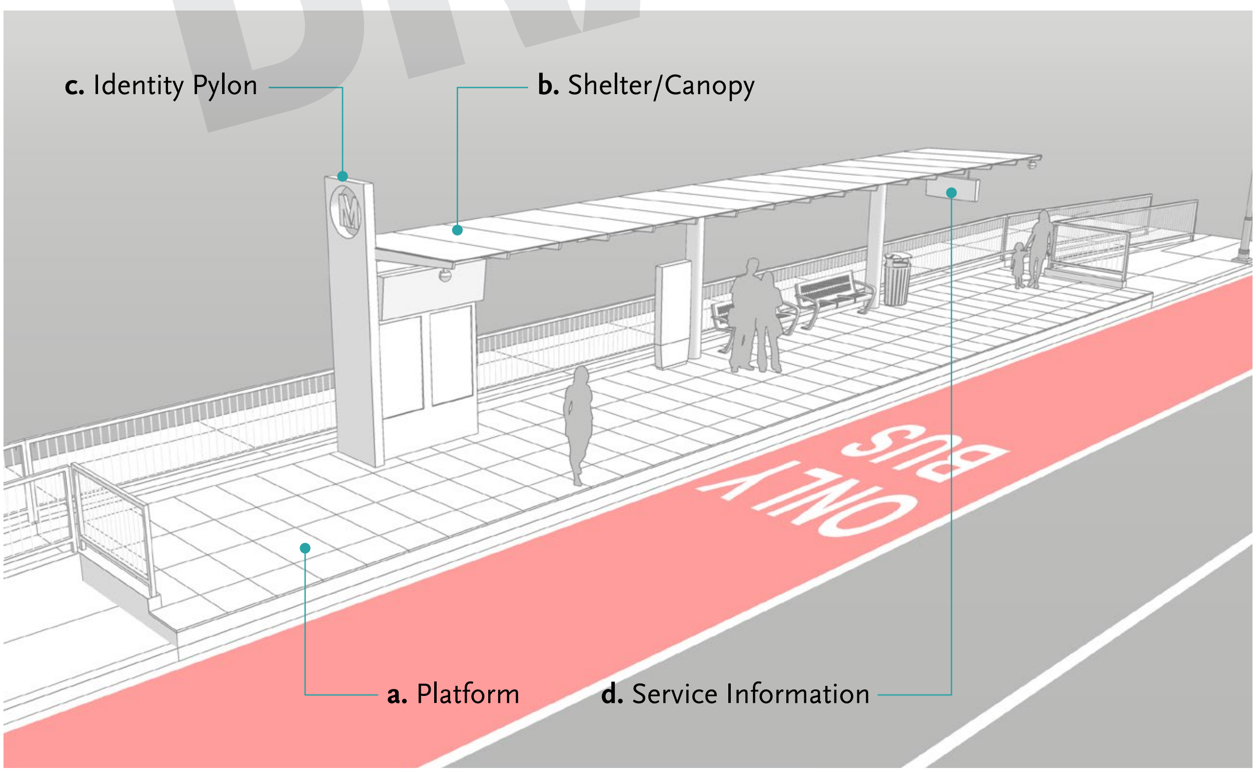
Thermoplastic Bus Lane Coating

Bus Lane Pavement Markings and Label

4 Stations

a. Platform
b. Shelter/Canopy
c. Identity Pylon
d. Lighting
e. Service Information/Wayfinding

Although components of BRT stations are not branding in the strictest sense, their visual character contributes to the look and feel of the transit network and are the most significant way in which the general public experiences transit, beyond BRT vehicles themselves. When they are coordinated and follow consistent standards, stations can create positive, deep associations with the BRT network.



Station components diagram - see section 7.2 for detailed station design & configuration

a. Platform

Description

A BRT station that is well-organized and responds to local community context adds value to BRT brand awareness and recognition. BRT station platforms are to be more spacious than standard bus stops and made of durable, high-quality materials, such as poured-in-place concrete floor finishes, and stainless steel furnishings. Site furnishing such as benches, trash receptacles, leaning rails, and bike racks are within the same brand family and consistent across all BRT stations.

Metro Standards and Goals

> Architectural design of platforms is determined by Metro's standard kit-of-parts as identified in the Systemwide Station Design Standard Policy.

Guidelines for Implementation

Consideration: BRT stations are ideal for enhancing the brand exposure for the BRT system. Capitalize on their many surfaces to introduce branding elements to reinforce distinct service.

Recommendation:

> Choose surfaces and materials that are durable and easy to maintain.

GRTC Pulse BRT Platform - Richmond, VA

b. Shelter/Canopy

Description

Branded shelters and canopies at BRT stations reinforce brand identity and recognition for transit riders and can further distinguish from standard bus service. Proper naming conventions also provide a transit rider with trust and confidence to quickly navigate the BRT stations. In addition, new trends in shelter and canopy design embedded with smart technologies, such as cell phone charging stations, solar panels and WiFi can also be integrated in the shelter design. Refer to Chapter 7.2 Station and Platforms Design Guidelines for further guidance about canopy and shelter design.

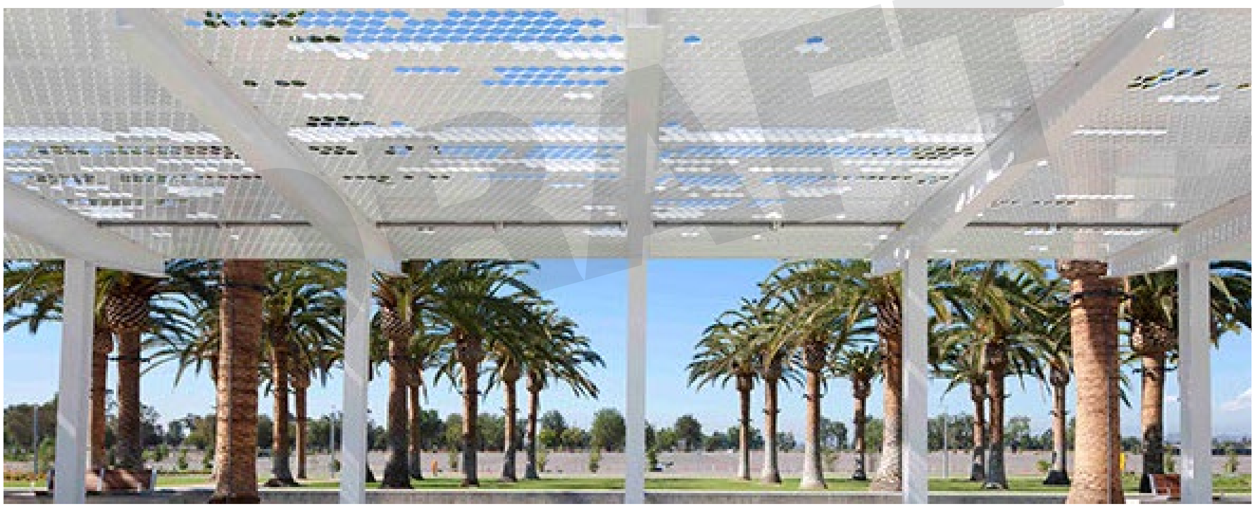
Metro Standards and Goals

> Design canopies that follow architectural standards and Metro's Kit of Parts.

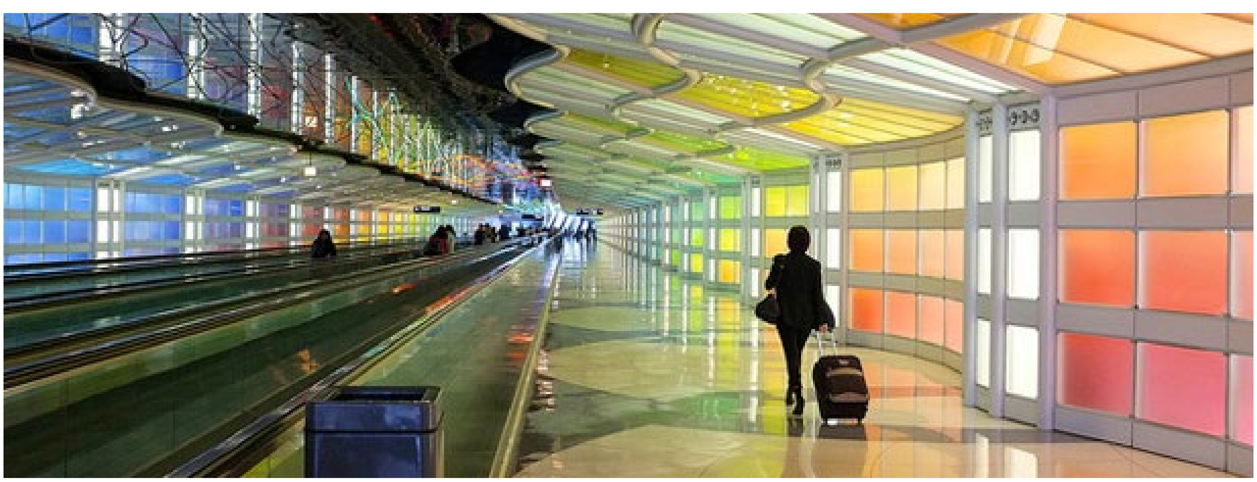
> Select materials and designs that are consistent across stations.

Guidelines for Implementation

Consideration: BRT station shelters and canopies are ideal for incorporating branding motifs into their functional elements.



Perforated pattern in canopy creates interesting shade pattern on ground - Great Park, Irvine



Color and/or art into top and side panels adds interest.

c. Identity Pylon

Description

Whether integrated into the canopy as incorporated in the BRT station design guidelines, or as standalone elements, pylons can be utilized to further define the station boundaries and support brand identity. The identity pylon should be consistent across all BRT stations and at the minimum include the transit agency logo and an element that indicates the station name or BRT line. These elements can either include the BRT name, color or specific logo. In order to address concerns about spatial constraints, the identity pylons can be integrated into other station elements.

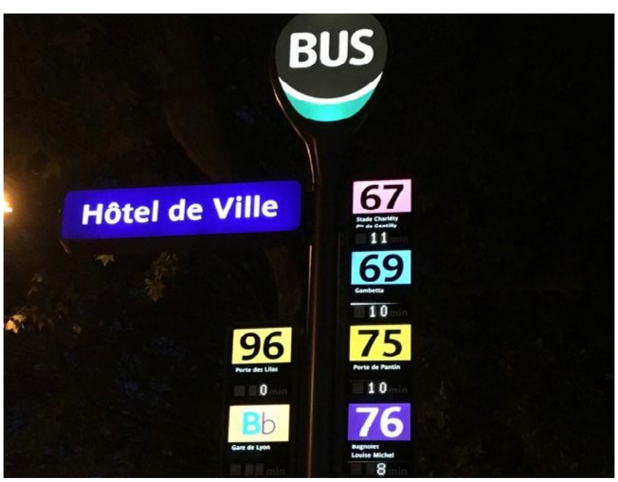
Metro Standards and Goals

Metro's Pin concept was first implemented in 2016 at the North Hollywood station as a standalone element. The Chapter 7.2 Station and Platforms Design Guidelines specify how BRT-specific versions of an identity pylon will be integrated into canopies.

Guidelines for Implementation

- **Consideration:** Full BRT service shall utilize a signifier/identity pylon that is integrated with the station/canopy design to reinforce the BRT brand and agency.
- **Recommendation:**
  - Consider how multiple lines of service or transit providers should be shown on the pylon.
  - Properly locate pylons that are easily recognizable from a distance.
  - Where BRT lines share stations with other lines of service, consider combining route labels in the identity pylon.

Incorporate Key Elements From Current System



Service routes clearly shown at night - Paris, France

Transit mall pylon and route information - Portland, OR

d. Lighting

Description

Lighting ensures that riders feel safe and secure at BRT stations, but it also influences the look and feel of BRT station design. Station elements such as the shelter, identity pylon, signage, and wayfinding should be well-lit and fully integrated with LED lighting to support perceptions of comfort and security. In addition to providing visibility at all times of day, lighting poles immediately surrounding the station can support navigation to and from the station. The use of sufficient indirect LED lighting can create a place of respite and further promote brand identity. The Section 7.2 Stations and Section 7.4 Systems chapters in this document also include guidance regarding lighting.

Metro Standards and Goals

> Lighting standards are dictated by Metro's architectural standards and must conform to specific accessibility and safety requirements.

> Variations are unlikely to occur for branding purposes.

Guidelines for Implementation

- **Consideration:** Lighting presents an ideal opportunity to creatively brand a BRT station location and, further, to distinguish it from local bus stops.
- **Recommendation:**
  > Ensure proper lighting and illumination for platforms, signage, pylons, and other branded station elements.

  > Consider additional artistic lighting elements that could support BRT branding efforts through coloring of unique elements or unique treatments at transfer/ terminal stations

Lit canopy acts as beacon - Onmitrans SB, San Bernardino, CA Photo Credit: Gruen Associates

Transit mall pylon and router information - Portland, OR

e. Service Information/Wayfinding

Description

Signage and wayfinding at BRT stations guides transit riders to the BRT line, their next destination through transfer information, and directional key points of interest. Signage and wayfinding should accompany the BRT brand collateral and be coordinated with other transit agencies and jurisdictions. BRT lines will also have service information readily available at every station.

In addition to posted service and route maps, interactive digital display boards provide an improved user experience with up-to-date alerts and service times.

Global cities are increasingly moving toward the primary use of symbols in order to better accommodate residents visitors and residents who speak a variety of languages. Metro has followed this trend in preparation for upcoming world events such as the 2028 Los Angeles Summer Olympic Games. Wherever possible, care and consideration should be given to the development of service information and wayfinding programs that are primarily reliant on symbols rather than words.

Metro Standards and Goals

- > Review BRT Station Design Criteria (Chapter 2 of this document), Metro Systemwide Station Design Standards and the Metro Transfers Design Guide for requirements based on station size.
- > Avoid station clutter with clear and concise signage and standardized icons.

Guidelines for Implementation

Consideration: It is important to convey a uniformly high quality service for BRT customers.

Recommendation:

- > Provide relevant information including frequency of service and headway change times, clearly presented in easy-to-read font types on real-time arrival displays.
- > Use minimal text (in English and Spanish), fortified by symbols and graphics over using extraneous words.
- > Coordinate city or district-level wayfinding with local jurisdictions.
- > Refer to Metro Transfers Design Guide for best practices.

Consistent branding across several pylon and sign sizes - London, UK *Photo Credit: Transport for London*

5 Vehicles

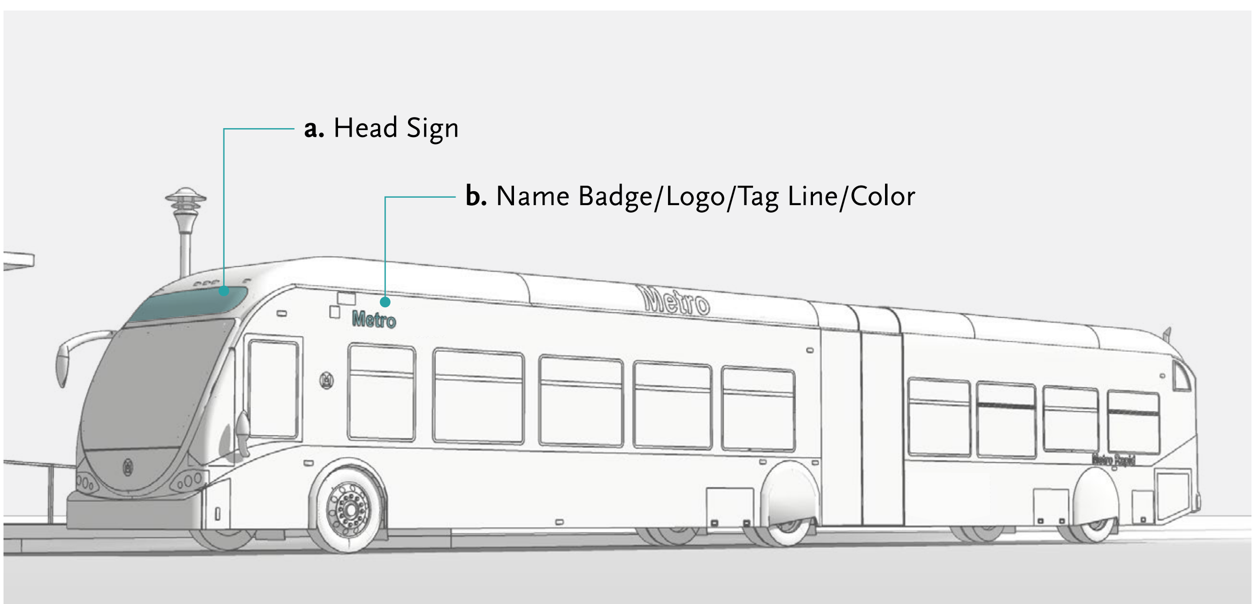
a. Vehicle
b. Head Sign
c. Name Badge/Logo/Tag Line/Color

a. Vehicle

A significant contributor to the BRT brand is the vehicle type. The vehicle serves as the rider's direct interaction with the BRT line and provides multiple opportunities for the establishment of a consistent brand. BRT vehicles may include distinct characteristics that differentiate them from standard bus fleets, while maintaining design consistency with the transit agency as a whole.

The vehicle's BRT brand is visible by the name, logo, tag line or symbol. Although branding opportunities vary across transit agencies and depend on existing or planned naming conventions, it is essential the vehicle reflect a distinguishable brand hierarchy that clearly calls out the transit provider and BRT service.

In addition to providing transit, the vehicle itself interacts as a wayfinding mechanism for transit riders. Clear and direct head signs, as well as printed route maps in the vehicle's interior contribute to clear navigation in boarding, stops, and transfers between lines.



Bus Diagram Indicating Vehicle Branding Components

b. Head Sign

Description

Digital head signs on the BRT bus front can provide low-cost methods to support the BRT brand.

Indistinct or mislabeled head signs can lead to confusion during the boarding process, as riders quickly scan the head sign to determine the vehicle heading to their destination. Today's best practices are to provide additional route cues beyond the route name/number or destination, such as key boulevards or points of interest the line is passing through. This also signals to transit riders their multiple options to reach their destination. Head signs are often utilized for seasonal greetings, special events, or support for local sport teams, though these are best used sparingly to ensure clearly labeled lines at all times.

Metro Standards and Goals

> Metro's Transit Service Policy (2015) specifies that "headsigns will list the destination in which the vehicle is traveling towards in one frame."

Guidelines for Implementation

- **Consideration:** The BRT vehicle itself is an effective way to promote the positive aspects of enhanced transit service. Every effort should be made to maximize that opportunity.
- **Recommendation:**
  - If a dedicated fleet is operationally feasible, establish distinct BRT colors.
  - Maximize legibility of route number/name.
  - Consider digital maps that can be updated faster than paper.

Typical Metro head sign with route number, route name and destination displayed. Color and contrast increase legibility from a distance. Photo Credit: Jonathan Riley

c. Name Badge/Logo/ Tag Line/Color

Description

The name badge, logo, tag line, and livery for BRT should be developed in unison to ensure cohesion between the multiple brand elements. BRT lines often include unique signifiers, represented by either a logo, color, or secondary badge. These signifiers should be easily replicable along the BRT branding elements as a way of establishing brand hierarchy. Agencies implementing BRT for the first time should consider future growth and whether or not branding of the line will accommodate expansion efforts or new routes.

Metro Standards and Goals

> Metro uses 700-799 route numbers for Rapid service.

> Silver Line route numbers 910/950/950X indicate stop frequency and route configuration.

> Orange Line service was reconfigured to remove route numbers and uses simple orange-colored Metro Liner Branding text.

> Orange and Silver Lines will become the G and J Lines, respectively, as the system's naming convention is updated.

Guidelines for Implementation

Consideration: Beyond the color of the rolling stock, the essence of a branding strategy for BRT service is the development of route "name badge, logo, and color."

Recommendation:

> The name badge might also feature neighborhood/destination placed squarely in front of the route number.

> Review latest efforts by other transit agencies (such as Transport for London) to ensure best practices given that graphic "looks," strategies and techniques are continually evolving.

> Once a graphic style for the BRT services has been determined, produce a graphic standards manual for the route, clearly articulating its intended purpose, logo, and color specifications for repetition and/or evolution of the branding program with regard to existing or future service.

> Identify clearance requirements for use of branding elements.

SBX Bus Design Excerpt

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6 Other Considerations

a. Customer Experience
b. Bus Advertising/Art Bus
c. Station Advertising
d. Public Art

While not branding in the strictest sense, the combined elements of running ways, stations and vehicles contribute to an agency's image and can influence public perception of the system. These element should be coordinated with overall branding efforts in order to support consistency across the many ways in which the public views the transit network in a positive light.

a. Customer Experience

Enhancements

The customer experience on board is influenced by interior design, which plays a role in distinguishing the BRT line from standard bus services. BRT lines typically include spacious interiors, comfortable seating and ample lighting. Real-time arrival information and next stops shown on digital displays can help further mimic the interior of rail service. Also refer to the Chapter 7.4 ITS Systems chapter of this document for further guidance on real-time customer information.

Metro Standards and Goals

> Automatic voice announcements should use the same number and naming conventions as maps, timetables, and station signs.

Guidelines for Implementation

Consideration: Customer experience is enhanced if bus interiors are well thought out with the use of harmonious, easy-to-maintain materials, combined with the provision of 'cutting edge' technology.

Recommendation:

> Provide comfortable seating and real time arrival and next stop digital displays.

> Provide route mapping beginning and end points, and stations between in advertising strip above the windows.

> Ensure ample provision of hanging straps to facilitate standing.

> Emphasize ample lighting and clearly visible linear route maps.

> Provision of WiFi capability and, possibly, USB charging ports is a positive nod to connectivity.

> Consider green/sustainable materials made from recycled plastic bottles or clothing fibers for seating and other interior finishes to demonstrate sustainability commitments.

> Consider deploying digital maps that can be updated faster than paper maps.

b. Bus Advertising/Art Bus

Description

Striking and creative BRT vehicle wraps are occasionally utilized as a form of advertising or public art. Some transit agencies have partnered with local artists, organizations or galleries to display appealing works of art on their transit fleet or in stations. The challenge is to integrate these visual elements without distracting from BRT brand awareness. Within the Metro system, the Orange Line does not prominently feature advertising, and the Silver Line features playful illustrations of passengers on windows. Other transit lines, such as Foothill Transit, have opted not to include any advertising on their bus exteriors as a way of strengthening brand identity.

Metro Standards and Goals

> Metro Communications determines advertising contracts, vehicle wraps, and any deviations from established standards.

Guidelines for Implementation

Consideration: Current and emerging bus wrap technology is a cost-effective way to enhance BRT transit service in an artful manner.

Recommendation:

> Establish standards and/or uniform placement of bus wraps/advertisements to make sure that ad visuals do not interfere with Metro brand identity or passenger security.

> Consider how unique bus wraps or advertising can serve larger municipal goals or support cross-promotion with cultural institutions or civic initiatives.

> Investigate partnerships with local art galleries/museums to co-sponsor bus wrap programs based upon cultural or seasonal themes.

Translink bus wrap collaboration with Vancouver's Contemporary Art Gallery (CAG) - Vancouver BC

c. Station Advertising

Description

Advertising on BRT lines can be included at stations, on shelters, and on display modules in order to generate revenue. Although advertising can be a form of revenue generation, overabundant use of visuals could distract from the BRT brand and navigation.

A transit agency should determine the appropriate use of advertising along the BRT lines and should be coordinated with any internal communications department or the municipal agency responsible for marketing and branding. Also refer to the Section 7.4 ITS Systems chapter of this document for further guidance regarding digital advertising.

Metro Standards and Goals

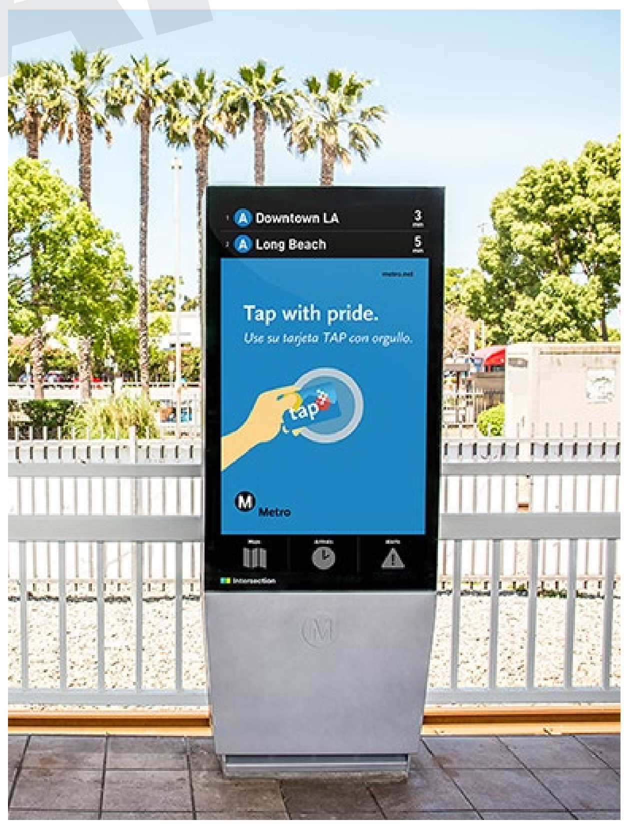
> Metro's Creative Services department determines policies and negotiates advertising.

Guidelines for Implementation

- **Consideration:** Advertising along BRT routes, including stations, will be subject to Metro, city and/or municipal transit agency policies. If it is allowed, ensure that its placement does not detract from branding strategies.
- **Recommendation:**
  - > Consider limiting advertising to transit-supportive initiatives, equity-focused programs, and public safety awareness.
  - > Follow agency guidelines on advertising dimensions and locations within the station canopy.

Site-Specific Ad Blends Into Surrounding Station Components

Non-profit advertising on glass panels - Vancouver BC International Airport Photo Credit: IBI Group



Consider Integrating Ads into Interactive System Panels/Kiosks

d. Public Art

Description

Integrating public art along BRT stations serves more than ornamental purposes by contributing to station identity and sense of place. While public art offers limitless opportunities to personalize station elements, the upkeep can lead to increasing maintenance and operational cost.

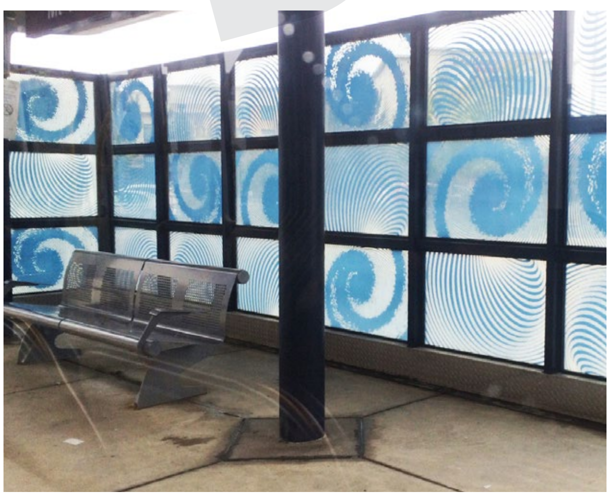
Providing clear guidelines on dimensions, materials, and locations that are adaptable along stations can provide more meaningful displays of public art that are easily coordinated with local artists. In instances where the physical representation of public art may not be feasible, other creative solutions that are adaptable include displaying art through digital displays, or artistic lighting within BRT station elements.

Metro Standards and Goals

> Metro has streamlined the ways in which public art will be incorporated into stations by adding it into station design criteria. The Metro Public Art department will define and administer the provision of work for new lines of service.

Guidelines for Implementation

- **Consideration:** One of the clearest ways to distinguish a bus shelter within a distinct neighborhood is by incorporating public art into its design. It is also a way to foster community pride and support local artists.
- **Recommendation:**
  - Local jurisdictions should look to industry best practices for guidance as well establish public art guidelines.
  - Utilize durable materials such as glass art panels, porcelain enamel steel work, or pylons.
  - Incorporate creative elements such as digital displays or lighting.
  - Investigate local partnerships with local artists to provide their work for nearby BRT stations.



Public art along Red Line differs in style while maintaining overall consistent use of materials and location - Portland, OR Photo Credit: IBI Group

Etched glass panels at Trimet station - Portland, OR

6

BRT Planning and Integration Into Transit-oriented Communities

Existing policies related to transit-oriented communities help in evaluating the opportunities and constraints of transit-supportive planning efforts related to BRT and define a vision for integrating TOC principles into the planning of the Countywide BRT network.

1 TOC Design Objectives

2 Policy Context

3 BRT Required and Supporting Elements

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1 TOC Design Objectives

a. TOC Policy Goals
b. Objective of TOC Design Guidelines
c. Partnerships with Local Municipalities

Transit-oriented communities (TOCs) are places that, by their design, allow people allow people to drive less and access transit more.

A transit-oriented community maximizes equitable access to a multi-modal transit network as a key organizing principle of land use planning and holistic community development. TOCs differ from Transit Oriented Development (TOD) in that a TOD is a specific building or development project that is fundamentally shaped by close proximity to transit. TOCs promote equity and sustainable living in a diversity of community contexts by: (a) offering a mix of land uses that support transit ridership of all income levels (e.g. housing, jobs, retail, services and recreation); (b) ensuring appropriate building densities, parking policies, and urban design that support accessible neighborhoods connected by transit; (c) elevating vulnerable road users and their safety in design; and (d) ensuring that transit related investments provide equitable benefits that serve local, disadvantaged and underrepresented communities.

The purpose of this BRT Planning and Integration into transit-oriented communities Design Guidelines is to provide additional guidance to planners and policy makers from within local jurisdictions and Metro on how to include TOC principles and policies within BRT projects.

Although Metro BRT projects are the main focus of the chapter and its geographic context is for projects in LA County, these guidelines can also provide guidance to other transit agencies looking to incorporate TOC concepts into their BRT plans.

Metro's TOC Policy promotes policies and actions that maximize the benefits of the transportation investments in communities by incorporating equity and community development as critical considerations.

Metro's TOC Policy defines Metro's goals in how the Agency "considers, funds, enables, and/or incentivizes activities that support the development of balanced communities throughout LA County." The Policy outlines "TOC activities" that can be considered as serving a transportation purpose, and establishes the geographic reach of these activities.

Figure 1 on the following page illustrates the geographic boundaries within which TOC activities can take place. First/Last Mile amenities can be implemented throughout the catchment area of a BRT station and are often focused closer to the station.

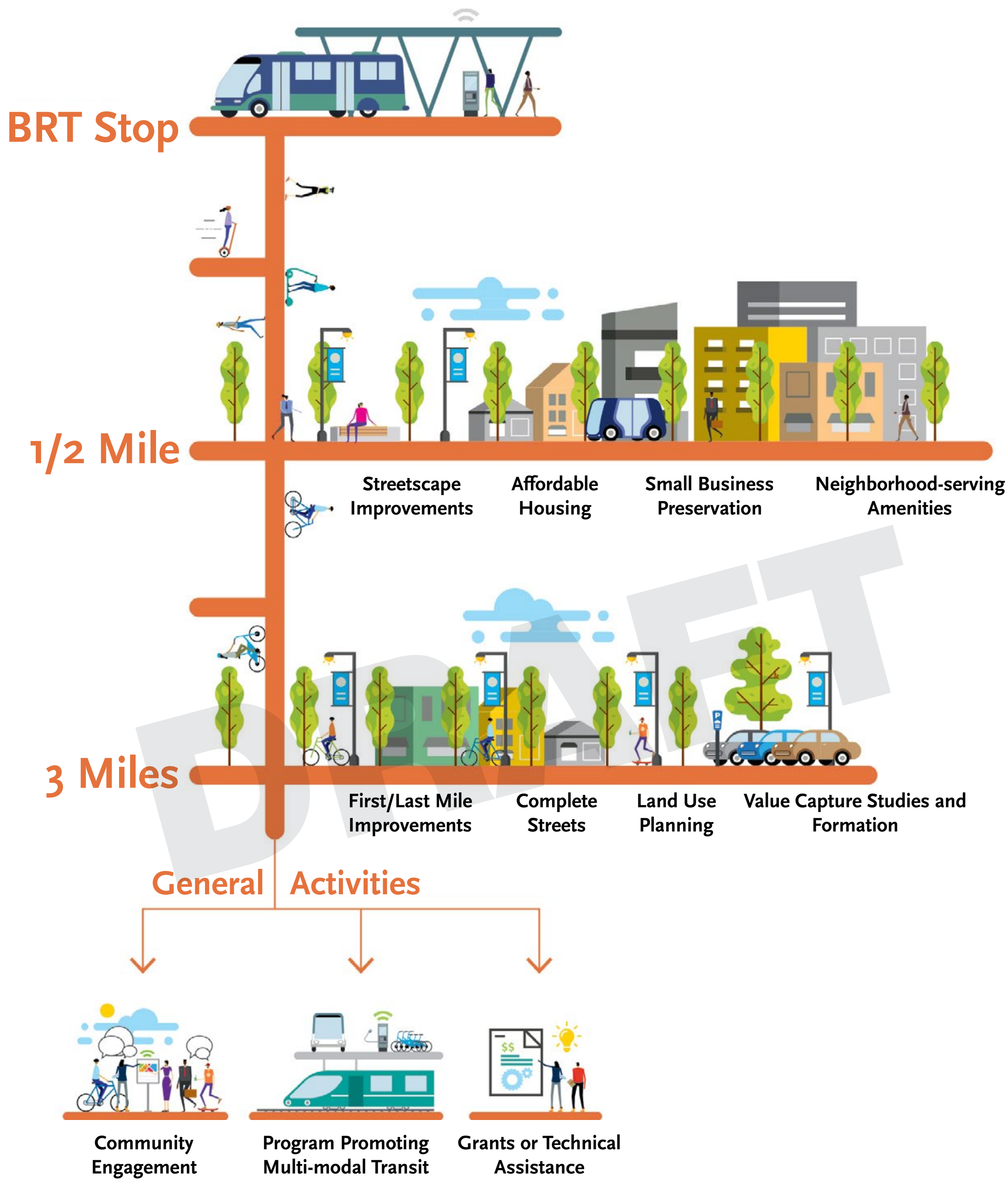

Figure 1: TOC Activity Boundaries

a. TOC Policy Goals

The five goals of Metro's TOC Policy are:

1. *Increase transportation ridership and choice* – through promotion of alternate, non-motorized modes of transportation, enhanced first/last mile connectivity, and working to create safer environments.
2. *Stabilize and enhance communities surrounding transit* – by prioritizing transit-adjacent affordable housing, supporting local residents and business, and creating sustainable infrastructure.
3. *Engage organizations, jurisdictions, and general public* – by including intentional outreach to communities that are harder to reach through traditional outreach strategies, and increased collaboration with local residents, businesses, and community organizations.
4. *Distribute transit benefits to all* – by incorporating equity metrics into the planning and evaluation process.
5. *Capture value created by transit* – by considering value capture mechanisms around transit investments that are reinvested in TOC activities.

Metro's TOC Policy Goals and its Equity Focus Communities metric are integral to the corridor identification, evaluation, and screening processes as well as the planning, design and implementation of future BRT projects.

b. Objective of TOC Design Guidelines

The objective of this chapter is to provide guidance to transit and land use planners on integrating TOC into the planning and implementation of new BRT corridors, summarize existing policies and best practices related to TOCs, and evaluate the opportunities and constraints of transit-supportive planning efforts related to BRT. These guidelines also distinguish those elements that are required for BRT planning, and those which are TOC supportive but may be optional due to budgetary, schedule, policy, or site constraints. These guidelines can be used as a "playbook" to build partnerships between the implementing agency and local jurisdictions.

c. Partnerships with Local Municipalities

As LA County's largest provider of transit services, Metro's primary role is to plan and operate transit service. Additionally, Metro's TOC unit includes five core functions that help encourage, incentivize and support local jurisdictions to plan for equitable TOCs. These five core TOC functions include:

- The Joint Development team works with local communities and developers to develop viable Metro owned properties that remain after the public transit infrastructure is built. This process is outlined in the Joint Development Policy.
- The Adjacent Development Review team coordinates with private development occurring adjacent to Metro right-of-way to ensure safety, avoid impacts to transit service, and identify synergies between the development and Metro stations to increase ridership.
- The First/Last Mile team works with local communities to develop First/Last Mile Plans (FLM) for all Measure M corridors. The FLM team's work is guided by the Agency's FLM Policy, as well as its First/Last Mile Strategic Plan and Active Transportation Strategic Plan.
- The Systemwide Design team reviews station design of all Measure M corridors focusing on:
    - Providing a safe, accessible and comfortable Metro experience.
    - Connecting Metro stations to the greater regional transit network.
    - Orienting stations to neighborhood destinations and pedestrian routes.
    - Improving the durability of Metro's infrastructure to reduce maintenance.
    - Supporting the vision of transit-oriented communities.
- TOC Strategic Initiatives group administers Metro's Transit Supportive Planning efforts that include:
    - TOD Planning Grant Program.
    - The Transit Supportive Planning Toolkit.
    - Metro's Union Station redevelopment program.
    - Mobility Corridor Integration.
    - The Policy and Planning group is also lead for the West Santa Ana Branch TOD Strategic Implementation Plan (TOD SIP) and is responsible for developing the TOC Implementation Plan.

As a partner, Metro supports local agencies in setting the land use and design policies that regulate the public right-of-way in which BRT will operate.

Collaboration between Metro and local jurisdictions is therefore essential to the implementation of successful BRT projects. The TOC Policy further defines areas that fall within Metro's functional jurisdiction and those that are within the realm of local jurisdictions.

2 Policy Context

a. Overview
b. First/Last Mile Policy
c. Metro Systemwide Station Design Standards Policy
d. AB 1560
e. City of Los Angeles TOC Affordable Housing Incentive Program
f. Housing Crisis Act of 2019 (SB330)
g. Equity and Community Engagement
h. TOC Policy and Implementation Plan

a. Overview

Transit projects exist within a policy context that is larger than that defined by the agency providing service. Clear guidelines and a transparent planning process are essential to building community trust, improving communication, and delivering projects within requirements set by policy, but TOC policies continue to evolve. This section reviews some TOC-related connections such as community character, housing affordability, and gentrification/displacement that are impacted from a policy perspective.

b. First/Last Mile Policy

First/Last Mile (FLM)—describes the space that connects transit service such as BRT with a rider's origin and destination. FLM planning for transit-oriented communities in the context of BRT is covered in greater detail in Section 3, but Metro's First/Last Mile (FLM) Planning and Implementation Policy (Board Motion 14.1) provided the initial direction to Metro staff to begin FLM planning on a countywide basis. Subsequent evolving policy documents have further defined the FLM process and were reviewed to inform this document.

c. Metro Systemwide Station Design Standards Policy

This policy requires that all future BRT station designs conform to the Metro BRT Design Criteria and Standard Drawings that are developed as part of the BRT Vision and Principles Study. It reaffirms a commitment to Metro's Systemwide Station Design Standards or "Kit-of-Parts" design toolkit and emphasizes safety, state-of-the-art design, maintainability, sustainability, consistency, legibility, and accessibility of stations. These priorities contribute to a station's integration with the community and support overall TOC goals.

d. AB 1560

Assembly Bill 1560 provides State-level guidance on what constitutes Bus Rapid Transit, as well as its relationship to the environmental clearance processes for residential projects under CEQA. The bill defines BRT as including all of the following:

1. Full-time dedicated bus lanes or operation in a separate right-of-way dedicated for public transportation with a frequency of service interval of 15 minutes or less during the morning and afternoon peak commute periods.

2. Transit signal priority.
3. All-door boarding.
4. Fare collection system that promotes efficiency.
5. Defined BRT Stations.

Infill residential projects located within ½ mile of a BRT stop that meets the above guidelines would therefore be exempt from certain restrictions under CEQA. These implications should be considered early in the project development process both by the lead agencies implementing a BRT project and the local jurisdictions in which the project is built.

e. City of Los Angeles TOC Affordable Housing Incentive Program

Although the City of Los Angeles is not the only local jurisdiction in which Metro operates, its population and geographic size constitute a large portion of Metro's ridership and service area.

The city's recently-enacted TOC ordinance is an important consideration for the integration of transit and land use planning and represent a significant effort to reduce Vehicle Miles Traveled (VMT) and address California's housing crisis. The TOC guidelines provide tiers of affordable housing incentives for areas adjacent to major transit stops, and the policy demonstrates how density can be concentrated in the areas best suited to handle it: at major transit stations and stops, as well as intersections of frequent bus lines where transit access is highest. Due to the nuances of the policy, Metro and the City of Los Angeles will need to coordinate how the planning of new BRT service interacts with eligibility for housing development incentives.

f. Housing Crisis Act of 2019 (SB330)

Senate Bill 330, "The Housing Crisis Act of 2019" is a statewide bill designed to accelerate the approval of housing developments, including residential development, mixed-use development with a large residential component, and transitional housing until 2025. Among other goals, it limits a local jurisdiction's ability to downzone residential areas, speeds up permitting requirements and processing times, and limits development fees and building requirements. The bill also contains measures to address displacement. It bans demolition of affordable and rent-controlled units unless developers replace them, pay to rehouse tenants, and offer them first right of return at the same rent.

g. Equity and Community Engagement

Metro is committed to involving stakeholders and the public in the decision-making process. Metro's Equity Platform Framework (February 15, 2018), recognized transportation as "an essential lever" to enable access to opportunity. The platform is built on four pillars which should guide community engagement practices and the decision making process:

1. *Define and Measure* – by using consistent metrics throughout the project development phase.
2. *Listen and Learn* – by building partnerships with communities and incorporating their input throughout.
3. *Focus and Deliver* – by prioritizing those metrics which Metro as a transit provider is most capable of influencing.
4. *Train and Grow* – by educating staff and the next generation of transit planners.

h. TOC Policy and Implementation Plan

In 2018, the Board adopted the TOC Policy as a commitment to incorporate equity and community development in how the agency plans and realizes its transportation investments across the county, with a near-term next step of developing an implementation plan.

Metro is in process of developing the TOC Implementation Plan as the primary implementation tool of the TOC Policy. The TOC Implementation Plan is grounded in four initiatives:

1. *Creating TOC Corridor Baselines Assessments for Measure M Transit Corridors:* Highlight community characteristics, opportunities, and needs to support communities in leveraging the positive benefits of the transit investment and preparing for potential unintended consequences.
2. *Continually Improving Metro TOC Programmatic Areas:* Includes a series of actions that Metro will undertake to ensure that Metro TOC Programs align with the Policy goals and outcomes.
3. *Enhancing Metro's Internal Coordination:* Activities that Metro will undertake to align internal coordination in support of creating TOCs in LA County.
4. *Strengthening Coordination and Collaboration with Metro's Partners:* Calls for the essential ongoing coordination and collaboration with municipalities, local communities, and advocacy organizations for the region to realize equitable TOCs, given that many of the activities that are critical to TOCs are outside of Metro's jurisdiction.

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3 BRT Required and Supporting Elements

a. BRT Required Elements
b. BRT Supporting Elements
c. Conclusion

The section includes two key definitions:

> BRT Required Elements, those TOC items that are required for consideration in BRT planning; and

> BRT Supporting Considerations, those items that extend the reach of a holistic planning practice but may be constrained due to budget, schedule or jurisdictional control.

a. BRT Required Elements

EVALUATING TOC OPPORTUNITIES & CHALLENGES IN CORRIDOR PLANNING

Zoning, development and land use patterns, affordable housing policies, and active transportation infrastructure have major impacts on the provision and success of public transit. As such, evaluating these types of TOC factors as part of the BRT planning process is critical to a successfully integrated transportation project in the community. As part of early planning for new BRT corridors, Metro will evaluate TOC opportunities and constraints along each alignment option to inform the selection of a locally preferred alignment, along with technical review on engineering, real estate acquisitions, etc. Development incentives such as density bonuses or reduced parking minimums for projects adjacent to high-quality transit are important tools to help address the state and city's housing affordability crisis. These types of incentives also concentrate development of new housing stock and denser development in the areas that are best designed to handle it: at major intersections and along arterial roads, away from more sensitive and less developed neighborhoods. While Metro does not control local land use policy or development incentives, understanding the land use and development context is essential to making decisions on the preferred alignment and preferred station locations.

Opportunities

> Evaluating land use, development patterns, and local zoning/development policies as part of BRT corridor alignment and station studies.

> Work with cities to proactively update land use and development policies to support transit, as well as affordable housing and rent stabilization policies to protect communities from displacement along major transit corridors or in proximity to major transit lines.

> Prioritizing the implementation of BRT lines and stations in locations where transit supportive development patterns currently exist, are planned, or are more likely to occur in the future.

Challenges

> Prioritizing BRT alignments along high density and/or mixed use corridors may overlook areas where high-quality transit options are lacking or where there are historical patterns of disinvestment.

> Updating local zoning standards and housing policies requires resources, which are often constrained in small cities, or cities with high risk of displacement as investment occurs near transit.

Reference Documentation

> Metro TOC Policy (2018)

STATION LOCATION

Chapter 2 of these design guidelines contains the core materials that will guide the detailed station design and location process. Due to the greater distances between stations on BRT as compared with local bus service and the greater capital costs of building them, properly locating stations is critical. Stations that are thoughtfully designed, attractive, and optimally placed to serve the surrounding community will encourage transit ridership and retention of existing riders. Table 2 below describes factors that must be considered during the process of selecting station locations.

Opportunities

> Excellent opportunity to solicit and incorporate community and key stakeholder feedback.

Challenges

> Balancing hard restrictions such as right of way/property restrictions and traffic engineering with soft concepts like urban design requires a high degree of coordination.

Reference Documentation

> BRT Vision and Principles Design Guideline 7.2 – Stations

> Metro Transfers Design Guide (2018)

> Local zoning/land use policies

Criteria	Relevance to BRT
Metro policies	Metro projects must comply with all relevant Metro policies.
Major trip generators	Large employers and key activity centers such as hospitals and universities are more conducive to transit use.
Supportive land uses	Land that is developed at a greater density provides higher ridership potential.
Sidewalks and condition of sidewalks	Conversely, new transit projects can provide an opportunity to address these deficiencies with First/Last Mile improvements.
Bus/bike connections	Locating stations near other lines of service or bike infrastructure reduces friction between travel modes.
Adequate right of way, space constraints, safety	The greater footprint of BRT stations requires additional space for safe circulation.
Station usage forecasts	Stations with projected higher ridership may need to be located in an area that can accommodate the demand.
Congestion planning	Intersection density is a measurement that can be used as a proxy for walkability. Station location must balance proximity to intersections with congestion and impacts caused by other modes of travel.

Table 2: Station Location Criteria

FIRST/LAST MILE PLANNING

Although individuals may complete the bulk of their journey between places on a bus or a train, they must first walk, bike, or roll to access transit. According to Metro's regular trip surveys, 89% of bus riders used some form of active transportation (walking, biking, skateboards, scooters) to reach their bus stop. This segment of their journey—the first/last mile—was analyzed in Metro's First/Last Mile (FLM) Strategic Plan in order to provide a strategy to improve FLM conditions by increasing safety and accessibility to transit. The Plan provides a toolkit to analyze existing conditions around potential BRT stations to identify needs in BRT corridors (such as improved lighting, crosswalks, or bike lanes), and emphasizes the important role that local jurisdictions play in connecting to transit. FLM treatments should be rightsized for each project and its local context, primarily by focusing on the highest ridership stations and those with the greatest number of transfers.

In 2016, Metro established FLM Policy (Board Motion 14.1). The policy calls for FLM planning, design, and construction around new transit stations. Over the last few years, Metro has conducted FLM planning for transit stations along several existing and future corridors. The agency is in the process of developing its First/Last Mile Guidelines, a coordination framework that describes processes for integration of FLM planning into transit project delivery. Metro will initiate the FLM planning process, working closely with local jurisdictions and stakeholders, including community-based organizations, to reflect local needs and priorities along primary access routes to the station. In this framework, local agencies would implement and maintain these FLM improvements located in their own right-of-way. FLM planning and implementation processes specific to BRT projects are currently being discussed; while BRT development phases are similar to other transit projects, there are differences that could prompt various considerations including, but not limited to, a focus on particular stations along a BRT corridor or a change in the studied area for FLM improvements surrounding the station. Metro BRT projects planned in the future should budget for FLM activities in consultation with FLM staff and BRT-specific processes will be finalized in the First/Last Mile Guidelines (anticipated in Fall 2020).

Opportunities

> FLM planning/improvements can increase collaboration with local jurisdictions and encourage additional investment around transit projects.

> New transit lines provide a benefit to all street users through FLM infrastructure improvements.

Challenges

> FLM planning outside of the immediate station area requires additional coordination with local jurisdictions and property owners.

> Under constrained project budgets, FLM improvements can be difficult to implement.

Reference Documentation

> Metro First/Last Mile Strategic Plan (2014)

> Metro First/Last Mile Guidelines (Expected 2020)

JOINT DEVELOPMENT

BRT projects typically do not require acquisition of significant amounts of property, and therefore Metro is unlikely to undertake joint development at a large scale. In places where more intensive land development exists, bus maintenance and layover facilities may present potential for mixed-use joint development projects. Where property acquisition is necessary for construction support, agencies should consider whether consolidating several small acquisitions into one larger parcel makes sense both for construction staging and for long-term joint development purposes.

However, major transfer points or terminal stations may deviate from this generalization, such as at Metro's North Hollywood station. The station is the northern terminal of the Metro Red Line, and the current joint development plan occurring at the station includes a redesigned and expanded transit plaza to accommodate Metro's existing Orange Line BRT and local bus service, as well as the future North San Fernando

Valley BRT and North Hollywood to Pasadena BRT projects. The plaza will better accommodate bus-to-rail transfers and provide improved outdoor spaces.

Opportunities

> Identify parcel acquisition needs as early as possible in a project and consolidate them for maximum benefit.

Challenges

> Joint development is a complicated process that requires coordination with additional private firms, property owners, and stakeholders.

Reference Documentation

> Metro Joint Development Policy

TRANSFER CONSIDERATIONS

Over 60% of Metro's riders transfer at some point in their journey. A well-designed transfer experience can help ensure that people make a seamless connection between modes or routes, thereby supporting ridership. Items like clear signage, safe crosswalks, and real-time arrival screens can encourage discretionary trips (where an individual may be traveling outside of their normal routine) by making them easier to navigate. Transfers should also be safe, clean and comfortable at all times of day, and in all kinds of weather. Metro's Transfer Design Guidelines extensively studied the transfer experience of current riders and contains guidelines and recommendations for improving both the existing system and future lines of service.

Opportunities

> Consider the transfer experience when locating stations to connect with other transit lines in order to maximize rider satisfaction.

Challenges

> Expanded transfer infrastructure can be costly to implement where right-of-way is constrained or property acquisition costs are high.

> Enhanced safety measures in the street right-of-way (e.g. crosswalks, bulbouts, pedestrian priority signals, lighting) requires close coordination with local city departments (e.g. Public Works, Street Services, Transportation) to implement.

Reference Documentation

> Metro Transfers Design Guide (2018)

b. BRT Supporting Elements

Beyond the considerations above that are required for successful corridor planning and design, the planning process for new BRT lines should consider to what degree additional TOC concepts can be incorporated into the project scope and budget.

MANAGING MOBILITY ACCESS

The First/Last Mile planning process covered above is the formal process by which active transportation connections to stations will be evaluated and planned. BRT planning, particularly station-area planning, should also consider new mobility models that have developed over recent years. Examples include privately-operated bicycle and scooter micromobility providers (such as Bird, Jump, and Lime), as well as ride-hail/ Transportation Network Companies ("TNCs", such as Uber and Lyft).

These new mobility models can help transit riders connect to stations, link major local destinations, and leverage upgrades to the wider active transportation network, but planning for and accomodating them is complex. Metro is responsible for planning for micromobility within the station area boundary. Outside of the station area, partnerships between Metro, local jursidictions, and private property owners can support safer, multimodal access to and from transit. Key enhancements to support these efforts may include signal prioritization, fully separated bike paths, and managing micromobility "corrals" so that they enhance rather than impede transit access.

In addition, designated pick-up and drop-off areas for TNCs and new curb management programs can help reduce interference with bus operations, increase safety for passengers, and potentially drive foot traffic to nearby businesses. Metro is also running pilot programs to study and partner with micromobility and ride-hailing services. These pilot programs provide additional opportunities for local jurisdictions to learn from industry best practices and engage with Metro on mutually-beneficial programs.

Opportunities

> Integrate bicycle/scooter parking into station planning efforts.

Challenges

> BRT station footprints in many areas may be highly constrained, making accommodation for other vehicles difficult and/or expensive.

> Increasing on-board accommodations for bicycles and scooters can reduce vehicle seating capacity and may increase dwell times.

> Local policies on micromobility devices are changing rapidly.

URBAN HEAT ISLAND/URBAN GREENING

As climate change makes extreme temperatures and weather events longer, more frequent, and more intense, planning initiatives will need to provide greater priority to mitigation. In the Southern California context in particular, lack of shade and high temperatures leave many riders vulnerable—especially in those communities identified by Metro's EFC metric. To the largest extent possible, each and every consideration for the design and delivery of BRT service should be looked upon with the filter of climate change as a key criteria for decision making. Although transit service may provide negligible improvement to the urban heat island effect, its accompanying infrastructure can incorporate sustainability elements and protect riders. Corridors that provide greater reductions in VMT and GHG should receive higher evaluations in the screening process. Similarly, stations that create spaces where heat impacts can be mitigated through greening, shading and other design strategies should be more favorably evaluated.

In addition, the concept of design resilience is the capacity to adapt to changing conditions while maintaining service functionality. It will increasingly be a factor in the maintenance of the value of this design manual as society and technology progress.

Opportunities

> Increased transit ridership is seen as part of the solution to climate change. Its increasing contribution to mitigation of the negative effects of climate should be real and apparent.

Challenges

> The increased cost of addressing climate change is often looked upon as a negative, but the cost of avoiding it head on, is likely a greater factor in the long term.

Reference Documentation

> Metro Moving Beyond Sustainability Plan

> Metro Green Places Toolkit

c. Conclusion

Chapter 6 is intended to be a 'Living Document.' Given that TOC planning and implementation is a transitional link between Metro, local municipalities and the County of Los Angeles, it is subject to a wider array of external considerations that will assuredly influence the evolution of BRT service moving forward.

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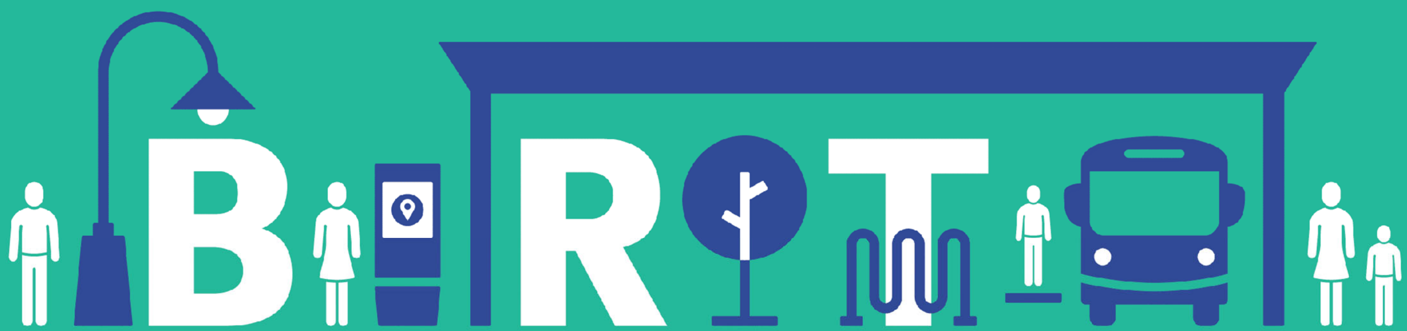
Los Angeles County
Metropolitan Transportation Authority

Bus Rapid Transit Vision & Principles Study



January 2019 – October 2020

Stakeholder Engagement Report

Metro

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Bus Rapid Transit Vision & Principles Study

1. Overview

The Bus Rapid Transit (BRT) Vision & Principles Study was undertaken to establish a cohesive set of guidelines and standards to direct Metro investment in on-street BRT projects. The Study establishes a local definition of BRT, supportive design guidelines and identifies the corridors where BRT can best meet Metro mobility goals as defined in the Vision 2028 Strategic Plan. Through this effort, the standard of a future LA County BRT network will be established and Metro's goal of creating a world-class transportation system will be further supported. Overall, the BRT Vision & Principles Study generated the following guiding deliverables:

> Metro BRT standards

> Metro Design Guidelines Manual

> Final Report with a recommended list of potential BRT corridors

2. Stakeholder and Public Engagement Program

To assist Metro in achieving the goals of the study, the outreach team worked closely with the technical contractor and Metro project management to develop a comprehensive outreach program designed to inform, educate and solicit input from a variety of stakeholders, including municipal transit operators, city officials, elected officials, Metro employees, community and transit organizations and members of the general public. Throughout the project, stakeholder engagement at was conducted to complement and help inform the technical process. Activities have included stakeholder workshops, presentations and project briefings, survey engagement, and formation of a Technical Advisory Committee. The team also worked with Metro's NextGen Bus Plan project staff to leverage opportunities for outreach at public meetings and collaborate where possible to assist in maximizing outreach options and stakeholder relationships and share data relevant for both projects. Outreach was tailored to be inclusive and gather feedback that accurately reflects the diversity of LA County's population including ethnicity, race, age, language, income levels and level of transit access and utilization.

3. Project Communication Resources

Outreach strategies included a number of communications tools to aid in building project awareness and encourage participation. Materials were developed in coordination with the project team and designed to effectively communicate project information. The following outlines the communication materials developed for this study.

3.1. Project Database

The project database served as the primary resource for public and stakeholder notification and communication. Database contacts received invitations to meetings and project updates by email, digital e-blasts, and through extended outreach calls to key stakeholders. To initiate the project, a primary database of contacts was developed with an initial 300+ stakeholders collected from existing project database sources, including the NextGen Bus Plan database, Orange Line Improvements database, and other contacts provided by the Metro technical contractor. Database contact categories included public agencies, transportation agencies, community organizations, neighborhood associations, business associations, academic institutions, special interest groups, Metro staff, interested parties and others.

3.2. Collateral and Educational Materials

Story Map

ESRI "Story Map" is an interactive mapping tool that combines maps with narrative text, images, interactive maps and multimedia content. The Story Map for the BRT Vision & Principles Study served as the main online portal for public project information and provided stakeholder access to:

- Core project information and graphics
- Project contact information as a method of input
- Project interactive maps and technical data, which were updated several times to reflect project milestones
- Links to the project survey in both English and Spanish
- Links to other relevant information, including related projects and Metro initiatives

Fact Sheet

An 8 ½" x 11" branded Fact Sheet was developed by the Project Team in both English and Spanish as a foundational collateral tool. This two-sided project sheet provided a brief project overview and purpose, goals of the study, information on the study process, schedule and project contact information. This handout was reviewed and updated as needed throughout the life of the project.

Comment Card

Comment cards were made available at all Technical Advisory Committee meetings, stakeholder workshops and NextGen Bus Plan public workshops. This method of feedback allowed stakeholders to provide their contact information for future project updates and information as well as feedback on any aspect of the project. To ensure complete communication with the public, this piece was created in both English and Spanish.

Survey

A survey was developed as the primary mechanism for soliciting general public input on the project. It was designed to gather input on priorities for design elements as well as travel preferences and patterns. The survey was promoted in-person at public and stakeholder workshops and was also shared extensively online via countywide geotargeting and extended outreach partners.

Interactive Mapping Tools

In order to fully immerse the TAC and key stakeholders in the corridor study process, custom interactive mapping tools were created. These tools allowed technical data and specific corridor criteria to be presented on a live platform so that viewers could explore the possibilities and provide informed feedback to the technical team. The tools allowed analyzed BRT corridors to be layered with Metro's planned and existing transit lines as well as the proposed NextGen Bus Plan and other key landmarks and destinations in order to see transit system coverage and connections across the county. Users had the ability in real-time to comment on existing data and lines as well as draw new corridor lines for review and consideration by the technical team.

4. Outreach Activities

The outreach activities conducted provided project stakeholders with the necessary tools and resources to be educated, informed and offer valuable input at major milestones in the study. Identified key stakeholders and the public were given opportunities to connect directly with the BRT Study team, through both in-person and digital interactions. The following summarizes all outreach efforts and activities completed by the project team in support of the study.

4.1. Technical Advisory Committee (TAC)

To help guide the study process, a Technical Advisory Committee (TAC) was established in the early months of the project and was comprised of staff from Metro departments, cities and municipal transit operators. The TAC served as a collaborative discussion forum to provide input and feedback on the guidelines and standards being developed for the project and provided expertise on specific department and/or domain subject matter. The TAC also provided insight on the identification and validation of BRT corridors and direction on the identification of the future BRT network. This body also helped communicate project information and progress made to their respective member organizations, colleagues and constituents. The TAC convened for the first time in February 2019 and held its final meeting in September 2020. A total of 12 TAC meetings were held over the course of the project and detailed minutes were provided to Metro following each meeting. A listing of dates and topics for those meetings is provided in the table below.

Date	Meeting Topic
2/22/2019	Project kick-off; development of project guiding principles
3/18/2019	Development of project goals & objectives
4/15/2019	Refinement/review of vision, guiding principles & goals
6/4/2019	BRT standards and corridor selection criteria development
7/25/2019	BRT standards & thresholds; elements of design discussion
9/24/2019	Stations & Running Ways
10/24/2019	Corridor Analysis
11/21/2019	Branding, Stations & Running Ways
12/12/2019	Operating, TOC & ITS Characteristics
4/16/2020	Corridor Analysis – Top 15
07/29/2020	Corridor Analysis – Top 7; update on design guidelines
09/03/2020	Strategic Network and Design Guidelines Review

4.2. Stakeholder Workshops

During the course of the study, the project team identified a list of 50+ stakeholders based on shared interests, geographic location, relevant industry/agency groups, local community organization and business representation. These included Valley Industry Commerce Association, Southeast LA Collaborative, Cal State LA, FASTLink DTLA, Pacoima Beautiful, LA Walks, Move LA, BizFed, ACT-LA, and local Councils of Government and Transportation Commissions, to name a few. A total of three workshops were conducted (2/7, 5/20 and 9/1, 2020) with these stakeholders and provided an opportunity to inform and gather insight on their unique perspectives regarding relevant issues and opportunities related to the development of LA County's BRT network. Organizations were also provided with project updates through email and phone calls. Project materials were regularly shared with these stakeholders in an effort to further the reach and distribution of study information and in turn, increase awareness and feedback from the public. Detailed notes from each of the stakeholder workshops is provided in the appendix.

4.3. Stakeholder Briefings and Presentations

To further assist the technical team with narrowing down the corridor recommendations, presentations and briefings were scheduled with key representatives and elected officials, with a specific focus on feedback related to the highest ranked seven corridors. These stakeholders helped the team identify local opportunities, support and constraints or issues. This input allowed the team to ascertain the level of public and/or policy support that might be expected for each of the corridors.

Additionally, throughout the project, updates and presentations were provided to a host of other key groups and Metro committees. A list of all presentations and workshops is provided below.

Date	Organization	Date	Organization
10/17/18	Planning & Programming	8/20/20	CD-1 Cedillo
12/11/18	Policy Advisory Council	8/20/20	CD-5 Koretz
4/9/19	Policy Advisory Council	8/21/20	South Bay Cities COG
4/10/19	General Manager Meeting	8/21/20	CD-11 Bonin
5/21/19	Bus Operations Subcommittee	8/21/20	Gateway Cities COG
6/11/19	Policy Advisory Council	8/21/20	SD-1 Solis
6/20/19	Streets & Freeways	8/24/20	LA Mayor Garcetti
7/18/19	Local Transit Systems Subcommittee	8/24/20	CD-4 Ryu
2/7/20	Key Stakeholder Workshop	8/25/20	SD-3 Kuehl
2/11/20	San Gabriel Valley COG	8/26/20	CD-10 Wesson
3/9/20	South Bay Cities COG	8/28/20	SD-5 Barger
3/10/20	Policy Advisory Council	8/28/20	Board Member Garcia
5/20/20	Key Stakeholder Workshop	8/31/20	City of Bell
5/21/20	BizFed	8/31/20	City of Beverly Hills
8/18/20	CD-13 O'Farrell	09/01/20	Board Member Najarian
8/18/20	SD-4 Hahn	09/02/20	LACDPW
8/18/20	SD-2 Mark Ridley-Thomas	09/03/20	City of West Hollywood
8/19/20	San Gabriel Valley COG	09/03/20	City of Long Beach/Long Beach Transit
8/19/20	CD-14 Staff (vacant)	09/9/20	City of Culver City
8/19/20	CD-9 Price	09/10/10	City of Lynwood
8/19/20	Westside Cities COG	09/11/20	FASTLink DTLA
8/20/20	CD-15 Buscaino		

Key Stakeholder Input Themes and Comments

Comment Theme	Comment Theme Summary
Proposed Routes Comments and questions that addressed the proposed routes and top 7 BRT corridors.	> **Atlantic:** Several stakeholders were supportive of the Atlantic BRT Corridor moving forward. > **Broadway:** Minimal issues with the Broadway corridor were voiced and interest was expressed in this corridor moving forward at several of the presentations. > **LA Cienega:** Stakeholders feel that while La Cienega is an important corridor, the LAX-Crenshaw Line will address concerns in that corridor. Others indicated a connection to the new LRT would also be beneficial and were supportive of the La Cienega Corridor. > **Sunset:** Concerns were expressed over the topography of the Sunset Corridor as it has steep inclines within the corridor. The corridor received support from several groups. > **Venice:** It was noted that residents in Palms Neighborhood Council want protected bike lanes on Venice Blvd. Other's also expressed support for the Venice Corridor. > **West Olympic:** Concern was expressed over the politics of selecting this corridor. It was also noted there is existing bus bunching near UCLA within this corridor as well as relevance once the Purple Line extension is completed. Concerns were also expressed by the auto-centric nature of this corridor

	and the unfriendly pedestrian nature of it. Some expressed support for this corridor to alleviate dangerous driving conditions in the corridor. > **Western:** Stakeholders expressed support for this corridor but it was mentioned that this may be too close to the Vermont Corridor. > Several Stakeholders expressed the lack of corridors that were presented that were north-south connections instead of east-west connections. Stakeholders also expressed concerns that the proposed routes were heavily concentrated in downtown Los Angeles and there were limited routes that offered connectivity for San Fernando or San Gabriel Valley residents.
Funding Comments and questions related to the funding of the BRT corridors and ancillary improvements.	> Multiple stakeholders requested cost estimates for what BRT corridors would cost to construct. > Several stakeholders also wanted comparisons to other modes of transit like Light Rail Transit or non-BRT bus transit.
Bike/Pedestrian Accessibility Comments and questions relating to the accessibility of BRT by pedestrians and bicyclists as well as adjacent infrastructure that would tie into a future BRT corridor.	> Interest expressed for standardizing safety features in the corridors including lighting and sidewalks. > Stakeholders expressed that enhanced bicycle and pedestrian safety measures in the corridor would improve the viability of the BRT corridor. > Several jurisdictions expressed interest in or noted there were street-scape improvements planned in the corridors.

Safety/Security Comments and questions relating to the safety on the future BRT lines as well as at the stations. Comments and questions also related to traffic safety and emergency access.	> Several stakeholders expressed concerns about security issues on existing Metro BRT lines. > A clarification was also raised as to whether or not emergency vehicle access would be hindered by the inclusion of a BRT line in these corridors.
Community Development Comments and questions related to community development that would support future BRT corridors.	> A suggestion was made for Metro to provide more information to cities on economic development opportunities that will help make them more supportive of future BRT implementation. > Clarifications were also requested as to how community development and TOC factored into the selection of the corridors.
Traffic/Parking Comments and questions related to the impact or benefits the proposed BRT lines would have in their corridors.	> Stakeholders expressed concerns about on-street parking and the possible removal of parking in the La Cienega or Sunset corridors. > Analysis conducted by a stakeholder shows that repurposing the Atlantic Corridor for BRT transit would help improve traffic flow.
Operations/Connectivity Comments and questions related to the future operation of the BRT lines in the proposed corridors as well as connectivity to other modes of existing or future transit.	> Clarification requested regarding the ability to include bus layover zones and mobility hubs. Interest expressed in the connectivity of La Cienega BRT to the North Crenshaw-LAX Project. Multiple stakeholders expressed interest in bus only lanes as a part of any BRT implementation project. > Also expressed support for transit connections with the NoHo to Pasadena BRT and the Glendale Metrolink Station.

	> Concerns expressed over the frequency of BRT service in existing corridors that don't accommodate early morning or late-night workforce.
Outreach/Perception Comments and questions related to the perception of BRT and anticipated support or issues communities may have with the implementation of specific corridors.	> Expressed concern over potential opposition to Venice. > Mentioned importance of coordinating with Atlantic Corridor Cities to gauge support. > Requested clarification on what outreach will be like to neighborhood councils and organizations if the Broadway Corridor is selected.

4.4. Public Workshop Engagement

Between January 2019 and March 2020, a total of 33 public workshops were hosted throughout Los Angeles County related to the Metro NextGen Bus Plan project. Given the ongoing coordination amongst the two projects and the similar target audience, these workshops served as an ideal opportunity to piggyback and share information about the BRT Vision & Principles Study. Study staff attended all NextGen public workshops and distributed project materials and information. The 2019 workshops served as an initial launch and awareness campaign for the project, while the 2020 public workshops allowed the team to engage with the public to a greater degree and further engage them by way of a project survey, one-on-one discussions and an open comment and question & answer forum. Comment cards were also available for those interested in providing a more detailed narrative or written input on the project. During the workshops, a total of 136 surveys and 27 comment cards were collected. A list of workshops dates and locations is provided below as well as a summary of the comments collected at the workshops.

2019 NextGen Workshops Date and Meeting Location by Service Council Area	
January 8, 2019	San Fernando Valley
January 9, 2019	Westside/Central
January 12, 2019	Gateway Cities

January 16, 2019	San Gabriel Valley
January 17, 2019	South Bay Cities
January 23, 2019	Gateway Cities
January 24, 2019	San Gabriel Valley
January 26, 2019	Westside-Central
January 31, 2019	Westside-Central
February 6, 2019	San Fernando Valley
February 28, 2019	San Fernando Valley
March 2, 2019	South Bay
March 4, 2019	Westside-Central
March 5, 2019	South Bay
March 7, 2019	South Bay
March 12, 2019	San Fernando Valley
March 13, 2019	Westside-Central
March 19, 2019	San Gabriel Valley
2020 NextGen Workshops Date and Meeting Location by Service Council Area	
February 2, 2020	All Regions-LATTC
February 4, 2020	South Bay Cities
February 5, 2020	San Fernando Valley
February 10, 2020	San Gabriel Valley
February 12, 2020	Westside-Central
February 13, 2020	Gateway Cities
February 19, 2020	Westside-Central
February 20, 2020	San Gabriel Valley
February 22, 2020	All Regions-Metro Headquarters
February 25, 2020	Gateway Cities
February 26, 2020	South Bay Cities
February 27, 2020	San Fernando Valley
March 5, 2020	Gateway Cities
March 7, 2020	South Bay Cities
March 11, 2020	San Gabriel Valley

Summary of Public Input and Comments

Public comment received during the in-person engagement activities was sorted by themes and catalogued for further review into the project comment log. Overall key themes that organically emerged included the following:

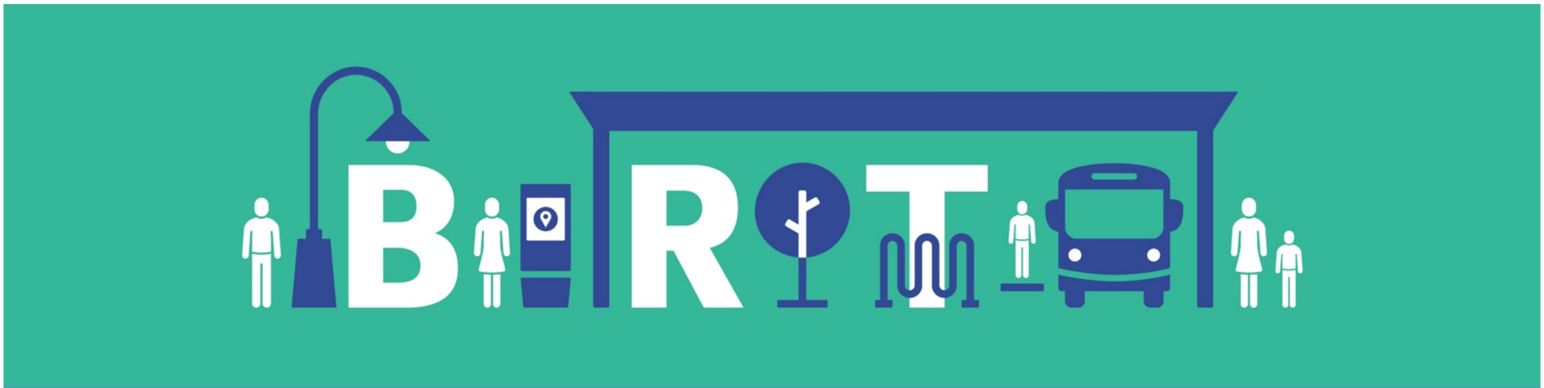
- The overall rider experience while using Metro BRT is lacking. Riders consistently raise concerns over bus cleanliness, bus overcrowding, rude operators and inconsiderate fellow riders. Commenters see the future of BRT as an opportunity to make improvements to these conditions
- Respondents are calling for future BRT lines that stretch across large sections of the county, primarily in the central portion. Regularly referenced corridors included Vermont Ave, Wilshire Blvd, and Santa Monica Blvd. The San Fernando Valley has also been referenced in respect to routes spanning across Sepulveda Blvd and Reseda Blvd. Outside of these specific regions, additional comments called for future BRT routes to link regions of Los Angeles such as San Fernando Valley – West Los Angeles.
- Any future BRT routes in Los Angeles should be more efficient and have better frequency than existing Metro BRT like the Silver Line and Orange Line. Riders regularly reference these lines as the benchmark that future BRT lines in Los Angeles should outperform in efficiency and customer experience.

COVID-19 Transition

Due to the COVID-19 public health crisis, which began in March 2020, eight of the Metro NextGen public workshops were cancelled. As a result, the BRT Vision & Principles Study transitioned the in-person engagement planned for these workshops to a digital outreach program. Geofenced targeted ads were deployed to continue the promotion of the project survey and were tailored to ensure a wide spectrum of reach, both from a geographic and demographic perspective. This included a targeted focus on reaching low-income communities, women, underrepresented ethnicities and stakeholders over the age of 50. A toolkit was prepared for use by the BRT TAC and key stakeholder groups mentioned earlier to share with their respective audiences and networks via social media and other online platforms. The results of this campaign as well as the collective survey effort both in-person and online are detailed in the next section of this report.

4.5. Project Survey

The project survey was live for input in both English and Spanish between February 1 and May 31, 2020. Surveys were available in a digital and hard copy format at all public meetings. Attendees were able to complete the survey on the spot using provided digital devices or paper copies of the survey. If requested, they were also able to take the survey online at a later time. Following the outreach of the COVID-19 pandemic, the survey was distributed online and through community-based organization and key stakeholder networks, as outlined above. Survey topics included information on the level of familiarity with current Metro BRT service, public transit use and habits, preferences and ranking of BRT features and amenities as well as a series of demographic questions. A total of 513 English and 13 Spanish surveys were submitted at the conclusion of the survey period. Below are highlights of the results from the survey engagement. A detailed report of the survey results is included in the appendix.



Bus Rapid Transit Vision & Principles Study

GENERAL OVERVIEW

Over **88%** of respondants are already **familiar with BRT service**, and more than **56%** currently use Metro's BRT Service

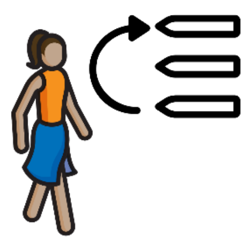
More than **58%** of those surveyed use public transit **3 or more days a week**, with over **80%** using Metro Bus and Rail services for that travel.

More than **97%** of respondents would **support more BRT corridors** as part of the solution to mobility needs in LA County

Segment 1 included a specific reach for **low-income**, **age group 50+**, **Asian and African American populations**; Segment 2 included an additional target of **women** across the county

TOP 5 PRIORITIES FOR BRT FEATURES & AMENITIES

- Frequency
- Dedicated bus lanes
- Reliability
- Real-time information
- Faster travel times (origin to destination)



5. Project Outcomes & Next Steps

The BRT Vision & Principles study furthers Metro's first Vision 2028 Strategic Plan goal to "provide high quality mobility options that enable people to spend less time traveling." Upon Board approval, staff will proceed with the application of BRT design guideline manual to Metro's future BRT mobility corridor studies and work to incorporate the design guidelines into select administrative and technical documents where necessary to ensure adherence to the adopted guidance. The study identified a top five BRT corridors recommended for future project implementation. Metro staff will present this top five list to the Metro Board for consideration, recommending that one of these corridors be taken into project development in the near-term. With Board concurrence on a specific corridor, staff will return to the Board at a later date with recommended programming actions and next steps. This will necessarily involve more detailed corridor level analysis, conceptual design work and public engagement with corridor communities and stakeholders.

APPENDIX

Appendix A

Outreach Materials:

Fact Sheet

Comment Card

BUS RAPID TRANSIT VISION & PRINCIPLES STUDY

PROJECT

The Bus Rapid Transit (BRT) Vision & Principles Study is a comprehensive study that will establish the standard of a future Metro BRT network and serve as a pillar for Metro's goal of creating a world-class transportation system.

PURPOSE

This study will develop the overall vision, goals and objectives for BRT in LA County. Specifically, the project will define local BRT operational standards and design guidelines that will guide future development of BRT routes and services, identify & prioritize ideal candidate corridors for BRT implementation and create a network of future potential BRT corridors throughout the county.

WHAT

BRT is a high-quality, high capacity bus-based transit system that delivers fast, comfortable and cost-effective service. Distinct rail-like stations, off-board fare collection, traffic signal priority and dedicated running lanes may all be part of future BRT lines serving Los Angeles County. Local examples of BRT type projects here in Los Angeles County include the Orange Line, serving the San Fernando Valley and the Silver Line serving EL Monte, Downtown LA and San Pedro.

NETWORK

This study will help improve LA County's public transit network. BRT fulfills a distinct role as a mode of transportation that enhances and integrates with existing LA County mobility services and future mobility hubs, as part of the world-class transportation system envisioned for all LA Metro customers.

PROCESS

Key data is one factor in driving the process. We will look at activity centers, population density, employment density, underinvested communities, as well as current, planned and previously studied projects to identify areas in the transportation network that would benefit from BRT service. Input received from the Technical Advisory Committee, key stakeholders and the public will also inform the study.

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WHEN

This is just the first step. This study began in early 2019 and will continue through summer 2020. Ultimately, the final report will identify and recommend a set of design guidelines and criteria that will define future BRT projects, along with a list of ideal BRT corridors for consideration by the LA Metro Board.

COMPLEMENT

Metro currently has three projects in the early stages of development that are considering BRT as a transit option; Vermont, North Hollywood to Pasadena and North San Fernando Valley Transit Corridors. The BRT system design guidelines developed through the Vision & Principles Study will directly inform and outline service features for all BRT projects moving forward and will tie into other transit improvement studies that are also currently underway.

COORDINATE

The project team are coordinating with Metro's NextGen Bus Plan to share data and better understand the analysis that was completed and outcomes of that study. We are using this information to help inform the BRT Vision & Principles Study.

LEARN MORE

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ESTUDIO DE VISION Y PRINCIPIOS DEL TRANSPORTE RÁPIDO DE AUTOBÚS

PROYECTO

El estudio de visión y principios del transporte rápido de autobús (BRT) es un estudio integral que establecerá las normas para una futura red de BRT de Metro y servirá como pilar para el objetivo de Metro de crear un sistema de transporte de clase mundial.

OBJETIVO

En este estudio, se desarrollará la visión general, los propósitos y los objetivos del BRT en el condado de Los Angeles. Específicamente, el proyecto definirá las normas operativas y las directrices de diseño locales para el BRT que guiarán el desarrollo futuro de las rutas y los servicios del BRT, identificarán y priorizarán los corredores viables ideales para la implementación del BRT y crearán una red de futuros corredores posibles para el BRT en todo el condado.

QUÉ ES

El BRT es un sistema de tránsito de alta calidad y capacidad basado en autobuses que ofrece un servicio de rápido, cómodo y económico. Es posible que estaciones con características similares a las del ferrocarril, el cobro del pasaje antes de subir al autobús, la prioridad de las señales de tráfico y los carriles de circulación exclusivos formen parte de las futuras líneas del BRT que funcionarán en el condado de Los Angeles. Algunos ejemplos locales de proyectos similares al BRT en el condado de Los Angeles incluyen Metro Orange Line, con servicio en el San Fernando Valley, y Metro Silver Line, con servicio en El Monte, el centro de Los Angeles y San Pedro.

RED

Este estudio ayudará a mejorar la red de transporte público del condado de Los Angeles. El BRT cumple una función distintiva como modo de transporte que mejora e integrar con los servicios de movilidad existentes en el condado de Los Angeles y los centros de movilidad futuros, como parte del sistema de transporte de clase mundial imaginar para todos los clientes de Metro.

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PROCESO

Los datos clave son uno de los factores para avanzar adelante el proceso. Analizaremos los centros de actividad, la densidad de población, la densidad de empleo, las comunidades en las que no se ha invertido lo suficiente, y también los proyectos actuales, planificados y estudiados previamente para identificar áreas en la red de transporte que se beneficiarían del servicio del BRT. Los comentarios recibidos del Comité Asesor Técnico, las principales partes interesadas y el público serán parte del estudio.

CUÁNDO

Este es el primer paso. Este estudio comenzó a principios de 2019 y continuará hasta el verano de 2020. En última instancia, el informe final identificará y recomendará un conjunto de directrices y criterios de diseño que definirán los proyectos futuros del BRT, junto con una lista de los corredores ideales del BRT para que la Junta Directiva de Metro los analice.

COMPLEMENTO

Metro en este momento tiene tres proyectos en las primeras fases de desarrollo que están considerando autobuses de tránsito rápido como opción; Vermont, North Hollywood a Pasadena y North San Fernando Valley Transit Corridors. Las directrices de diseño del sistema del BRT desarrolladas a través del estudio de visión y principios describirán las características del servicio y aportarán información sobre ellas de manera directa para todos los proyectos del BRT de aquí en adelante, y se vincularán a otros estudios de mejora del tránsito que también estén en curso en la actualidad.

COORDINACIÓN

El equipo del proyecto está coordinando con el Plan de Autobuses NextGen de Metro para compartir datos y comprender mejor el análisis que se completó y los resultados de ese estudio. Estamos utilizando esta información para contribuir al estudio de visión y principios del transporte rápido de autobús.

OBTENGA MÁS INFORMACIÓN

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@metrolosangeles

losangelesmetro

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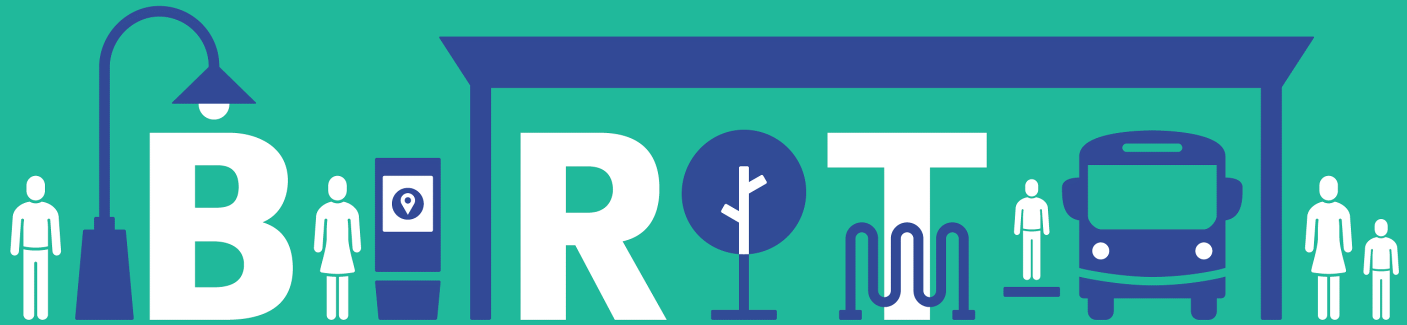

BUS RAPID TRANSIT VISION & PRINCIPLES STUDY

COMMENT CARD (OPTIONAL INFORMATION)

NAME:	DATE:	ZIP:

AGE: ☐ Under 18 ☐ 18-24 ☐ 25-34 ☐ 35-49 ☐ 50-64 ☐ 65 or older

GENDER: ☐ Male ☐ Female ☐ Non-binary

AFFILIATION:	EMAIL:

ADDITIONAL COMMENTS:

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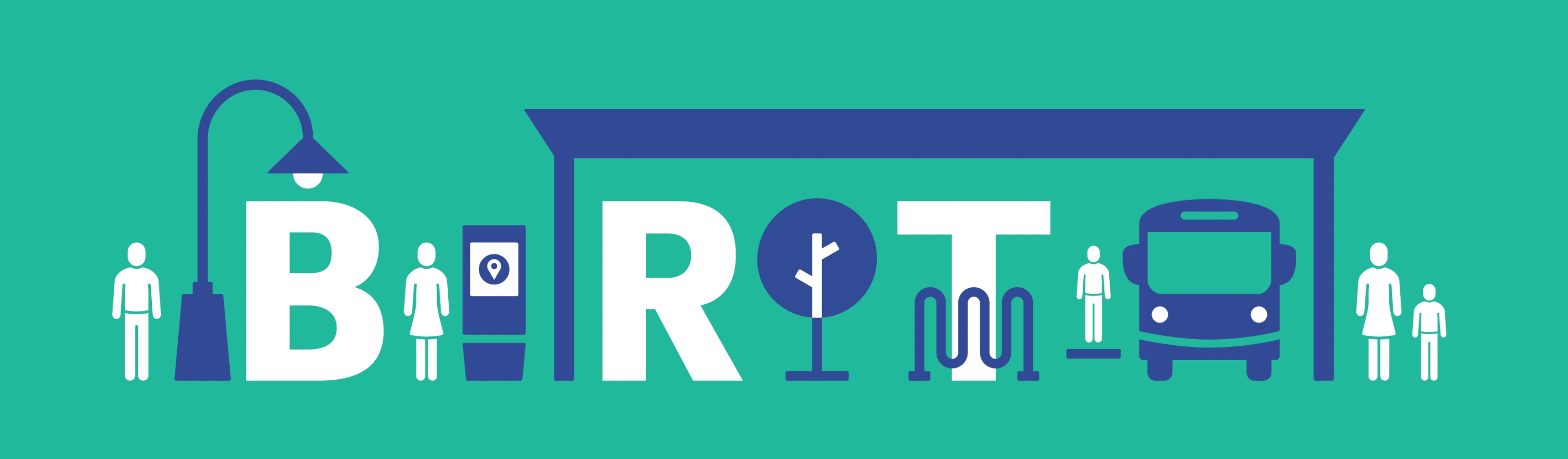

EL ESTUDIO DE VISIÓN Y PRINCIPIOS SOBRE EL AUTOBÚS DE TRÁNSITO RÁPIDO

TARJETA DE COMENTARIOS (INFORMACIÓN OPCIONAL)

NOMBRE:	FECHA:	CÓDIGO POSTAL:

EDAD: ☐ Menor de 18 años ☐ 18-24 ☐ 25-34 ☐ 35-49 ☐ 50-64 ☐ 65 años o mayor

GÉNERO: ☐ Masculino ☐ Femenino ☐ No binario

AFILIACIÓN:	CORREO ELECTRÓNICO:

COMENTARIOS ADICIONALES:

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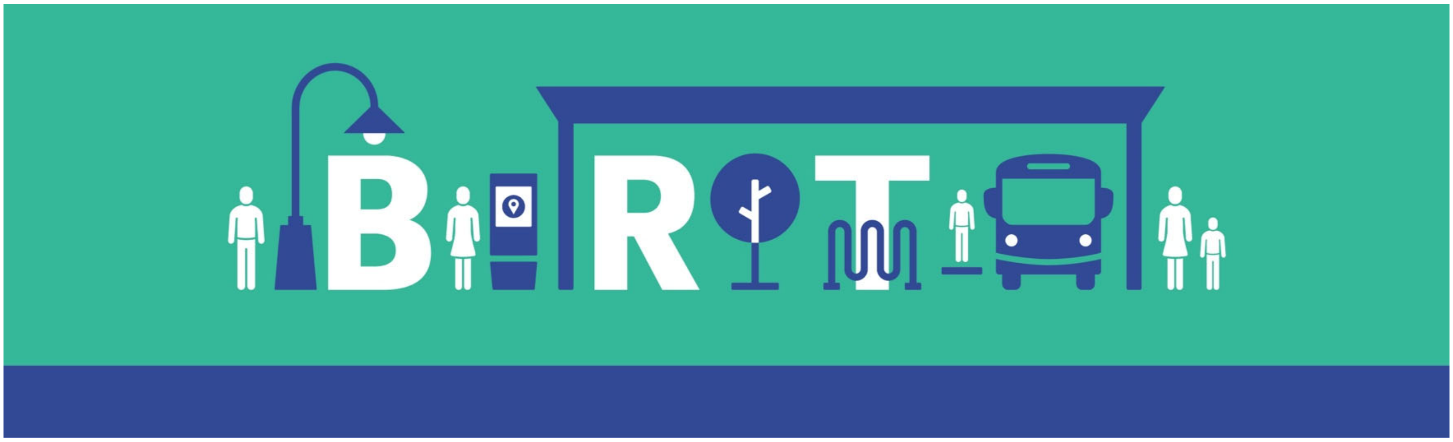


Appendix B

Project Survey:

Online Survey
Paper Survey
Survey Report

Metro Bus Rapid Transit Vision & Principles Study

GENERAL USE QUESTIONS:

Page exit logic: Skip / Disqualify Logic
IF: #1 Question "**Are you familiar with Bus Rapid Transit (BRT)?**

" is exactly equal to ("No, BRT is a new concept to me") **THEN:** Jump to page 4 - (untitled)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*
ID 2
1. **Are you familiar with Bus Rapid Transit (BRT)?**

- ☐ No, BRT is a new concept to me
- ☐ I've heard of BRT, but I don't know much about it
- ☐ Yes, I am familiar with BRT

(untitled)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*
LOGIC Show/hide trigger exists.
ID 3
2. **Do you currently use any Metro BRT services?**

- ☐ Yes
- ☐ No

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 2 *(if answered)*
LOGIC Hidden unless: #2 Question "**Do you currently use any Metro BRT services?**
" is one of the following answers ("Yes")
ID 26
3. **What Metro BRT services do you currently use?** *Select all that apply.*

- ☐ Orange Line
- ☐ Silver Line

(untitled)

VALIDATION Max. answers = 6 *(if answered)*
ID 4
4. **Do you use any additional public transit or mobility services?** *If so, please select all that apply.*

- ☐ Metro Bus
- ☐ Metro Rail
- ☐ Metro Bikeshare
- ☐ Other public transit providers (Metrolink, DASH, other local bus services, etc.)
- ☐ Ride hailing services (Uber, Lyft, etc.)
- ☐ Electric scooters (Lime, Byrd, etc.)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*
ID 5
5. **How many days a week do you usually use public transit services?**

- ☐ <1 day
- ☐ 1-2 days
- ☐ 3-4 days
- ☐ 5 or more days

BRT FEATURES AND AMENITIES:

Page description:
What features of BRT service would be important to you? *Select your top three choices in each category.*

Min. answers = 3 *(if answered)* Max. answers = 3 *(if answered)*
6
6. **Operating Characteristics** *(*Required)*
*

- ☐ BRT vehicles arrive every 5-10 minutes or more frequently
- ☐ BRT vehicles are reliably on time
- ☐ BRT stops spaced approximately every mile so that buses spend less time stopping and starting
- ☐ Traffic Signal Priority: BRT vehicles get an extended green light at intersections thus reducing stop time at red lights
- ☐ Dedicated bus lanes or physically separated busways in which buses can operate free from congestion: Median running lane or Curbside bus lane or Off-set bus lane
- ☐ Enforcement of dedicated bus lanes to ensure other vehicles do not block BRT vehicles

Min. answers = 3 *(if answered)* Max. answers = 3 *(if answered)*
7
7. **Enhanced Station Amenities** *(*Required)*
*

- ☐ Attractive shelters with seating
- ☐ Ample lighting
- ☐ Emergency phones and security cameras
- ☐ Real-time bus arrival information
- ☐ Off-board fare payment option
- ☐ Adequate shelter canopies to provide shade and shelter from rain
- ☐ Trees and landscaping

Min. answers = 3 *(if answered)* Max. answers = 3 *(if answered)*
8
8. **Traveling to the Station** *(*Required)*
*

- ☐ Add signalized crossings/crosswalks
- ☐ Repair sidewalks connecting to BRT stations and replace missing sidewalk segments
- ☐ Enhance facilities for people with disabilities and/or people travelling with strollers
- ☐ Secure bike parking at BRT stations
- ☐ Improved bike facilities connecting to and/or parallel to BRT corridors
- ☐ Connections to bike-share stations or other mobility devices such as scooters

Min. answers = 3 *(if answered)* Max. answers = 3 *(if answered)*
9
9. **Enhanced BRT Vehicle Features** *(*Required)*
*

- ☐ More room for people on BRT Vehicles
- ☐ WiFi on board
- ☐ Level boarding
- ☐ All door boarding

Min. answers = 3 *(if answered)* Max. answers = 3 *(if answered)*
10
10. **Regional Benefits** *(*Required)*
*

- ☐ Faster travel times from origin to destination
- ☐ More reliable and frequent service to major employers and destinations outside of central Los Angeles
- ☐ Zero emission buses that reduce greenhouse gas emissions
- ☐ Provide an attractive alternative to car travel
- ☐ Reduce traffic congestion and contribute to cleaner air
- ☐ Provide seamless connectivity to Metro’s entire mobility network

Now rank your top three features and amenities. Click NEXT

13

Action: Page Timer
Page Timer to Auto Submit

Top three features and amenities:

Page exit logic: Skip / Disqualify Logic
IF: #13 Question "**How do you feel about BRT as a part of the solution to mobility needs in Los Angeles County?** *(*Required)*


" is exactly equal to ("I support more BRT corridors","I do not support more BRT corridors") **THEN:** Jump to page 8 - DEMOGRAPHIC QUESTIONS (Optional):

Min. answers = 3 *(if answered)* Max. answers = 3 *(if answered)*
14
Piped Values From Question 11. (Secret Question to put all of the previously selected choices in one place.)
12. **Based on your previous responses, please select your top 3 features and amenities.** *(*Required)* *

Min. answers = 1 *(if answered)* Max. answers = 1 *(if answered)*
17
13. **How do you feel about BRT as a part of the solution to mobility needs in Los Angeles County?** *(*Required)* *

- ☐ I support more BRT corridors
- ☐ I do not support more BRT corridors
- ☐ I support more BRT corridors but have some concerns. Please describe:

DEMOGRAPHIC QUESTIONS (Optional):

Page description:
The following information will be kept confidential and used only to ensure that we hear from residents of the diverse county we serve.

Min. answers = 1 *(if answered)* Max. answers = 1 *(if answered)*
19
14. **What is your ethnicity?** *Select one.*

- ☐ Native American
- ☐ Hispanic/Latino
- ☐ African American
- ☐ White/Caucasian
- ☐ Asian/Pacific Islander
- ☐ Two or more races
- ☐ Other - Write In

Min. answers = 1 *(if answered)* Max. answers = 1 *(if answered)*
20
15. **What is your annual household income?** *Select one.*

- ☐ Under $5,000
- ☐ $5,000-$9,999
- ☐ $10,000-$14,999
- ☐ $15,000-$19,999
- ☐ $20,000-$24,999
- ☐ $25,000-$34,999
- ☐ $35,000-$49,999
- ☐ $50,000- $99,999
- ☐ $100,00 or more

Min. answers = 1 *(if answered)* Max. answers = 1 *(if answered)*
21
16. **What is your age?**

- ☐ <18
- ☐ 18-24
- ☐ 25-34
- ☐ 35-49
- ☐ 50-64
- ☐ 65 or more

Min. answers = 1 *(if answered)* Max. answers = 1 *(if answered)*
22
17. **What is your gender identity?**

- ☐ Male
- ☐ Female
- ☐ Non-binary

23

18. **What is your 5-digit zip code?** *(*Required)*

Enter a number (Minimum 90000, Maximum 99999). *

24

19. **Please provide an email address if you would like updates regarding Metro's BRT Vision & Principles Study:**

Thank You!

1

Estudio de Visión y Principios sobre el Autobús de Tránsito Rápido de Metro

PREGUNTAS DE USO GENERAL:

Page exit logic: Skip / Disqualify Logic
IF: #1 Question "**¿Está familiarizado con el autobús de tránsito rápido (BRT)?**

" is exactly equal to ("No, el BRT es un concepto nuevo para mí") **THEN:** Jump to page 4 - (untitled)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 2

1. **¿Está familiarizado con el autobús de tránsito rápido (BRT)?**

- ☐ No, el BRT es un concepto nuevo para mí
- ☐ He oído hablar del BRT, pero no sé mucho al respecto
- ☐ Sí, estoy familiarizado con el BRT

(untitled)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

LOGIC Show/hide trigger exists.

ID 3

2. **¿Usa actualmente el servicio del BRT de Metro?** *Seleccione todas las opciones que correspondan.*

- ☐ Sí
- ☐ No

LOGIC Hidden unless: #2 Question "**¿Usa actualmente el servicio del BRT de Metro?** *Seleccione todas las opciones que correspondan.*
" is exactly equal to ("Sí")

ID 4

3. **¿Qué servicios de Metro BRT utiliza actualmente?** *Seleccione todas las que correspondan.*

- ☐ "Orange Line" Linea Naranja
- ☐ "Silver Line" Linea Plateada

(untitled)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 6 *(if answered)*

ID 5

4. **¿Usa algún servicio adicional de transito o movilidad?** *Si es así, seleccione todas las opciones que correspondan.*

- ☐ Metro Bus (Autobús de Metro)
- ☐ Metro Rail (Tren de Metro)
- ☐ Metro Bikeshare (Sistema de bicicletas compartidas de Metro)
- ☐ Otros proveedores de transporte público (Metrolink, DASH, otros servicios locales de autobuses, etc.)
- ☐ Servicios de transporte de pasajeros (Uber, Lyft, etc.)
- ☐ Escuteres eléctricos (Lime, Byrd, etc.)

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 6

5. **¿Cuántos días a la semana usa los servicios de transporte público?**

- ☐ Menos de 1 día
- ☐ Entre 1 y 2 días
- ☐ Entre 3 y 4 días
- ☐ 5 días o más

CARACTERÍSTICAS Y COMODIDADES DEL BRT:

Page description:
¿Qué características del servicio del BRT serían importantes para usted? *Seleccione sus tres opciones principales en cada categoría.*

VALIDATION **Min. answers = 3** *(if answered)* Max. answers = 3 *(if answered)*

ID 7

6. **Características operativas** *(*Necesitamos esta información)*

*

- ☐ Vehículos del BRT que lleguen cada 5 a 10 minutos o con más frecuencia
- ☐ Vehículos del BRT confiables en cuanto a la puntualidad
- ☐ Paradas del BRT con una distancia de aproximadamente una milla de manera que los autobuses pasen menos tiempo parando
- ☐ Prioridad de las señales de tráfico: que los vehículos del BRT tengan una luz verde más larga en las intersecciones para reducir el tiempo que el vehículo pasa detenido en la luz roja
- ☐ Carriles exclusivos de autobús o vías de autobús separadas físicamente en los que los autobuses pueden circular sin congestión: carril de circulación central o carril de autobús adyacente a la acera o área de descanso
- ☐ Creación de carriles de autobús exclusivos para garantizar que otros vehículos no bloqueen los vehículos del BRT

VALIDATION **Min. answers = 3** *(if answered)* Max. answers = 3 *(if answered)*

ID 9

7. **Comodidades mejoradas de la estación** *(*Necesitamos esta información)*

*

- ☐ Paradas atrayentes con asientos
- ☐ Amplia iluminación
- ☐ Teléfonos de emergencia y cámaras de seguridad
- ☐ Información de la llegada de los autobuses en tiempo real
- ☐ Opción de pago de billetes antes de subir al autobús
- ☐ Marquesinas adecuadas para dar sombra y refugio contra la lluvia
- ☐ Árboles y paisajismo

VALIDATION **Min. answers = 3** *(if answered)* Max. answers = 3 *(if answered)*

ID 10

8. **Viaje a la estación** *(*Necesitamos esta información)*

*

- ☐ Añadir cruces/cruces peatonales señalizados
- ☐ Reparar las aceras que conectan con las estaciones del BRT y reemplazar los tramos faltantes de las aceras
- ☐ Mejorar las comodidades para las personas con discapacidades y/o las personas que viajan con carriolas
- ☐ Estacionamiento de bicicletas seguro en las estaciones del BRT
- ☐ Mejores instalaciones para bicicletas que conectan y/o que están en paralelo con corredores del BRT
- ☐ Conexiones a estaciones de bicicletas compartidas u otros dispositivos de movilidad como escúteres

VALIDATION **Min. answers = 3** *(if answered)* Max. answers = 3 *(if answered)*

ID 11

9. **Características mejoradas de los vehículos del BRT** *(*Necesitamos esta información)*

*

- ☐ Más espacio para las personas en los vehículos del BRT
- ☐ WiFi a bordo
- ☐ Abordaje a nivel
- ☐ Abordaje en todas las puertas

VALIDATION **Min. answers = 3** *(if answered)* Max. answers = 3 *(if answered)*

ID 25

10. **Beneficios regionales** *(*Necesitamos esta información)*

*

- ☐ Tiempos de viaje más rápidos de origen a destino
- ☐ Servicio más frecuente y confiable para los principales empleadores y destinos fuera del centro de Los Ángeles
- ☐ Autobuses de cero emisiones que reducen las emisiones de gases de efecto invernadero
- ☐ Alternativa atractiva al viaje en automóvil
- ☐ Reducción de la congestión del tránsito y contribución a la limpieza del aire
- ☐ Conectividad fluida a toda la red de movilidad de Metro

Ahora clasifique sus tres características y servicios principales. Continua a la siguiente página.

ID 13

Action: Page Timer

Page Timer to Auto Submit

Las tres características y comodidades principales:

Page exit logic: Skip / Disqualify Logic
IF: #13 Question "**¿Qué opina del BRT como parte de la solución a las necesidades de movilidad en el condado de Los Ángeles?** *(*Necesitamos esta información)*

" is exactly equal to ("Estoy a favor de más corredores del BRT","No estoy a favor de más corredores del BRT") **THEN:** Jump to page 8 - PREGUNTAS SOBRE DATOS DEMOGRÁFICOS (Opcional):

VALIDATION **Min. answers = 3** *(if answered)* Max. answers = 3 *(if answered)*

ID 14

PIPING Piped Values From Question 11. (Secret Question to pull all of the previously selected choices in one place.)

12. **Según sus respuestas anteriores, seleccione sus 3 características y servicios principales.** *(*Necesitamos esta información)* *

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 15

13. **¿Qué opina del BRT como parte de la solución a las necesidades de movilidad en el condado de Los Ángeles?** *(*Necesitamos esta información)*

*

- ☐ Estoy a favor de más corredores del BRT
- ☐ No estoy a favor de más corredores del BRT
- ☐ Estoy a favor de más corredores del BRT, pero tengo algunas preocupaciones. Descríbalas:

PREGUNTAS SOBRE DATOS DEMOGRÁFICOS (Opcional):

Page description:
La siguiente información permanecerá confidencial y se usará únicamente para garantizar que recibimos información de los residentes del condado diverso en el que prestamos servicios.

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 16

14. **¿Cuál es su origen étnico?** *Seleccione una opción.*

- ☐ Nativo estadounidense
- ☐ Hispano/latino
- ☐ Afroamericano
- ☐ Blanco/caucásico
- ☐ Asiático/isleño del Pacífico
- ☐ Dos o más razas
- ☐ Otro:

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 17

15. **¿Cuáles son los ingresos anuales de su casa?** *Seleccione una opción.*

- ☐ Menos de $5,000
- ☐ De $5,000 a $9,999
- ☐ De $10,000 a $14,999
- ☐ De $15,000 a $19,999
- ☐ De $20,000 a $24,999
- ☐ De $25,000 a $34,999
- ☐ De $35,000 a $49,999
- ☐ De $50,000 a $99,999
- ☐ $100,00 o más

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 18

16. **¿Qué es su edad?**

- ☐ Menos de 18
- ☐ 18-24
- ☐ 25-34
- ☐ 35-49
- ☐ 50-64
- ☐ 65 o más

VALIDATION **Min. answers = 1** *(if answered)* Max. answers = 1 *(if answered)*

ID 19

17. **¿Cuál es su identidad de género?**

- ☐ Masculino
- ☐ Femenino
- ☐ No binario

ID 20

18. **¿Cuál es el código postal de 5 dígitos de su casa?** *(*Necesitamos esta información)*

Ingrese un número (Mínimo 90000, máximo 99999).

*

ID 21

19. **Por favor, proporcione una dirección de correo electrónico si desea recibir actualizaciones relacionadas con el estudio de visión y principios sobre el BRT de Metro:**

¡Gracias!

ID 1

Metro Bus Rapid Transit Vision & Principles Study

The Los Angeles County Metropolitan Transportation Authority (Metro) is conducting the Bus Rapid Transit (BRT) Vision & Principles Study. The goal of the study is to develop standards and design criteria that will guide future development of BRT routes and services in Los Angeles County. Simply defined, BRT is a high-quality, high-capacity bus-based transit system that delivers fast, comfortable and cost-effective transit service. Metro's BRT network will fulfill a distinct role within the existing LA County transportation network and serve as a pillar towards Metro's goal of creating a world class transportation system. We want to understand what design elements are most important to you. To date, the project team has examined key information and conducted analysis in order to rank and evaluate corridor feasibility and define BRT standards. The team continues to gather additional input from the public and key stakeholders in order to further inform the study. The final recommendations of the study are targeted to be presented to the Metro Board for consideration in summer 2020. Please take 5-10 minutes to complete the survey and provide your input.

GENERAL USE QUESTIONS:

1) Are you familiar with Bus Rapid Transit (BRT)?

[ ] No, BRT is a new concept to me

[ ] I've heard of BRT, but I don't know much about it

[ ] Yes, I am familiar with BRT

2) Do you currently use any Metro BRT services?

[ ] Yes

[ ] No

3) What Metro BRT services do you currently use? *Select all that apply.*

[ ] Orange Line

[ ] Silver Line

4) Do you use any additional public transit or mobility services? *If so, please select all that apply.*

[ ] Metro Bus

[ ] Metro Rail

[ ] Metro Bikeshare

[ ] Other public transit providers (Metrolink, DASH, other local bus services, etc.)

[ ] Ride hailing services (Uber, Lyft, etc.)

[ ] Electric scooters (Lime, Byrd, etc.)

5) How many days a week do you usually use public transit services?

[ ] <1 day><1 day

[ ] 1-2 days

[ ] 3-4 days

[ ] 5 or more days

BRT FEATURES AND AMENITIES:

What features of BRT service would be important to you? *Select your top three choices in each category.*

6) Operating Characteristics *(*Required)*

[ ] BRT vehicles arrive every 5-10 minutes or more frequently

[ ] BRT vehicles are reliably on time

[ ] BRT stops spaced approximately every mile so that buses spend less time stopping and starting

[ ] Traffic Signal Priority: BRT vehicles get an extended green light at intersections thus reducing stop time at red lights

[ ] Dedicated bus lanes or physically separated busways in which buses can operate free from congestion: Median running lane or Curbside bus lane or Off-set bus lane

[ ] Enforcement of dedicated bus lanes to ensure other vehicles do not block BRT vehicles

7) Enhanced Station Amenities *(*Required)*

[ ] Attractive shelters with seating

[ ] Ample lighting

[ ] Emergency phones and security cameras

[ ] Real-time bus arrival information

[ ] Off-board fare payment option

[ ] Adequate shelter canopies to provide shade and shelter from rain

[ ] Trees and landscaping

8) Traveling to the Station *(*Required)*

[ ] Add signalized crossings/crosswalks

[ ] Repair sidewalks connecting to BRT stations and replace missing sidewalk segments

[ ] Enhance facilities for people with disabilities and/or people travelling with strollers

[ ] Secure bike parking at BRT stations

[ ] Improved bike facilities connecting to and/or parallel to BRT corridors

[ ] Connections to bike-share stations or other mobility devices such as scooters

9) Enhanced BRT Vehicle Features *(*Required)*

[ ] More room for people on BRT Vehicles

[ ] WiFi on board

[ ] Level boarding

[ ] All door boarding

10) Regional Benefits *(*Required)*

[ ] Faster travel times from origin to destination

[ ] More reliable and frequent service to major employers and destinations outside of central Los Angeles

[ ] Zero emission buses that reduce greenhouse gas emissions

[ ] Provide an attractive alternative to car travel

[ ] Reduce traffic congestion and contribute to cleaner air

[ ] Provide seamless connectivity to Metro's entire mobility network

---

13) How do you feel about BRT as a part of the solution to mobility needs in Los Angeles County? *(*Required)*

[ ] I support more BRT corridors

[ ] I do not support more BRT corridors

[ ] I support more BRT corridors but have some concerns. Please describe:

____

DEMOGRAPHIC QUESTIONS (Optional):

The following information will be kept confidential and used only to ensure that we hear from residents of the diverse county we serve.

14) What is your ethnicity? *Select one.*

[ ] Native American

[ ] Hispanic/Latino

[ ] African American

[ ] White/Caucasian

[ ] Asian/Pacific Islander

[ ] Two or more races

[ ] Other - Write In: ____

15) What is your annual household income? *Select one.*

[ ] Under $5,000

[ ] $5,000-$9,999

[ ] $10,000-$14,999

[ ] $15,000-$19,999

[ ] $20,000-$24,999

[ ] $25,000-$34,999

[ ] $35,000-$49,999

[ ] $50,000- $99,999

[ ] $100,00 or more

16) What is your age?

[ ] <18

[ ] 18-24

[ ] 25-34

[ ] 35-49

[ ] 50-64

[ ] 65 or more

17) What is your gender identity?

[ ] Male

[ ] Female

[ ] Non-binary

18) What is your 5-digit zip code? ***(*Required)***
Enter a number (Minimum 90000, Maximum 99999).*

____

19) Please provide an email address if you would like updates regarding Metro's BRT Vision & Principles Study:

____

Thank You!

Estudio de Visión y Principios sobre el Autobús de Tránsito Rápido de Metro

La Autoridad de Transporte Metropolitano del Condado de Los Ángeles (Metro) está realizando el Estudio de Visión y Principios sobre el Autobús de Tránsito Rápido (BRT por sus siglas en inglés). El objetivo del estudio es definir normas y criterios de diseño que guiarán el futuro desarrollo de rutas y servicios del BRT en el condado de Los Ángeles. En términos sencillos, el BRT es un sistema de tránsito de alta calidad y capacidad basado en autobuses que ofrecen un servicio de tránsito rápido, cómodo y económico. El BRT de Metro cumplirá una función distinta dentro de la red de transporte existente del condado de Los Ángeles y será un apoyo hacia el objetivo de Metro de crear un sistema de transporte de primera categoría. Queremos entender qué elementos de diseño son más importantes para usted. Hasta la fecha, el equipo del proyecto ha examinado la información clave y realizado análisis para clasificar y evaluar la viabilidad del corredor y definir los estándares BRT. El equipo continúa recabando comentarios adicionales del público y las partes interesadas clave para informar aún más el estudio. Las recomendaciones finales del estudio están dirigidas a la Junta del Metro para su consideración en el verano de 2020. Tómese entre 5 y 10 minutos para completar la encuesta y proporcionar su opinión.

PREGUNTAS DE USO GENERAL:

1) ¿Está familiarizado con el autobús de tránsito rápido (BRT)?

[ ] No, el BRT es un concepto nuevo para mí

[ ] He oído hablar del BRT, pero no sé mucho al respecto

[ ] Sí, estoy familiarizado con el BRT

2) ¿Usa actualmente el servicio del BRT de Metro? *Seleccione todas las opciones que correspondan.*

[ ] Sí

[ ] No

3) ¿Qué servicios de Metro BRT utiliza actualmente? ***Seleccione todas las que correspondan.***

[ ] "Orange Line" Linea Naranja

[ ] "Silver Line" Linea Plateada

4) ¿Usa algún servicio adicional de transito o movilidad? ***Si es así, seleccione todas las opciones que correspondan.***

[ ] Metro Bus (Autobús de Metro)

[ ] Metro Rail (Tren de Metro)

[ ] Metro Bikeshare (Sistema de bicicletas compartidas de Metro)

[ ] Otros proveedores de transporte público (Metrolink, DASH, otros servicios locales de autobuses, etc.)

[ ] Servicios de transporte de pasajeros (Uber, Lyft, etc.)

[ ] Escuteres eléctricos (Lime, Byrd, etc.)

5) ¿Cuántos días a la semana usa los servicios de transporte público?

[ ] Menos de 1 día

[ ] Entre 1 y 2 días

[ ] Entre 3 y 4 días

[ ] 5 días o más

CARACTERÍSTICAS Y COMODIDADES DEL BRT:

¿Qué características del servicio del BRT serían importantes para usted? *Seleccione sus tres opciones principales en cada categoría.*

6) Características operativas ***(*Necesitamos esta información)***

[ ] Vehículos del BRT que lleguen cada 5 a 10 minutos o con más frecuencia

[ ] Vehículos del BRT confiables en cuanto a la puntualidad

[ ] Paradas del BRT con una distancia de aproximadamente una milla de manera que los autobuses pasen menos tiempo parando

[ ] Prioridad de las señales de tráfico: que los vehículos del BRT tengan una luz verde más larga en las intersecciones para reducir el tiempo que el vehículo pasa detenido en la luz roja

[ ] Carriles exclusivos de autobús o vías de autobús separadas físicamente en los que los autobuses pueden circular sin congestión: carril de circulación central o carril de autobús adyacente a la acera o área de descanso

[ ] Creación de carriles de autobús exclusivos para garantizar que otros vehículos no bloqueen los vehículos del BRT

7) Comodidades mejoradas de la estación *(*Necesitamos esta información)*

[ ] Paradas atrayentes con asientos

[ ] Amplia iluminación

[ ] Teléfonos de emergencia y cámaras de seguridad

[ ] Información de la llegada de los autobuses en tiempo real

[ ] Opción de pago de billetes antes de subir al autobús

[ ] Marquesinas adecuadas para dar sombra y refugio contra la lluvia

[ ] Árboles y paisajismo

8) Viaje a la estación *(*Necesitamos esta información)*

[ ] Añadir cruces/cruces peatonales señalizados

[ ] Reparar las aceras que conectan con las estaciones del BRT y reemplazar los tramos faltantes de las aceras

[ ] Mejorar las comodidades para las personas con discapacidades y/o las personas que viajan con carriolas

[ ] Estacionamiento de bicicletas seguro en las estaciones del BRT

[ ] Mejores instalaciones para bicicletas que conectan y/o que están en paralelo con corredores del BRT

[ ] Conexiones a estaciones de bicicletas compartidas u otros dispositivos de movilidad como escúteres

9) Características mejoradas de los vehículos del BRT *(*Necesitamos esta información)*

[ ] Más espacio para las personas en los vehículos del BRT

[ ] WiFi a bordo

[ ] Abordaje a nivel

[ ] Abordaje en todas las puertas

10) Beneficios regionales *(*Necesitamos esta información)*

[ ] Tiempos de viaje más rápidos de origen a destino

[ ] Servicio más frecuente y confiable para los principales empleadores y destinos fuera del centro de Los Ángeles

[ ] Autobuses de cero emisiones que reducen las emisiones de gases de efecto invernadero

[ ] Alternativa atractiva al viaje en automóvil

[ ] Reducción de la congestión del tránsito y contribución a la limpieza del aire

[ ] Conectividad fluida a toda la red de movilidad de Metro

13) ¿Qué opina del BRT como parte de la solución a las necesidades de movilidad en el condado de Los Ángeles? ***(*Necesitamos esta información)***

[ ] Estoy a favor de más corredores del BRT

[ ] No estoy a favor de más corredores del BRT

[ ] Estoy a favor de más corredores del BRT, pero tengo algunas preocupaciones. Descríbalas:: ____

PREGUNTAS SOBRE DATOS DEMOGRÁFICOS (Opcional):

La siguiente información permanecerá confidencial y se usará únicamente para garantizar que recibimos información de los residentes del condado diverso en el que prestamos servicios.

14) ¿Cuál es su origen étnico? ***Seleccione una opción.***

[ ] Nativo estadounidense

[ ] Hispano/latino

[ ] Afroamericano

[ ] Blanco/caucásico

[ ] Asiático/isleño del Pacífico

[ ] Dos o más razas

[ ] Otro:: ____

15) ¿Cuáles son los ingresos anuales de su casa? ***Seleccione una opción.***

[ ] Menos de $5,000

[ ] De $5,000 a $9,999

[ ] De $10,000 a $14,999

[ ] De $15,000 a $19,999

[ ] De $20,000 a $24,999

[ ] De $25,000 a $34,999

[ ] De $35,000 a $49,999

[ ] De $50,000 a $99,999

[ ] $100,00 o más

16) ¿Qué es su edad?

[ ] Menos de 18

[ ] 18-24

[ ] 25-34

[ ] 35-49

[ ] 50-64

[ ] 65 o más

17) ¿Cuál es su identidad de género?

[ ] Masculino

[ ] Femenino

[ ] No binario

18) ¿Cuál es el código postal de 5 dígitos de su casa? ***(*Necesitamos esta información)***
Ingrese un número (Mínimo 90000, máximo 99999).
*****

____

19) Por favor, proporcione una dirección de correo electrónico si desea recibir actualizaciones relacionadas con el estudio de visión y principios sobre el BRT de Metro:

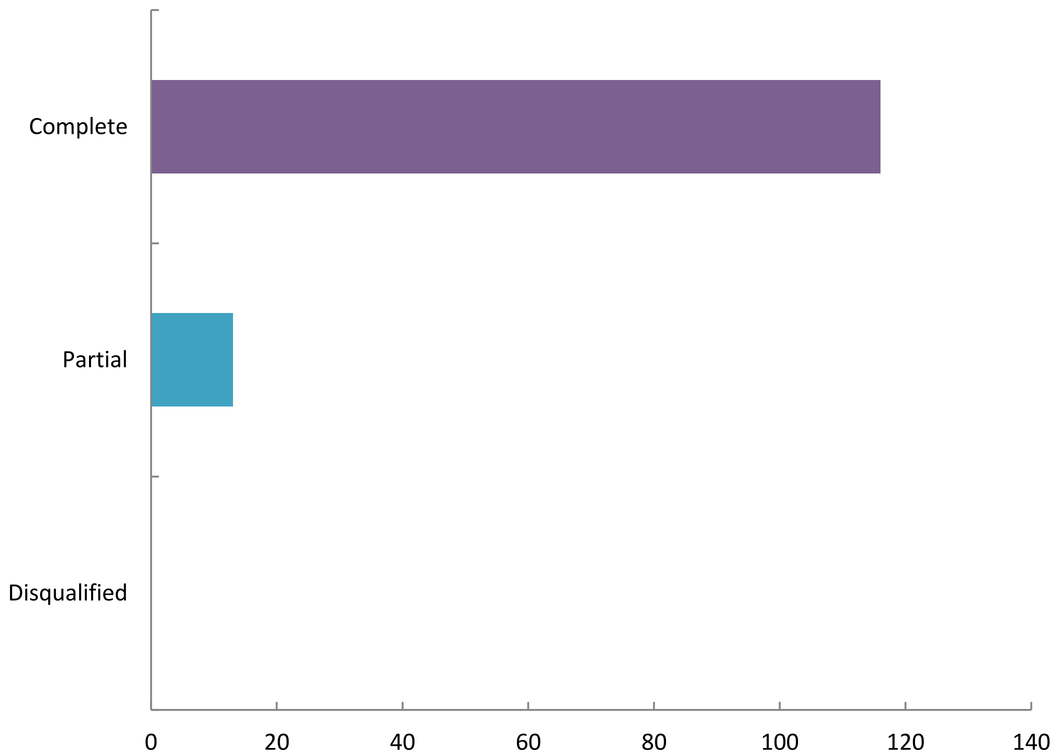
____

¡Gracias!

Report for Metro Bus Rapid Transit Vision & Principles Study

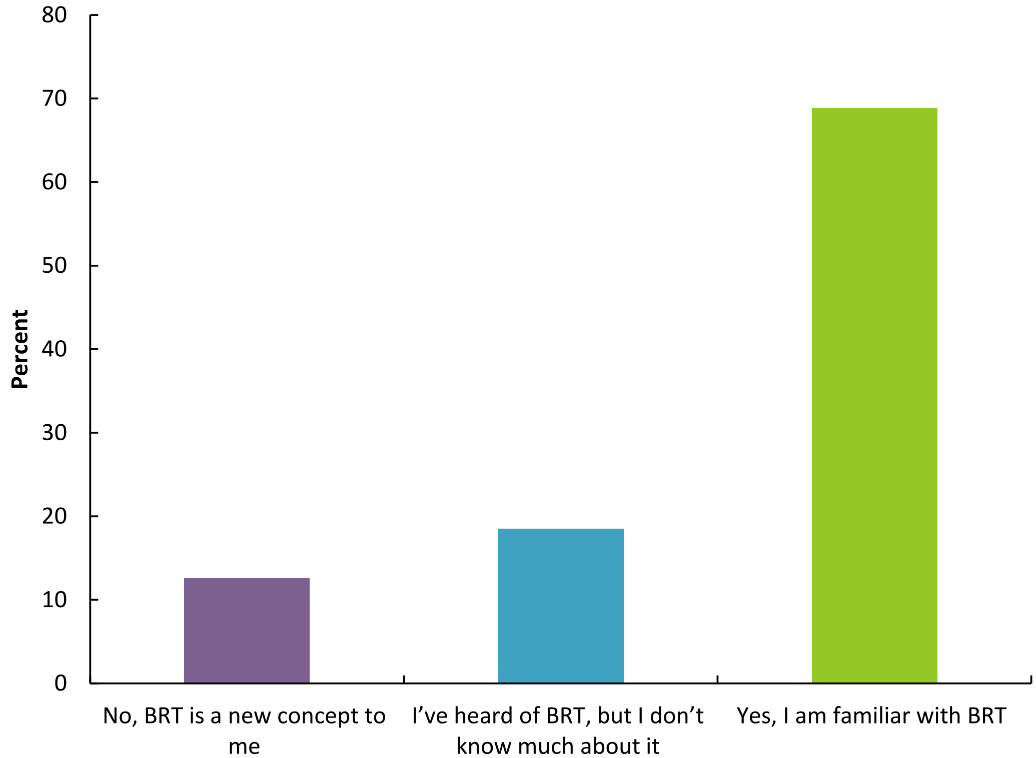
Metro Bus Rapid Transit Vision & Principles Study

Response Statistics



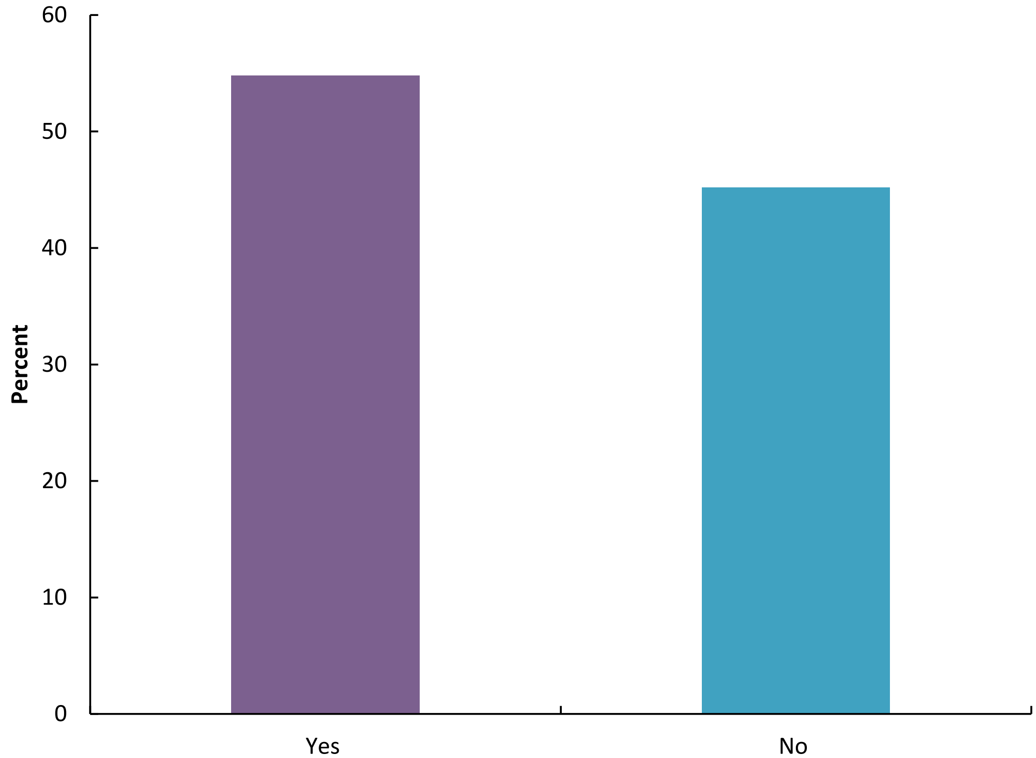
	Count	Percent
Complete	116	89.9
Partial	13	10.1
Disqualified	0	0
Totals	129	

1.Are you familiar with Bus Rapid Transit (BRT)?



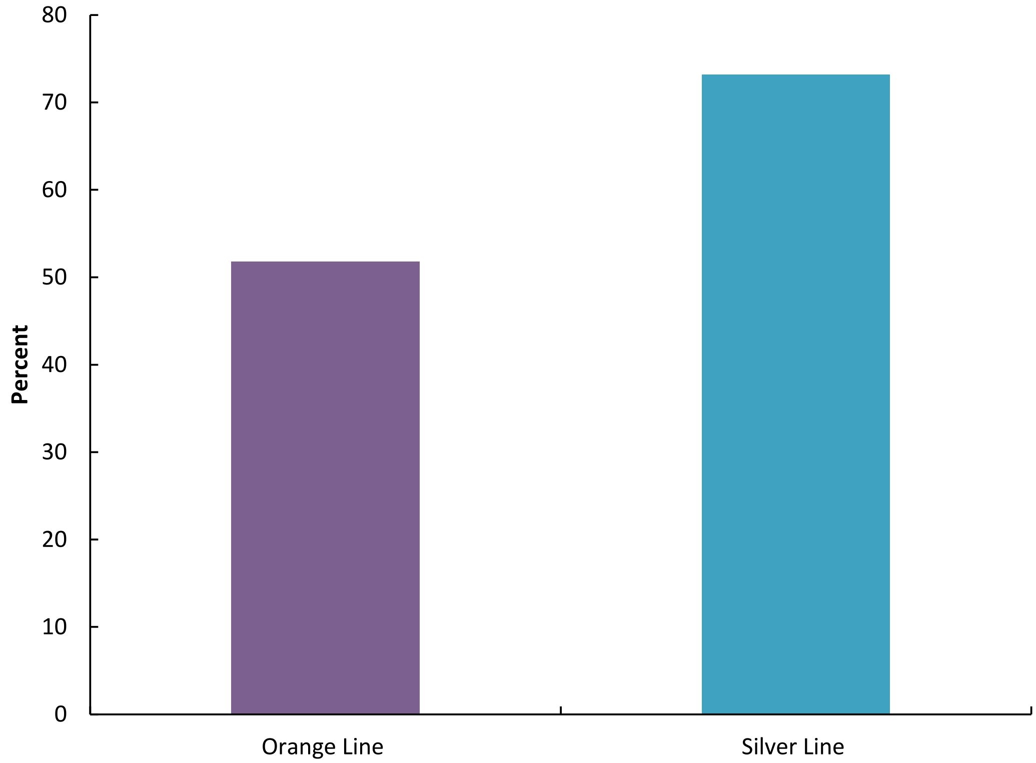
Value	Percent	Count
No, BRT is a new concept to me	12.6%	15
I've heard of BRT, but I don't know much about it	18.5%	22
Yes, I am familiar with BRT	68.9%	82

2.Do you currently use any Metro BRT services?



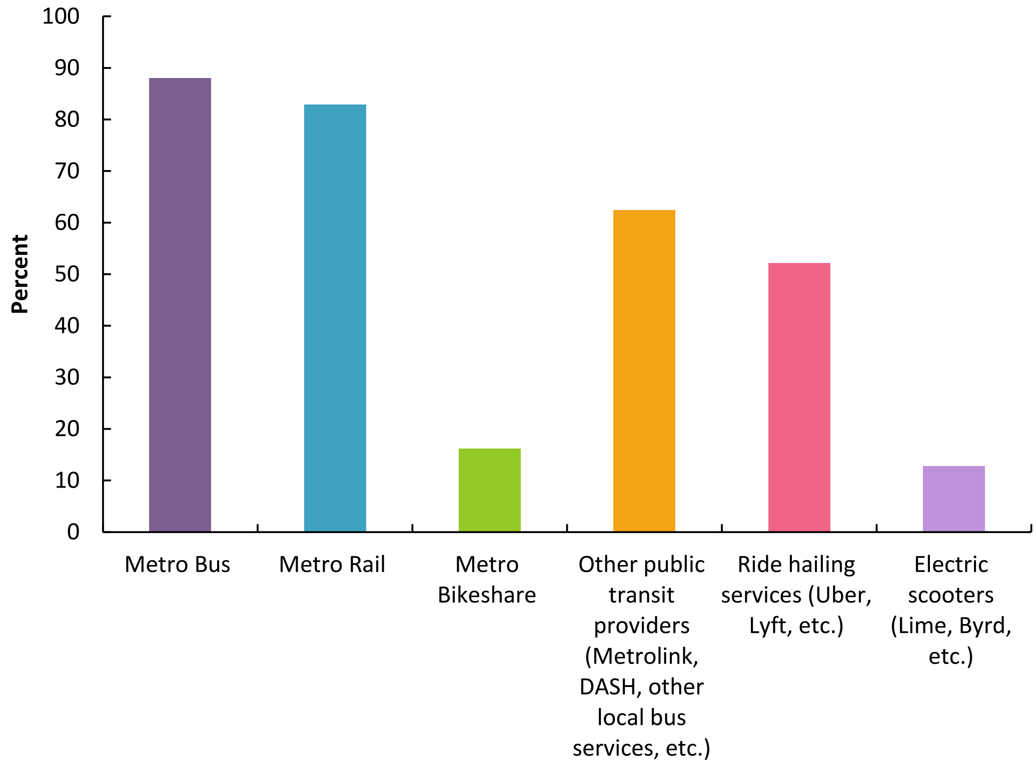
Value	Percent	Count
Yes	54.8%	57
No	45.2%	47

3.What Metro BRT services do you currently use? Select all that apply.



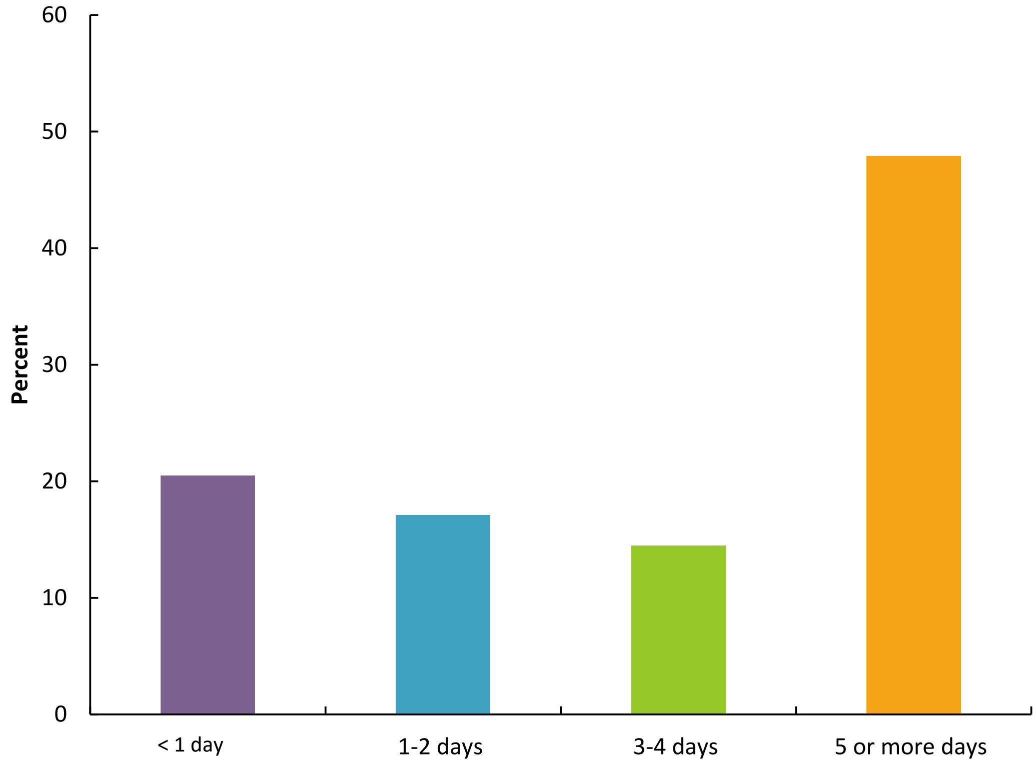
Value	Percent	Count
Orange Line	51.8%	29
Silver Line	73.2%	41

4.Do you use any additional public transit or mobility services? If so, please select all that apply.



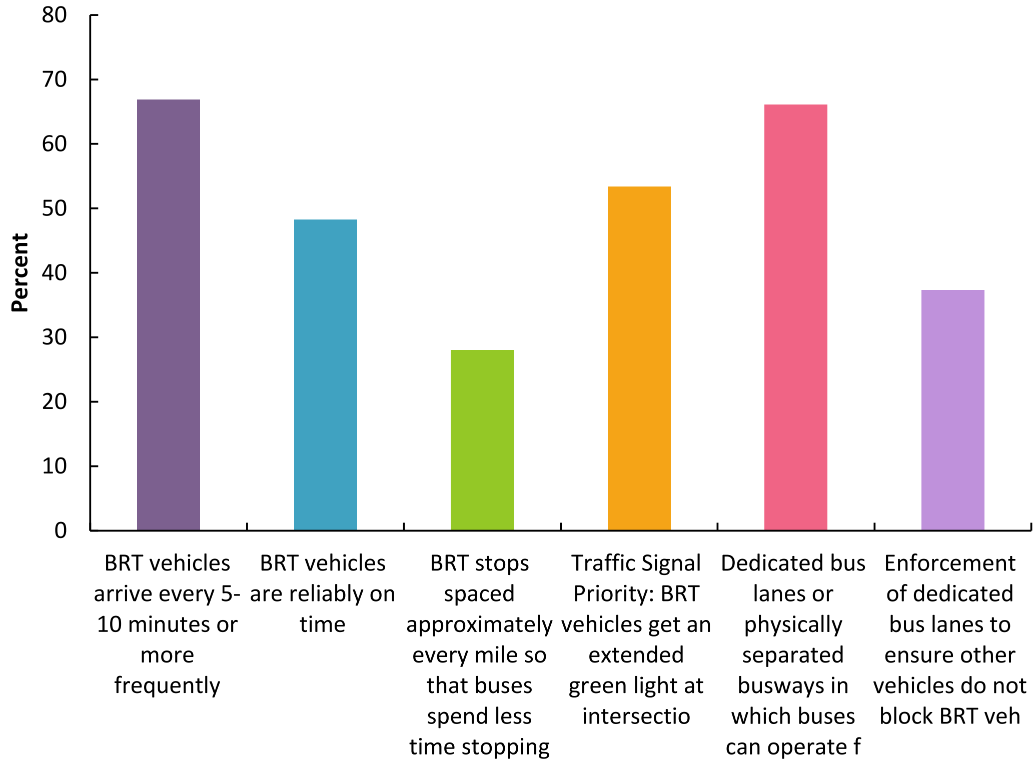
Value	Percent	Count
Metro Bus	88.0%	103
Metro Rail	82.9%	97
Metro Bikeshare	16.2%	19
Other public transit providers (Metrolink, DASH, other local bus services, etc.)	62.4%	73
Ride hailing services (Uber, Lyft, etc.)	52.1%	61
Electric scooters (Lime, Byrd, etc.)	12.8%	15

5.How many days a week do you usually use public transit services?



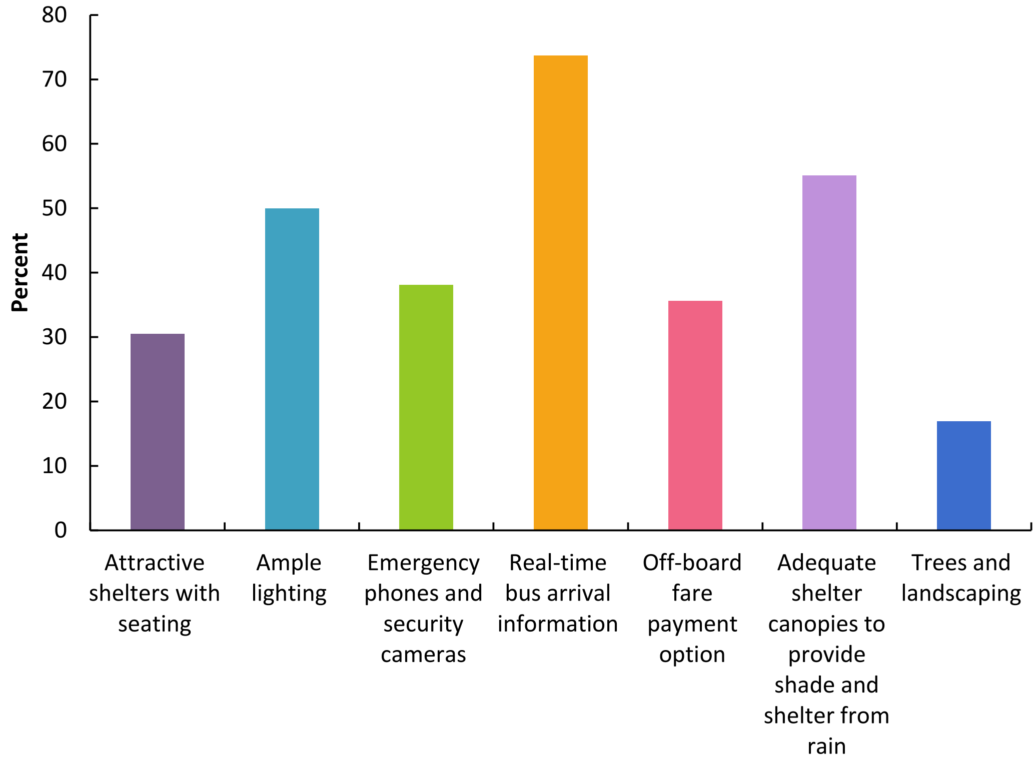
Value	Percent	Count
< 1 day	20.5%	24
1-2 days	17.1%	20
3-4 days	14.5%	17
5 or more days	47.9%	56

6.Operating Characteristics (*Required)



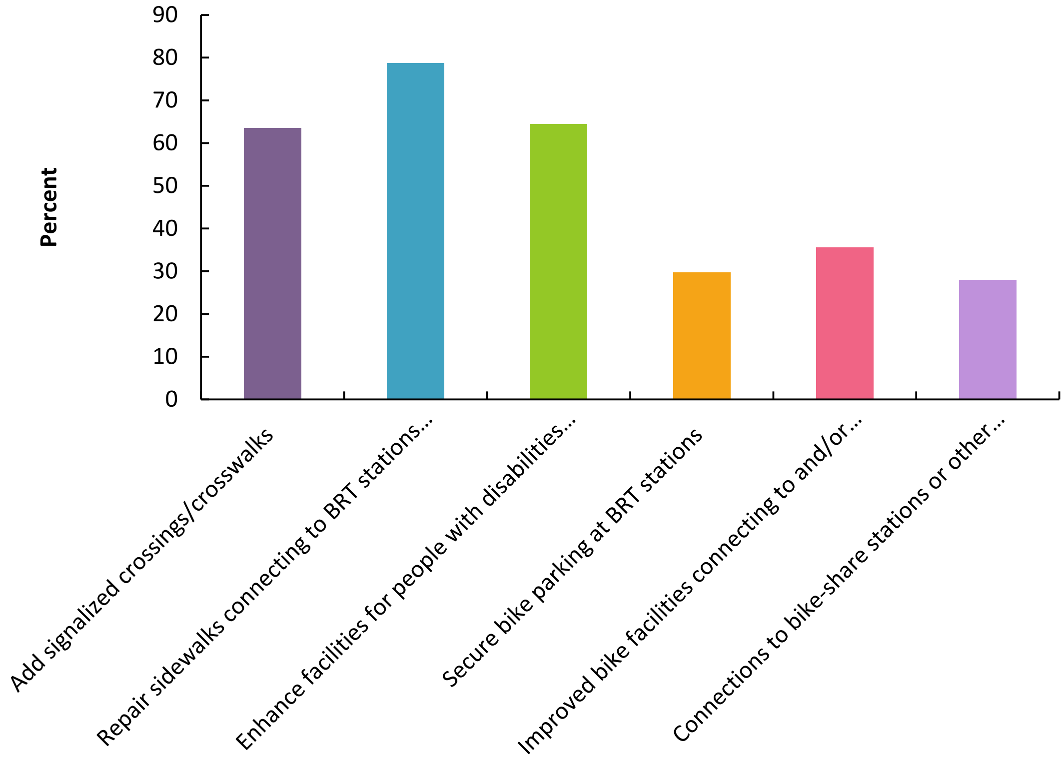
Value	Percent	Count
BRT vehicles arrive every 5-10 minutes or more frequently	66.9%	79
BRT vehicles are reliably on time	48.3%	57
BRT stops spaced approximately every mile so that buses spend less time stopping and starting	28.0%	33
Traffic Signal Priority: BRT vehicles get an extended green light at intersections thus reducing stop time at red lights	53.4%	63
Dedicated bus lanes or physically separated busways in which buses can operate free from congestion: Median running lane or Curbside bus lane or Off-set bus lane	66.1%	78
Enforcement of dedicated bus lanes to ensure other vehicles do not block BRT vehicles	37.3%	44

7.Enhanced Station Amenities (*Required)



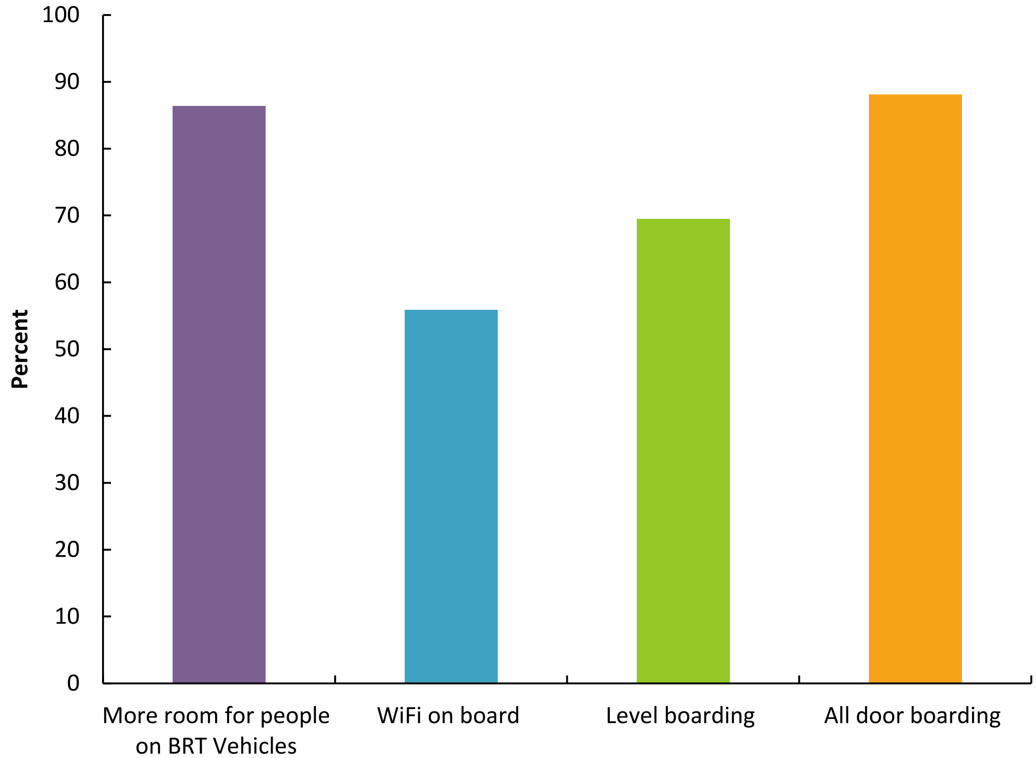
Value	Percent	Count
Attractive shelters with seating	30.5%	36
Ample lighting	50.0%	59
Emergency phones and security cameras	38.1%	45
Real-time bus arrival information	73.7%	87
Off-board fare payment option	35.6%	42
Adequate shelter canopies to provide shade and shelter from rain	55.1%	65
Trees and landscaping	16.9%	20

8.Traveling to the Station (*Required)



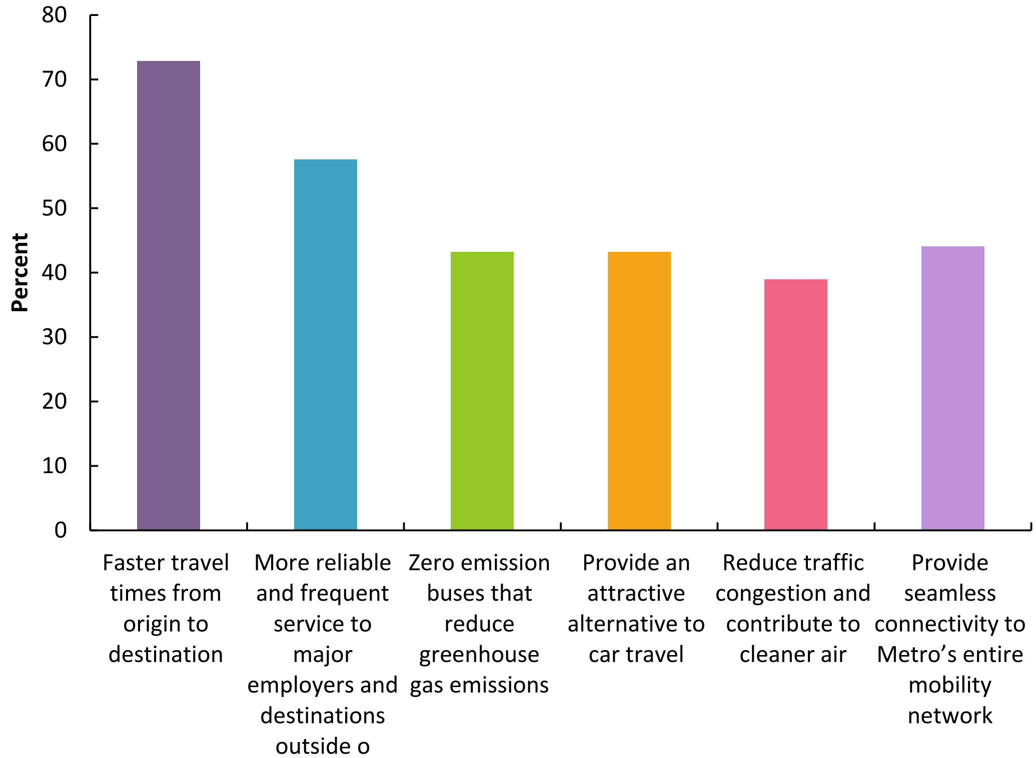
Value	Percent	Count
Add signalized crossings/crosswalks	63.6%	75
Repair sidewalks connecting to BRT stations and replace missing sidewalk segments	78.8%	93
Enhance facilities for people with disabilities and/or people travelling with strollers	64.4%	76
Secure bike parking at BRT stations	29.7%	35
Improved bike facilities connecting to and/or parallel to BRT corridors	35.6%	42
Connections to bike-share stations or other mobility devices such as scooters	28.0%	33

9.Enhanced BRT Vehicle Features (*Required)



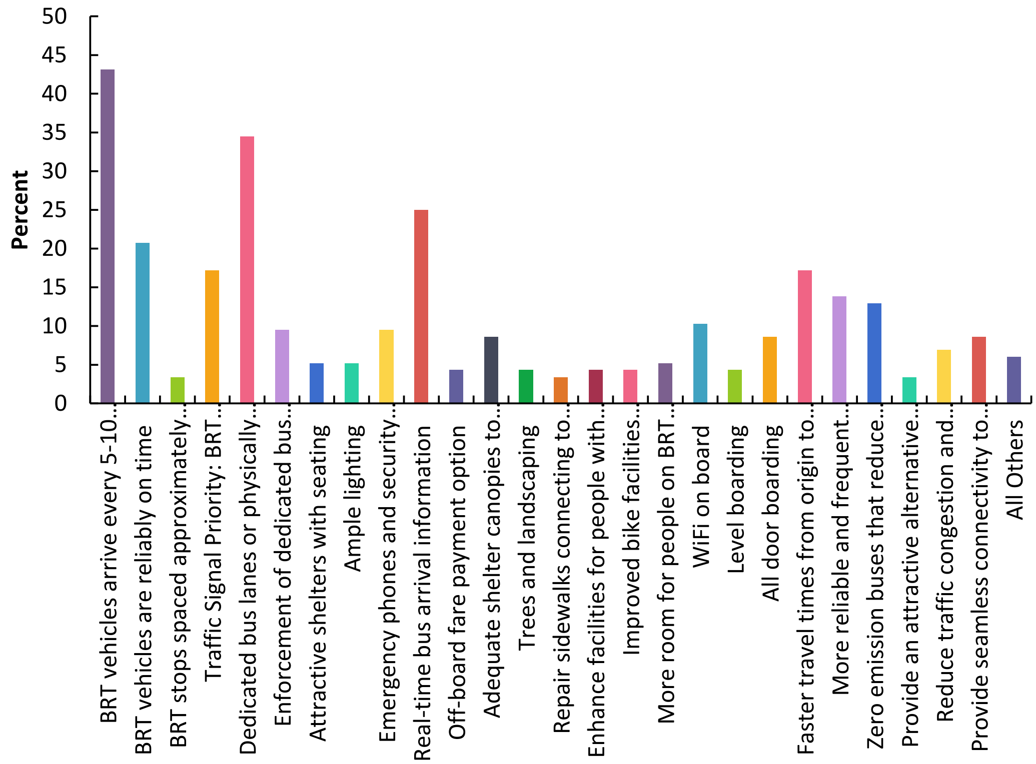
Value	Percent	Count
More room for people on BRT Vehicles	86.4%	102
WiFi on board	55.9%	66
Level boarding	69.5%	82
All door boarding	88.1%	104

10.Regional Benefits (*Required)



Value	Percent	Count
Faster travel times from origin to destination	72.9%	86
More reliable and frequent service to major employers and destinations outside of central Los Angeles	57.6%	68
Zero emission buses that reduce greenhouse gas emissions	43.2%	51
Provide an attractive alternative to car travel	43.2%	51
Reduce traffic congestion and contribute to cleaner air	39.0%	46
Provide seamless connectivity to Metro's entire mobility network	44.1%	52

11.Based on your previous responses, please select your top 3 features and amenities. (*Required)



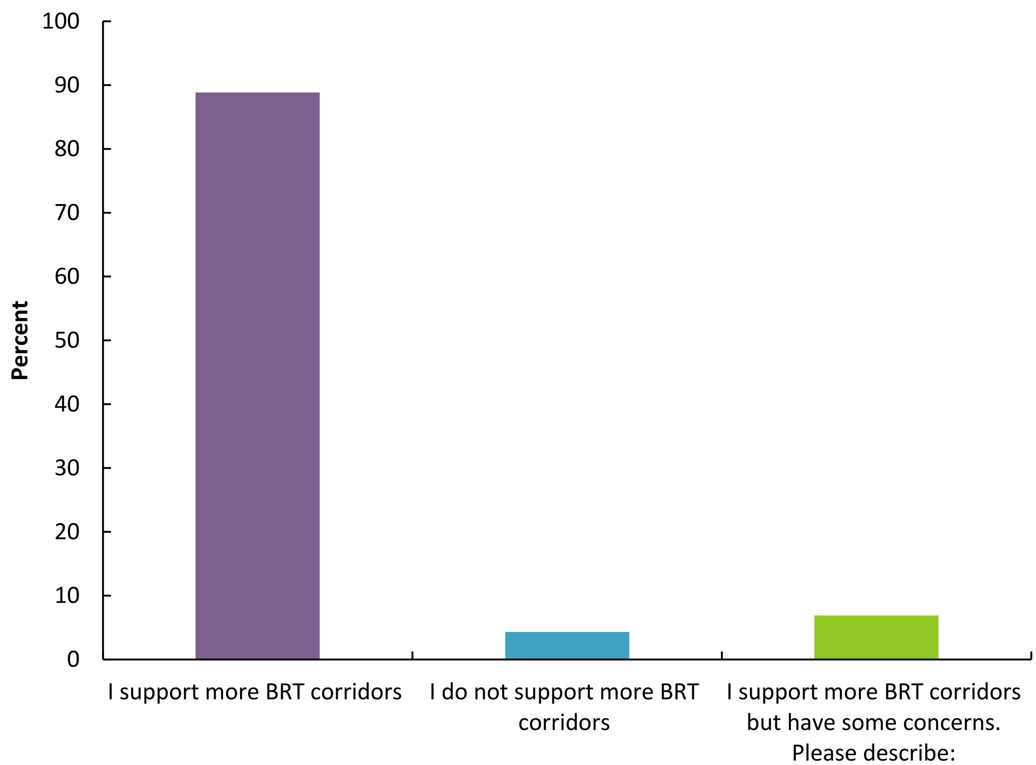
Value	Percent	Count
BRT vehicles arrive every 5-10 minutes or more frequently	43.1%	50
BRT vehicles are reliably on time	20.7%	24
BRT stops spaced approximately every mile so that buses spend less time stopping and starting	3.4%	4
Traffic Signal Priority: BRT vehicles get an extended green	17.2%	20

light at intersections thus reducing stop time at red lights		
Dedicated bus lanes or physically separated busways in which buses can operate free from congestion: Median running lane or Curbside bus lane or Off-set bus lane	34.5%	40
Enforcement of dedicated bus lanes to ensure other vehicles do not block BRT vehicles	9.5%	11
Attractive shelters with seating	5.2%	6
Ample lighting	5.2%	6
Emergency phones and security cameras	9.5%	11
Real-time bus arrival information	25.0%	29
Off-board fare payment option	4.3%	5
Adequate shelter canopies to provide shade and shelter from rain	8.6%	10
Trees and landscaping	4.3%	5
Add signalized crossings/crosswalks	1.7%	2

Repair sidewalks connecting to BRT stations and replace missing sidewalk segments	3.4%	4
Enhance facilities for people with disabilities and/or people travelling with strollers	4.3%	5
Secure bike parking at BRT stations	2.6%	3
Improved bike facilities connecting to and/or parallel to BRT corridors	4.3%	5
Connections to bike-share stations or other mobility devices such as scooters	1.7%	2
More room for people on BRT Vehicles	5.2%	6
WiFi on board	10.3%	12
Level boarding	4.3%	5
All door boarding	8.6%	10
Faster travel times from origin to destination	17.2%	20
More reliable and frequent service to major employers and destinations outside of central Los Angeles	13.8%	16

Zero emission buses that reduce greenhouse gas emissions	12.9%	15
Provide an attractive alternative to car travel	3.4%	4
Reduce traffic congestion and contribute to cleaner air	6.9%	8
Provide seamless connectivity to Metro's entire mobility network	8.6%	10

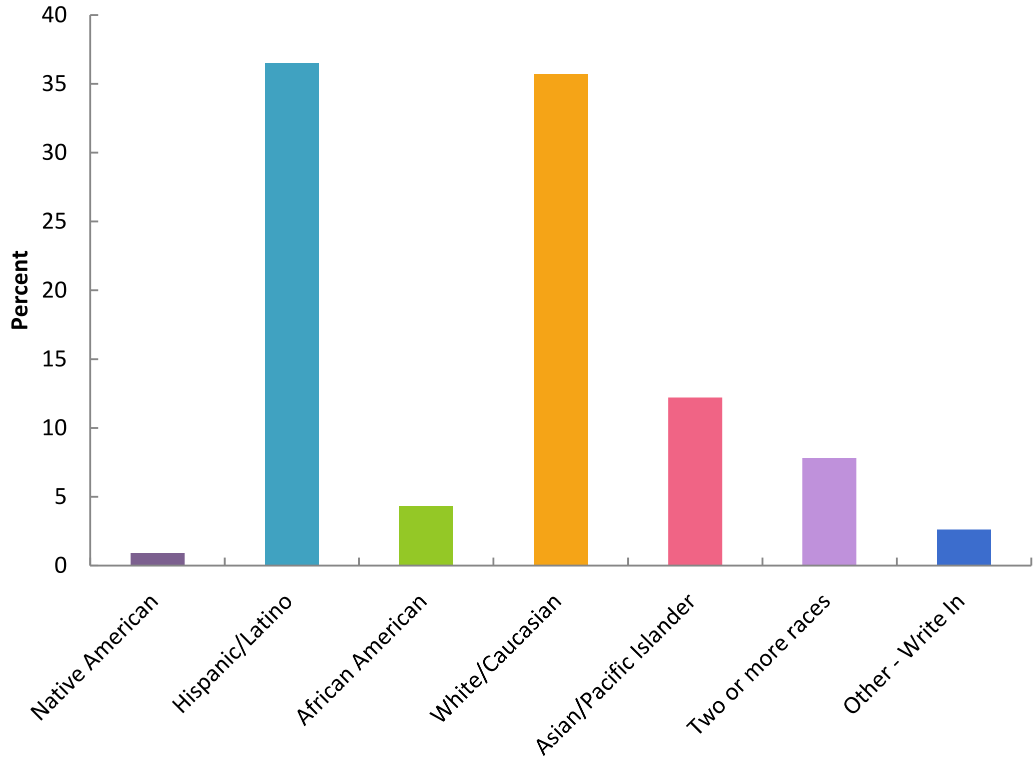
12.How do you feel about BRT as a part of the solution to mobility needs in Los Angeles County? (*Required)



Value	Percent	Count
I support more BRT corridors	88.8%	103
I do not support more BRT corridors	4.3%	5
I support more BRT corridors but have some concerns. Please describe:	6.9%	8

I support more BRT corridors but have some concerns. Please describe:	Count
Congestion during construction	1
Do it right and not on the cheap!!!!!!!!!!	1
Doesnt take away lanes	1
I understand street space is limited and I would not want BRT to be installed at the expense of existing or proposed bike lanes.	1
Indecisive because I haven't used the system yet.	1
Pasadena	1
more bus only lanes...	1
Totals	7

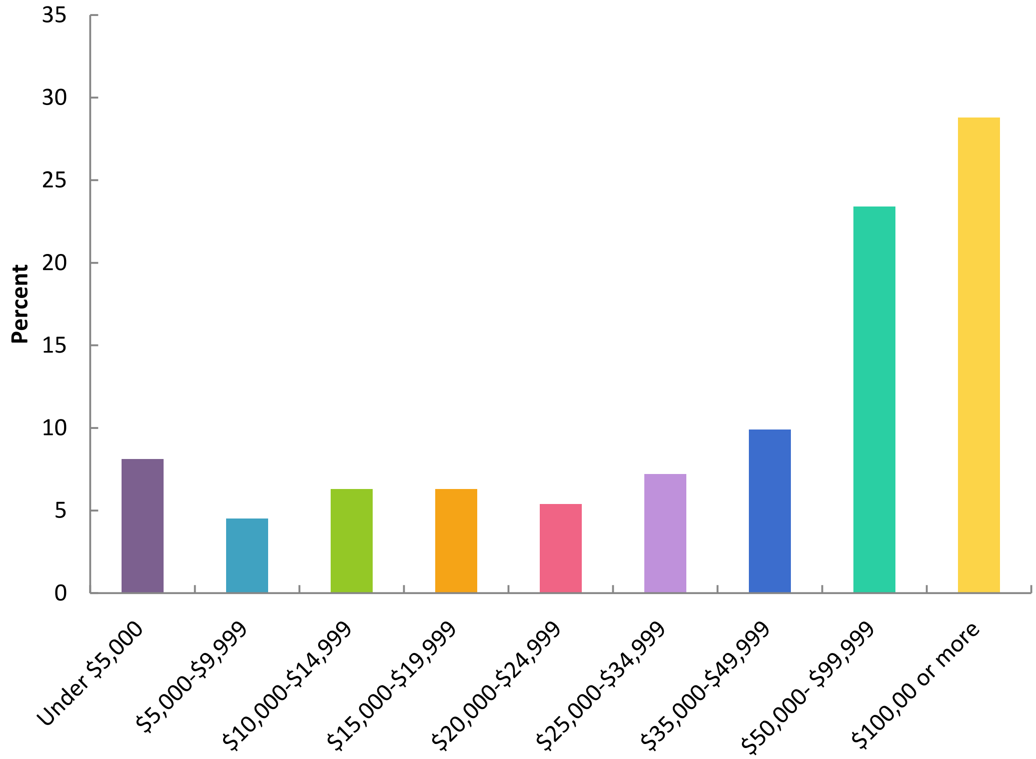
13.What is your ethnicity? Select one.



Value	Percent	Count
Native American	0.9%	1
Hispanic/Latino	36.5%	42
African American	4.3%	5
White/Caucasian	35.7%	41
Asian/Pacific Islander	12.2%	14
Two or more races	7.8%	9
Other - Write In	2.6%	3

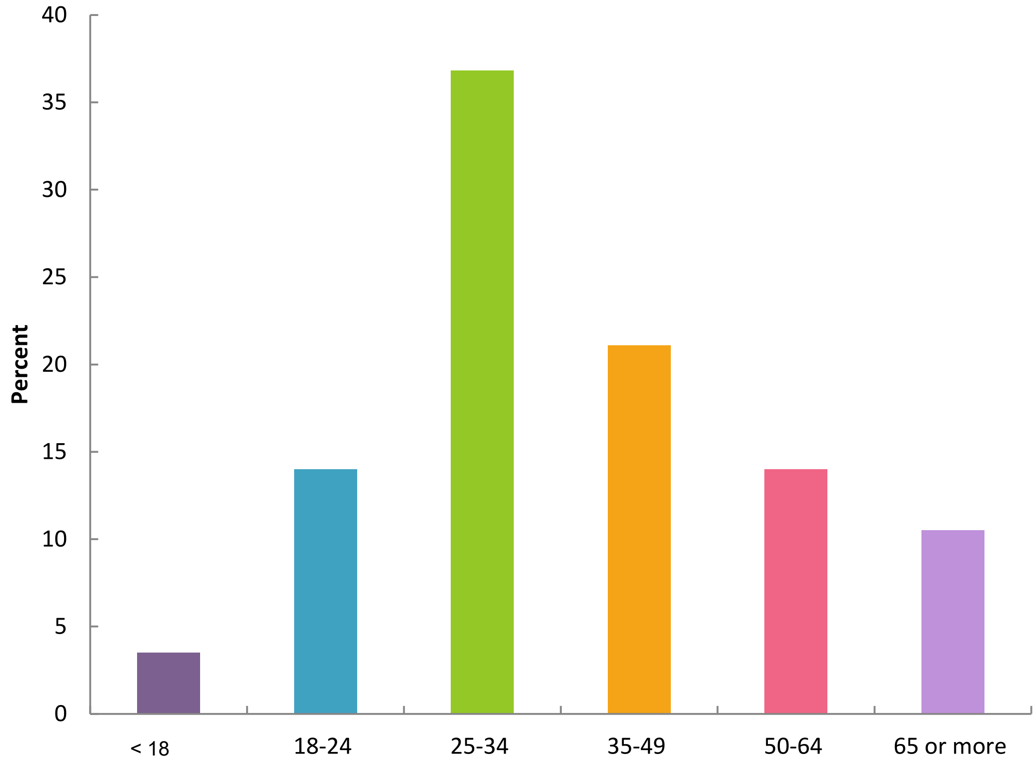
Other - Write In	Count
African	1
Mexican, chinese, white	1
Totals	2

14.What is your annual household income? Select one.



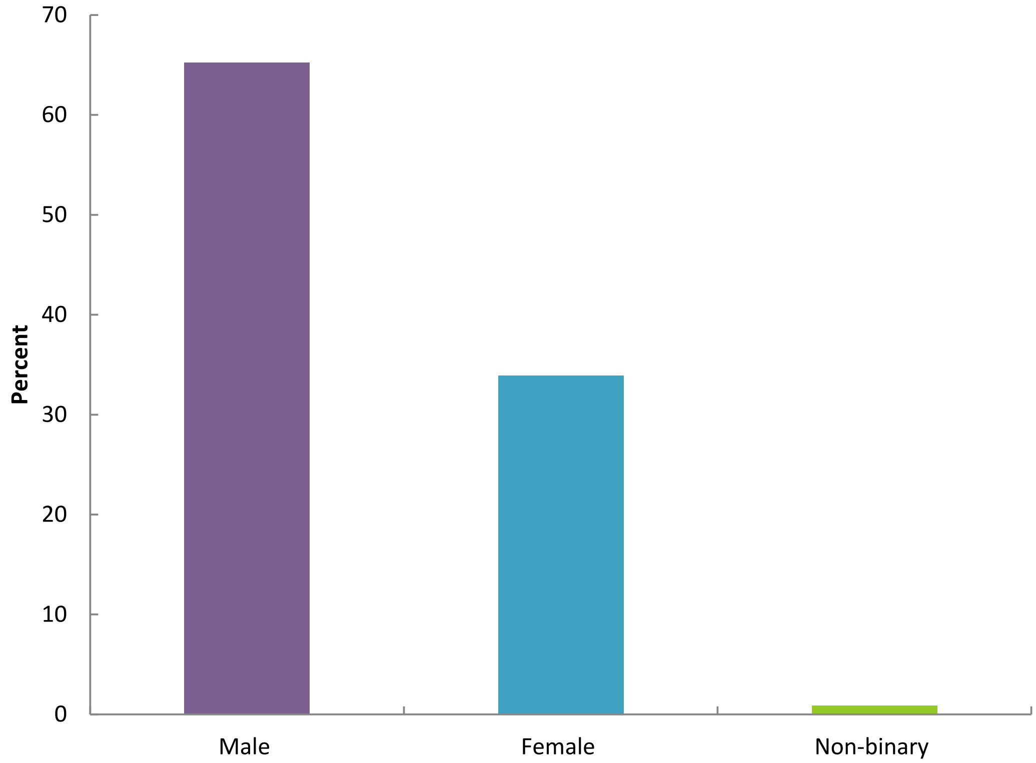
Value	Percent	Count
Under $5,000	8.1%	9
$5,000-$9,999	4.5%	5
$10,000-$14,999	6.3%	7
$15,000-$19,999	6.3%	7
$20,000-$24,999	5.4%	6
$25,000-$34,999	7.2%	8
$35,000-$49,999	9.9%	11
$50,000- $99,999	23.4%	26
$100,00 or more	28.8%	32

15.What is your age?



Value	Percent	Count
< 18	3.5%	4
18-24	14.0%	16
25-34	36.8%	42
35-49	21.1%	24
50-64	14.0%	16
65 or more	10.5%	12

16.What is your gender identity?



Value	Percent	Count
Male	65.2%	75
Female	33.9%	39
Non-binary	0.9%	1

Note: There are 8 English paper surveys.

Appendix C

Stakeholder Workshops:

Stakeholder List
Workshop Presentations
Workshop Summaries

Organization	Category	First Name	Last Name
Arroyo Verdugo Communities JPA	Government Agencies	Ann	Wilson
Central City of Los Angeles	Government Agencies	Stacy	Weisfeld
Central City of Los Angeles	Government Agencies	Michelle	Boehm
Gateway Cities Council of Governments	Government Agencies	Nancy	Pfeffer
Gateway Cities Council of Governments	Government Agencies	Stephanie	Cadena
Las Virgenes/Malibu Council of Governments	Government Agencies	Terry	Dipple
Las Virgenes/Malibu Council of Governments	Government Agencies	Elizabeth	Shavelson
North County Transportation Coalition	Government Agencies	Arthur	Sohikian
San Fernando Valley Council of Governments	Government Agencies	John	Bwarie
San Gabriel Valley Council of Governments	Government Agencies	Marisa	Creter
South Bay Cities Council of Governments	Government Agencies	Jacki	Bacharach
South Bay Cities Council of Governments	Government Agencies	David	Leger
Westside Cities Council of Governments	Government Agencies	Cecilia	Estolano
Westside Cities Council of Governments	Government Agencies	Winnie	Fong
AARP	Community Based Organization	Stephanie	Ramirez
Access Services	Transportation Services and Groups	Erick	Haack
Aging & Disability Transportation Network	Community Based Organization	Dina	Garcia
Angelinos Against Gridlock	Community Based Organization	David	Murphy
BizFed	Business Organizations	Jerard	Wright
Citizen's Advisory Council	Advisory Council	Darrell	Clarke
Climate Resolve	Community Based Organization	Bryn	Lindblad
Communities for a Better Environment	Community Based Organization	Darryl	Molina-Sarmiento
Communities for a Better Environment	Community Based Organization	Byron	Ramos-Gudiel
FAST	Transportation Services and Groups	Hilary	Norton
Investing in Place	Community Based Organization	Jessica	Meaney
LA County Bicycle Coalition	Community Based Organization	Eli	Akira Kaufman
LA Walks	Community Based Organization	John	Yi
Move LA	Transportation Services and Groups	Denny	Zane
Multicultural Communities for Mobility	Community Based Organization	Jill	Contreras
Sustainable Streets (Active Trans)	Community Based Organization	Ron	Durgin
Alliance for Community Empowerment (ACE) SFV focused	Community Based Organization	Michelle	Miranda
Alliance for Community Transit-LA	Transportation Services and Groups	Laura	Raymond
Best Start Metro LA	Community Based Organization	Brenda	Aguilera
Best Start Watts	Community Based Organization	Guadalupe	Zapata
Best Start Watts	Community Based Organization	Maria	Manzano
Best Start Wilmington	Community Based Organization	Irais	Colin
Cal State University System	Educational Institution	Carmen	Gapuchin
DayOne (SGV focused)	Community Based Organization	Catalina	Gonzalez
LA Chamber of Commerce	Business Organizations	Kendal	Asuncion
LA Chamber of Commerce	Business Organizations	Diana	Yedoyan
LA Community College District	Educational Institution	Maria	Iacobo
LAUSD	Educational Institution	Renee	Bell-Harbor
Pacoima Beautiful	Community Based Organization	Veronica	Padilla-Campos

SELA Collaborative	Community Based Organization	Wilma	Franco
SGV Economic Partnership	Business Organizations	Bill	Manis
SlateZ	Community Based Organization	Effie	Turnbull
Temple City Youth Committee	Community Based Organization	Peggy	Kuo
LA Forward	Community Based Organization	Alfonso	Directo
Valley Industry Commerce Association (VICA)	Business Organizations	Armando	Flores
Valley Industry Commerce Association (VICA)	Business Organizations	Stuart	Waldman
Watts Rising Collaborative	Community Based Organization	Wajeha	Bilal
LA County Supervisorial District 1	Elected Official Staff	Martin	Reyes
LA County Supervisorial District 1	Elected Officials	Hilda	Solis
LA County Supervisorial District 2	Elected Official Staff	David	Riccitiello
LA County Supervisorial District 2	Elected Officials	Mark	Ridley-Thomas
LA County Supervisorial District 3	Elected Official Staff	Nicole	Englund
LA County Supervisorial District 3	Elected Officials	Sheila	Kuhl
LA County Supervisorial District 4	Elected Official Staff	Young-Gi	Kim Harabedian
LA County Supervisorial District 4	Elected Officials	Janiche	Hahn
LA County Supervisorial District 5	Elected Official Staff	Dave	Perry
LA County Supervisorial District 5	Elected Officials	Kathryn	Barger

Metro

BRT Vision & Principles Study

Purpose of the Study

The Bus Rapid Transit (BRT) Vision & Principles Study is a comprehensive study that will establish the standard of a future Metro BRT network and serve as a pillar towards Metro's goal of creating a world class transportation system. This study will develop the overall vision, goals and objectives for BRT in LA County. It will define local BRT operational standards and design guidelines and identify new corridors that align with current and future needs and opportunities so that when funding is available, the County can strategically invest in the construction of innovative mobility options that will benefit the entire region.

The BRT survey will be open for responses through May 31, 2020.

Survey (English) Survey (Spanish)

Relationship to existing BRT service and active projects

This work will directly inform and outline service features for all BRT projects moving forward and will be integrated into existing efforts, to the extent possible. The Study will also tie into other transit improvements studies that are currently underway. The project team will coordinate to share data with programs and initiatives that have a direct impact on the study, including the NextGen Bus Plan, Long Range Transportation Plan and Mobility Matrices project. Metro currently has three projects in the early stages of development that are considering BRT as a transit option; Vermont, North Hollywood to Pasadena and North San Fernando Valley Transit Corridors.

BRT Technical Advisory Committee

A Technical Advisory Committee (TAC), comprised of Metro departments and staff from other transit providers and local cities, was formed at the outset of the project and has convened regularly since that time. The TAC has been an integral part of the technical process and provides a broad level of expertise, experience and input on all elements of the project.

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Stakeholder Engagement

Metro is working to conduct targeted engagement with stakeholders across the county. Ongoing activities include:

- Stakeholder briefings/presentations
- Stakeholder workshop
- BRT Technical Advisory Committee input
- Participation in NextGen Bus Plan public workshops
- Countywide survey engagement and education (click to take the survey)

Goals and Objectives

- Develop local BRT standards and guidelines
- Identify and prioritize candidate BRT corridors
- Identify a network of future potential BRT corridors

Development of local BRT design guidelines and standards

In order to develop standards and guidelines, Metro reviewed key information from internal sources as well as international, national and peer agencies (ITDP, FTA, APTA, TRB, NBRTI) and organized BRT standards into a

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- cross comparison of national and international BRT standards
- consideration of what standards are most applicable to LA County
- refinement of standards specific to Los Angeles for each element

Metro opted for a combination of performance and prescriptive-based standards that together will outline the necessary elements to achieve a world-class mobility experience. Metro defines two levels of BRT: Full-BRT and BRT-Lite, which include minimum standards.

Approach to candidate corridor identification and selection

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The corridor selection process incorporated industry-standard best practices for transportation planning best suited to the LA context. The intent behind the methodology is to integrate corridors previously studied by Metro with potential new corridors for consideration, evaluate them through a clear process and provide recommendations of new corridors for BRT service. Four methods were utilized to gather a broad list of potential corridors for BRT implementation. These included:

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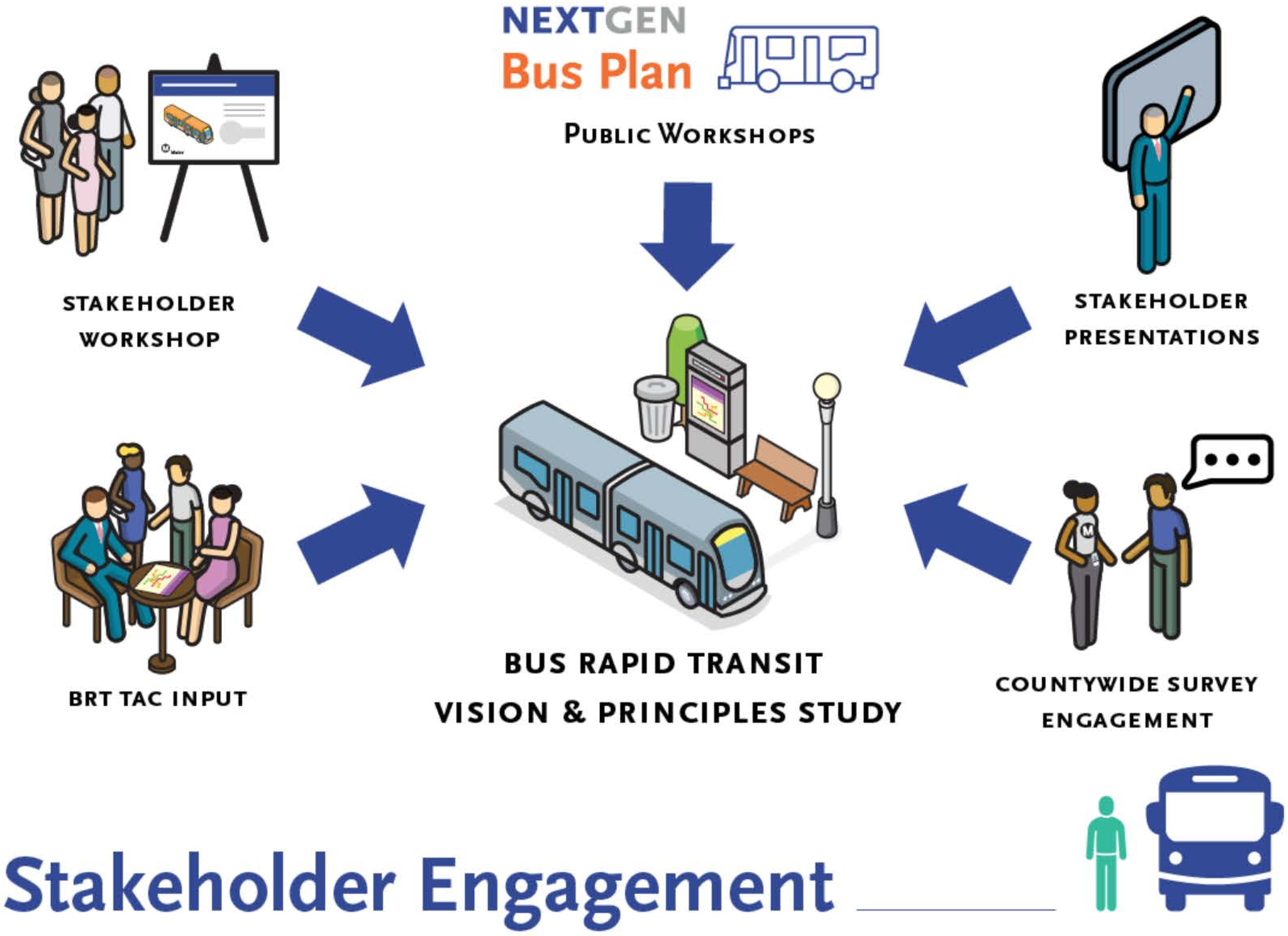

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Analyzed BRT Corridors

After compiling all identified potential corridors, the technical team conducted several levels of screening and analysis and coordinated with Metro's NextGen Bus Study in order to rank and evaluate each corridor for feasibility. The top 30 highest performing corridors were carried forward for additional screening. During the second round of evaluation, the team will gather additional input from the public and key stakeholders and add in

PERFORMANCE STANDARDS

Dwell Time

Speed

On-Time Performance/Reliability

Headway/Frequency

PRESCRIPTIVE STANDARDS

All-Door Boarding

Signal Priority (TSP)

Dedicated Lanes

Branding

Station Amenities

BRT Standards

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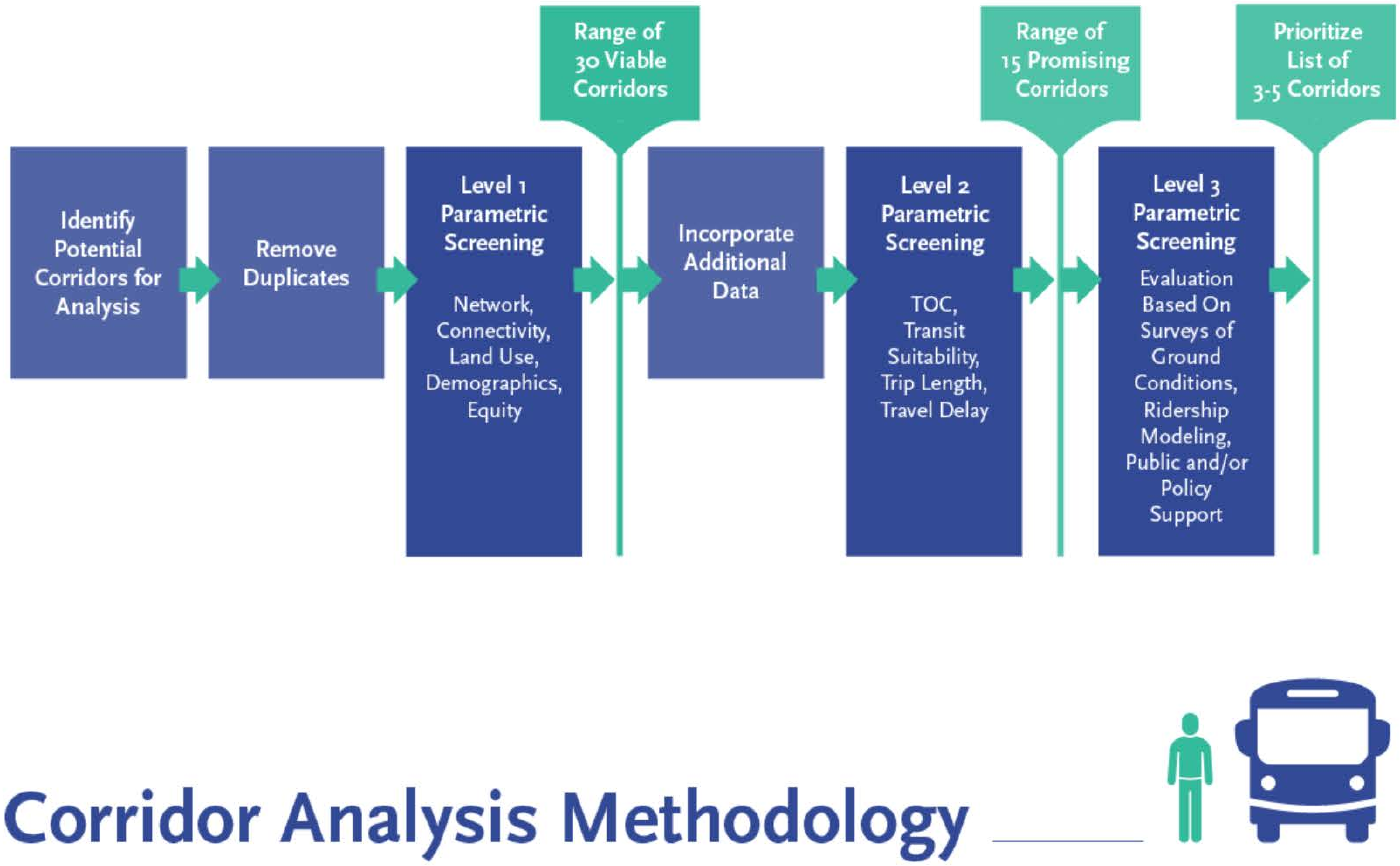
Identification of a future network of potential BRT corridors

How and where should Metro build LA's future BRT network?

Use our online interactive mapping tool to view analyzed corridors and provide your input on the future BRT network.



BRT Vision & Principles Study

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Next Steps

- Finalize standards & guidelines
- Refine priority corridor selections
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- Recommendations of the study are targeted to be presented to the Metro Board in Fall 2020

More Information

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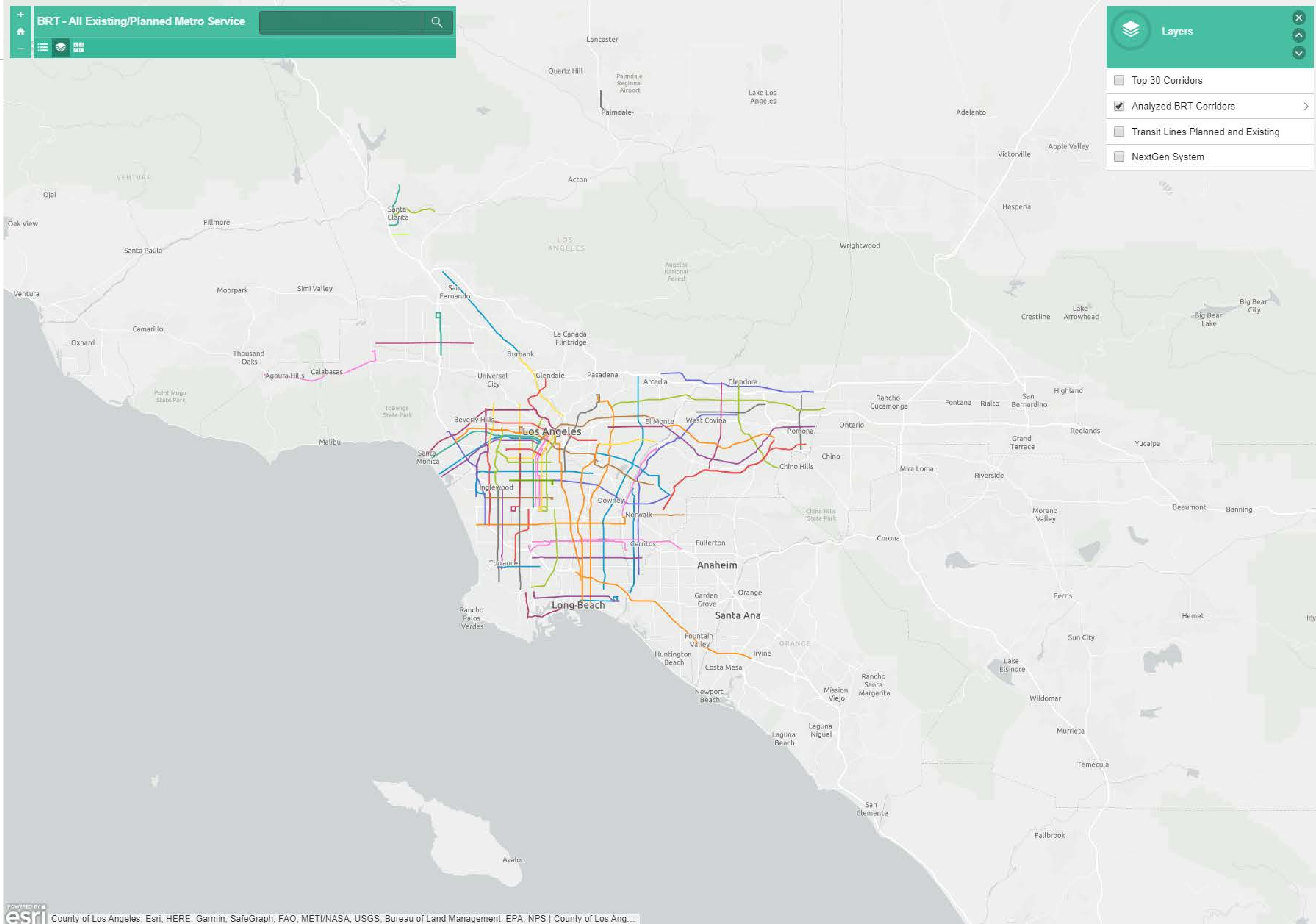

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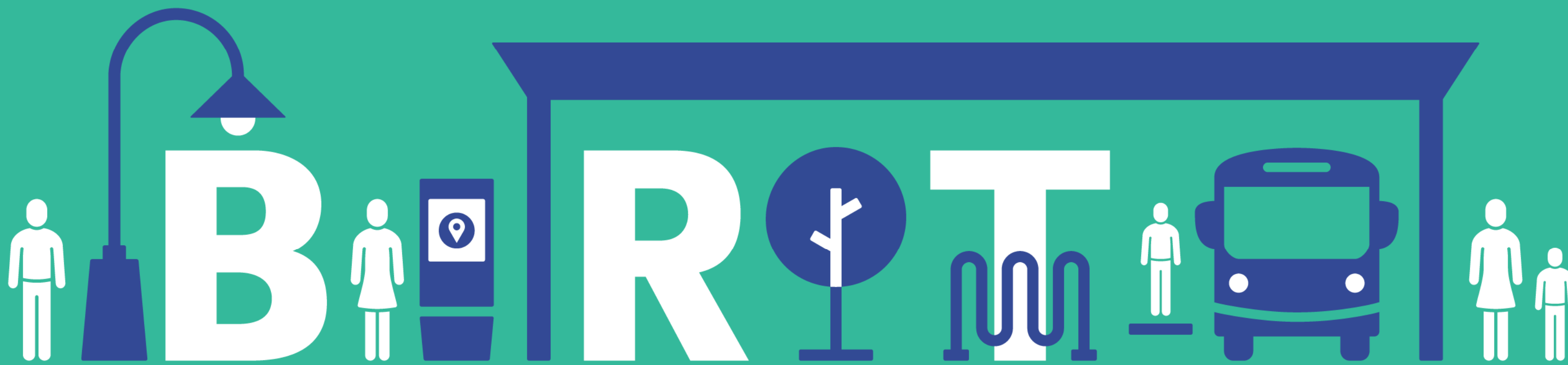

visioning BRT

BUS RAPID TRANSIT STUDY

Key Stakeholder Workshop

Wednesday May 20, 2020

Metro

Agenda

visioning BRT
BUS RAPID TRANSIT STUDY

BRT - The Convenient Choice Connecting Customers and Communities

- Study Overview
- Recap of Comments
- Corridor Analysis Methodology
- Top 15 Corridors
- Future BRT Network Overview
- Stakeholder and Public Engagement
- Next Steps

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BRT Vision & Principles Study Overview

- **Study Purpose**
  - Define BRT
  - Provide the foundation for the assignment of Measure M BRT program funds
  - Support Measure M BRT projects
- **Study Outcomes**
  - BRT standards
  - Design criteria
  - Identify and prioritize BRT corridors
  - Future BRT network

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Stakeholder Workshop – What We Heard

Connectivity is Fundamental

- BRT routes should connect to major transit hubs and bus/rail lines

Coordinate with Municipal Operators and Cities

- Collaborate with municipal operators to avoid service inefficiencies
- Facilitate community development opportunities, including affordable housing

Operational and Design Details Matter

- Opportunity to update standards for support systems onboard buses and at stations—provides for future network efficiency
- BRT stops and stations should increase the efficiency of boarding/alighting

Stakeholder Workshop – What We Heard

Public Acceptance Continues to be a Challenge

- BRT currently has a negative connotation that should be corrected

Leverage Metro Policies

- BRT criteria should be tied to Metro Transit Oriented Communities (TOC) outcomes

Future BRT Network

- Eighteen new corridors or supplements to existing corridors

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Open Discussion

Questions or Comments?

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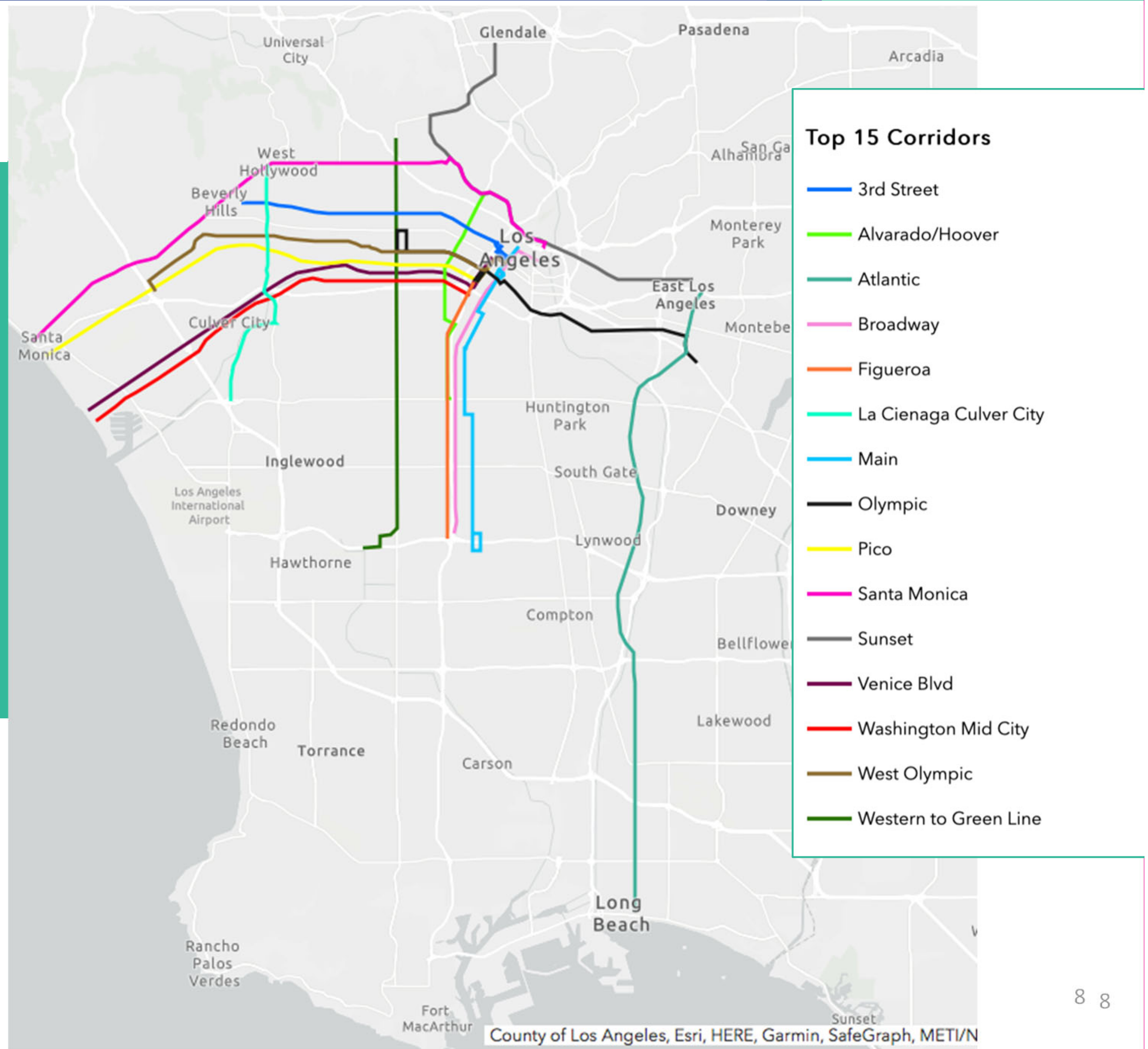
Corridor Analysis Methodology

1. Identify Potential Corridors for Analysis
2. Remove Duplicates
3. **Level 1 Parametric Screening**
   Network, Connectivity, Land Use, Demographics, Equity
   → Range of 30 Viable Corridors
4. Incorporate Additional Data
5. **Level 2 Parametric Screening**
   TOC, Transit Suitability, Trip Length, Travel Delay
   WE ARE HERE
   → Range of 15 Promising Corridors
6. **Level 3 Parametric Screening**
   Evaluation Based On Surveys of Ground Conditions, Ridership Modeling, Public and/or Policy Support
   → Prioritize List of 3-5 Corridors

Top 15 Corridors

15 Potential Corridors



[Top 15 Potential BRT Corridors]

Metro

Future BRT Network

Build upon strong candidate corridors identified in a multi-step screening process that used the following criteria:

- NETWORK CONNECTIVITY
- RIDERSHIP POTENTIAL
- SURROUNDING LAND USES
- EQUITY
- TRIP LENGTH
- EXISTING CONDITIONS

Utilize a gap analysis that:

> Considers existing and planned rail/BRT network

> Identifies gaps in coverage

> Connects future BRT corridors to one another and the Metro rail network

> Leverages corridors identified and screened through the project study

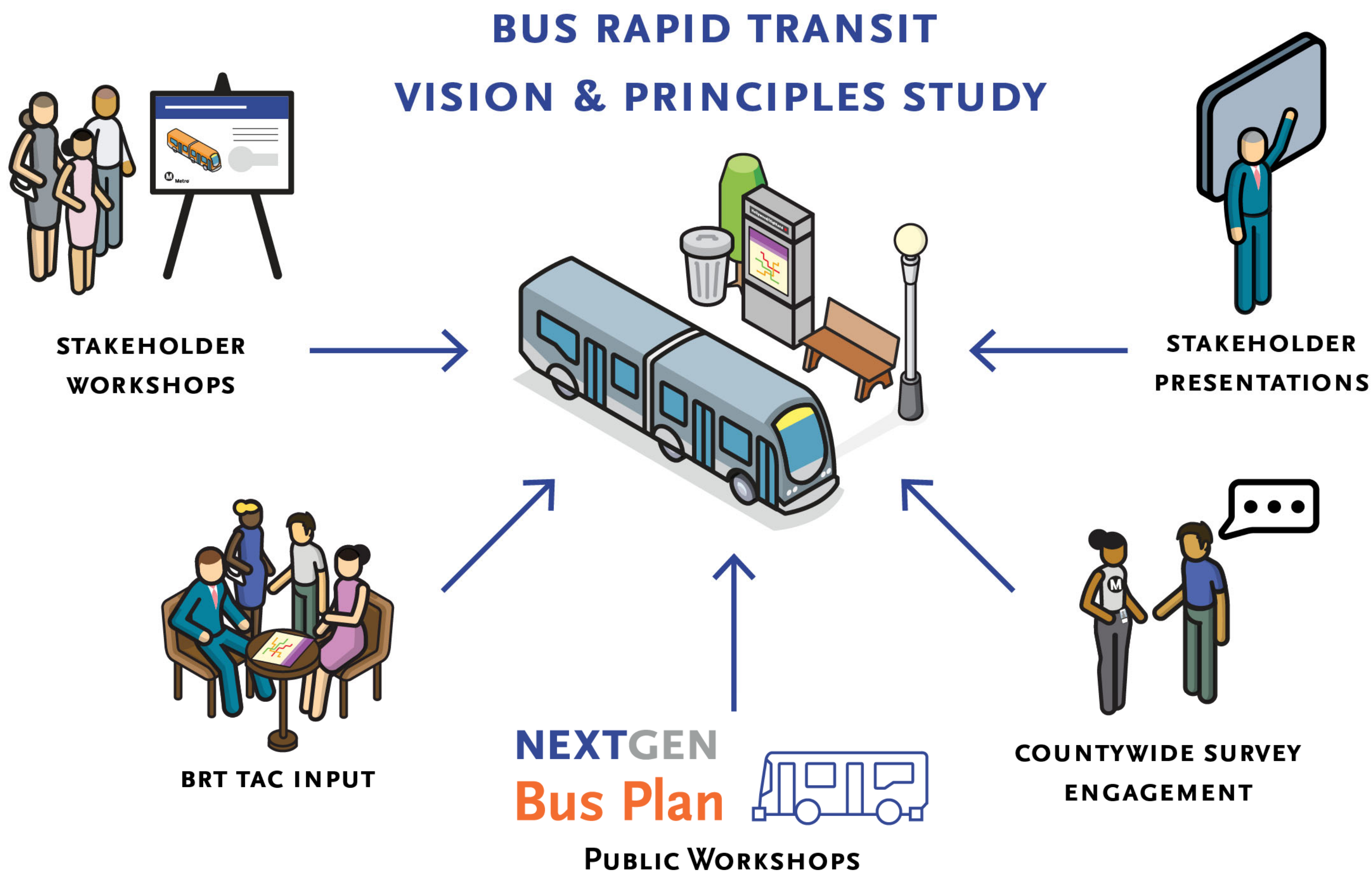
Metro

Open Discussion

Questions or Comments?

Metro

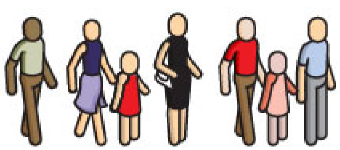
Public and Stakeholder Input



Survey Results

GENERAL OVERVIEW

Over 60% of respondants are already familiar with BRT service, and more than 54% currently use Metro's BRT Service

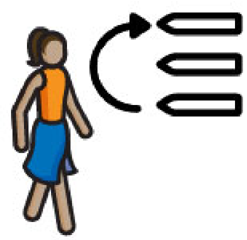


More than 65% of those surveyed use public transit 3 or more days a week, with over 79% using Metro Bus and Rail services for that travel.

More than 91% of respondents would support more BRT corridors as part of the solution to mobility needs in LA County

TOP 5 PRIORITIES FOR BRT FEATURES & AMENITIES

- Frequency
- Dedicated bus lanes
- Reliability
- Real-time information
- Emergency phones & security cameras



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Stakeholder Input – Next Steps

BRT Survey

- Push to your membership
- Survey closes May 30, 2020

Map Comment Tool

- Record your comments on Top 15 Potential BRT Corridors
- Comment Tool closes May 30, 2020

Stakeholder Workshop

- Summer 2020
- Final 3 to 5 Select BRT Corridors
- Future BRT Network

Demonstration of Map Comment Tool

Interactive Tool Demonstration for Review & Comment on 15 Corridors

Top 15 Potential BRT Corridors

Open Discussion

Questions or Comments?

Metro

Contact Us

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Thank you!

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BUS RAPID TRANSIT STUDY

Key Stakeholder Workshop

Tuesday September 1, 2020

Metro

Agenda

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BRT - The Convenient Choice Connecting Customers and Communities

- Study Overview and Purpose
- Recap of Key Stakeholder Comments and Input to Date
- Stakeholder and Public Engagement
- Development of BRT Standards & Design Guidelines
- Corridor Analysis Methodology
- Corridor Prioritization Process
- Future Unfunded Network
- Next Steps

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BRT Vision & Principles Study Overview

- **Study Purpose**
  - Define BRT
  - Provide the foundation for the assignment of Measure M BRT program funds
  - Support Measure M BRT projects
- **Study Outcomes**
  - BRT standards
  - Design criteria
  - Identify and prioritize BRT corridors
  - Future BRT network

Metro

Stakeholder Workshops– What We Heard

Connectivity is Fundamental

- BRT routes should connect to major transit hubs and bus/rail lines

Coordinate with Municipal Operators and Cities

- Collaborate with municipal operators to avoid service inefficiencies
- Facilitate community development opportunities, including affordable housing
- Consider ‘complete streets’ studies and other initiatives or plans currently underway that could compliment or provide opportunities for this Study

Metro

Stakeholder Workshops– What We Heard

Public Acceptance Continues to be a Challenge

- BRT currently has a negative connotation that should be corrected

Leverage Metro Policies

- BRT criteria should be tied to Metro Transit Oriented Communities (TOC) outcomes

Operational and Design Details Matter

- Opportunity to update standards for support systems onboard buses and at stations—provides for future network efficiency
- BRT stops and stations should increase the efficiency of boarding/alighting

Metro

Summary of Outreach

Survey Engagement

- Distributed in-person and online through digital and extended outreach methods
  - 526 total surveys completed
  - 27 comment cards submitted

Public Meetings

- Tabling at 33 NextGen public meetings

Stakeholder Workshops and Presentations

- 40+ presentations and workshops with key organizations and stakeholders have been held
- 11 TAC meetings

Story Map Site Traffic

- 5,100+ views since launch

Survey Highlights

GENERAL OVERVIEW

Over **88%** of respondants are already **familiar with BRT service**, and more than **56%** currently use Metro's BRT Service

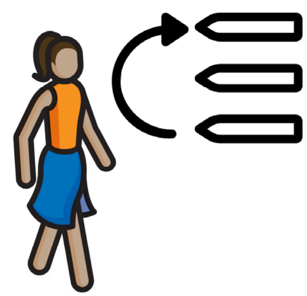
More than **58%** of those surveyed use public transit **3 or more days a week**, with over **80%** using Metro Bus and Rail services for that travel.

More than **97%** of respondents would **support more BRT corridors** as part of the solution to mobility needs in LA County

Segment 1 included a specific reach for **low-income**, **age group 50+**, **Asian and African American populations**; Segment 2 included an additional target of **women** across the county

TOP 5 PRIORITIES FOR BRT FEATURES & AMENITIES

- Frequency
- Dedicated bus lanes
- Reliability
- Real-time information
- Faster travel times (origin to destination)



Open Discussion

Questions or Comments?

Metro

BRT Standards

Full BRT and BRT lite

- Accommodate the complex geographical and political constraints of LA County

BRT standards

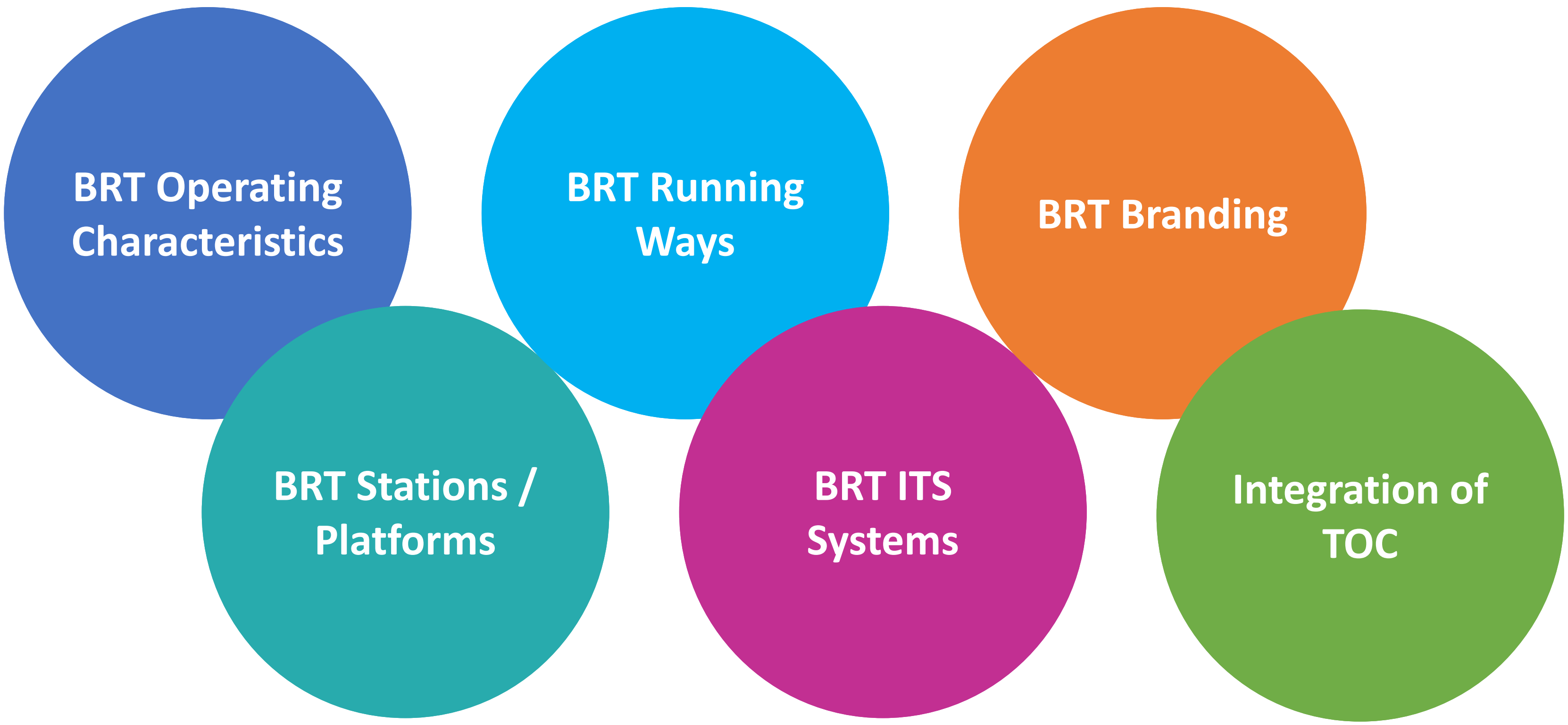
- Use both performance and prescriptive standards
- TAC discussion on thresholds for each standard

BRT Standards

- Dwell Time
- Speed
- On-Time Performance / Reliability
- Headway
- All-Door Boarding
- Intersection Priority (TSP)
- Dedicated Lanes
- Branding
- Station Amenities

BRT Elements of Design

Purpose:
Design guidelines are recommendations intended to provide clear instructions to designers and developers on how to adopt specific principles, such as intuitiveness, learnability, efficiency, and consistency.



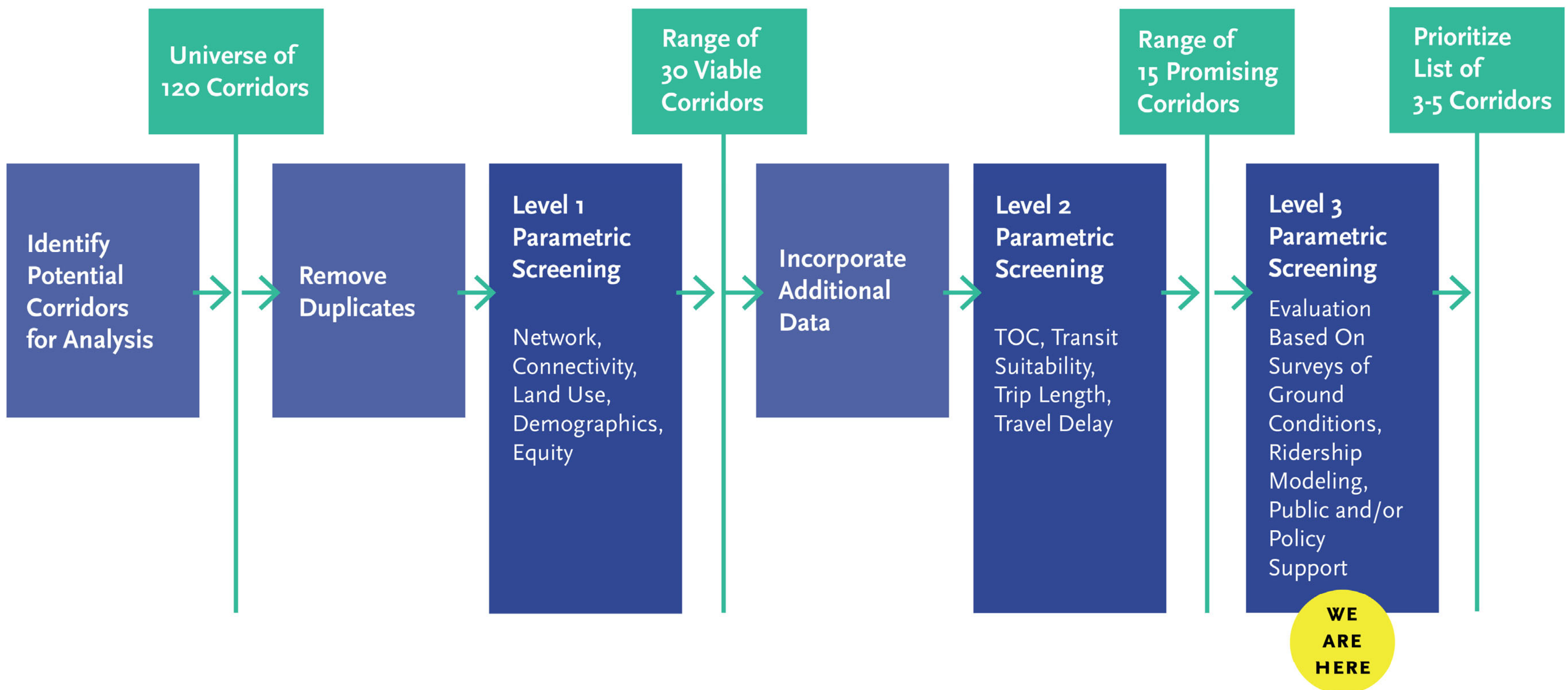
BRT Stations

Open Discussion

Questions or Comments?

Metro

Corridor Prioritization Methodology



Analysis From 15 to 7 Corridors

Highest Ranked 7 Corridors

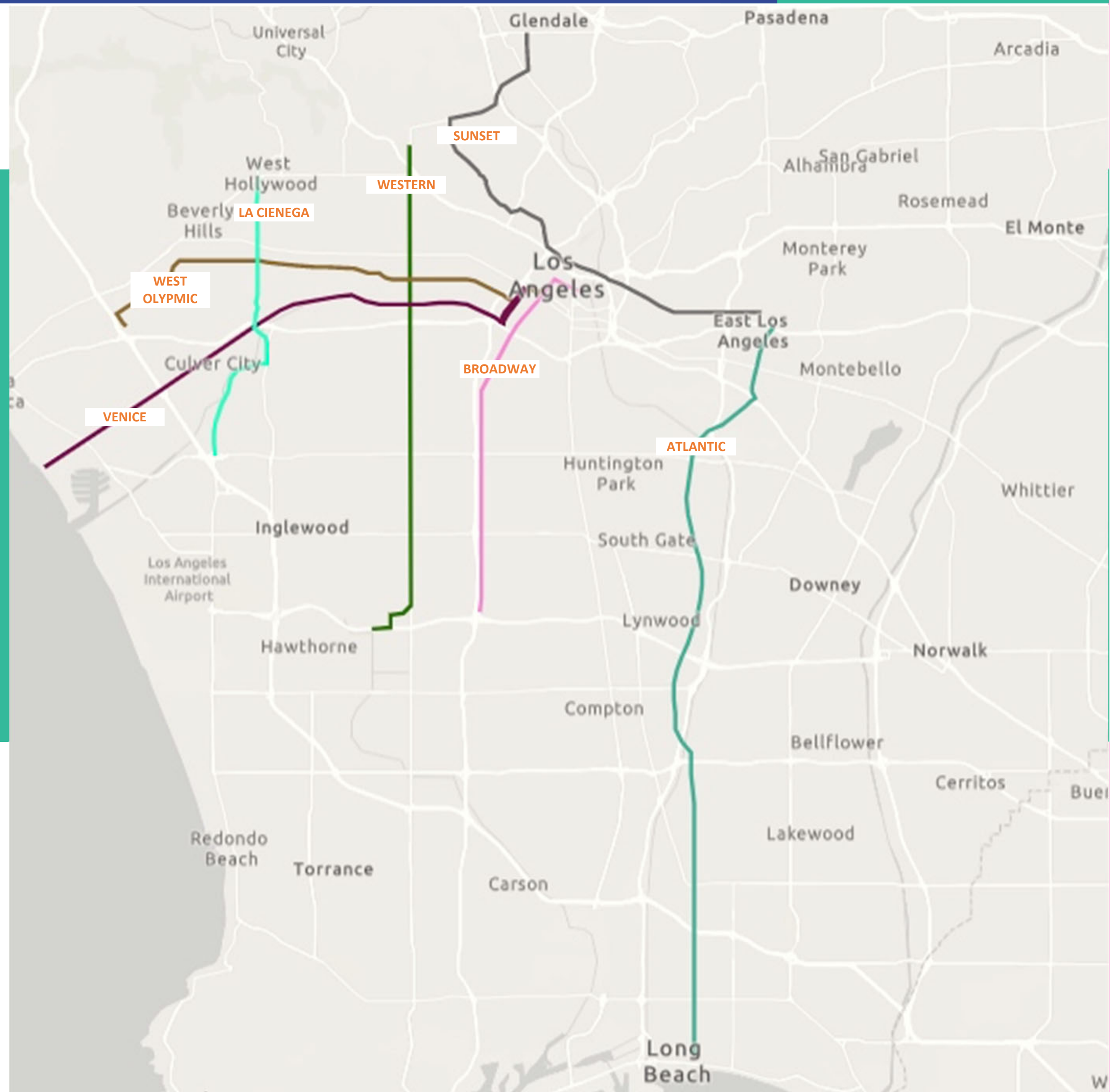
- West Olympic
- Venice
- La Cienega
- Western
- Sunset
- Broadway
- Atlantic

Corridors Not in the Highest Ranked 7

- Santa Monica
- 3rd Street
- Olympic
- Pico
- Washington
- Alvarado/Hoover
- Figueroa
- Main

Highest Ranked 7 Corridors

7 Potential Corridors



[7 Potential BRT Corridors Interactive Map]()

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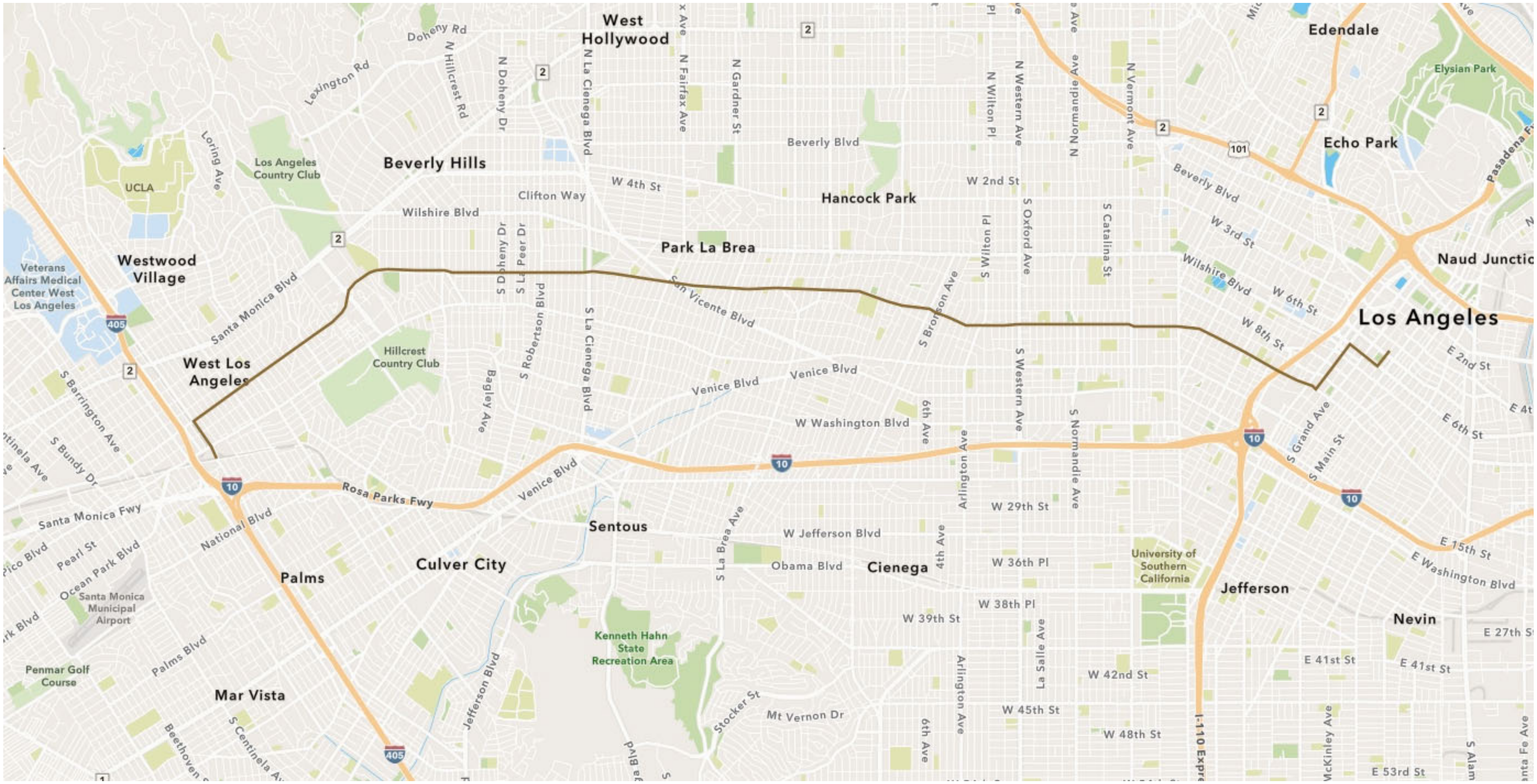
West Olympic



West Olympic

- Very high network connectivity
- Very high ridership
- High opportunity to build BRT-friendly infrastructure and realize travel time savings
- Parallel to and ½ mile from the Purple Line extension
- Potential to extend the corridor further west via Pico

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Venice

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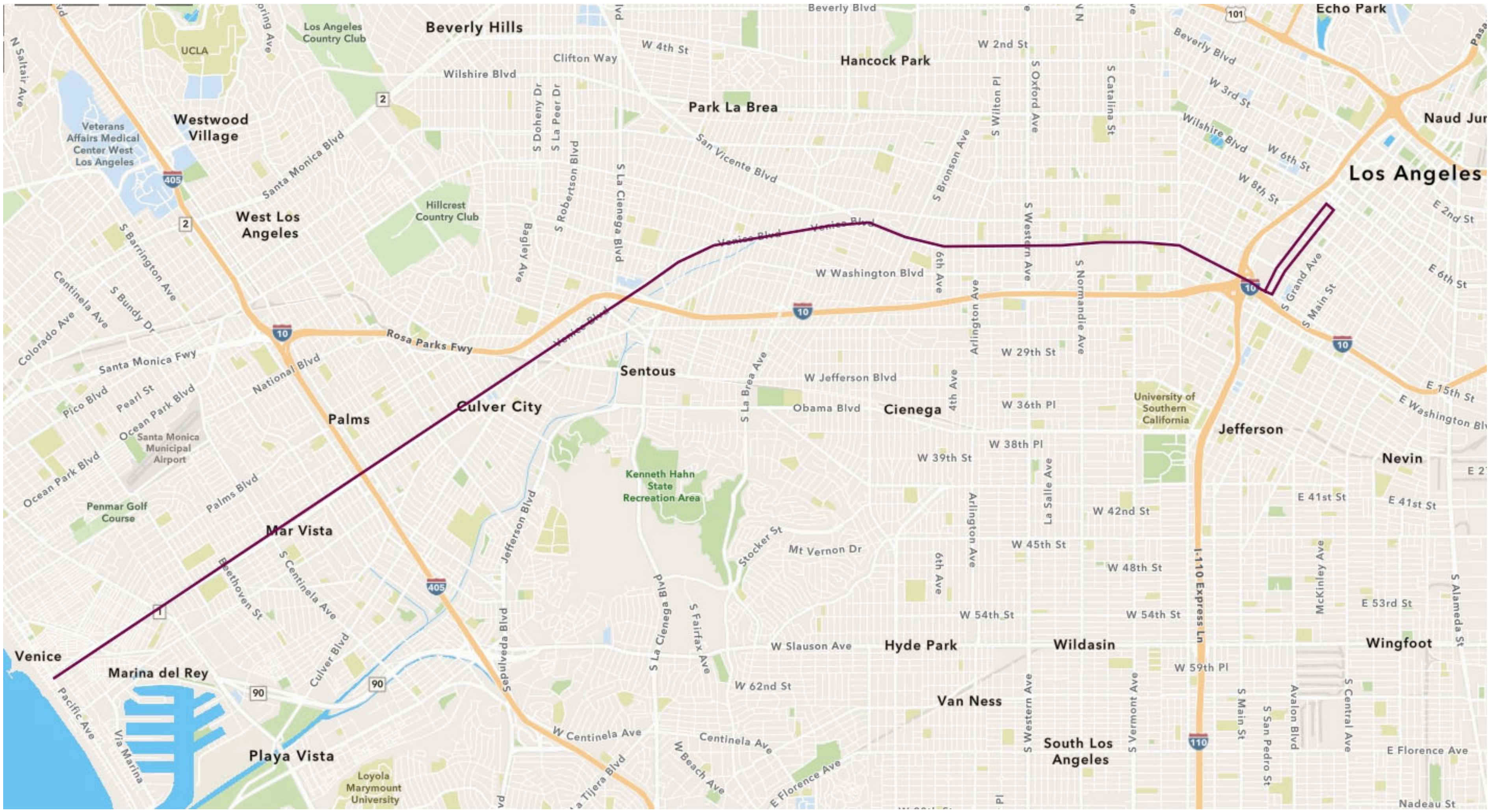
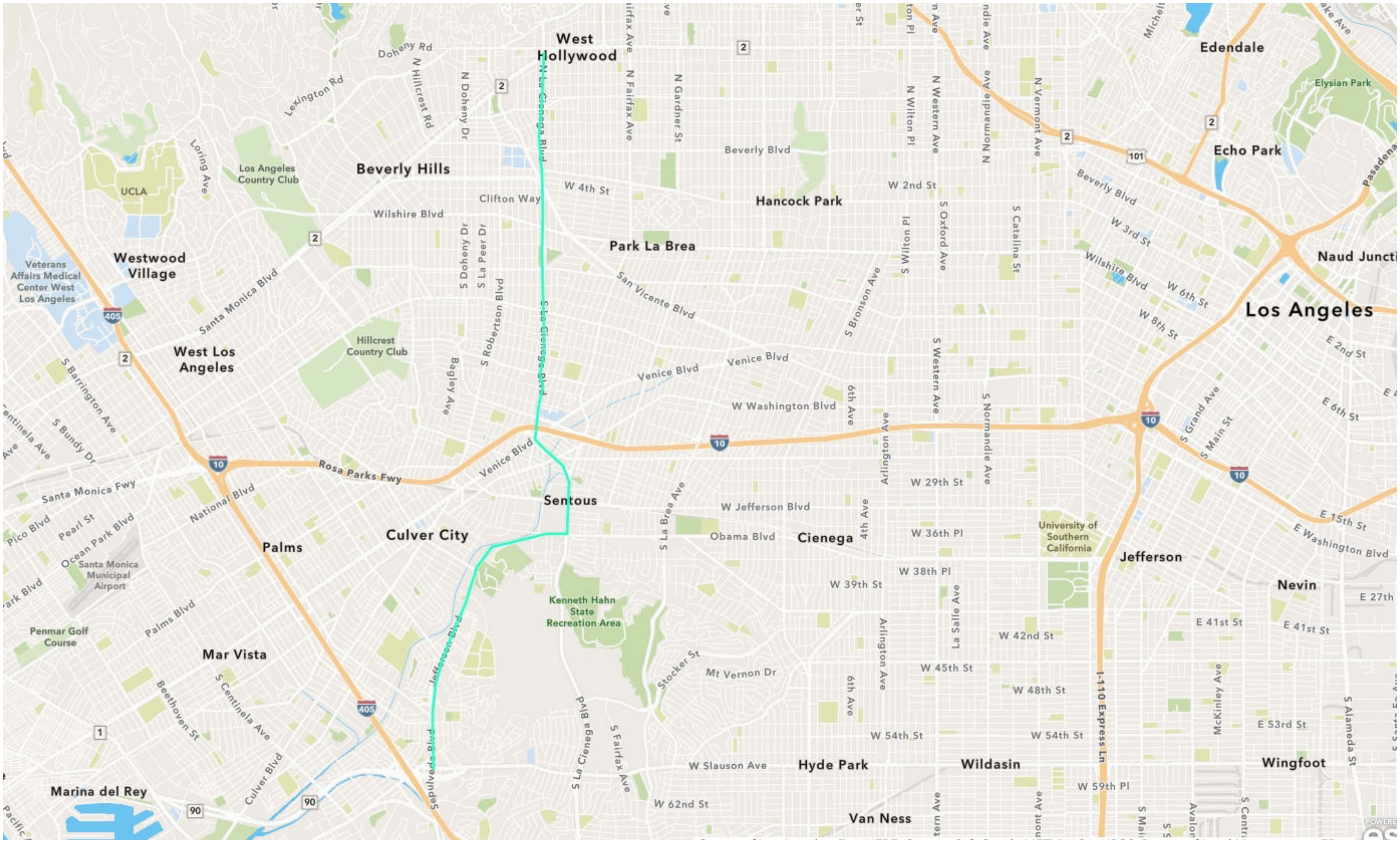


Venice

- Very high network connectivity
- Very high ridership
- High opportunity to build BRT-friendly infrastructure and realize travel time savings
- Pedestrian-friendly and street-oriented land uses
- Transit supportive policies including City of LA Community Plans and Culver City
- Strong transit-supportive policies along corridor
- Neighborhood sensitivity related to the Great Street Initiative

Metro

La Cienega

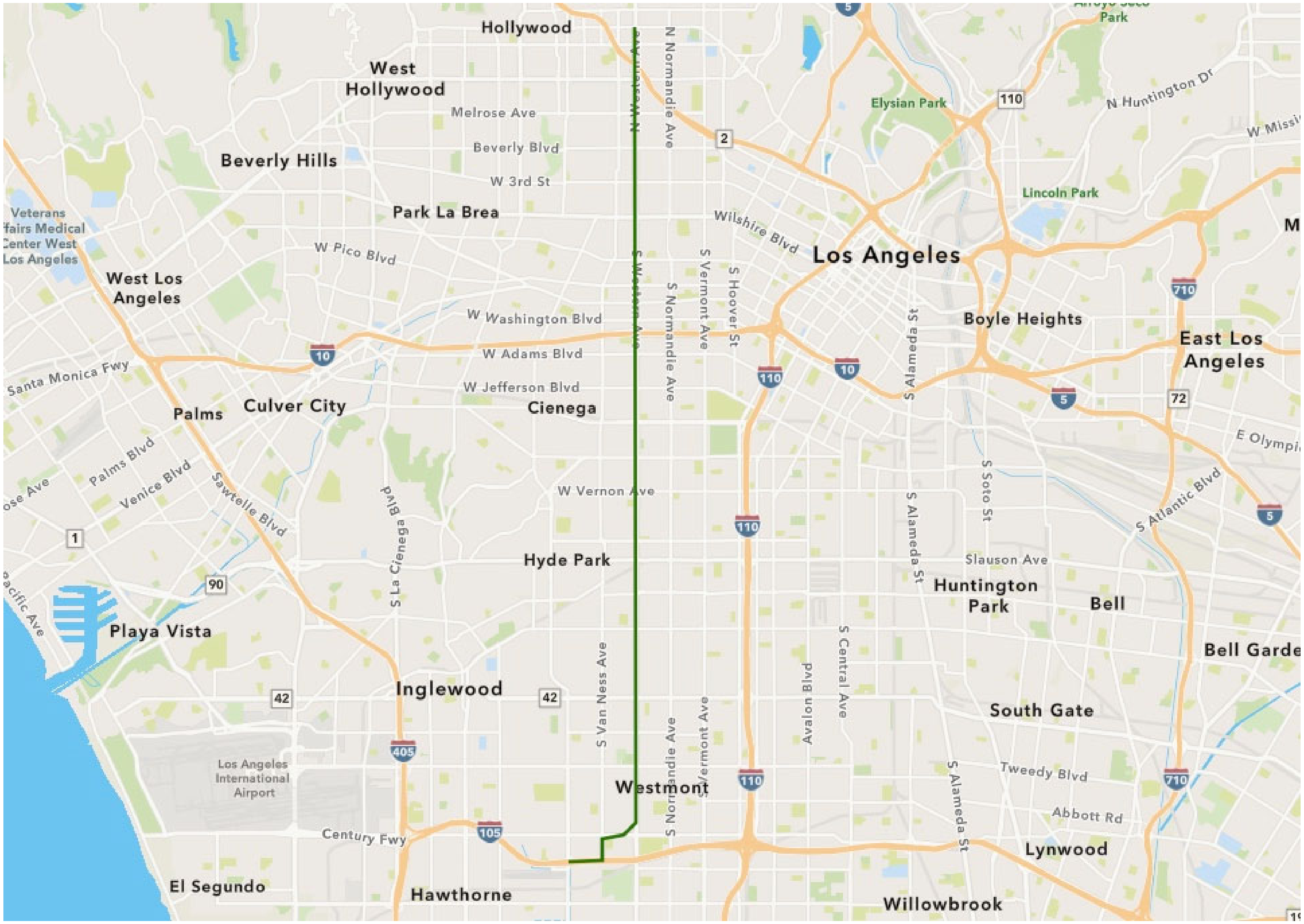

West Hollywood
Edendale
Elysian Park
Echo Park
Beverly Hills
Los Angeles Country Club
UCLA
Hancock Park
Park La Brea
Naud Juncti
Westwood Village
Veterans Affairs Medical Center West Los Angeles
Los Angeles
West Los Angeles
Hillcrest Country Club
Sentous
Culver City
Palms
Cienega
University of Southern California
Jefferson
Nevin
Santa Monica Municipal Airport
Kenneth Hahn State Recreation Area
Penmar Golf Course
Mar Vista
Marina del Rey
Hyde Park
Wildasin
Wingfoot
Van Ness
Beverly Blvd
Wilshire Blvd
Clifton Way
W 4th St
W 2nd St
San Vicente Blvd
Venice Blvd
W Washington Blvd
Rosa Parks Fwy
Santa Monica Fwy
Santa Monica Blvd
National Blvd
W Jefferson Blvd
Obama Blvd
W 29th St
W 36th Pl
W 38th Pl
W 39th St
W 42nd St
W 45th St
W 48th St
W 54th St
W Slauson Ave
W 62nd St
W 59th Pl
Mt Vernon Dr
Palms Blvd
Sepulveda Blvd
Jefferson Blvd
S La Cienega Blvd
N La Cienega Blvd
S Robertson Blvd
Bagley Ave
S La Brea Ave
S Western Ave
S Normandie Ave
I-110 Express Ln
E Washington Blvd
E 15th St
E 41st St
E 53rd St

La Cienega

- Provides high-capacity north-south network coverage on the Westside
- Transit supportive policies including City of LA Community Plans and Culver City
- Interest from Culver City and Westside Cities COG
- Moderate opportunity to build BRT-friendly infrastructure and realize travel time savings
- May overlap with future Crenshaw North project
- Low network connectivity
- Low ridership
- Low potential equity benefit

Metro

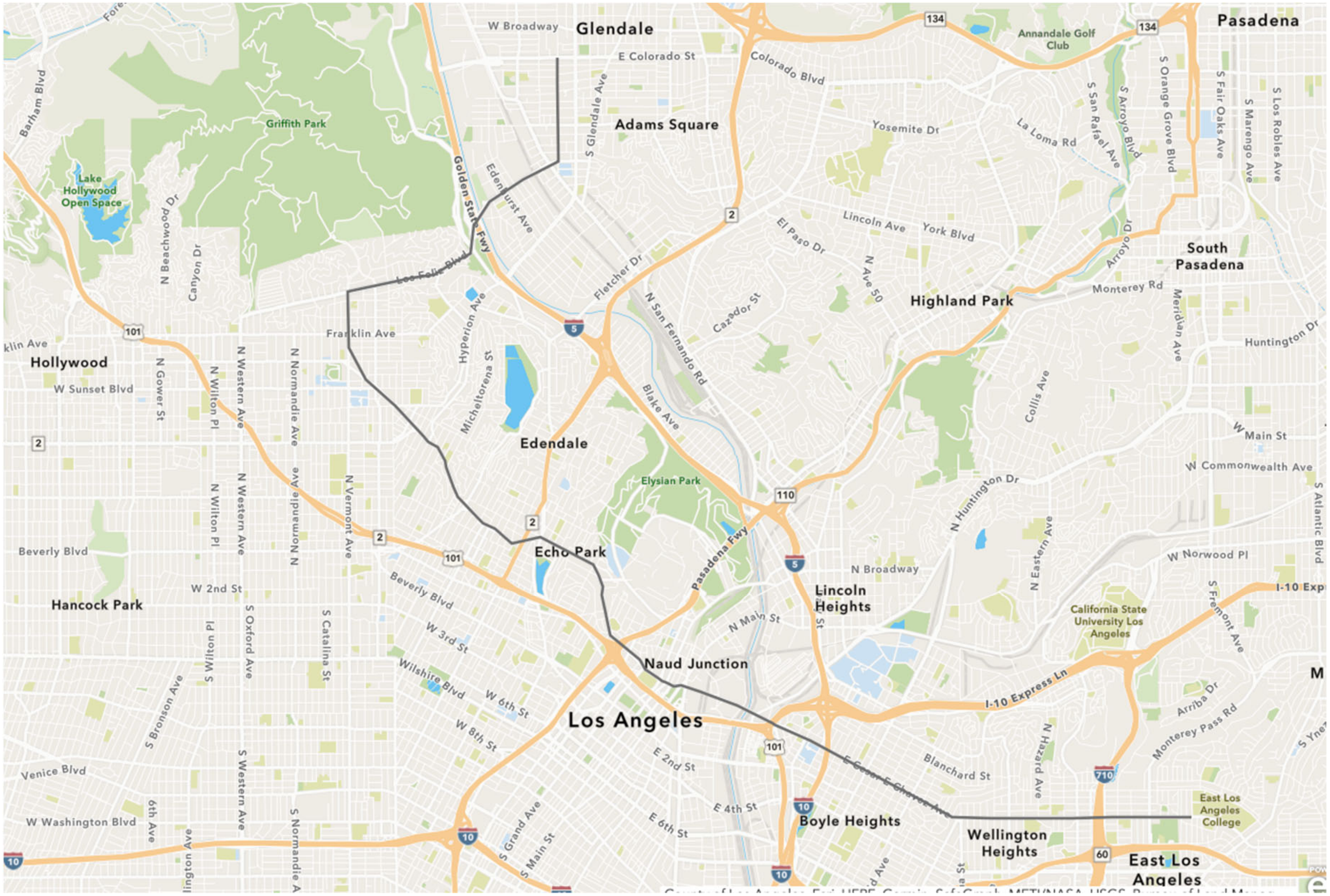
Western


Hollywood
West Hollywood
Beverly Hills
Park La Brea
Los Angeles
West Los Angeles
Culver City
Palms
Cienega
Boyle Heights
East Los Angeles
Hyde Park
Huntington Park
Bell
Playa Vista
Inglewood
South Gate
Westmont
Lynwood
El Segundo
Hawthorne
Willowbrook
Melrose Ave
Beverly Blvd
W 3rd St
Wilshire Blvd
W Pico Blvd
W Washington Blvd
W Adams Blvd
W Jefferson Blvd
W Vernon Ave
Santa Monica Fwy
Century Fwy
N Western Ave
S Western Ave
N Normandie Ave
S Normandie Ave
S Vermont Ave
S Hoover St
S Alameda St
S Soto St
S Central Ave
Avalon Blvd
S Van Ness Ave
S La Cienega Blvd
Sawtelle Blvd
Venice Blvd
Palms Blvd
Slauson Ave
Tweedy Blvd
Abbott Rd
S Atlantic Blvd
N Huntington Dr
Elysian Park
Lincoln Park
Los Angeles International Airport
Veterans Affairs Medical Center West Los Angeles

Western

- Very high equity benefit
- Connects to 4 existing rail lines; moderate network connectivity for other services
- Currently Metro's 5th highest ridership corridor with 28,000 average weekday riders
- Good mix of land uses and several TOC-supportive areas along corridor
- Runs through 3 City of LA Community Plan areas which feature or are being updated to feature TOC and transit-supportive policies
- The City of Hawthorne and the unincorporated West Athens-Westmont community also has TOC-supportive policies in place
- High-priority corridor per LADOT
- Limited opportunity to build BRT-friendly infrastructure and realize travel time savings

Cesar Chavez/Sunset



Cesar Chavez/Sunset

- Very high network connectivity
- Connects downtown Los Angeles with the San Fernando Valley
- Runs through 6 City of LA Community Plan areas which feature or are being updated to feature TOC and transit-supportive policies
- Moderate ridership
- Moderate opportunity to build BRT-friendly infrastructure and realize travel time savings

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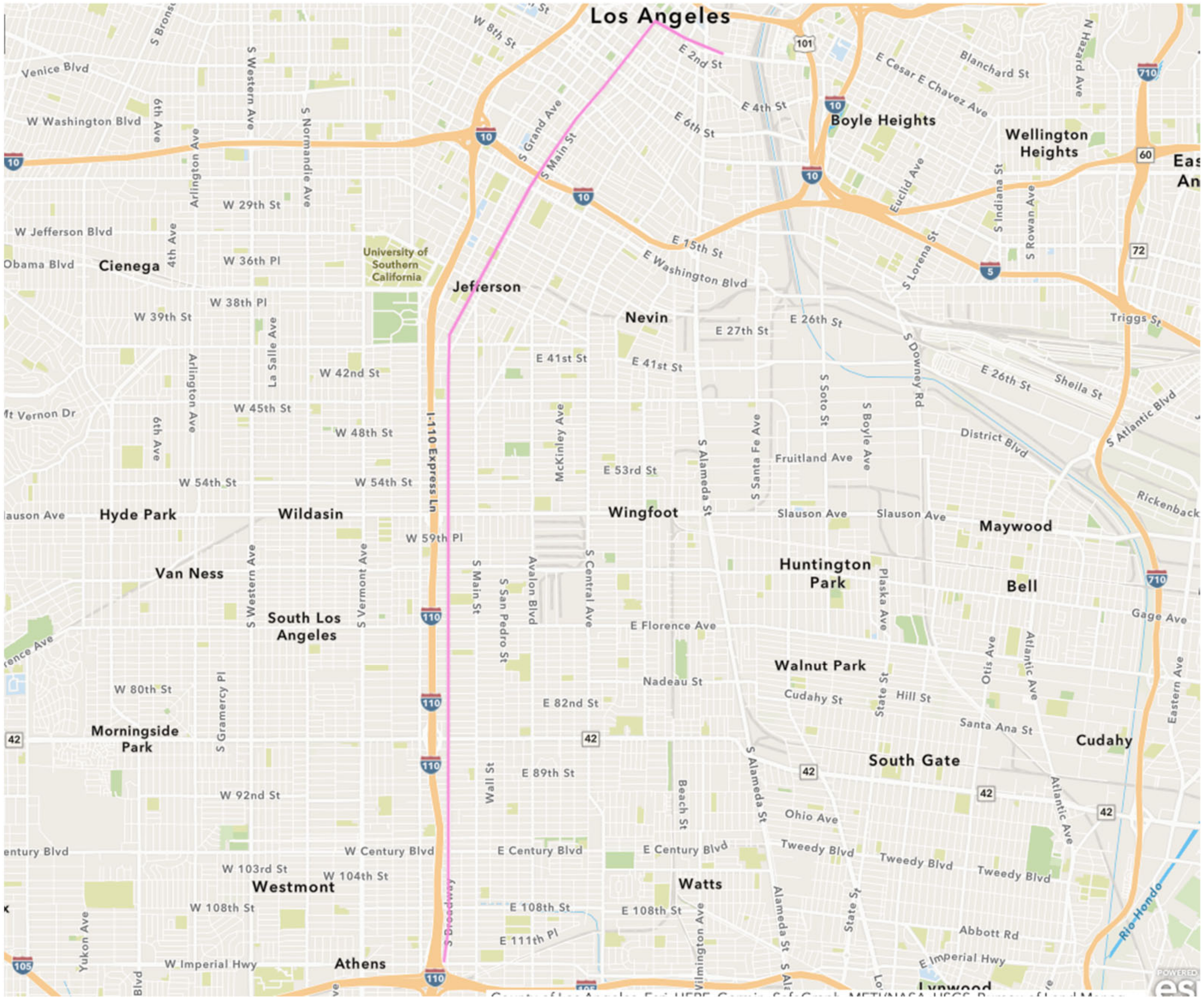
Broadway


Los Angeles
E 2nd St
Venice Blvd
W Washington Blvd
S Western Ave
S Normandie Ave
6th Ave
Arlington Ave
W 8th St
E 4th St
E 6th St
Boyle Heights
Wellington Heights
E Cesar E Chavez Ave
Blanchard St
N Hazard Ave
S Grand Ave
S Main St
W 29th St
W Jefferson Blvd
Obama Blvd
Cienega
4th Ave
W 36th Pl
University of Southern California
Jefferson
E 15th St
E Washington Blvd
Euclid Ave
S Indiana St
S Rowan Ave
S Lorena St
W 38th Pl
W 39th St
La Salle Ave
Nevin
E 27th St
E 26th St
Triggs St
E 41st St
W 42nd St
W 45th St
W 48th St
Mt Vernon Dr
I-110 Express Ln
McKinley Ave
E 53rd St
S Alameda St
S Santa Fe Ave
S Soto St
S Boyle Ave
S Downey Rd
E 26th St
Sheila St
S Atlantic Blvd
District Blvd
Fruitland Ave
W 54th St
Slauson Ave
Hyde Park
Wildasin
Wingfoot
Maywood
Rickenback
W 59th Pl
Van Ness
S Vermont Ave
S Main St
S San Pedro St
Avalon Blvd
S Central Ave
Huntington Park
Pluska Ave
Bell
South Los Angeles
E Florence Ave
Gage Ave
Walnut Park
Nadeau St
W 80th St
S Gramercy Pl
E 82nd St
Cudahy St
State St
Hill St
Otis Ave
Atlantic Ave
Eastern Ave
Santa Ana St
Morningside Park
Cudahy
South Gate
W 92nd St
E 89th St
Wall St
Beach St
Ohio Ave
Century Blvd
W Century Blvd
E Century Blvd
Tweedy Blvd
W 103rd St
W 104th St
Westmont
Watts
W 108th St
E 108th St
E 111th Pl
S Broadway
Wilmington Ave
Abbott Rd
Rio Hondo
Yukon Ave
W Imperial Hwy
Athens
E Imperial Hwy
Lynwood

Broadway

- Very high network connectivity
- Very high equity benefit
- High-priority corridor per LADOT
- Runs through 2 City of LA Community Plan areas which feature TOC and transit-supportive policies
- Moderate ridership
- Moderate opportunity to build BRT-friendly infrastructure and realize travel time savings
- A future Alternatives Analysis could consider both Broadway and Figueroa, which closely parallel each other and perform comparably

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Atlantic

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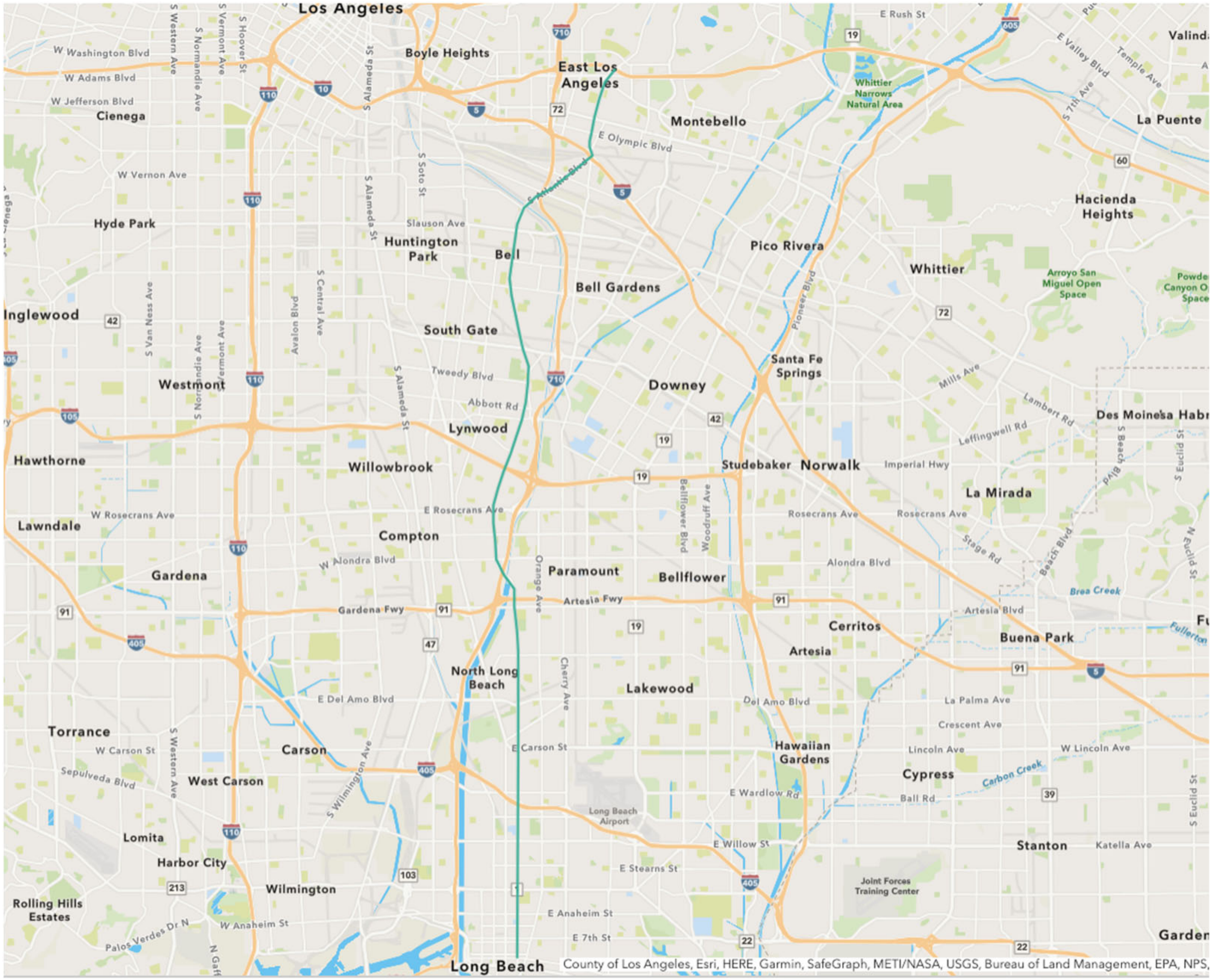

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Atlantic

- Connects East LA to Long Beach
- Interest from the Gateway Cities COG
- Moderate network connectivity
- Moderate activity for time savings
- Wide sidewalks provide good opportunity to build stations and passenger amenities
- Low ridership, but does provide access to industrial jobs for lower-income workers, addressing equity goals

Open Discussion

Questions or Comments?

Metro

Future BRT Network

Build upon strong candidate corridors identified in a multi-step screening process that used the following criteria:

NETWORK CONNECTIVITY

RIDERSHIP POTENTIAL

SURROUNDING LAND USES

EQUITY

TRIP LENGTH

EXISTING CONDITIONS

Utilize a gap analysis that:

> Considers existing and planned rail/BRT network

> Identifies gaps in coverage

> Connects future BRT corridors to one another and the Metro rail network

> Leverages corridors identified and screened through the project study

Future BRT Network Map

Next Steps

Stakeholder Input and Engagement

- TAC #12 on 9/3
- Ongoing stakeholder briefings(COG's, Electeds, Cities)

Fall 2020

- Finalize design manual and final report
- Narrow down to 3-5 priority corridors
- Future unfunded network
- Present recommendations to Board in October

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Contact Us

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Thank you!

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Fabian Gallardo
Transportation Planner
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Metro BRT Vision & Principles Study
Stakeholder Workshop
February 7, 2020
LA Metro Headquarters
9:30 – 11am

Attendance	16 Key Project Stakeholders were in attendance
Comments	• 3 written comment card submissions • 12 GIS mapping tool submissions • 2 online map comments • **17 Total Comments**
Key Stakeholders	• Armando Flores, Valley Industry Commerce Association (VICA) • Arthur Sohikian, North County Transportation Coalition • Dora Armenta, Pacoima Beautiful • Hilary Norton, California Transportation Commission (CTC) • Eli Lipmen, Move LA • Jerard Wright, BizFed • Laura Raymond, Alliance for Community Transit-LA • Nancy Pfeffer, Gateway Cities Council of Governments • Peggy Kuo, Temple City Youth Committee • Reed Alvarado, Fast Link DTLA • Bob Wolfe, Citizens Advisory Committee • Tom Chavez, Mayor Pro Tem, City of Temple City • Gloria Ohland, Move LA • Brian Bowens, Citizens Advisory Committee • Riley O'Brien, Westside Cities Council of Governments • Betina Cervantes, Cal State Los Angeles
Input Highlights	• BRT criteria should be tied to Metro Transit Oriented Communities (TOC) outcomes. BRT design criteria of stops and stations should align with implementation policies of TOC. • Design features of future BRT stops and stations should increase the efficiency and access of bus boarding and exiting. • BRT routes should intersect with and/or connect to existing major transit hubs like LAX, Union Station, Metro Transit Stations, etc. • BRT routes should connect with Metro Rail lines. • Very important for Metro to facilitate community development opportunities along BRT routes. These programs must include affordable housing programs.

	• BRT currently has a negative connotation within LA County due to North San Fernando Valley and North Hollywood to Pasadena projects. A project objective should be to improve this sentiment. • This project must consistently interact and collaborate with municipal operators to avoid service inefficiencies. • As BRT design criteria and operating standards are established and upgraded through this study, information technology support must be elevated as well. Support systems onboard buses and at stations will support future network efficiency.

Metro BRT Vision & Principles Study Stakeholder Workshop May 20, 2020 Meeting streamed online via Lifesize platform 10:00 – 11:15am		
Attendance	28 Project Stakeholders were in attendance	
Comments	• 2 GIS online map comment submissions (post workshop) • 12 questions/comments related to the presentation or study were submitted in the live chat and all were addressed during the course of the workshop.	
Key Stakeholders	• Alexander Fung, SGVCOG, • Amy Wong • Angela Babcock, SFVCOG • Armando Flores, VICA • Arthur Sohikian, NCTC • Carmen Gapuchin, Cal State LA • Chase Engelhardt • Coby King, VICA • David Leger, SBCCOG • Denny Zane, Move LA • Dora Armenta, Pacoima Beautiful • Hilary Norton, FASTLinkDTLA, CTC • Eli Kaufman, LACBC • Eli Lipmen, Move LA	• Gloria Ohland, Move LA • Jamal White • John Yi, LA Walks • Josie, SLATE-Z • Jerard Wright, BizFed • Kendal Ascunsion, LA Chamber • Kevin Shin, LACBC • Marisa Creter, SGVCOG • Reed Alvarado, FASTLinkDTLA • Riley O'Brien, WCCOG • Veronica Padilla, Pacoima Beautiful • Wilma Franco, SELA • Winnie Fong, WCCOG • Yvette Kirrin, GCCOG
Questions & Comment Highlights	• The Atlantic Corridor and Florence-Whittier corridors are the subject of GCCOG Complete Street Studies that are on-going, and therefore we will specifically be seeking additional input regarding the viability of the BRT system on these Corridors, which we can report back via our study. • To what extent will TOC/community development and opportunities for affordable housing play a role in corridor selection? • Are you looking to other Metro areas (like Houston or even San Bernardino County) for examples of how other "car-centric" cities have approached BRT?	

- Do any of the 1st priority, 15 corridors include recent Metro Board actions such as the SR60 alternative replacement to the Eastside Gold Line LRT?
- How much money was set aside in M for BRT?
- How has COVID-19 impacted BRT analysis? For instance, certain lines have seen level boardings or even increases. This indicates lifeline and essential riders need these services. Is there an opportunity to use new data to assess these lines?
- I like that Metro is making the connection between BRTs and TOCs. Since the state is supposed to be applying VMT standards starting July 1st, is Metro going to seek federal funding to support the nexus between affordable housing and BRT?
- What has Metro done to dismiss the negative connotations of BRT in the community, especially in the San Gabriel Valley?
- Are there any plans for future BRT projects in the San Gabriel Valley or the Gateway Cities subregions?
- There are "complete streets" studies underway, e.g., Venice Blvd and Atlantic. To what extent do you see that as opportunity?
- What type of existing room is needed for BRT infrastructure to be implemented?
- While I understand that your top 15 is data-driven, it is striking that none of them are north or east of downtown. The eastside and San Fernando, Conejo, Santa Clarita, and San Gabriel Valleys are all shut out. Are the criteria too narrow?
- Is there room in the funding to enable bus layover zones, transit centers and mobility hubs? Because with the region focused on increasing density, these zones will become increasingly scarce for operators to rest the bus and get their breaks.

Metro BRT Vision & Principles Study
Stakeholder Workshop
September 1, 2020
Meeting streamed online via Lifesize platform
10:00 – 11:15am

Attendance	28 Project Stakeholders were in attendance	
Comments	• 15 questions related to the presentation or study were submitted in the live chat and all were addressed during the course of the workshop. • 4 comments were submitted in the live chat (marked below in grey)	
Key Stakeholders	• Alexander Fung, SGVCOG • Yazdan Emrani, City of Glendale • Andrew Ross, LACDPW • Ann Wilson, AVJPA • Reed Alvarado, FASTLinkDTLA • Gloria Ohland, Move LA • John Yi, LA Walks • Armando Flores, VICA • Carmen Gachupin, Cal State LA • Edward Hitti, City of La Canada Flintridge • Eric Haack, Access Services • Laura Cornejo, City of Pasadena	• Dora Frietze-Armenta, Pacoima Beautiful • Angela Babcock, SFVCOG Jerard Wright, BizFed • Mark Yamarone, Metro • David Leger, SBCCOG • Eli Lipmen, Move LA • Daniel Tabor, LATTC • Riley O'Brien, WCCOG • Cynthia Cortez, SELA • Hilary Norton, FASTLinkDTLA • Arthur Sohikian, NCTC • David Kriske, City of Burbank • Elizabeth Hannon, Sutra • Jody Litvak, Metro • Maria Manzano, Best Start LA • Martha D'Andrea, LADOT

Questions & Comment Highlights	1. Was there any further clarification on the assignment of costs for BRT?
	  a. This is more "the study before the study", but we are currently on our final report, where we will be studying a high-level range of costs
	2. Is survey data available to be broken down by neighborhoods?
	  a. Some data has the zip-codes available, but it was optional
	3. What role do quality of experience standards play here? Cleanliness, safety, etc?	

4. Can we get a copy of the list of the standard details mentioned? Particularly, can the breakdown include the difference in standard between light and full BRT?
    a. Yes, we can certainly make this available.
5. Given that most of the parametric screenings in levels 1 and 2 were conducted before COVID, are there any considerations to review the trip length, travel delays, and transit suitability for corridors that were not selected for prioritization?
    a. The analysis that was conducted was not affected by COVID, although ridership has plummeted.
6. Why did La Cienga not continue south to the LAX Crenshaw Line?
7. How is network connectivity measured? It seems like La Cienga would have higher network connectivity due to the lack of north/south Rail/BRT in Westside Cities.
    a. That is a good question; would imagine because there is probably some redundancies and overlap, but we have to look at this in detail.
8. If you connected to the Greenline Station at Imperial, you may incentivize the South Bay ridership from Lomita, Torrance, and other beach cities.
9. The irony and dilemma are that the highest-ranked corridors are poor candidates to actually build the needed BRT infrastructure like the dedicated lanes, queue jumpers, etc. Given the analysis that only 2 of the Top 7 corridors you can actually build the infrastructure on, how do corridors 8 through 14 measure in terms of actually building infrastructure to given the needed bus speed improvements?
    a. All of the top 7 have strong opportunities, but some are simply better than others. Some of the corridors have some restraints.
10. With the 7 corridors prioritized for further studies, how does Metro plan on moving forward with this study?
    a. To get down to the final 3-5, with the public engagement process we are going through.
11. Would love to get a copy of the survey by neighborhood and gender.
12. What is the average per mile cost for these BRT corridors? A range is helpful.

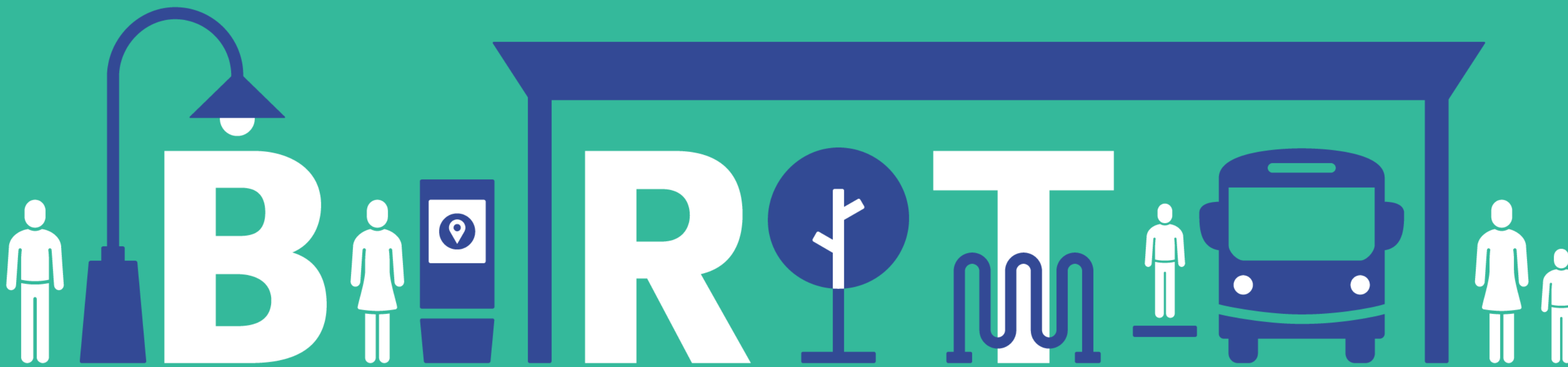
a. These numbers will be available in the final report. Typically, $100M - $300M for any of the given corridors.

13. If you had all the money you needed, how much would that be and how many lines would that fund?
14. How is equity and job access prioritized in the weighting of prioritizing funding for these BRT corridors? Are all BRT corridors planned to be served by EV buses?
15. Does Metro plan on incorporating BRT as an alternative to future Rail projects (considering the relative cost savings vs. Rail)?
    a. Not something we are looking at in this study; that is more of a Board decision.
16. Are you considering additional BRT service as part of the expansion of the ExpressLane network to build on the success of the Silver Line and use tolling as a funding sources to increase BRT service?
    a. There may be opportunities to fund some of these projects to compliment a tolling process. It is in consideration but still need to be studied through
17. Will you be available to make this presentation to community groups, if asked?
    a. Yes, we can do some presentations, if needed.

Appendix D

Stakeholder Briefings:

Full Presentation



visioning BRT

BUS RAPID TRANSIT STUDY

August 24, 2020

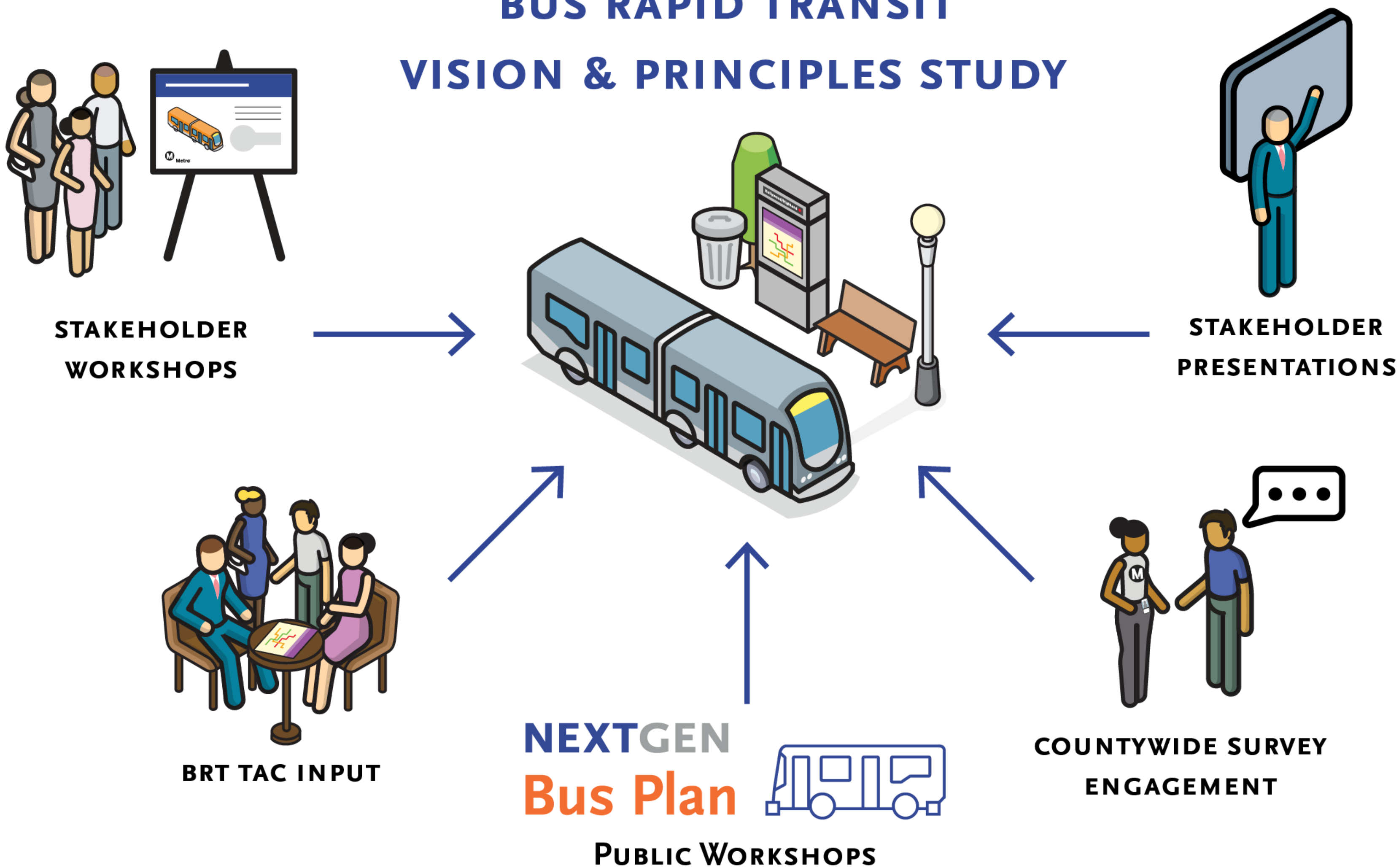
Metro

BRT Vision & Principles Study Overview

- **Study Purpose**
  - Define BRT
  - Provide the foundation for the assignment of Measure M BRT program funds
  - Support Measure M BRT projects
- **Study Outcomes**
  - BRT standards
  - Design criteria
  - Identify and prioritize BRT corridors
  - Future BRT network

Public and Stakeholder Input

BUS RAPID TRANSIT VISION & PRINCIPLES STUDY



BRT Standards

Full BRT and BRT lite

- Accommodate the complex geographical and political constraints of LA County

BRT standards

- Use both performance and prescriptive standards
- TAC discussion on thresholds for each standard

BRT Standards

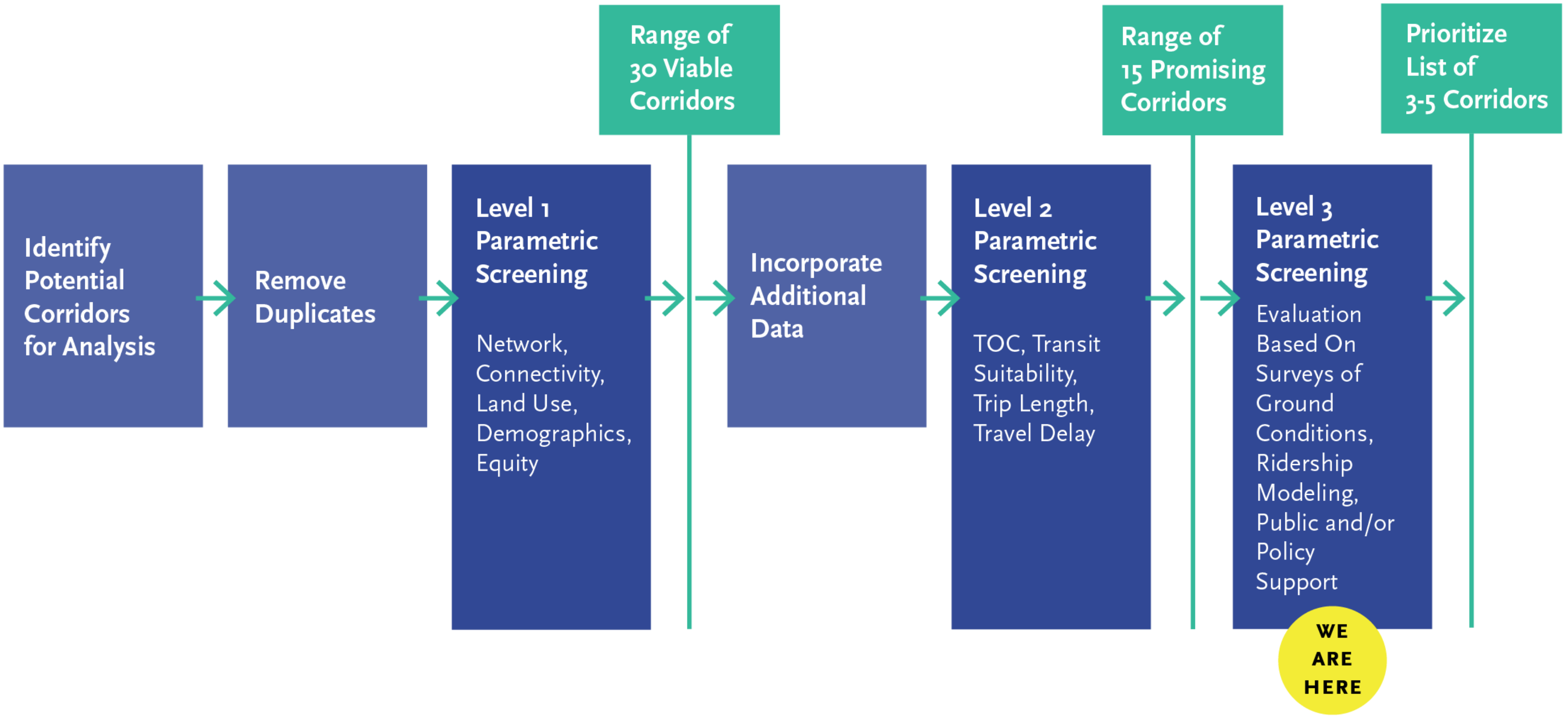
- Dwell Time
- Speed
- On-Time Performance / Reliability
- Headway
- All-Door Boarding
- Intersection Priority (TSP)
- Dedicated Lanes
- Branding
- Station Amenities

BRT Elements of Design

- BRT Operating Characteristics
- BRT Running Ways
- BRT Branding
- BRT Stations / Platforms
- BRT ITS Systems
- Integration of TOC

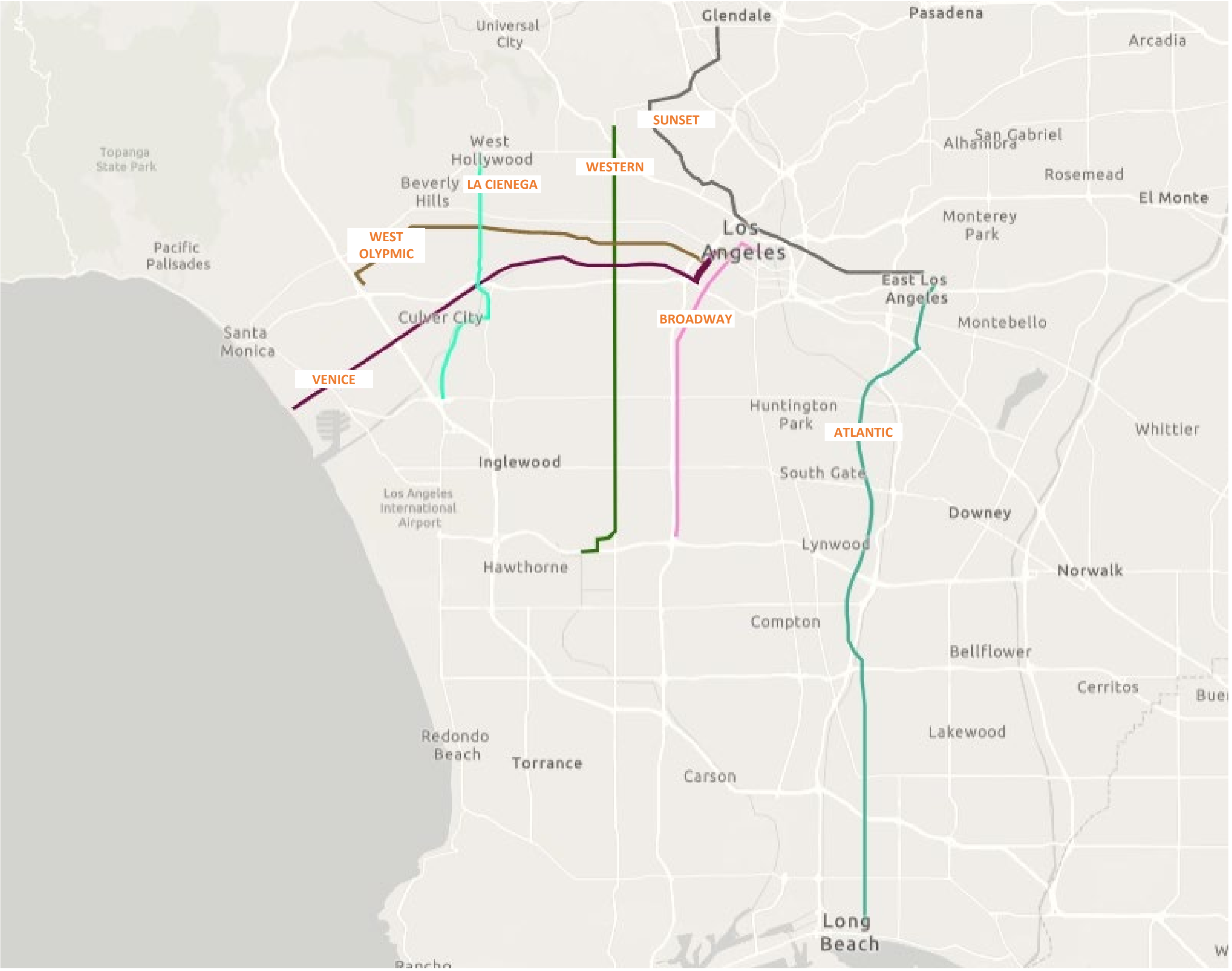
BRT Stations

Corridor Prioritization Methodology

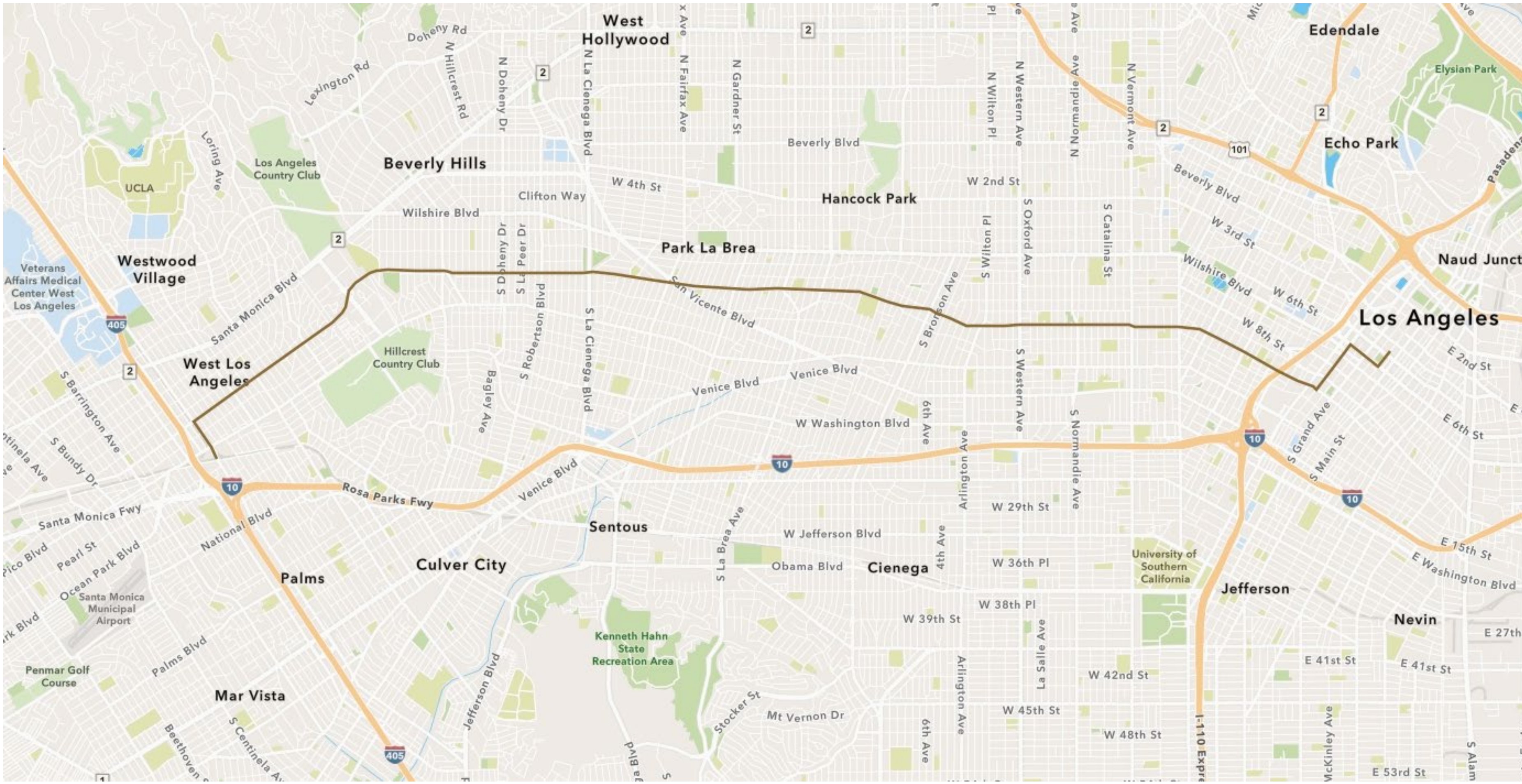


Metro

Top 7 Corridors – Map Overview



West Olympic



West Olympic

- Very high network connectivity
- Very high ridership
- High opportunity to build BRT-friendly infrastructure and realize travel time savings
- Parallel to and ½ mile from the Purple Line extension
- Potential to extend the corridor further west via Pico

Metro

Venice

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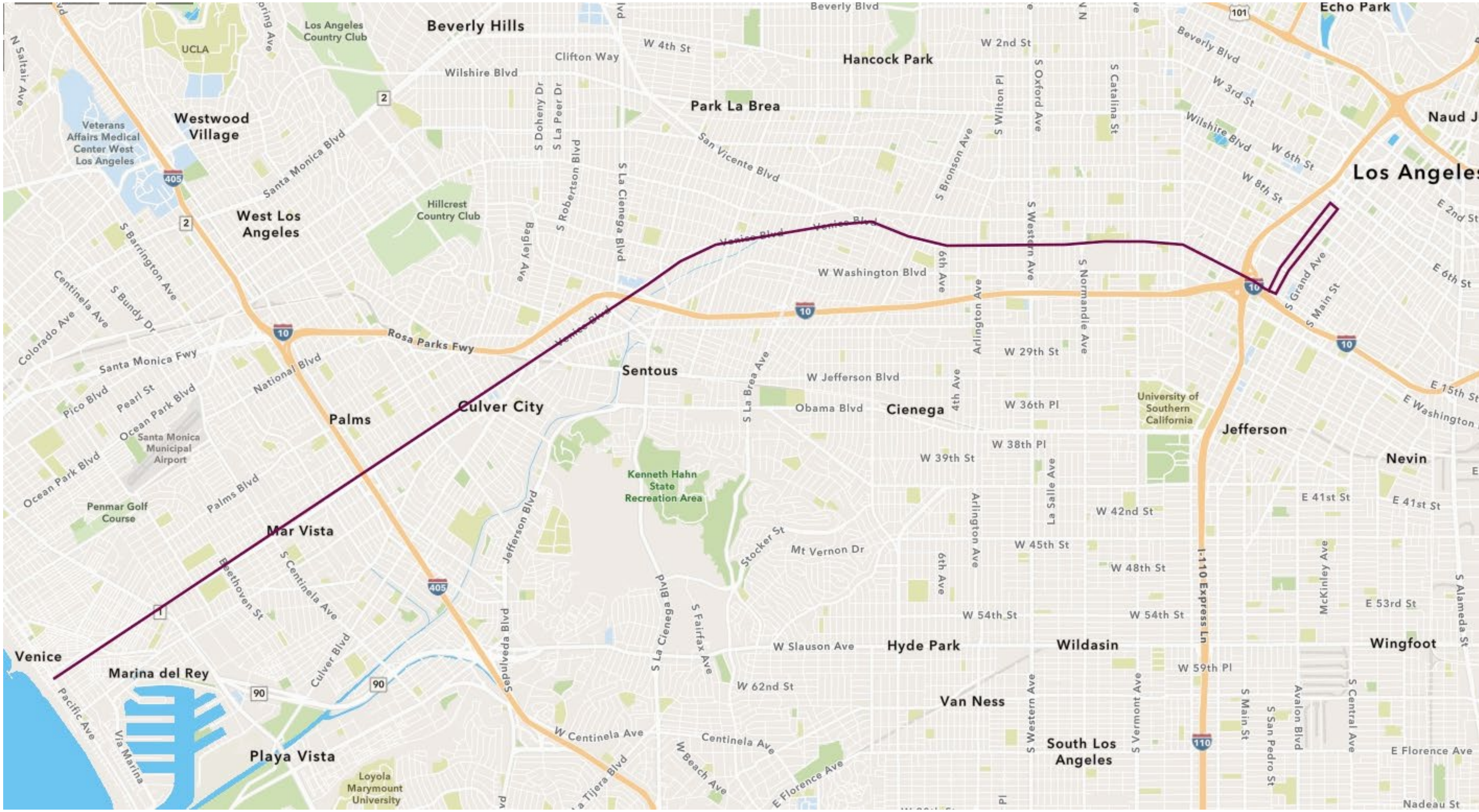

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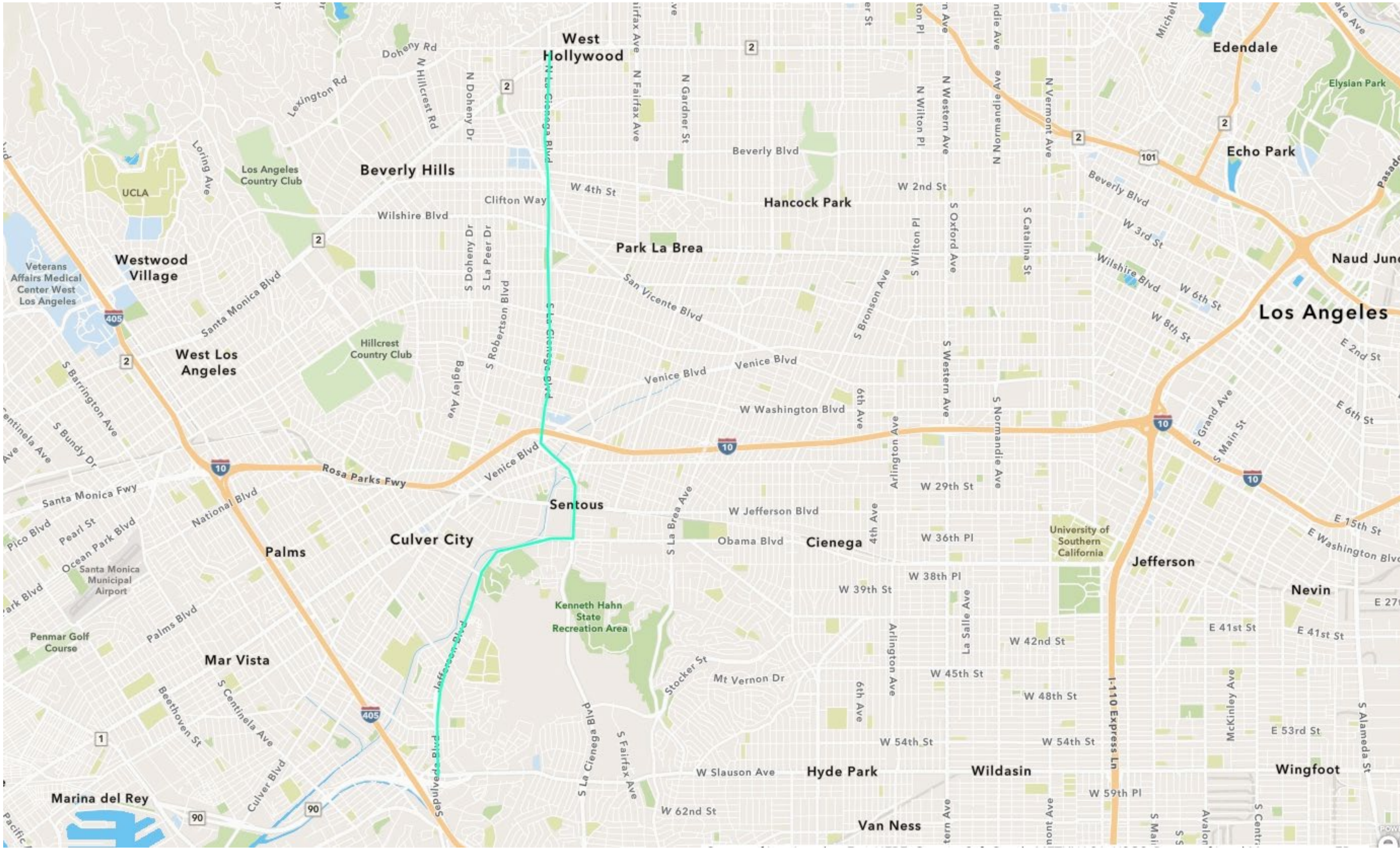
Venice

- Very high network connectivity
- Very high ridership
- High opportunity to build BRT-friendly infrastructure and realize travel time savings
- Pedestrian-friendly and street-oriented land uses
- Transit supportive policies including City of LA Community Plans and Culver City
- Strong transit-supportive policies along corridor
- Neighborhood sensitivity related to the Great Street Initiative

La Cienega

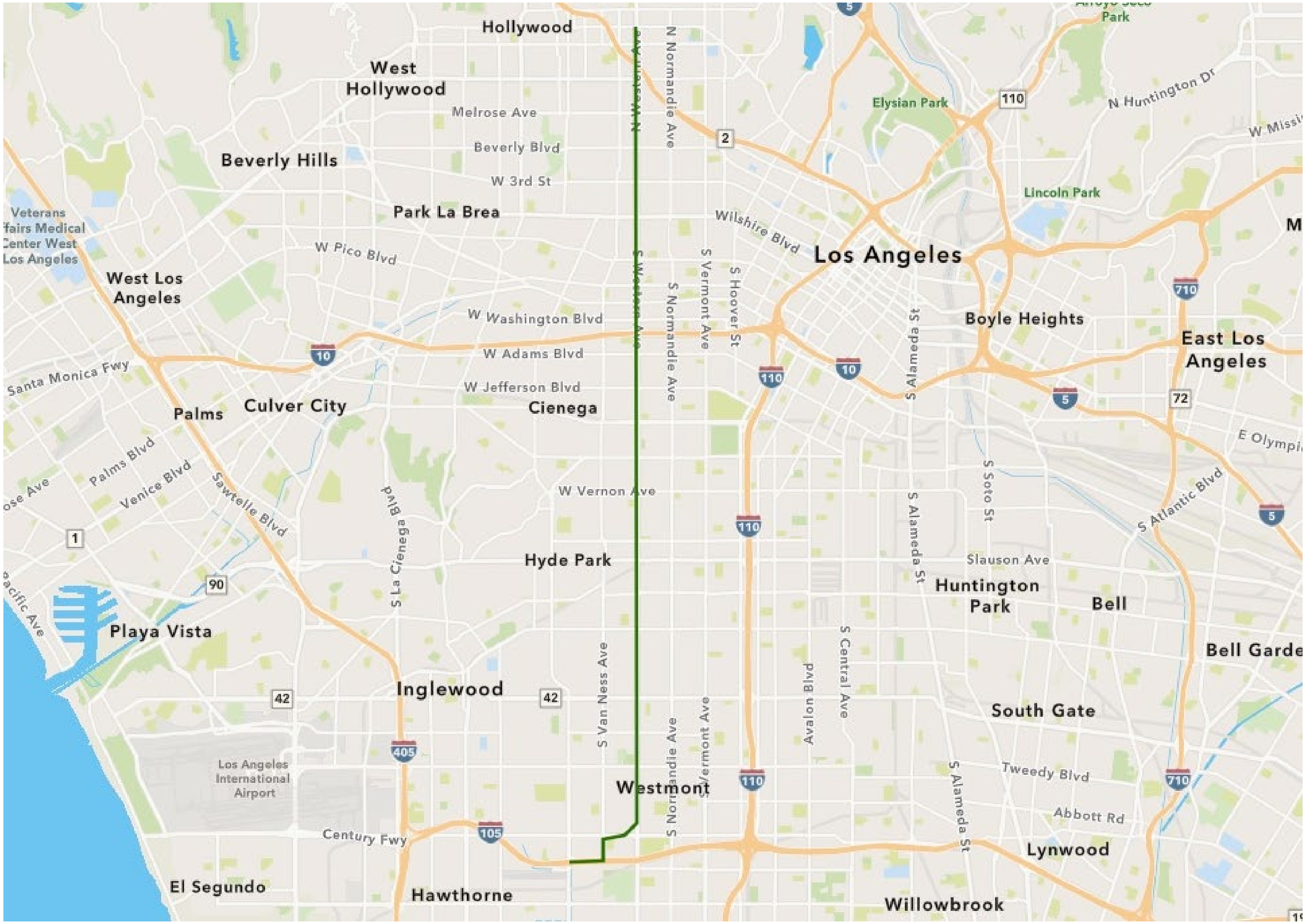

West Hollywood
Beverly Hills
Hancock Park
Park La Brea
Edendale
Echo Park
Elysian Park
Naud Juncti
Los Angeles
Westwood Village
Veterans Affairs Medical Center West Los Angeles
UCLA
Los Angeles Country Club
Hillcrest Country Club
West Los Angeles
Culver City
Sentous
Cienega
Palms
Mar Vista
Marina del Rey
Santa Monica Municipal Airport
Penmar Golf Course
Kenneth Hahn State Recreation Area
University of Southern California
Jefferson
Nevin
Hyde Park
Wildasin
Van Ness
Wingfoot
Doheny Rd
Lexington Rd
N Hillcrest Rd
N Doheny Dr
N La Cienega Blvd
N Fairfax Ave
N Gardner St
Beverly Blvd
W 4th St
Clifton Way
Wilshire Blvd
W 2nd St
N Wilton Pl
N Western Ave
N Normandie Ave
N Vermont Ave
S Doheny Dr
S La Peer Dr
S Robertson Blvd
S La Cienega Blvd
San Vicente Blvd
S Bronson Ave
S Wilton Pl
S Oxford Ave
S Catalina St
W 3rd St
W 6th St
W 8th St
Santa Monica Blvd
Loring Ave
Bagley Ave
Venice Blvd
W Washington Blvd
6th Ave
S Western Ave
S Normandie Ave
Arlington Ave
S Grand Ave
S Main St
E 2nd St
E 6th St
S Barrington Ave
S Bundy Dr
Rosa Parks Fwy
Santa Monica Fwy
National Blvd
Pico Blvd
Pearl St
Ocean Park Blvd
W 29th St
W Jefferson Blvd
S La Brea Ave
Obama Blvd
W 36th Pl
4th Ave
E 15th St
E Washington Blvd
W 38th Pl
W 39th St
La Salle Ave
E 27th St
E 41st St
W 42nd St
W 45th St
W 48th St
Stocker St
Mt Vernon Dr
Palms Blvd
Jefferson Blvd
Beethoven St
S Centinela Ave
S Fairfax Ave
I-110 Express Ln
McKinley Ave
S Alameda St
E 53rd St
W 54th St
W Slauson Ave
W 59th Pl
W 62nd St
Culver Blvd
Sepulveda Blvd

La Cienega

- Provides high-capacity north-south network coverage on the Westside
- Transit supportive policies including City of LA Community Plans and Culver City
- Interest from Culver City and WSCOG
- Moderate opportunity to build BRT-friendly infrastructure and realize travel time savings
- May overlap with future Crenshaw North project
- Low network connectivity
- Low ridership
- Low potential equity benefit

Metro

Western



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Western

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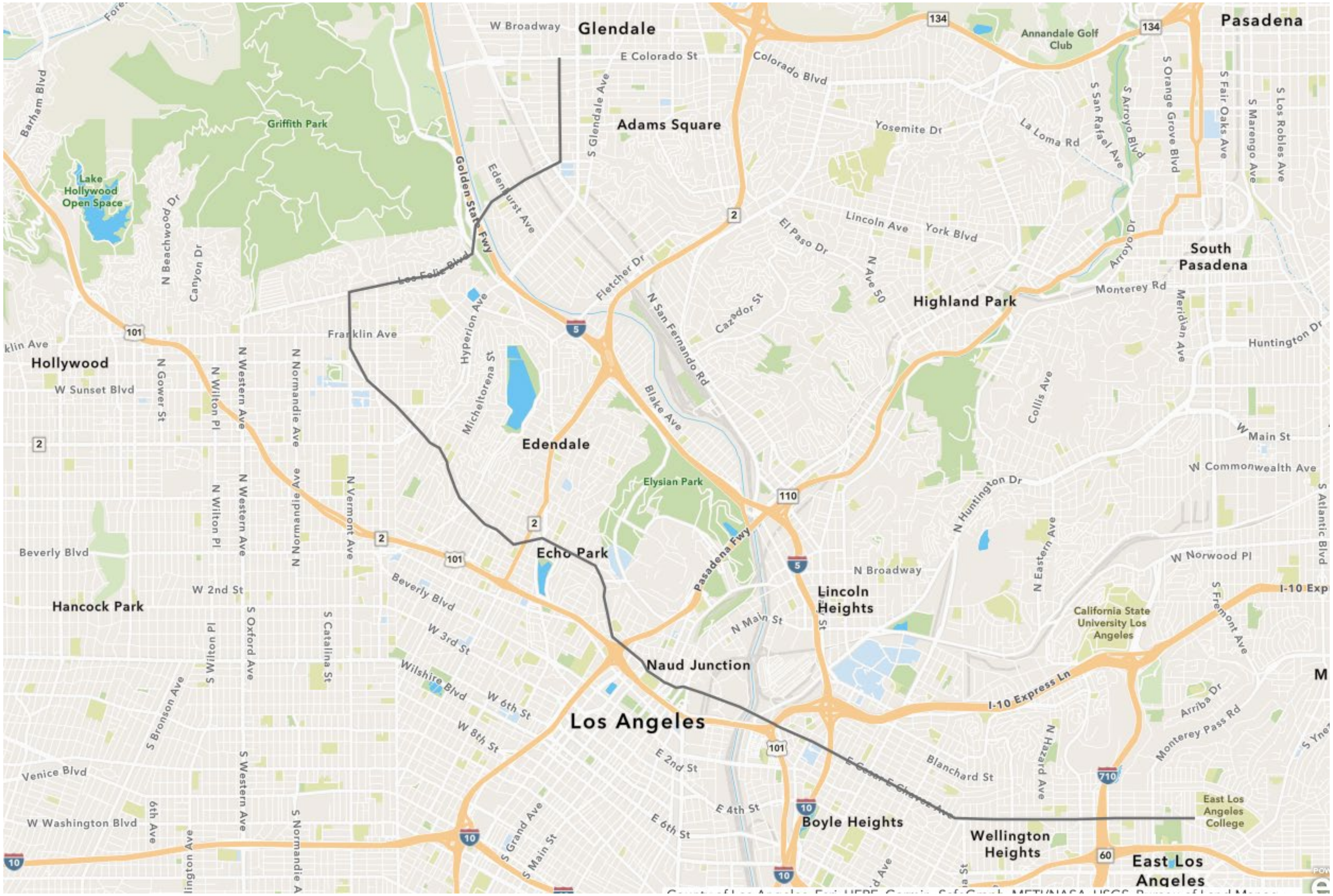
BUS RAPID TRANSIT STUDY

- Very high equity benefit
- Connects to 4 existing rail lines; moderate network connectivity for other services
- Currently Metro's 5th highest ridership corridor with 28,000 average weekday riders
- Good mix of land uses and several TOC-supportive areas along corridor
- Runs through 3 City of LA Community Plan areas which feature or are being updated to feature TOC and transit-supportive policies
- The City of Hawthorne and the unincorporated West Athens-Westmont community also has TOC-supportive policies in place
- High-priority corridor per LADOT
- Limited opportunity to build BRT-friendly infrastructure and realize travel time savings

Metro

Cesar Chavez/Sunset

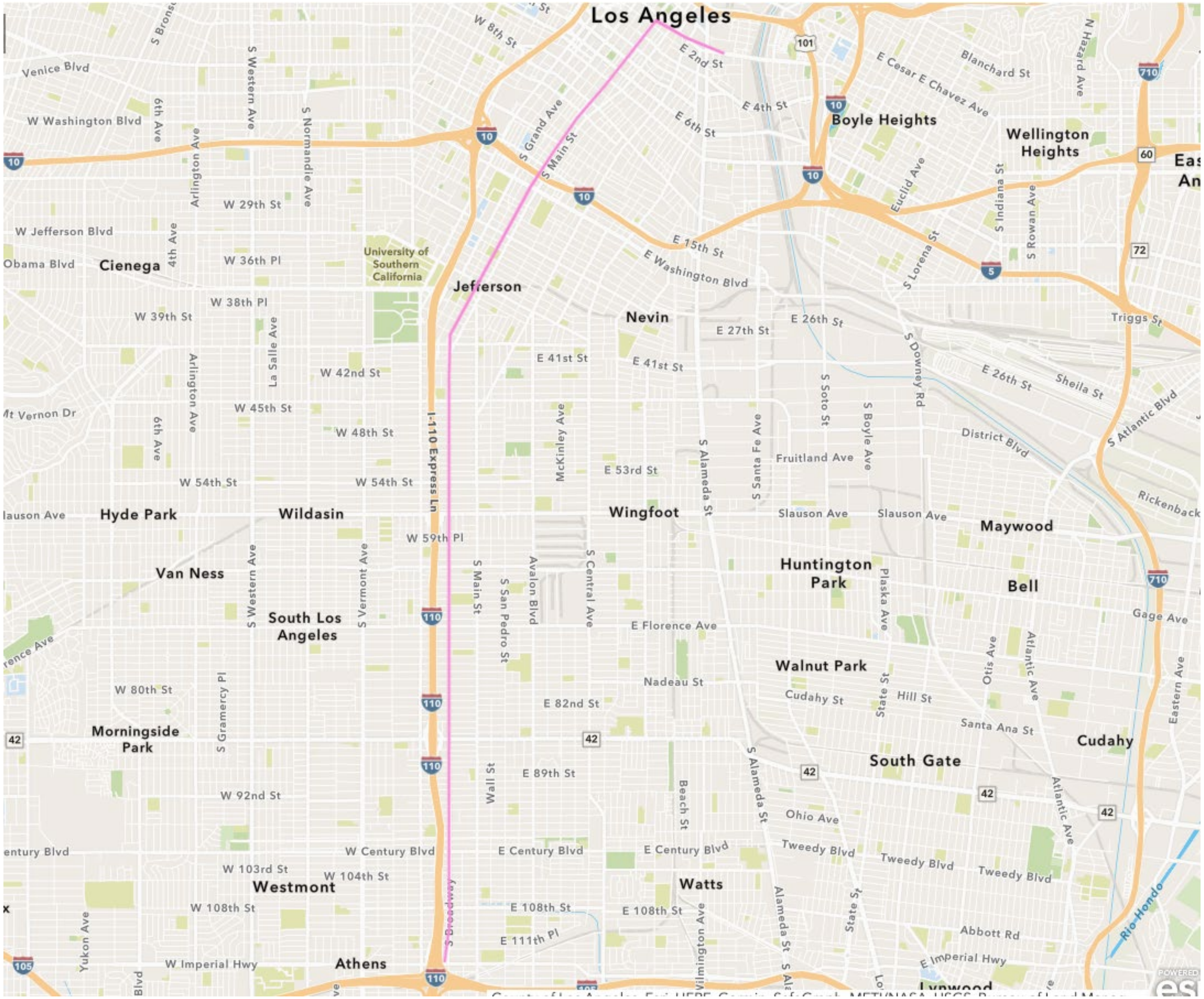


Cesar Chavez/Sunset

- Very high network connectivity
- Connects downtown Los Angeles with the San Fernando Valley
- Runs through 6 City of LA Community Plan areas which feature or are being updated to feature TOC and transit-supportive policies
- Moderate ridership
- Moderate opportunity to build BRT-friendly infrastructure and realize travel time savings

Metro

Broadway



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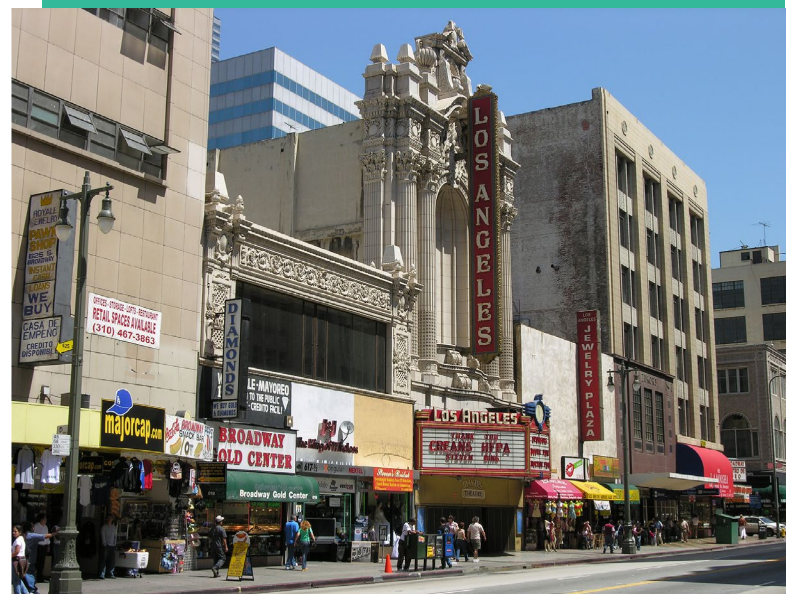
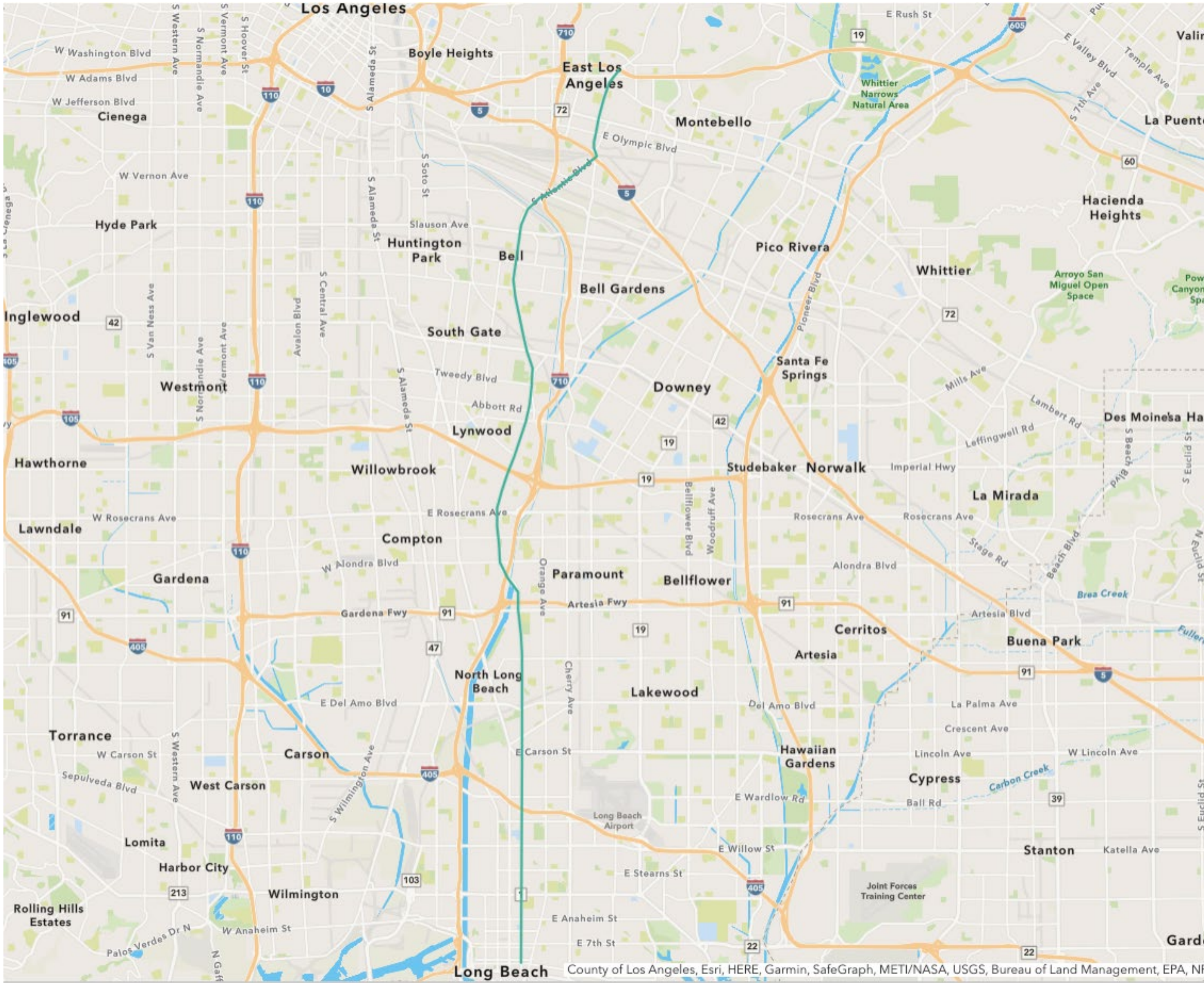
Broadway

- Very high network connectivity
- Very high equity benefit
- High-priority corridor per LADOT
- Runs through 2 City of LA Community Plan areas which feature TOC and transit-supportive policies
- Moderate ridership
- Moderate opportunity to build BRT-friendly infrastructure and realize travel time savings
- A future Alternatives Analysis could consider both Broadway and Figueroa, which closely parallel each other and perform comparably



Atlantic

visioning BRT
BUS RAPID TRANSIT STUDY



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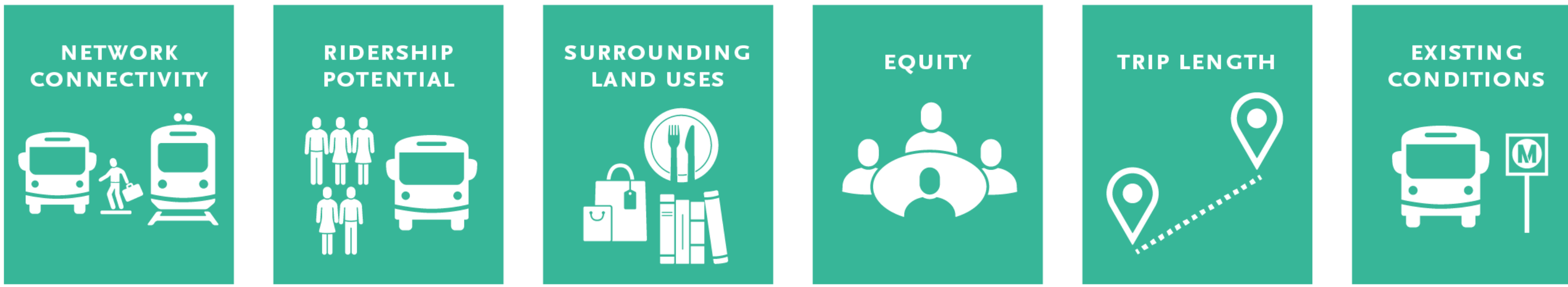
Atlantic

- Connects East LA to Long Beach
- Interest from the Gateway Cities COG
- Moderate network connectivity
- Moderate activity for time savings
- Wide sidewalks provide good opportunity to build stations and passenger amenities
- Low ridership, but does provide access to industrial jobs for lower-income workers, addressing equity goals

Future BRT Network

Build upon strong candidate corridors identified in a multi-step screening process that used the following criteria:



Utilize a gap analysis that:

> Considers existing and planned rail/BRT network

> Identifies gaps in coverage

> Connects future BRT corridors to one another and the Metro rail network

> Leverages corridors identified and screened through the project study

Metro

Contact Us

Thank you!

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Los Angeles County
Metropolitan Transportation
Authority
One Gateway Plaza
3rd Floor Board Room
Los Angeles, CA

File #: 2021-0147, **File Type:** Motion / Motion Response **Agenda Number:** 16.1.

**PLANNING AND PROGRAMMING COMMITTEE
MARCH 17, 2021**

Motion by:

DIRECTORS BONIN, SOLIS, AND HAHN

Related to Item 16: BRT Vision & Principles Study

Measure M catalyzed Metro's Bus Rapid Transit (BRT) network by funding multiple lines identified by subregions through a bottoms-up planning process and by creating a new countywide BRT program. The BRT Vision & Principles Study advances Measure M's commitment to build out a unified countywide BRT network. While ambitious, the proposed pace of one BRT project per decade is simply not fast enough to meet the region's mobility, sustainability, and equity goals. Bus riders stuck in traffic today deserve rapid transit now. Metro needs a BRT Early Action Program to accelerate the benefits of BRT to more corridors more quickly.

In parallel with the BRT Vision & Principles Study, Metro completed and has begun implementing the NextGen Bus Plan to realign and speed up bus service systemwide. NextGen's Tier 1 bus network provides high-frequency, all-day service along Metro's highest ridership routes. The NextGen Speed & Reliability Working Group has already begun delivering bus priority projects on particularly congested bus routes. These routes are also targeted for customer experience improvements, including bus stop amenities, real-time arrival information, and all-door boarding. These features are a core subset of the "BRT-Lite" standards in the Vision & Principles Study.

Metro should align its BRT work program with NextGen and the Better Bus Initiative to deliver bus improvements at scale as quickly as possible across the entire network. This approach should roll out BRT features systemwide whenever feasible, starting with high-ridership lines. Where there is alignment between the Vision & Principles strategic BRT network and NextGen's Tier 1 network, the BRT program should develop early action projects that can be delivered immediately by leveraging Measure M with other Metro and municipal funds. Metro should pilot this early action/quick build approach on the Top 7 Corridors identified in the Vision & Principles Study.

SUBJECT: AMENDMENT TO BRT VISION & PRINCIPLES STUDY

RECOMMENDATION

We, therefore move, that the Board adopt the recommendations of the BRT Vision & Principles Study staff report (Item 16).

WE, FURTHER, MOVE that the Board direct the Chief Executive Officer to report back to the Board in June 2021 with a BRT Early Action Program that includes the following:

1. Advancing the Broadway corridor as a first decade Measure M project, as recommended by staff.

2. Identifying the essential elements of a “quick build” approach to BRT, based on the BRT Vision & Principles Study and experience from the NextGen Bus Speed & Reliability Working Group.

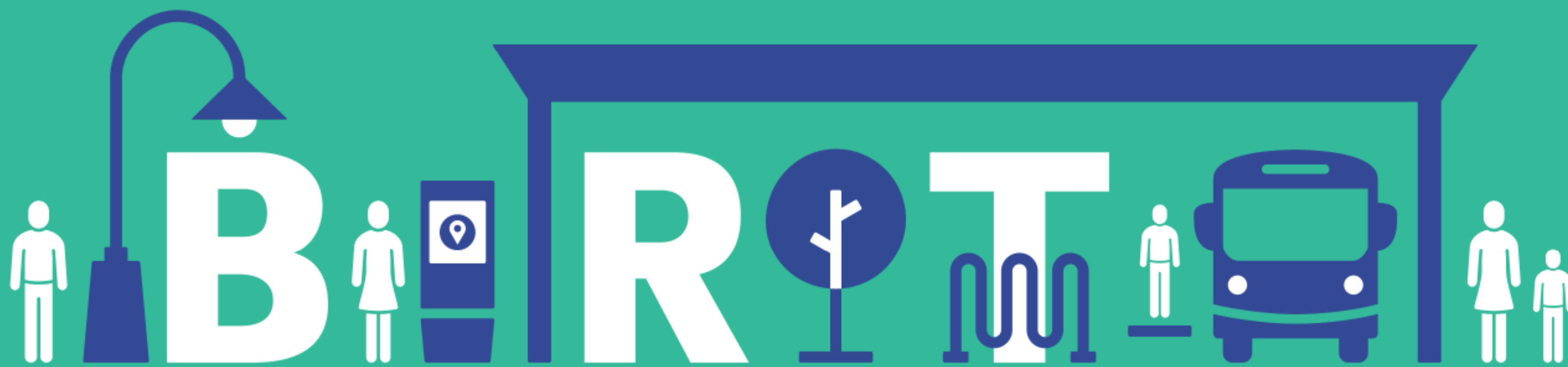
3. Consulting with Metro Operations, the Office of Equity and Race, local jurisdictions, and municipal operators to identify which of the Top 7 Corridors would be suitable for a quick build approach, including consideration of parallel NextGen Tier 1 corridors. **Hahn Amendment:** Additionally, evaluate extending the Western Ave BRT corridor to San Pedro.

4. Pursuing a near-term delivery strategy for each of the identified early action corridors, with emphasis on quick build transit priority improvements and leveraging city and county partnerships to provide BRT features, including pavement, striping, signal priority, and street furniture.

5. Systemwide implementation of All Door Boarding, starting with NextGen Tier 1 lines.

6. Estimated costs and staffing needed and opportunities to leverage Measure M dedicated Countywide BRT funding to accomplish the above work.

###



visioning BRT

BUS RAPID TRANSIT STUDY

Planning & Programming Committee

March 17, 2021

Metro

Visioning BRT Study Overview

Study Purpose - Consistent with Measure M Countywide BRT Expansion Guidelines

- Define BRT
- Evaluate potential BRT corridors
- Provide the foundation for the assignment of Measure M BRT program funds

Study Outcomes

- BRT Standards
- Design Guidelines
- Identify and prioritize BRT corridors

What We Heard

- Connectivity is essential
- Coordinate with municipal operators and cities
- Benefits of BRT not well understood
- Leverage Metro policies
- Operational and design details should be sharpened
- The fundamentals matter

BRT Standards

Provides the foundational definition of BRT

- Tiered to provide flexibility
- Use both prescriptive- and performance-based criteria

- Dwell Time
- Speed
- On-Time Performance / Reliability
- Headway
- All-Door Boarding
- Intersection Priority (TSP)
- Dedicated Lanes
- Branding
- Station Amenities

Metro

BRT Design Guideline Manual

- BRT Operating Characteristics
- BRT Running Ways
- BRT Branding
- Integration of TOC
- BRT ITS Systems
- BRT Stations / Platforms

Top 5 BRT Corridors

Corridor Prioritization

- Three-Step Screening Process
  - Demographics
  - Connectivity
  - Land Use
  - Equity
  - TOC
  - Transit Suitability
  - Trip Length
  - Travel Delay
  - Ridership
  - Field Checks
  - Public and/or Policy Support

Metro

Recommended Top Corridor

visioning BRT
BUS RAPID TRANSIT STUDY

Broadway - 1st St to Imperial Hwy

- High network connectivity
- High equity score
- Next Gen Tier 1 corridor with five-minute frequencies
- Identified need to address bus delays due to congestion
- Opportunity to leverage planned city initiatives
- A future Alternatives Analysis could consider parallel corridors on both Figueroa and Main

Next Steps

- Continued coordination with current BRT corridor projects to ensure consistent application of standards and design guidelines
- Further refinement of the design guidelines into design criteria
- Return to the Board with a programming recommendation to advance the Broadway corridor into project development

Metro