ATTACHMENT B

OC TRANSIT VISION

Transit Opportunity Corridors

Line Evaluation

October 2017

NELSON
NYGAARD

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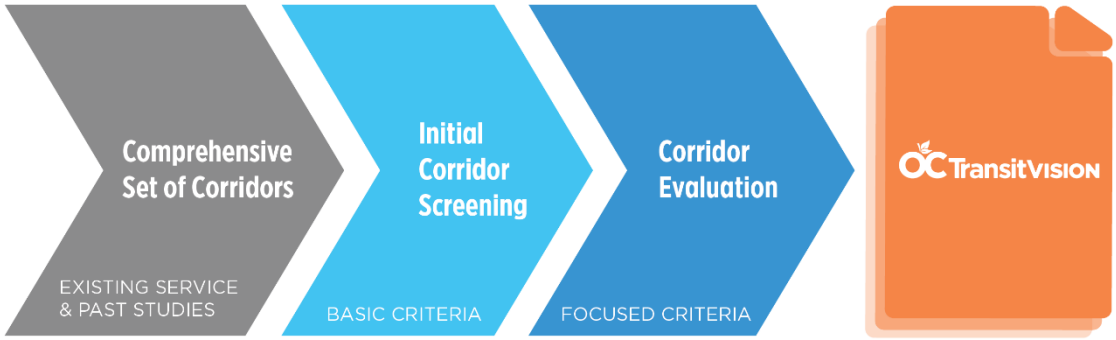
1 EXECUTIVE SUMMARY

This report describes the final evaluation of Transit Opportunity Corridors (TOCs) for the OC Transit Vision project. TOCs are those corridors in Orange County that—based on an initial screening of more than 30 corridors—are candidates for investment in high-quality transit service, including high-capacity or rapid transit service using modes such as rapid streetcar, bus rapid transit, and rapid bus on arterial corridors and Freeway BRT on state routes and interstates (see the State of OC Transit report for more information on transit modes).

Figure 1 illustrates the screening and evaluation process, which has included the identification of candidate corridors, screening of those corridors, and detailed evaluation and prioritization of the TOCs (the focus of this report).

Figure 1 Corridor Evaluation Process



This report is organized into five chapters. Chapter 2 includes a description of the evaluation framework. Chapter 3 summarizes the initial screening and identification and definition of the 11 transit lines evaluated in this document. Chapter 4 details findings from that evaluation. Chapter 5 identifies potential next steps for advancing the TOCs.

Following is a brief summary of each chapter:

SCREENING AND EVALUATION CRITERIA

In this chapter, the evaluation framework used for both initial screening and the detailed evaluation is described. The 29 performance metrics in the framework are based on the previously developed and adopted OC Transit Vision goals and objectives, and are organized into the following 11 categories:

- Speed and Reliability
- Ridership/VMT Reduction
- Density/Connections to Activity Centers

- Multimodal Connectivity
- Capacity
- Safety
- Passenger Comfort/Amenities
- Equity
- Economic Development
- Transit-Supportive Policy
- Cost-Effectiveness/Productivity

TRANSIT OPPORTUNITY CORRIDORS

In this chapter, results of the initial screening are summarized and the process for developing the TOC lines evaluated in this report is described. That process involved converting the ten TOCs recommended for detailed evaluation at the conclusion of the initial screening into 11 transit lines that could be subjected to measures of route (and not just corridor) performance such as productivity and cost-effectiveness. This required initial assignment of modes, of which four were used: "rapid" streetcar (featuring transit-only lanes), bus rapid transit (also with transit-only lanes), rapid bus (without transit-only lanes, but with other transit-priority features), and freeway-based (rather than arterial-based) BRT. Based on projected demand, network connectivity, and available right-of-way, the following TOC lines were developed:

- North Harbor Boulevard-Santa Ana Boulevard: Rapid streetcar or bus rapid transit (BRT) between Cal State Fullerton and the Santa Ana Regional Transportation Center, primarily via Harbor Boulevard (and including the OC Streetcar alignment currently in design)
- Westminster Avenue-Bristol Street: Rapid streetcar or BRT between the Goldenwest Transportation Center and the University of California, Irvine, via 17th Street/Westminster Avenue and Bristol Street (including short segments of Main Street and the OC Streetcar alignment)
- Harbor Boulevard South: BRT or rapid bus on Harbor Boulevard between 17th Street/Westminster Avenue, and Hoag Hospital in Newport Beach
- State College Boulevard: BRT or rapid bus on Bristol Street and State College Boulevard between the Brea Mall and Downtown Santa Ana
- Beach Boulevard: Rapid bus on Beach Boulevard between the Fullerton Park-and-Ride and Downtown Huntington Beach
- Main Street: Rapid bus on Main Street between Anaheim Region Transportation Intermodal Center and the South Coast Plaza Park-and-Ride
- La Palma Avenue-Lincoln Avenue: Rapid bus on La Palma Avenue and Lincoln Avenue between Hawaiian Gardens and the Anaheim Canyon Station
- Chapman Avenue: Rapid bus on Chapman Avenue from Hewes Street to Beach Boulevard,
- McFadden Avenue-Bolsa Street: Rapid bus on McFadden Avenue and Bolsa Avenue from Goldenwest Transportation Center to Larwin Square
- Interstate 5 (I-5): Freeway BRT on I-5 from the Fullerton Park-and-Ride to Mission Viejo/Laguna Niguel Station
- State Route 55 (SR-55): Freeway BRT on SR-55 from the Santa Ana Regional Transportation Center to Hoag Hospital in Newport Beach

EVALUATION RESULTS

In this chapter, the evaluation results are described on a criterion-by-criterion basis.

CONCLUSION

Findings

The findings may be summarized as follows:

- The corridors evaluated for rapid streetcar/BRT lines, in particular North Harbor/Santa Ana, outperformed other lines by a wide margin, scoring higher across a broad range of categories. They were also projected, however, to have the highest capital costs.
- Performance among BRT and rapid bus projects varied, with lines on Main, McFadden/Bolsa, State College and Beach scoring highest overall (the highest projected ridership was in the La Palma/Lincoln corridor).
- Freeway BRT projects performed relatively well, in part due to their speed advantages and the proximity of major destinations to freeway interchanges.

Corridor Potential Next Steps

The corridor potential next steps may be summarized as follows:

- Conduct corridor studies for North Harbor/Santa Ana and Westminster/Bristol Corridors.
- Implement Bravo! Route 529 (Beach).
- Study feasibility of upgrading Main corridor from Xpress to Bravo! service.
- Develop strategy for incremental speed and amenity improvements for existing and future Bravo! Corridors.
- Conduct a network study of "freeway BRT" corridors and potential project design elements.

2 SCREENING AND EVALUATION CRITERIA

The OC Transit Vision corridor screening and evaluation criteria developed as part of the OCTA Transit Investment Framework are shown in Table 1. The criteria are based on and align with the OC Transit Vision adopted vision and goals[1]. The initial screening used a smaller number of criteria than the more detailed evaluation, which is typical for a process in which a large number of candidate corridors must be analyzed.

The screening and evaluation criteria measured both potential project performance as well as corridor characteristics such as population and employment density, transit propensity of the population based on demographic analysis, and other transit-supportive factors. The screening phase focused on corridor characteristics, while the evaluation phase focused on potential project performance based on preliminary definition of mode, design of the right-of-way, and stop locations. Note that some criteria were modified slightly during the evaluation process based on available data.

[1] The vision is: "Provide compelling and competitive transit service that expands transportation choices for current riders, attracts new riders, and equitably supports immediate and long-term mobility in Orange County." Goals included "Enhance" ("Make it more desirable to take transit"), "Connect" ("Connect Orange County's people and places with effective transit"), "Simplify" ("Make transit easier to use and more convenient"), "Collaborate" (Make Orange County a more attractive place to live, work, and visit by providing transit service that supports community priorities") and "Sustain" ("Create a system that is resilient over the long term"). There were a total of 47 objectives.

Table 1 Corridor Screening and Evaluation Criteria

Category	Measures	Initial Screening Methodology	Evaluation Methodology
Speed & Reliability	% of Route w/ Transit-Only ROW	--	Calculation based on conceptual design
	% of Route w/ Grade Separation	--	Calculation based on conceptual design
	Peak and Base Frequency	--	From conceptual service plan
	Average Speed	--	From model
Ridership/Mode Shift/VMT Reduction	New Transit Trips	--	Forecast project ridership per mile (from model)
	Vehicle Miles Traveled/CO2 Emissions	--	Based on ridership
Density/Connections to Activity Centers	Population Density Within ½ Mile	GIS analysis (Census data)	GIS analysis (Census data)
	Employment/Postsecondary Enrollment Density Within ½ Mile	GIS analysis (Census data)	GIS analysis (Census data)
	Density of Hospital Beds/Retail Stores Within ½ Mile	GIS analysis (available sources)	GIS analysis (available sources)
	Additional Major Destinations (e.g., Stadiums & Theme Parks) Within ½ Mile	GIS analysis (based on assessment of "destinations")	GIS analysis (based on assessment of "destinations")
	Traffic Volumes at Arterial Intersections per Corridor Mile (Within ½ Mile)	GIS analysis (available sources)	GIS analysis (available sources)
Multimodal Connectivity	# of Connections to Existing or Future Metrolink Stations, Transit Centers, Major Routes, and Park-and-Rides	GIS analysis (available sources)	GIS analysis (available sources)
	Intersection Density per Square Mile	GIS analysis (available sources)	GIS analysis (available sources)
	Pedestrian Network Serving Transit	WalkScore within ½ mile of corridor	WalkScore within ½ mile of corridor

Category	Measures	Initial Screening Methodology	Evaluation Methodology
	# of Connections to Existing or Planned High-Quality Bicycle Facilities (Off-Street or Protected On-Street)	--	Based on review of existing routes/plans
 Capacity	Person Throughput	--	Analysis based on vehicle capacity, conceptual service plan, and roadway capacity
	Traffic Impact	--	Change in volume/capacity ratio along TOC Line
 Safety	Potential for Reduction in Collision Rates and Severity	--	Based on ridership and existing rates of severe collisions
 Passenger Comfort/Amenities	Passenger Comfort	--	Qualitative assessment based on vehicle capacity, movement (e.g. lateral sway)
	System Legibility	--	Qualitative assessment based on visibility, alignment
 Equity	Density of Households with Annual Incomes < $40,000	GIS analysis (Census data)	GIS analysis (Census data)
	Density of Seniors and People with Disabilities	GIS analysis (Census data)	GIS analysis (Census data)
	CalEnviroScreen Scores	Analysis based on EnviroScreen ratings for disadvantaged communities	Analysis based on EnviroScreen ratings for disadvantaged communities

Category	Measures	Initial Screening Methodology	Evaluation Methodology
Economic Development	Support for Retail Activity	Density of retail jobs within ½ mile of corridor	Qualitative assessment based on project design (e.g., turn restrictions, additional sidewalk space, parking impacts)
Transit-Supportive Policy	Support for Transit-Oriented Development	Qualitative assessment based on inclusion of corridor in regional and local transit-oriented plans and adoption of supportive zoning	Qualitative assessment based on inclusion of corridor in regional and local transit-oriented plans and adoption of supportive zoning
Cost-Effectiveness/ Productivity	Capital Cost per Boarding	--	Analysis based on high-level capital cost estimates (based on peer review, service plan and high-level travel time estimates) + ridership from OCTAM model
	Operating Cost per Boarding	--	From OCTAM model
	Boardings per Revenue Hour	--	Ridership from OCTAM model / revenue hours derived from operating cost estimates
	Boardings per Revenue Mile		Ridership from OCTAM model / revenue miles derived from operating cost estimates

3 TRANSIT OPPORTUNITY CORRIDORS

The process used to develop the Transit Opportunity Corridors is described in this chapter, starting with the TOC identification and screening process.

Initial screening was conducted on more than 30 potential TOCs. To support more refined analysis, the corridors were divided into 96 corridor segments and 32 potential locations for freeway-based bus rapid transit (Freeway BRT) stops. These stops were identified to account for the fact that Freeway BRT would operate over long stretches without stopping, rendering corridor-based analysis irrelevant.

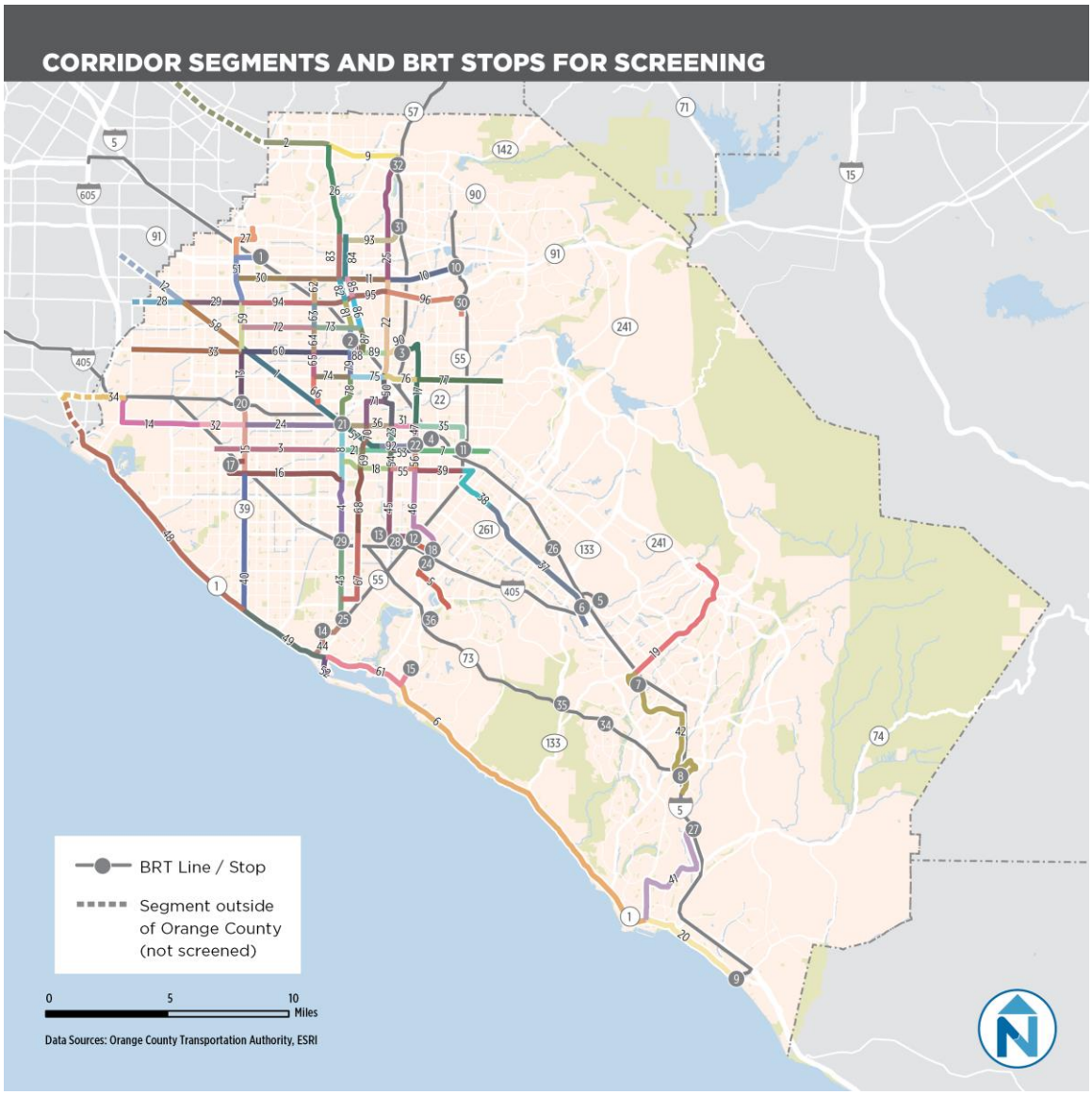
The corridors, segments, and Freeway BRT stop locations were identified based on the following sources:

- Public input including stakeholder interviews and the "Build Your Own Transit System" interactive survey;
- Corridors identified in previous studies, from 1990s proposed CenterLine light rail alignments to the current Central Harbor Boulevard Transit Corridor Study;
- Demographic, land use, and existing transit service analysis conducted as part of the OC Transit Vision and summarized in the State of OC Transit report;
- The Transit Investment Framework, which includes guidance for identifying potential high-capacity transit corridors;
- Discussions with OCTA staff from various departments, the OCTA Board, and the OCTA Citizens Advisory Committee; and
- Additional OCTA analysis of high-ridership segments of existing bus routes.

The potential corridors, segments, and Freeway BRT stops were located throughout Orange County, although the majority were in the more urbanized north and central parts of the county, where existing and projected future demand for transit service is higher. Some corridors also extended a short distance into Los Angeles County in order to provide connections to existing and planned regional transit hubs.

The comprehensive set of corridor segments and stop locations subjected to initial screening is shown in Figure 2.

Figure 2 Screening Segments and Stops



Results of the initial screening were detailed in the "Transit Opportunity Corridors Initial Screening and Preliminary Recommendations" report. Key findings included the following:

- The segments that scored highest overall were located in the northern and central part of the county, primarily in Santa Ana and Anaheim. This area has some of the highest population densities in the county as well as relatively low incomes and other factors indicative of transit demand. Existing transit services in this area include the highest-ridership OC Bus routes, consistent with the land uses and demographics.
- While several of the highest-scoring Freeway BRT stop locations were along or near the highest-ranking segments in the northern part of the county, stop locations in Downtown Costa Mesa and near Laguna Hills Mall also ranked highly.

Figure 3 illustrates summary findings from the screening of corridor segments, while Figure 4 shows findings from the screening of Freeway BRT stop locations.

Figure 3 Segment Screening Results

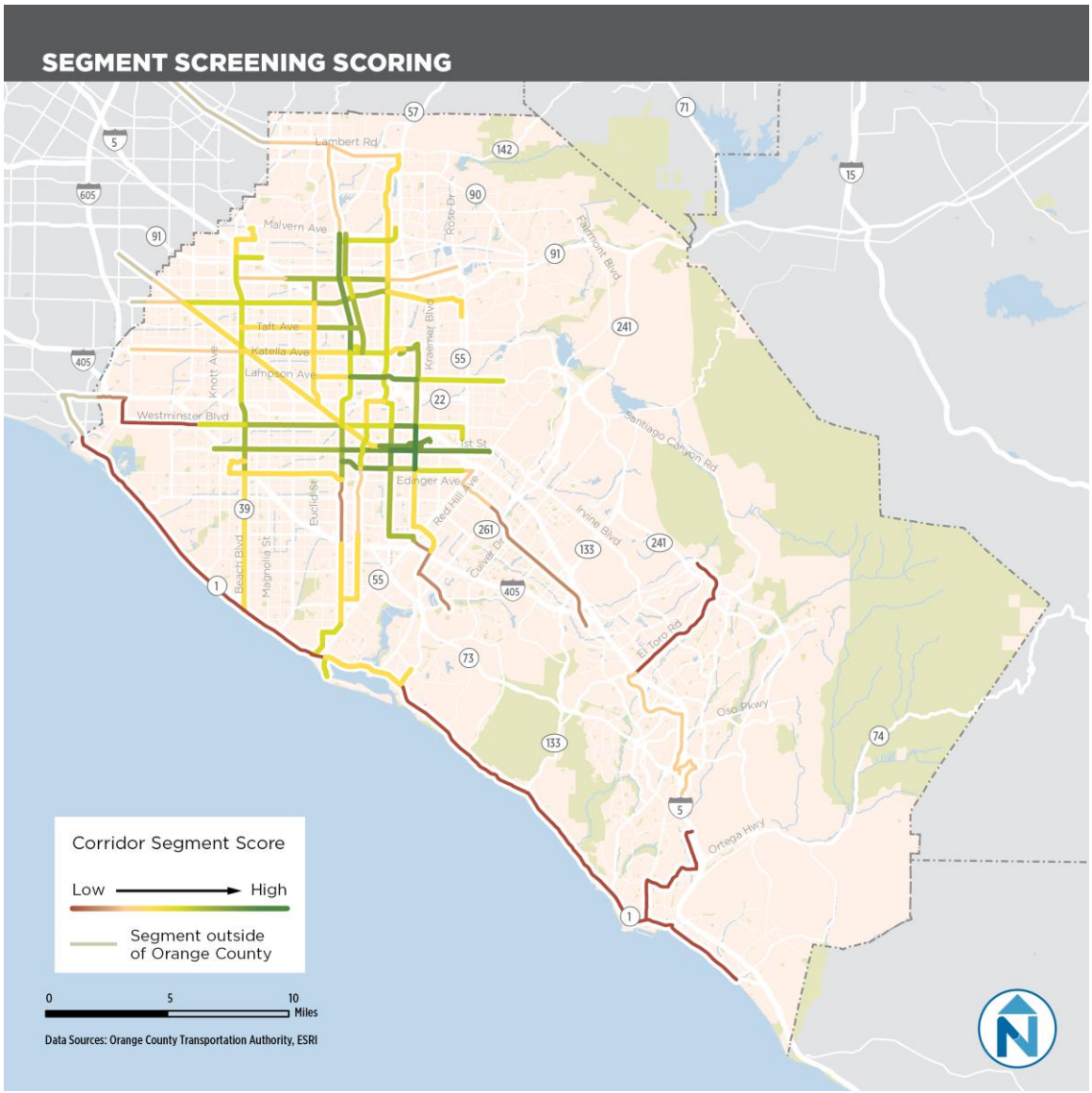
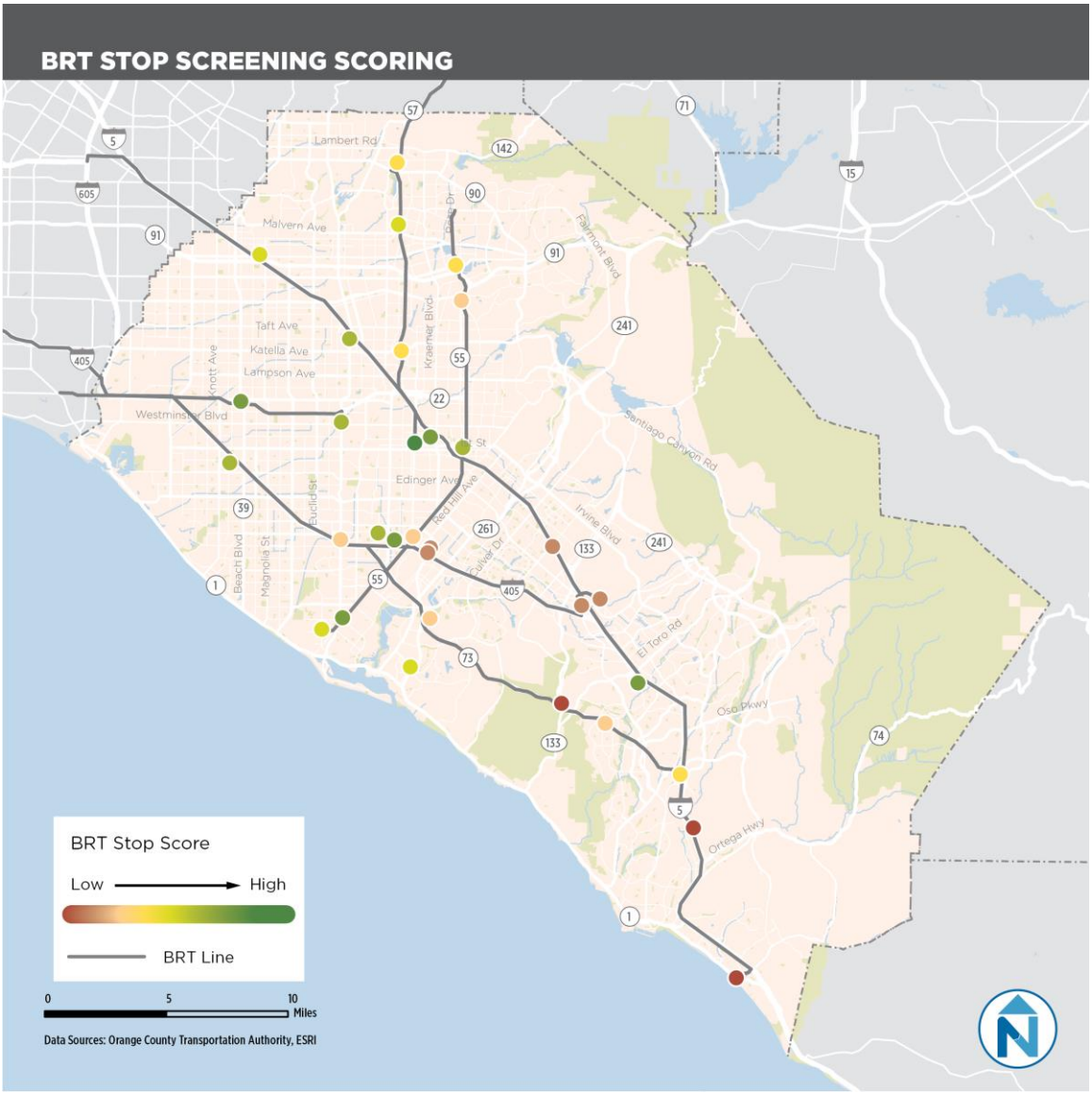


Figure 4 Stop Screening Results



Based on the screening results and subsequent discussions among the project team, 10 TOCs were recommended for detailed evaluation. Each of the corridors included segments or stop locations that rated highly in the initial screening. Some included segments that scored somewhat lower, but were included to form "complete" corridors with anchors (major destinations or transit hubs) at each end.

Eight arterial corridors (four north-south and four east-west) and two Freeway BRT corridors were advanced for further development and evaluation. Several of these follow or closely follows existing OC Bus routes.

Arterial corridors:

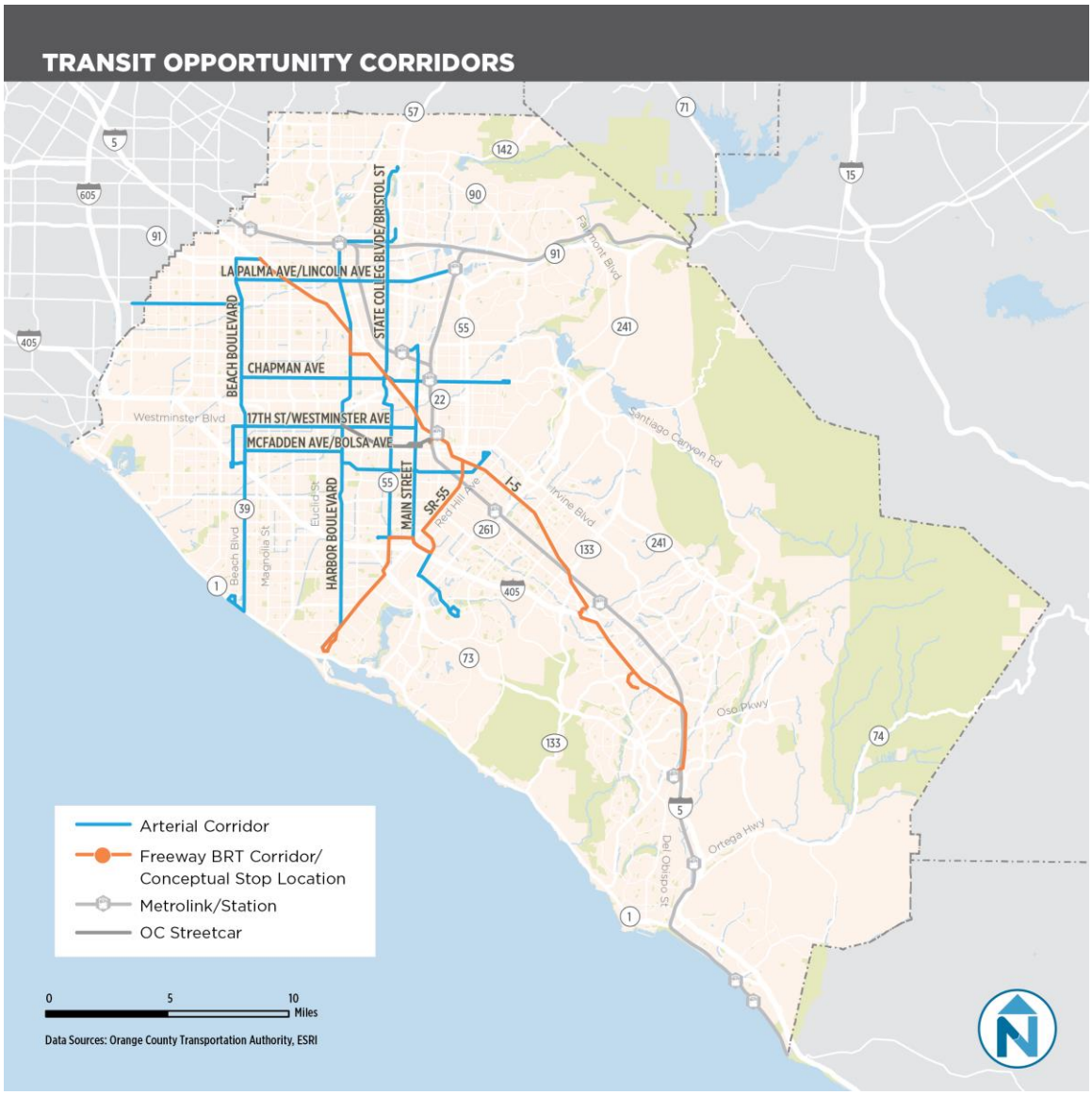
- **Beach Boulevard** from Fullerton Park-and-Ride to Downtown Huntington Beach
- **Harbor Boulevard** from Cal State Fullerton to Hoag Hospital Newport Beach
- **State College Boulevard/Bristol Street** from Brea Mall to the University of California, Irvine
- **Main Street** from Anaheim Regional Transit Intermodal Center (ARTIC) to South Coast Plaza Park-and-Ride
- **La Palma Avenue/Lincoln Avenue** from Hawaiian Gardens to Anaheim Canyon Station
- **Chapman Avenue** from Beach Boulevard to Hewes Street
- **17th Street/Westminster Avenue** from Cal State Long Beach to Tustin Street
- **McFadden Avenue/Bolsa Avenue** from Goldenwest Transportation Center to Larwin Square

Freeway BRT corridors:

- **I-5** from Fullerton Park-and-Ride to Mission Viejo/Laguna Niguel Station
- **SR-55** from Santa Ana Regional Transportation Center to Hoag Hospital Newport Beach

The corridors are shown in Figure 5.

Figure 5 Transit Opportunity Corridors



In order to evaluate the TOCs using the detailed evaluation criteria from the evaluation framework—several of which are measures of transit performance, such as cost-effectiveness, rather than corridor characteristics—it was necessary to identify conceptual transit lines that might operate in the corridors. This required selection of mode options for each corridor (and, in some cases, for individual segments) based on factors including projected demand, network connectivity, and available right-of-way. These modes were selected for purposes of evaluation, and different modes may be selected as part of future project development processes within corridors.

With the assignment of modes, transit lines were assembled from parts of different corridors and modifications were made to some corridors, including one significant change: Rapid streetcar was determined to be the most appropriate mode for the 17th/Westminster corridor east of Beach Boulevard. However, extending tracks and overhead catenary wires west to Long Beach would be expensive and cost-ineffective given likely insufficient demand; therefore the line was deviated to an existing rail right-of-way paralleling Hoover Boulevard and terminated at the Goldenwest Transportation Center (the western segment of the corridor would continue to be served by frequent bus service).

Four modes were assumed for the evaluation. These were described in detail in the *State of OC Transit* report and are summarized as follows:

- *Rapid streetcar*. This would be similar to the planned OC Streetcar line in Santa Ana, but because the TOCs are relatively long, stations would be more widely spaced and transit-only right-of-way would be provided wherever feasible, either in the roadway median or along the curb. In terms of speed and reliability, rapid streetcar would be similar to at-grade light rail such as the Los Angeles County Metro Blue, Expo, and Gold lines. However, it would use the same medium-capacity vehicles as the OC Streetcar line (and indeed, the conceptual routes would incorporate the OC Streetcar line). Rapid streetcar was assumed for segments of the most promising corridors that would allow connections to the under-construction OC Streetcar line.
- *Bus rapid transit (BRT)*. BRT lines would feature widely-spaced stations and transit-priority elements including transit-only right-of-way where feasible. As with rapid streetcar, BRT-only lanes could be shared with autos on a limited basis, for example by allowing right turns by motorists and reverting to parking lanes outside of peak periods, as on Wilshire Boulevard in Los Angeles. BRT was selected for segments of high-demand corridors that were not included in rapid streetcar lines.
- *Rapid bus*. This would be similar to BRT, but without transit-only lanes. Other transit-priority elements such as transit signal priority, queue jump bypass lanes at intersections, off-board fare payment, all-door boarding, and near-level boarding would be used to enhance speed and reliability. Rapid bus was selected for remaining arterial segments.
- *Freeway BRT*. Most of the TOCs primarily follow arterial streets, but I-5 and SR-55 corridors are freeway-based. In these corridors, buses would largely operate in existing high-occupancy vehicle (HOV, or carpool) lanes or planned "managed" high-occupancy toll (HOT) lanes. Unlike existing express routes that use these lanes, however, they would operate in both directions all day and could make use of transit-only on- and off-ramps or stations in the median of the freeway, such as those on the Harbor Freeway in Los Angeles County. For purposes of evaluation, stops at existing park-and-rides and other stops near freeway ramps were assumed.

In addition to modes and segments with transit-only lanes, general locations of stations (e.g., intersections) and service plans were identified. The service plan for most lines was based on 10-

minute peak and 15-minute off-peak service (15-minute peak and 30-minute off-peak service for Freeway BRT corridors), as well as spans of service (operating hours) consistent with the "Major" category in the Transit Investment Guidelines: 5 a.m. to midnight weekdays, and 6 a.m. to midnight weekends. Existing bus routes along the corridors covered by TOCs were modified to operate every 20 minutes peak and 30 minutes off-peak, or were assumed to be replaced (Route 83 along I-5, and Bravo! Routes 543 and 560 would be eliminated).

The 11 TOC lines were:

- North Harbor Boulevard-Santa Ana Boulevard: Rapid streetcar or bus rapid transit (BRT) between Cal State Fullerton and the Santa Ana Regional Transportation Center, primarily via Harbor Boulevard (and including the OC Streetcar alignment currently in design)
- Westminster Avenue-Bristol Street: Rapid streetcar or BRT between the Goldenwest Transportation Center and the University of California, Irvine, via 17th Street/Westminster Avenue and Bristol Street (including short segments of Main Street and the OC Streetcar alignment)
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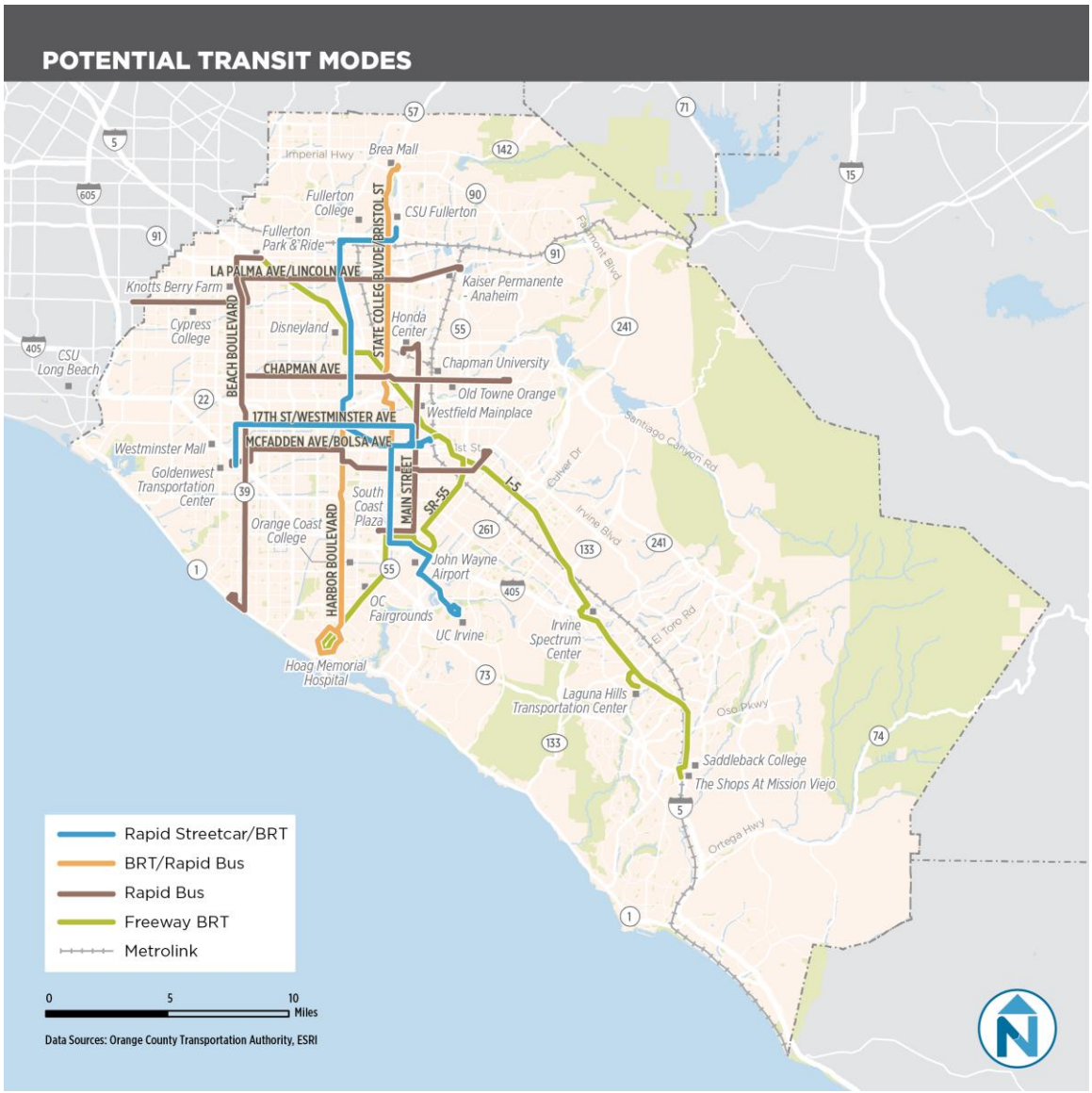
- State College Boulevard: BRT or rapid bus on Bristol Street and State College Boulevard between the Brea Mall and Downtown Santa Ana
- Beach Boulevard: Rapid bus on Beach Boulevard between the Fullerton Park-and-Ride and Downtown Huntington Beach
- Main Street: Rapid bus on Main Street between Anaheim Region Transportation Intermodal Center and the South Coast Plaza Park-and-Ride
- La Palma Avenue-Lincoln Avenue: Rapid bus on La Palma Avenue and Lincoln Avenue between Hawaiian Gardens and the Anaheim Canyon Station
- Chapman Avenue: Rapid bus on Chapman Avenue from Hewes Street to Beach Boulevard,
- McFadden Avenue-Bolsa Street: Rapid bus on McFadden Avenue and Bolsa Avenue from Goldenwest Transportation Center to Larwin Square
- Interstate 5 (I-5): Freeway BRT on I-5 from the Fullerton Park-and-Ride to Mission Viejo/Laguna Niguel Station
- State Route 55 (SR-55): Freeway BRT on SR-55 from the Santa Ana Regional Transportation Center to Hoag Hospital in Newport Beach

The TOC lines are illustrated in Figure 6, and in greater detail (including station locations) in Appendix A.

Figure 6 TOC Lines and Potential Modes



4 EVALUATION RESULTS

Following are summary findings from the detailed evaluation. Complete results can be found in Appendix B.

For each TOC line or freeway BRT station location and criterion, a score of 1 (lowest) to 5 (highest) was assigned based on the analysis. For corridor/station area-based criteria, the area of analysis was a half-mile radius around the alignment or station, representing a "typical" walkshed of about 10 minutes for an able-bodied adult. When mode was a factor in evaluation, the highest intensity mode considered for the line was used in the evaluation.

While quantitative values representative of the findings from analysis were assigned for each TOC line or freeway BRT station location and criterion, values should not simply be summed to calculate a "total score" for each line. This is because the evaluation exercise is not meant to serve as the sole basis for the decision-making process. Instead, it is one tool for planners and policy makers to use in developing recommendations.

Following are summary findings from the evaluation for each criterion.

SPEED AND RELIABILITY

Percentage of Route with Transit-Only Right-of-Way

This is a measure of potential travel time reliability or schedule adherence. As modes were associated with transit-only right-of-way as part of the TOC line development process (see Chapter 3), the selection of mode options for each line determined performance in this category: Lines with transit-only ROW from end to end (rapid streetcar and BRT lines) were assigned a value of 5; lines with transit-only lanes for most of their length (rapid streetcar lines, which would operate in traffic in central Santa Ana) were assigned a value of 4; freeway BRT lines operating primarily in HOV or managed lanes were assigned a value of 3; and rapid bus lines operating in traffic were assigned a value of 1.

Percentage of Route with Grade Separation

This is also a measure of potential travel time reliability or schedule adherence. Because freeway BRT lines would operate primarily (but not entirely) on freeways, they were assigned a value of 4, while lines operating at-grade, on surface streets with intersections, were assigned a value of 1.

Peak and Base Frequency

Performance in this category was a factor of service plan. Arterial lines with a service plan based on 10-minute peak and 15-minute off-peak headways were assigned a value of 4, while freeway BRT lines with a service plan based on 15-minute peak and 30-minute off-peak headways were assigned a value of 2.

Average Speed

Average projected year 2040 peak-period speeds for each line were projected as part of the modeling process, based on mode, right-of-way and traffic conditions. Freeway BRT lines were found to be significantly faster than arterial routes, and the I-5 line was found to be significantly faster (an average of 29.6 miles per hour) than the SR-55 line (21.8 mph). The I-5 Freeway line, then was assigned a value of 5, and the SR-55 line a value of 4. Arterial lines were found to have comparatively similar average speeds (between 15 and 20 mph), so each was assigned a value of "3." (Note that while transit-only lanes were not associated with significantly higher average speeds, they can be expected to improve both speed and reliability within a corridor.)

RIDERSHIP/VMT REDUCTION

New Transit Trips

This measure is based on projected year 2040 average weekday boardings per mile. Based on ridership forecasting conducted using the OCTAM model, lines with rapid streetcar as an option were projected to have high ridership – generally in the range of 20,000 boardings per weekday – while bus-only projects were projected to have significantly lower ridership. For this reason, rapid streetcar/BRT projects performed well, while bus-only projects showed mixed results: La Palma/Lincoln was projected to have the highest net increase among bus-only corridors.

Vehicle Miles Traveled/Carbon Emissions

This measure is based on net ridership, as reductions in VMT and corresponding carbon emissions generally correlate with increases in transit ridership.

DENSITY/CONNECTIONS TO ACTIVITY CENTERS

Population Density Within Half-Mile

Based on GIS analysis, the North Harbor/Santa Ana and McFadden/Bolsa lines were found to have the highest population densities within a half-mile, while the SR-55 Freeway line was found to have the lowest.

Employment/Postsecondary Density Within Half-Mile

This category takes into account both number of workers and numbers of college and university students, as people in both categories must make regular trips to the same destination. Based on GIS analysis, the State College and SR-55 Freeway lines were found to have the highest numbers of workers and students within a half-mile, while the Beach line was found to have the lowest.

Density of Hospital Beds/Retail Stores Within Half-Mile

This category takes into account other major generators of travel demand: medical centers and shops. Based on GIS analysis, the Chapman and SR-55 Freeway lines were found to have the highest numbers of hospital beds and retail stores within a half-mile, while the Westminster/Bristol, Beach and McFadden/Bolsa lines were found to have the lowest.

Additional Major Destinations (e.g. Stadiums and Theme Parks) Within Half-Mile

Analysis in this category was based on identification of other regional destinations such as Angel Stadium and Disneyland. Lines with two or more such destinations within a half-mile including the North Harbor/Santa Ana and Main lines, while lines with no such destinations within included the Westminster/Bristol, South Harbor, McFadden/Bolsa and SR-55 Freeway lines.

Traffic Volumes at Arterial Intersections per Corridor Mile (Within Half-Mile)

This category is an indirect measure of the presence of nearby destinations or travel demand generators; importantly, it was found through the transit propensity analysis described in the State of OC Transit report to be a key indicator of transit demand. The Beach line had the highest traffic volumes per mile within a half-mile, while the I-5 Freeway line was found to have the lowest.

MULTIMODAL CONNECTIVITY

Number of Connections to Existing or Future Metrolink Stations, Transit Centers, Major Routes, and Park-and-Rides

This is a measure of transit network connectivity. The North Harbor/Santa Ana and I-5 Freeway lines were found to have the most major connections within a half-mile, while the South Harbor, La Palma/Lincoln and Chapman lines had the fewest.

Intersection Density per Square Mile

This is a measure of pedestrian network connectivity. The South Harbor and Beach lines were found to have the highest intersection density within a half-mile, while the State College and I-5 Freeway lines were found to have the lowest.

Pedestrian Network Serving Transit

This measure was based on WalkScore scores, which in turn are based primarily on numbers of destinations within walking distance. The North Harbor/Santa Ana, South Harbor, Main, and McFadden/Bolsa lines were found to have highest WalkScores within a half-mile, while the I-5 Freeway line was found to have the lowest.

Number of Connections to Existing or Planned High-Quality Bicycle Facilities (Off-Street or Protected On-Street)

This is a measure of bicycle network connectivity. The Westminster/Bristol and Main lines were found to have the most major connections to existing or planned (as part of local bicycle plans) bike paths or separated bike lanes within a half-mile, while the La Palma/Lincoln line was found to have the fewest.

CAPACITY

Person Throughput

This is a measure of the capacity of a right-of-way to move people, and not just vehicles. Lines that would replace general-purpose lanes with higher-capacity transit-only lanes, and that could potentially use larger vehicles – rapid streetcar/BRT lines – were assigned a value of 5. BRT/rapid bus lines with transit-only lanes were assigned a value of 4, and remaining lines that would not change the capacity of the roadway were assigned a value of 3.

Traffic Impact

This is a measure of the potential impacts on auto delay and congestion of conversion of general-purpose lanes to transit-only lanes, as is proposed for rapid streetcar and BRT projects. The metric used was roadway segment volume-to-capacity ratio, a standard measure of traffic levels. Changes to V/C ratios in adjacent lanes were projected, and numbers of roadway segments in which the ratio would increase from less than 0.9 to more than 0.9 – the latter representing level of service (LOS) of "E" or "F" using the Highway Capacity Manual method – were counted. For all rapid streetcar and BRT lines, between three and five segments (out of between nine and 20, depending on the line) would be impacted, so each was assigned a value of 2. Remaining lines where numbers of traffic lanes would not be reduced were assigned a 3, representing no change.

SAFETY

Potential for Reduction in Collision Rates and Severity

Transit improvements like those evaluated here can improve safety in two ways: 1) through project design including safety features, and 2) by shifting trips to transit and reducing rates of driving. At this stage of project evaluation, prior to design, the former cannot be evaluated, but transit ridership and vehicle miles traveled can be, and are, under other metrics. For this measure, we multiplied projected net ridership in each corridor by numbers of severe collisions recorded in the corridor over an eight-year period, and normalized for route length. Rapid streetcar/BRT lines, with their higher projected ridership, were found to have the greatest potential to reduce collisions.

PASSENGER COMFORT/AMENITIES

Passenger Comfort

This is largely a measure of comfort aboard vehicles, as it is assumed that all stations would include shelters, benches and other high-quality amenities. Rapid streetcar/BRT lines, which could potentially use larger vehicles providing a smoother ride, were assigned a value of 5, and freeway BRT lines, which would make fewer stops and starts, were assigned a 4. All other lines, which would provide comfort levels similar to existing limited-stop lines, were assigned a value of 3.

System Legibility

This is largely a measure of the visibility of transit lines, as it is assumed that passenger awareness of all lines would be enhanced using branding, maps and other measures. Rapid streetcar/BRT lines, which might follow tracks, were assigned a value of 5, while BRT/rapid bus lines with transit-only lanes were assigned a value of 4. All other lines, which would largely use existing infrastructure, were assigned a value of 3.

EQUITY

Density of Households with Annual Incomes Below $40,000

Based on GIS analysis, the North Harbor/Santa Ana and McFadden/Bolsa lines were found to have the highest densities of low-income households within a half-mile, while the State College and I-5 Freeway lines were found to have the lowest.

Density of Seniors and Persons with Disabilities

Based on GIS analysis, the Beach and McFadden/Bolsa lines were found to have the highest densities of older persons and persons with disabilities within a half-mile, while the State College and SR-55 Freeway lines were found to have the lowest.

CalEnviroScreen Scores

CalEnviroScreen is a mapping tool that helps identify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects. The North Harbor/Santa Ana and La Palma/Lincoln lines were found to have the highest CalEnviroScreen scores, indicating the greatest impacts from pollution, while the South Harbor line had the lowest.

ECONOMIC DEVELOPMENT

Support for Retail Activity

Based on GIS analysis, the Main and SR-55 Freeway lines were found to have the highest densities of retail jobs within a half-mile, while the North Harbor/Santa Ana, La Palma/Lincoln and Chapman lines were found to have the lowest.

TRANSIT-SUPPPORTIVE POLICY

Support for Transit-Oriented Development

This measure was based on analysis of: current zoning, specifically transit-supportive zoning such as multifamily residential and mixed uses; year 2035 population and employment density, and increases to both over the base year of 2012; and proximity of Southern California Association of Government (SCAG)-designated "High Quality Transit Areas," or areas with frequent transit service (note that because all TOC lines would meet the HQTA definition of "frequent" – 15-minutes or better peak service – all lines were assumed to serve as the basis for a future HQTA). For each category, "high," "medium," and "low" values were assigned, and these were combined

to produce composite 1-to-5 scores. The North Harbor/Santa Ana, Westminster/Bristol, State College, Main, I-5 and SR-55 lines had the highest scores, while the South Harbor line had the lowest.

COST-EFFECTIVENESS/PRODUCTIVITY

Capital Cost per Boarding

This is a simple measure of estimated capital cost divided by estimated number of annual boardings. In more advanced stages of project development, capital cost estimates are itemized and costs are annualized based on different rates of depreciation in order to determine "true" costs per boarding. At this preliminary stage of project development, capital cost estimates are order-of-magnitude, in this case based on per-mile costs for similar recent projects in Orange County and Southern California. The Main and La Palma/Lincoln rapid bus projects were found to be least expensive to construct on a per-passenger basis and freeway BRT projects were found to be most expensive to construct, although this assumes some construction of dedicated facilities (rather than simply making use of existing ramps and park-and-rides).

Operating Cost per Boarding

This is a measure of estimated annual operating and maintenance (O&M) costs divided by annual numbers of boardings, for all new or modified lines in a TOC. O&M costs were estimated using revenue hours projections for the year 2040 and existing OCTA costs per hour of revenue service, adjusted to take into account additional costs for elements such as station maintenance (hours of revenue service are estimated based on service plans and projected speeds). The rapid streetcar/BRT corridors were found to have the lowest per-boarding costs, due to the high ridership projected for rapid streetcar/BRT lines, while the SR-55 Freeway corridor had the highest per-boarding costs.

Boardings per Revenue Hour

This is a widely used measure of productivity and cost-effectiveness, applied, once again, to all new or modified lines in a TOC. Once again, corridors with high-ridership rapid streetcar/BRT lines were found to have the strongest performance, while the SR-55 Freeway corridor had the weakest performance.

Boardings per Revenue Mile

This is another standard measure of productivity, taking into account distance. Once again, corridors with high-ridership rapid streetcar/BRT lines were found to have the strongest performance, while the SR-55 Freeway corridor had the weakest performance.

5 CONCLUSION

FINDINGS

As was noted in the introduction to the previous chapter, the evaluation exercise was not meant to serve as the sole basis for decision making. Instead, it is one tool for planners and policy makers to use in developing recommendations.

As was further described in Chapter 2, as part of the Transit Opportunity Corridors development process, modes were associated with corridor segments in order to form TOC lines or projects that could be subjected to evaluation using key performance measures such as ridership, productivity, and cost-effectiveness. Because many of the metrics were based on project performance, and because each mode has inherent advantages and disadvantages, mode played a major role in project performance.

In summary:

- Lines modeled with a rapid streetcar option outperformed other lines by a substantial margin. While the OCTAM model used for ridership forecasting projected ridership for rapid streetcar projects several times higher than for bus-based projects, the rapid streetcar projects were projected to have capital costs of several hundred million dollars. In return for this expense, however, they would perform well across a broad range of categories. (Note that rapid streetcar ridership could vary significantly depending on factors including whether or not to provide transit-only lanes.)
- Performance among bus-based projects varied: La Palma/Lincoln was projected to have the highest ridership, but Main, McFadden/Bolsa, State College and Beach were projected to have the strongest performance overall.
- The freeway BRT projects performed moderately well, in part due to their speed advantage over other modes and the proximity of major travel demand generators to I-5 and SR-55 interchanges. A key question going forward will be what Freeway BRT means in Orange County: all-day, bidirectional express lines, or full bus rapid transit lines with dedicated infrastructure. Depending on direction, capital costs could vary substantially (based on peer review, a cost of approximately $11.5 million per mile was assumed, but this could be significantly higher or lower).

CORRIDOR POTENTIAL NEXT STEPS

Our preliminary corridor potential next steps are as follows:

- Based on their superior performance in a broad range of categories, OCTA should conduct corridor studies for the North Harbor/Santa Ana and Westminster/Bristol corridors.

Implementation of rapid streetcar or BRT in these corridors would greatly expand the fixed-guideway network, suggesting a phased implementation strategy. The North Harbor/Santa Ana line somewhat outperformed the Westminster/Bristol line in the evaluation exercise, and indeed the Central Harbor segment is already undergoing study by OCTA. We recommend as part of all future streetcar or BRT project development processes that a project alternative based on exclusive right-of-way for rapid streetcar or BRT operations be considered.

- In the near term, OCTA should proceed with introduction of Bravo! service in the Route 29/Beach corridor, and over the medium term it should consider addition of Bravo! service to the Main corridor, as well as others. It should also seek to upgrade both these and existing Bravo! routes to improve speed and amenities. Initial steps could include introduction of off-board fare payment, all-door boarding, and transit signal priority. In the long-term OCTA should consider queue jumps, improved shelters, priority transit lanes on the highest ridership corridors.
- Freeway BRT is a new mode for OCTA, and one that has varied widely in its implementation elsewhere. Rather than advance individual projects, we recommend that OCTA proceed to a network study of potential Freeway BRT corridors including I-5, SR-55, and others such as I-405. This study would seek to both identify the most promising corridors as well as begin to define which infrastructure elements (e.g., dedicated ramps) should be included and where.

APPENDIX A CONCEPTUAL MAPS OF TOC LINES

Figure A-1 North Harbor-Santa Ana Rapid Streetcar/BRT Line

Figure A-2 17th-Westminster-Bristol Rapid Streetcar/BRT Line

Figure A-3 South Harbor BRT/Rapid Bus Line

Figure A-4 State College BRT/Rapid Bus Line

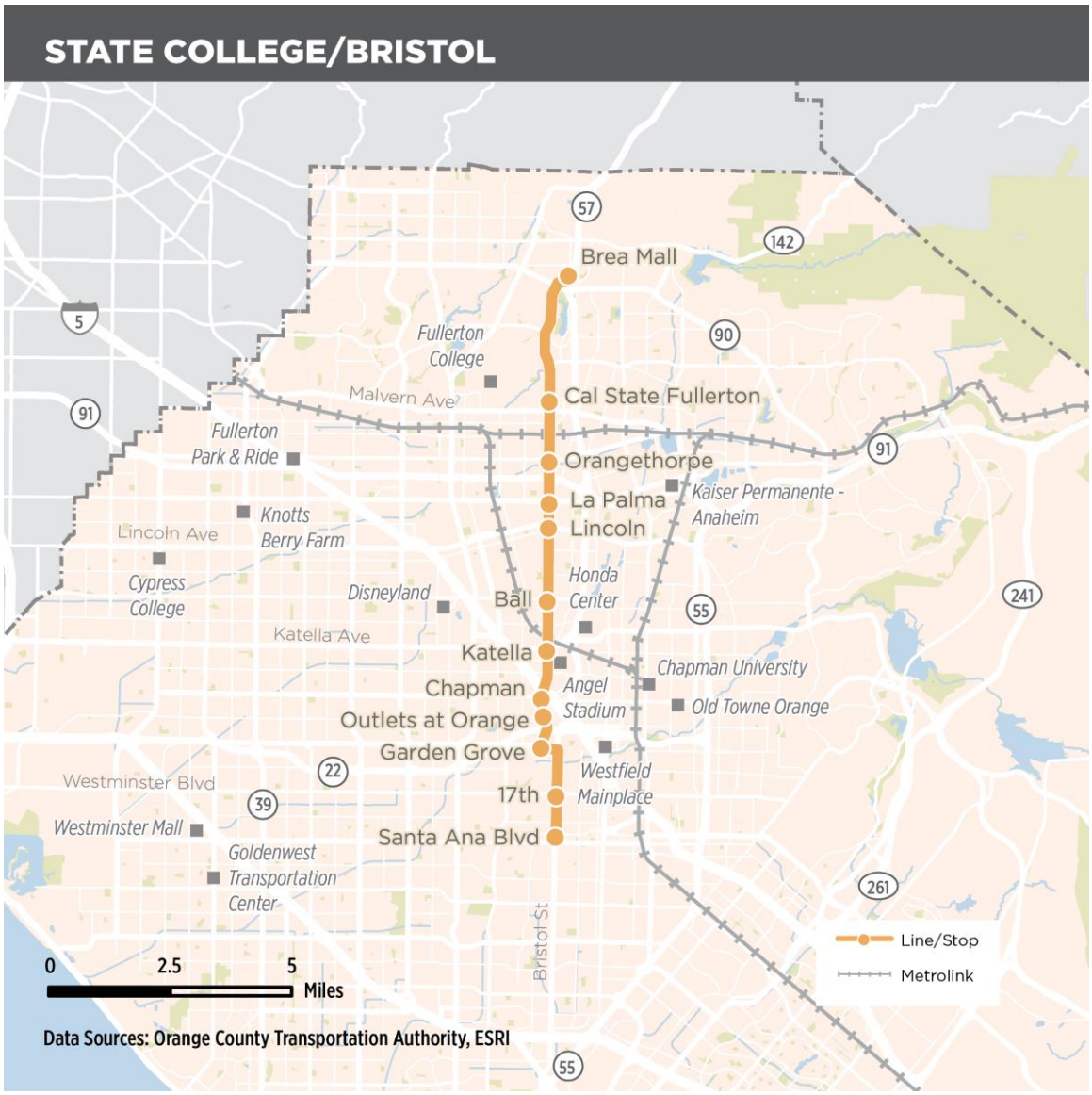


Figure A-5 Beach Rapid Bus Line

Figure A-6 Main Rapid Bus Line

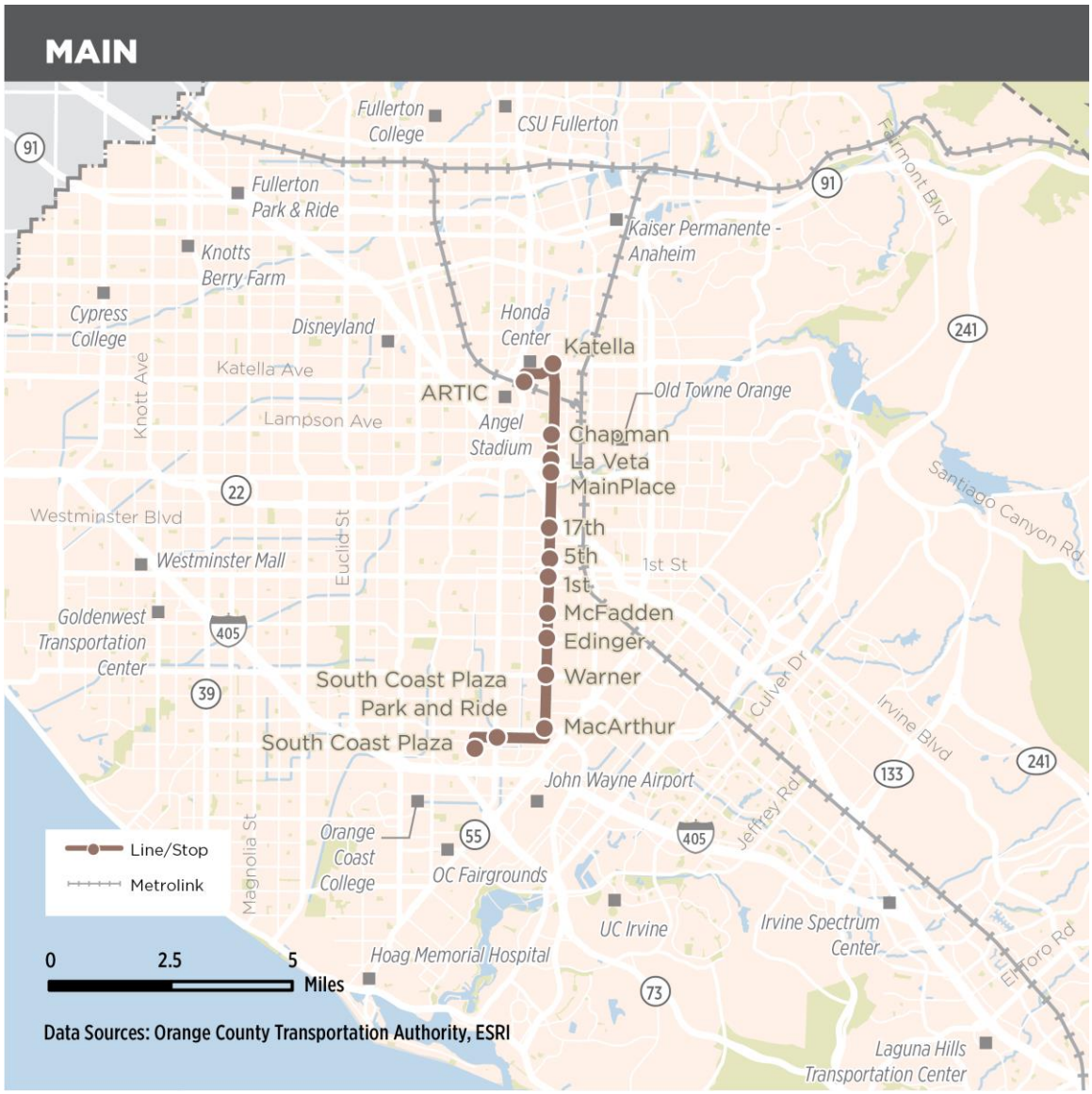


Figure A-7 La Palma/Lincoln Rapid Bus Line

Figure A-8 Chapman Rapid Bus Line

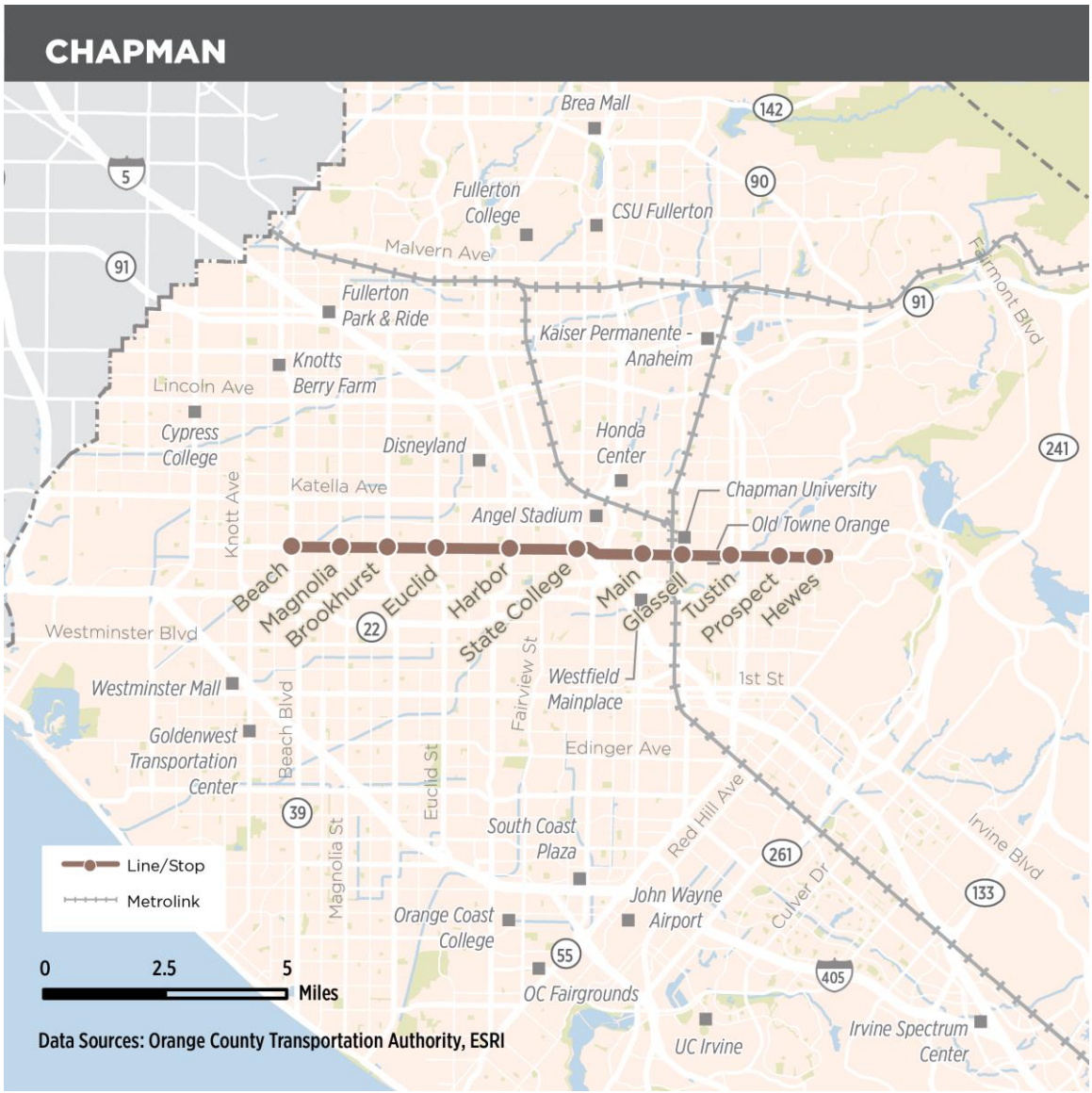


Figure A-9 McFadden/Bolsa Rapid Bus Line

Figure A-20 I-5 Freeway BRT Line

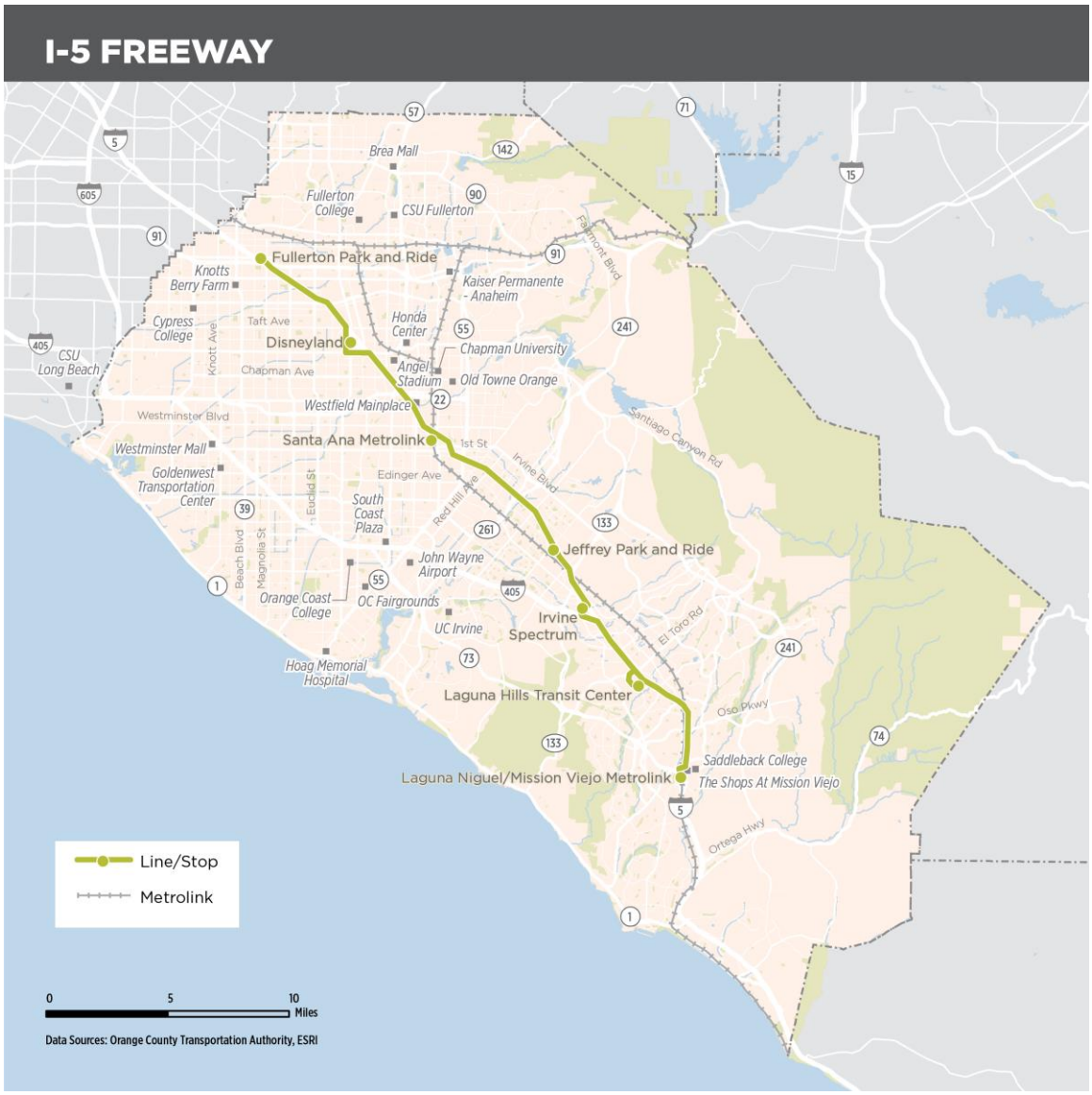


Figure A-31 SR-55 Freeway BRT Line

APPENDIX B COMPLETE EVALUATION RESULTS

Table B-1 provides scores for each criterion, TOC line and freeway BRT stop location. A score of "1" represents least benefit or most impact, while a score of "5" represents most benefit or least impact.

Table B-1 Complete Evaluation Results

Category	Measure	Rapid Streetcar/BRT		BRT/Rapid Bus		Rapid Bus					Freeway BRT	
		North Harbor/ Santa Ana	West-minster/ Bristol	South Harbor	State College	Beach	Main	La Palma/ Lincoln	Chap-man	Mc-Fadden/ Bolsa	I-5	SR-55
Speed & Reliability	% of Route w/ Transit-Only ROW	4	4	5	5	1	1	1	1	1	3	3
	% of Route w/ Grade Separation	1	1	1	1	1	1	1	1	1	4	4
	Peak and Base Frequency	4	4	4	4	4	4	4	4	4	2	2
	Average Speed	3	3	3	3	3	3	3	3	3	5	4
Ridership/Mode Shift/VMT Reduction	New Transit Trips	5	5	1	2	1	2	2	1	1	1	1
	Vehicle Miles Traveled/CO2 Emissions	5	5	1	2	1	2	2	1	1	1	1

Category	Measure	Rapid Streetcar/BRT		BRT/Rapid Bus		Rapid Bus					Freeway BRT	
		North Harbor/ Santa Ana	West-minster/ Bristol	South Harbor	State College	Beach	Main	La Palma/ Lincoln	Chap-man	Mc-Fadden/ Bolsa	I-5	SR-55
Density/ Connections to Activity Centers	Population Density Within ½ Mile	5	4	3	3	4	4	3	3	5	2	1
	Employment/Postsecondary Enrollment Density Within ½ Mile	4	4	3	5	1	4	3	2	2	4	5
	Density of Hospital Beds/Retail Stores Within ½ Mile	2	1	2	3	1	3	2	5	1	4	5
	Additional Major Destinations (e.g., Stadiums & Theme Parks) Within ½ Mile	5	1	1	3	3	5	3	3	1	3	1
	Traffic Volumes at Arterial Intersections per Corridor Mile (Within ½ Mile)	4	4	4	3	5	3	2	3	5	1	3

Category	Measure	Rapid Streetcar/BRT		BRT/Rapid Bus		Rapid Bus					Freeway BRT	
		North Harbor/ Santa Ana	West-minster/ Bristol	South Harbor	State College	Beach	Main	La Palma/ Lincoln	Chap-man	Mc-Fadden/ Bolsa	I-5	SR-55
Multimodal Connectivity	# of Connections to Existing or Future Metrolink Stations, Transit Centers, Major Routes, and Park-and-Rides	5	4	1	2	3	3	1	1	4	5	2
	Intersection Density per Square Mile	3	2	5	1	5	2	3	2	4	1	2
	Pedestrian Network Serving Transit	5	3	5	2	3	5	3	4	5	1	3
	# of Connections to Existing or Planned High-Quality Bicycle Facilities (Off-Street or Protected On-Street)	4	5	3	4	2	5	1	2	3	3	2
Capacity	Person Throughput	5	5	4	4	3	3	3	3	3	3	3
	Traffic Impact	2	2	2	2	3	3	3	3	3	3	3

Category	Measure	Rapid Streetcar/BRT		BRT/Rapid Bus		Rapid Bus					Freeway BRT	
		North Harbor/ Santa Ana	West-minster/ Bristol	South Harbor	State College	Beach	Main	La Palma/ Lincoln	Chap-man	Mc-Fadden/ Bolsa	I-5	SR-55
Safety	Potential for Reduction in Collision Rates and Severity	5	5	1	2	2	2	2	1	2	1	1
Passenger Comfort/Amenities	Passenger Comfort	5	5	3	3	3	3	3	3	3	4	4
	System Legibility	5	5	4	4	3	3	3	3	3	3	3
Equity	Density of Households with Annual Incomes < $40,000	5	4	3	1	3	3	2	2	5	1	3
	Density of Seniors and People with Disabilities	3	4	2	1	5	2	3	3	5	2	1
	CalEnviroScreen Scores	5	4	1	4	3	4	5	2	3	2	2

Category	Measure	Rapid Streetcar/BRT		BRT/Rapid Bus		Rapid Bus					Freeway BRT	
		North Harbor/ Santa Ana	West-minster/ Bristol	South Harbor	State College	Beach	Main	La Palma/ Lincoln	Chap-man	Mc-Fadden/ Bolsa	I-5	SR-55
Economic Development	Support for Retail Activity	1	2	2	3	4	5	1	1	2	3	5
Transit-Supportive Policy	Support for Transit-Oriented Development	5	5	3	5	4	5	4	4	4	5	5
Cost-Effectiveness/ Productivity	Capital Cost per Boarding	2	2	1	2	3	5	5	3	3	1	1
	Operating Cost per Boarding	5	5	3	4	3	3	4	2	3	3	2
	Boardings per Revenue Hour	5	5	2	4	3	3	4	2	3	2	2
	Boardings per Revenue Mile	5	5	2	3	2	3	3	2	3	1	1

Category	Measure	Rapid Streetcar/BRT		BRT/Rapid Bus		Rapid Bus					Freeway BRT	
		North Harbor/ Santa Ana	West-minster/ Bristol	South Harbor	State College	Beach	Main	La Palma/ Lincoln	Chap-man	Mc-Fadden/ Bolsa	I-5	SR-55
Average Score (1-to-5 scale)		4.0	3.7	2.6	2.9	2.8	3.2	2.7	2.4	3.0	2.6	2.6