



Board Report

File #: 2018-0710, File Type: Motion / Motion Response

Agenda Number: 28.

OPERATIONS, SAFETY, AND CUSTOMER EXPERIENCE COMMITTEE NOVEMBER 15, 2018

SUBJECT: CRENSHAW/LAX - GREEN LINE OPERATING PLAN

ACTION: APPROVE RECOMMENDATION

RECOMMENDATION

CONSIDER:

- A. APPROVING Alternative C-1 (Norwalk - Crenshaw/Expo, and Redondo Beach - Aviation/Century) as the preferred service plan for Crenshaw/LAX - Green Line; and
- B. DIRECTING the CEO to reevaluate the service plan one year prior to the opening of the Green Line extension to Torrance to determine if travel patterns and other relevant factors show a need for a change in service pattern.

ISSUE

On June 28, 2018, the Board of Directors (Board) approved Motion 40.1 by Directors Hahn, Butts, and Fasana (Attachment A), requesting staff to:

- Expand ridership estimates to include projected Green Line extension to Torrance;
- Add a third scenario that gives both ends of the Green Line a one-seat ride to the Expo Line; and
- Explain the pros and cons of each scenario and conduct a robust public engagement campaign with local cities, COGs, and the community.

Eleven alternative service plans were evaluated (Attachment B) and reviewed through the public engagement process. Based on stakeholder and public input, the two alternatives that surfaced with most support are:

- Alt C-1: trains every 6 minutes (peak) between Norwalk Station (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Redondo Beach (Green Line) and Century/Aviation Station.

- Alt C-3: trains every 6 minutes (peak) between Norwalk Station (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Willowbrook/Rosa Parks Station and Redondo Beach.

The staff recommendation is Alt C-1 for the following reasons:

- Connections to LAX from all directions - LAX is the fifth busiest airport in the world and third busiest in the US. In addition, LAX and the surrounding area generates 620,610 local jobs according to LAEDC (April 2016). Alt C-1 provides a direct connection from all three segments to and from the LAX area, while Alt C-3 eliminates direct service from South Bay.
- Special event service to the new Inglewood NFL Stadium - The new Inglewood Stadium will be a significant regional and national sports venue when completed in 2020. With 22+ NFL games per year, and major sporting events including the Super Bowl (2022), College Football National Championship (2023), FIFA World Cup (2026), and the Olympics and Paralympics Games (2028), it is imperative that convenient and direct connections are provided from all three directions of the Crenshaw/Green Line and the Downtown Inglewood Station on game days. Alt C-1 provides the opportunity to extend South Bay trains from the LAX station to Downtown Inglewood Station to support special events. However, South Bay would not have direct service to the Downtown Inglewood Station in Alt C-3 as South Bay trains would be headed east along the Green Line and not north along Crenshaw.
- New opportunities for South Bay residents - The cell phone location-based data confirmed that the predominant travel pattern of South Bay residents is north/south along the I-405 corridor. Alt C-3 continues the current east/west alignment for South Bay residents, and therefore does not serve their travel pattern. Alt C-1, however, provides a new opportunity to travel north/south from South Bay. Coupled with frequent bus connections at LAX north along the Sepulveda and Lincoln Blvd corridors, South Bay residents will have a new and competitive transit option to their primary travel destinations.
- Providing adequate capacity to meet demand - Alt C-1 matches train capacity to current and anticipated demand, and provides opportunities for capacity increases from 2 to 3 car trains along Crenshaw/LAX when ridership increases or to serve special events. Alt C-3, however, overserves the I-105 corridor of the Green Line between Aviation/Imperial and Willowbrook/Rosa Parks Stations by increasing service along this segment from 6 minute peak and 15 minute midday frequencies to 3 minute peak and 6 minute midday. This increased service is unwarranted and will cost \$10 million additional compared to Alt C-1. Alt C-1 requires 53 cars (peak requirement + spares) and 195,000 annual revenue vehicle hours to operate. At a marginal cost per revenue vehicle hour of \$395, the annual operating cost is \$77 million. Alt C-3 requires 60 cars (peak requirement + spares) and 221,000 annual revenue vehicle hours to operate. At a marginal cost per revenue vehicle hour of \$395, the annual operating cost is \$87 million. The \$395 cost per revenue vehicle hour consists of transportation (operators, supervisors, etc.), maintenance (vehicles, systems, right of way, etc), and other operating costs (security, utilities, etc.), minus support department costs,

including procurement, human resources, ITS, etc.

- In addition, with 2 car trains running every 3 minutes, there will not be sufficient traction power to increase service along the Crenshaw/LAX corridor from 2 to 3 car trains when needed. This means service will be capped at two thirds of design capacity on the Crenshaw corridor.

This report provides a more detailed response to the Motion and recommends Alt C-1 as the preferred Crenshaw/LAX - Green Line service plan based on the technical evaluation and public engagement process.

BACKGROUND

The Crenshaw/LAX Transit Project, currently under construction, is 85% complete. Unlike the recent Gold Line Foothill and Expo Line Santa Monica extensions in which case the rail line was further extended from the end of the line, the Crenshaw/LAX Line will connect with the Green Line at a mid-line location between Mariposa and Aviation Stations. Therefore, operations of both the Green and Crenshaw/LAX Lines must be planned as an integrated network vs. an extension of an existing line.

DISCUSSION

The opening of this new rail network will provide three potential directions for trains to operate.

- Between Norwalk Station and Redondo Beach Station (existing Green Line)
- Between Expo/Crenshaw Station and Norwalk Station
- Between Expo/Crenshaw Station and Redondo Beach Station

When accounting for both directions, the above three service patterns result in six potential train movements through the wye junction connecting the two lines.

There are several constraints at the junction that control the frequency and direction of train travel.

- Conflicting Moves - The wye junction where the Crenshaw/LAX Line meets the Green Line is a flat junction that only allows for certain train movements within each cycle. Like a street traffic intersection, a left-hand turn cannot be permitted while oncoming through traffic is moving. Three of the six train movements cannot be made concurrently due to this conflict: 1) Redondo Beach to Expo/Crenshaw, 2) Expo/Crenshaw to Norwalk, and 3) Norwalk to Redondo Beach. Therefore, any service plan requiring all three of these moves will result in at least three different phases of movements within each headway cycle (e.g. three phases within six minutes for a six-minute headway.)
- Traction Power - Traction power between the future 96th St/LAX Station and Expo/Crenshaw can support headways of up to 5 minutes per direction. Therefore, operating from both ends of the Green Line to the Expo/Crenshaw Station would result in trains every 10 minutes per branch, at best. Current Green Line service operates every 6 minutes during rush hour to accommodate the peak commute crowds.

Given these operating constraints, Metro evaluated 11 alternative service plans, as presented in Attachment B, based on the following criteria:

- Connection to LAX
- Current travel patterns
- Overall travel time for each of the six terminal-to-terminal moves
- Ridership demand for each of the three segments
- Consistent headways
- Network simplicity
- Annual Operating Cost

Motion 40.1 Response

Include Torrance Extension in Ridership Estimation

The Green Line currently carries about 33,000 average weekday boardings, with roughly 25,500 boardings on the segment along I-105 between Norwalk and Aviation, and about 7,500 on the Redondo Beach - Aviation segment. The Crenshaw/LAX and Airport Metro Connector is expected to carry an additional 16,400 new boardings along the extension.

Future ridership will include the Green Line Extension to Torrance anticipated in 2028. This segment plus the current Redondo Beach demand is expected to generate about 16,300 boardings, matching the ridership projections of the Crenshaw/LAX segment. Therefore, the service plan should be revisited at least one year prior to the Torrance Extension opening to determine if travel patterns and other relevant factors show a need to change the service plan.

Adjusting the operating plan of a rail line when demand changes is consistent with past practice. For example, the operating plan for the Gold Line Foothill Extension to Azusa was changed from every other train serving the extension on a 12 minute frequency from Sierra Madre Villa Station to every train serving Azusa on a 7 minute frequency. This change was made to accommodate the specific ridership patterns between Azusa and Old Town Pasadena, as well as increased demand along the extension.

Add a third scenario giving both ends of the Green Line a one-seat ride to the Expo Line

Staff developed two alternatives that address the Motion's directive. Alt D1: Operate trains from Norwalk and Redondo Beach to LAX every 6 minutes with every other train from each line extended to Expo/Crenshaw, and Alt D-2: Operate trains between Norwalk-Expo/Crenshaw and Redondo Beach - Expo/Crenshaw every 10 minutes. Please refer to Attachment B, for an illustration of the two additional alternatives.

Alt D1 is not recommended as the headways (spacing between trains) are uneven along the Green Line segments due to the conflicts at the junction as well as different running times along each of the three segments. The resulting headways would be a train every 9 minutes, then 3 minutes, then 9

minutes, etc. on the Redondo Beach and Norwalk/I-105 segments. This uneven headway will result in overcrowding followed by an underutilized train as well as inconsistent headways for transfers to and from the Blue Line.

Alt D-2 is also not recommended. Since the closest headway along Crenshaw is a train every 5 minutes, there can only be a train every 10 minutes each from Norwalk and Redondo Beach. Current peak demand on the Green Line requires a train every 6 minutes, so 10 minute service will result in severe overcrowding and pass ups.

During the public outreach efforts, South Bay Cities Council of Governments (SBCCOG), requested that a rail engineering consultant be retained to further evaluate the impacts of various train movements through the junction. Therefore, a task order was issued to Program Management's engineering bench to develop a rail simulation model to test the operational resilience and service regularity of each given the junction, traction power, and street running traffic signal phasing constraints along Crenshaw Blvd. Five operating scenarios that represent all possible movements through the junction were chosen to be tested, including:

- Alt C-1
This recommended alternative proposes trains every 6 minutes (peak) between Norwalk Station (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Redondo Beach (Green Line) and Century/Aviation Station.
- Alt C-2
This alternative swaps the service patterns for trains every 6 minutes (peak) between Redondo Beach (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Norwalk (Green Line) and Century/Aviation Station.
- Alt C-3
This alternative proposes trains every 6 minutes (peak) between Norwalk Station (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Willowbrook/Rosa Parks Station and Redondo Beach.
- Alt C-4
This alternative proposes trains every 6 minutes (peak) between Norwalk and Redondo Beach Station (existing Green Line), and trains every 6 minutes (peak) between Willowbrook/Rosa Parks (Green Line) and Expo/Crenshaw Station.
- Alt D-2
This alternative proposes trains every 6 minutes (peak) between Norwalk Station (Green Line) and Century/Aviation Station, then every 12 minutes (peak) to Expo/Crenshaw, and trains every 6 minutes (peak) between Redondo Beach (Green Line) and Century/Aviation Station, then every 12 minutes (peak) to Expo/Crenshaw. This means every other train from Norwalk or Redondo Beach would terminate at Century/Aviation Station.

These simulations provide an animated visualization of train movements along the entire network for a one hour peak period. Within the visualizations, one can see potential conflicts at the junction for

Alt B-1, B-2, and D-1 which, combined with different running times on each segment, results in uneven spacing between trains of 3 and 9 minutes along each of the Green Line segments. These simulation results were used to illustrate the complexity of the Crenshaw/LAX-Green Line operations during stakeholder and public engagement.

Public Engagement

Metro reviewed the various alternatives, including pros and cons of each, at several stakeholder outreach meetings and events, and working closely with the COGs, Regional Service Councils, and the local community. Meetings were conducted as follows:

Councils of Government

- Thursday, July 26 - South Bay COG Transportation Committee
- Monday, August 13 - South Bay COG Transportation Committee
- Wednesday, September 5 - Gateway Cities COG Transportation Committee and Board Meeting
- Thursday, September 20 - Westside COG Board Meeting
- Thursday, September 27 - South Bay COG Board Meeting
- Monday, October 8 - South Bay COG Transportation Committee

Regional Service Councils

- Wednesday, September 12 - Westside/Central Service Council
- Thursday, September 13 - Gateway Cities Service Council
- Friday, September 14 - South Bay Service Council

Community

- Tuesday, September 25 - Crenshaw Community Leadership Council (CLC) (Inglewood Public Library)
- Monday, September 17 - Public Meeting (Gateway Council of Governments)
- Thursday, September 20 - Public Meeting (The Proud Bird - 11022 Aviation Blvd)
- Wednesday, September 26 - Public Meeting (Baldwin Hills Crenshaw Mall)

In addition to these meetings staff met and briefed the offices of Los Angeles Councilmembers Wesson and Harris-Dawson, Westchester Neighborhood Council, LAX Coastal Chamber, Gateway LA Business Improvement District, and the North Redondo Beach Merchants Association.

Comments and recommendations varied widely depending on the groups represented. In general, constituents along the Crenshaw corridor favor staff's recommendation of Alt C-1 given the travel patterns of the vast majority of Green Line riders as well as potential new riders identified through cell phone based travel demand data. Gateway Cities stakeholders also agree with alternatives that connect the Norwalk/I-105 segment of the Green Line with the Crenshaw corridor, including Alt C-3 and staff's recommended Alt C-1. South Bay stakeholders prefer any alternative that preserves service for current Green Line riders and provides a fast service between the South Bay and Downtown LA via direct connections to the Silver and Blue Lines. This service would essentially help to augment LADOT's Commuter Express Line 438 between South Bay and Downtown LA, which only operates during the peak hours in the peak direction. Below is specific feedback received by

each of the groups.

South Bay Cities COG (SBCCOG)

- Overall, the SBCCOG agree that the Metro Board should approve a preferred alternative that maintains enough capacity to accommodate existing Green Line demand. They also believe that the Board should select an operating plan that meets the demand and travel patterns existing today, but that the plan should be revisited if demand changes such as with the Green Line Torrance Extension.
- Specific to South Bay, they are concerned that without a major line operating out of Redondo Beach, ridership will not increase along their segment. There was also significant discussion about the need for fast service all day between the South Bay and downtown LA, and several members mentioned LADOT's Commuter Express Line 438 as being the ideal service for them. The only drawback to Line 438 currently is the limited span of service (peak hour only).
- The SBCCOG prefers the following alternatives, in priority order:
 1. C-5 (Redondo Beach - Norwalk, and Redondo Beach - Expo/Crenshaw)
 2. C-4 (Redondo Beach - Norwalk, and Willowbrook/Rosa Parks - Expo/Crenshaw)
 3. C-3 (Redondo Beach - Willowbrook/Rosa Parks, and Norwalk - Expo/Crenshaw)

In addition, SBCCOG wanted to continue to explore opportunities to address the junction conflicts and uneven headways of B-2.

Gateway Cities COG (GCCOG)

- GCCOG selected the following as their preferred alternatives, in priority order:
 1. C-3 (Redondo Beach - Willowbrook/Rosa Parks, and Norwalk - Expo/Crenshaw). *Note that this option is only preferred if Metro will commit to maintaining 6 minute frequencies on both lines. This would result in over-service of the segment between Aviation Station and Willowbrook/Rosa Parks Station with trains every 3 min during the peak period compared to the current 6 minute frequency. If service along this segment is reduced to the current 6 minute frequency, GCCOG prefers Alt C-1.*
 2. C-1 (Norwalk - Expo/Crenshaw, Redondo Beach - LAX)

Regional Service Councils

- While this item was a receive and file at the service council meetings, Gateway Cities Service Council members prefer the staff recommendation of Alt. C-1.

- South Bay Service Council discussed this item and took public comment. There was no consensus on a preferred alignment.
- Westside Central Service Council had little comment on the operating plan.

Public Meetings

- The Crenshaw Community Leadership Council agreed that the staff recommended Alt C-1 is the preferred operating plan given current ridership patterns from the Green Line Norwalk/I-105 segment and the fact that most people travelling from the South Bay are destined along the I-405 corridor which is west of the Crenshaw Line.
- Comments at the Baldwin Hills Crenshaw Mall focused on bus service within the Crenshaw area rather than the rail operating plan.
- While GCCOG members reiterated their adopted recommendations at the public meeting held in Paramount, the general sentiment of the public participants was in favor of C-1.
- Comments at the Proud Bird public meeting favored alternatives that provided service between Redondo Beach and Expo/Crenshaw or direct connections between Redondo Beach and the Silver or Blue Lines for fast service into Downtown LA.
- Oral comments were provided by the public and recorded on tape. Six written comments were submitted for the public record.

Recommendation

Attachment C provides a comparison of the 6 alternatives that were selected by stakeholders for final consideration. Based on stakeholder and public input, the two alternatives that surfaced with most support are:

- Alt C-1: trains every 6 minutes (peak) between Norwalk Station (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Redondo Beach (Green Line) and Century/Aviation Station.
- Alt C-3: trains every 6 minutes (peak) between Norwalk Station (Green Line) and Expo/Crenshaw, and trains every 6 minutes (peak) between Willowbrook/Rosa Parks Station and Redondo Beach.

Both of these alternatives match the current travel patterns of the majority of Green Line riders as well as expected future ridership based on the cell phone travel demand data. As seen from the cell phone based travel demand data shown in Attachment B, people travelling from the I-105 corridor are

destined to many places that the Crenshaw Line will service. In contrast, people travelling from the El Segundo area are destined to places north and south along the I-405 corridor. Therefore, potential new ridership along the Crenshaw corridor would be expected from the I-105 corridor and not from El Segundo. However, 3,400 current Green Line riders who are destined to the Redondo Beach segment will incur a 7 minute transfer penalty under Alt C-1. This transfer is similar to the Blue - Expo Line transfer at Pico Station which requires 9 minutes (3 min from junction to Pico Station, 3 min transfer, 3 min from Pico Station to junction).

The tradeoff for the transfer penalty is that Alt C-1 provides direct connections to LAX and the future 96th Street Station from all three terminals, while Alt C-3 does not serve LAX/96th Street north of the new AMC/LAX Station directly from the Redondo Beach segment, reducing access to LAX and employment around the airport from the South Bay. In addition, it would limit the ability to provide weekend special event service directly from the South Bay to the new NFL stadium via the Downtown Inglewood Station since there would not be a train route from the Redondo Beach segment that could be extended north from LAX to Downtown Inglewood on game days. (Of note, due to the junction and traction power constraints identified above, it is not feasible to run every day service between the South Bay and Downtown Inglewood Station under Alt C-1).

The cell phone location-based data also confirms that the predominant travel pattern of South Bay residents is north/south along the I-405 corridor. Alt C-3 continues the current east/west alignment for South Bay residents, and therefore does not serve their travel pattern. Alt C-1, however, provides a new opportunity to travel north/south from South Bay. Coupled with frequent bus connections at LAX north along the Sepulveda and Lincoln Blvd corridors, South Bay residents will have a competitive transit option to their primary travel destinations.

Finally, C-3 overserves the 8 mile segment of the Green Line between Aviation Station and Willowbrook/Rosa Parks Station. Currently this segment of the Green Line operates every 6 minutes during peak hours and 15 minutes during midday using 2-car trains. This amount of capacity is sufficient to accommodate demand. C-3 would increase service along this segment to every 3 minutes during the peak and 6 minutes during midday. As a result, this corridor would be greatly overserved at an additional cost of \$10 million per year compared to Alt C-1. Alt C-1 requires 53 cars (peak requirement + spares) and 195,000 annual revenue vehicle hours to operate. At a marginal cost per revenue vehicle hour of \$395, the annual operating cost is \$77 million. Alt C-3 requires 60 cars (peak requirement + spares) and 221,000 annual revenue vehicle hours to operate. At a marginal cost per revenue vehicle hour of \$395, the annual operating cost is \$87 million. The \$395 cost per revenue vehicle hour consists of transportation (operators, supervisors, etc.), maintenance (vehicles, systems, right of way, etc), and other operating costs (security, utilities, etc.), minus support department costs, including procurement, human resources, ITS, etc.

In addition, with 2 car trains running every 3 minutes, there will not be sufficient traction power to increase service along the Crenshaw/LAX corridor from 2 to 3 car trains when needed. This means service will be capped at two thirds of design capacity on the Crenshaw corridor. Given the evaluation criteria, rail operations simulation, and public engagement results, staff recommends Alt C-1 as the preferred operations plan for initial revenue service of the Crenshaw/LAX - Green Line network.

DETERMINATION OF SAFETY IMPACT

The recommended action of Alt C-1 will improve the implementation of the Crenshaw/LAX Line by simplifying the operating plan and enhance Metro's ability to provide service that is safe and reliable.

FINANCIAL IMPACT

The operating cost for the Crenshaw/LAX and Green Line rail service will be approved through the FY20 budget process.

IMPLEMENTATION OF STRATEGIC PLAN GOALS

Approval of this recommendation supports several following Metro Strategic Plan Goals:

1. Provide high-quality mobility options that enable people to spend less time travelling
2. Deliver outstanding trip experience for all users of the transportation system
3. Enhance communities and lives through mobility and access to opportunity

ALTERNATIVES CONSIDERED

The remaining scenarios could be considered for the Crenshaw/LAX operating plan. However, staff does not recommend this approach. Staff asserts that there are distinct advantages to Alt C-1. Pursuing other alternatives could lead to significant overcrowding for today's customers, underutilized trains in other areas, poor transfer connectivity to the overall Metro system, and potentially negative impacts to the Blue and Expo Lines.

NEXT STEPS

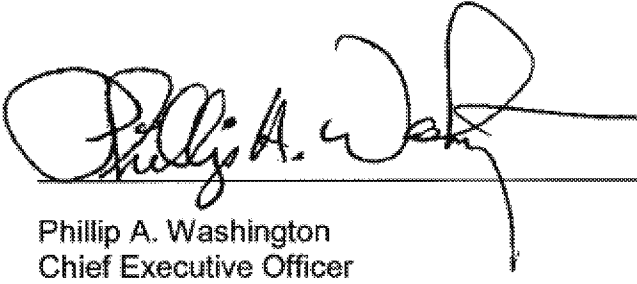
Staff will continue public outreach on the Crenshaw/LAX Line and update information, including station signage and maps, to match the recommended operating plan.

ATTACHMENTS

- Attachment A - Motion 40.1 - Crenshaw/Green Line Operating Plan
- Attachment B - Crenshaw/LAX - Green Line Alternative Service Plan Evaluation
- Attachment C - Comparison of Final 6 Operating Alternatives

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Phillip A. Washington
Chief Executive Officer

Motion 40.1:

DIRECTOR HAHN, DIRECTOR BUTTS, DIRECTOR FASANA

**Related to Item 40: CRENSHAW/LAX SERVICE PLAN AND BUS/RAIL
INTERFACE AND PLAN**

WE THEREFORE MOVE THAT THE CEO:

Direct Metro staff to report back on the following:

- A. To expand the ridership and travel pattern study to include the ridership versus the boarding numbers from Norwalk as well as the ridership projected from the Green Line extension to Torrance.
- B. To add a third scenario to the service plan that gives both ends of the Green Line a one-seat ride to the Expo Line.
- C. To clearly explain all the pros and cons of each scenario and to have a robust public engagement with the local cities, the COG, and the community, in order to give the opportunity for the public to know the good and bad of each option.
- D. To return to the board in September with the recommended plan for Board approval.

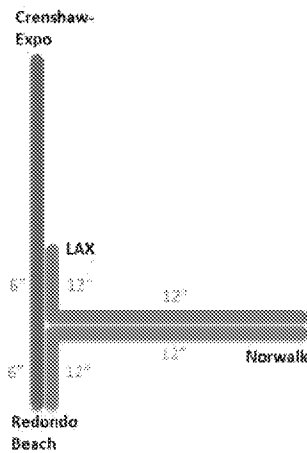
CRENSHAW/LAX – GREEN LINE ALTERNATIVE SERVICE PLAN EVALUATION

The Crenshaw/LAX Line will be connected to the existing Green Line mid-line between Mariposa and Aviation Stations. The opening of this new rail network will provide three potential directions for trains to operate.

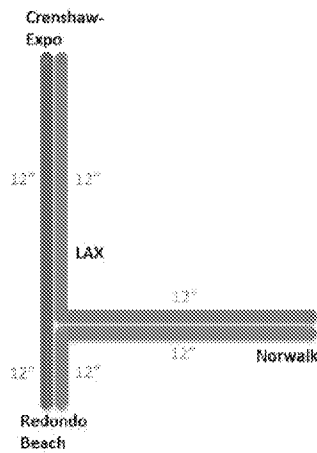
- Between Norwalk Station and Redondo Beach Station (existing Green Line)
- Between Expo/Crenshaw Station and Norwalk Station
- Between Expo/Crenshaw Station and Redondo Beach Station

Based on these train moves, 11 alternative service plans were developed, including:

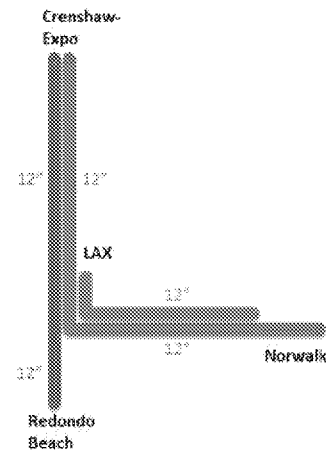
Alt B-1: Crenshaw/Redondo Green Line Branch



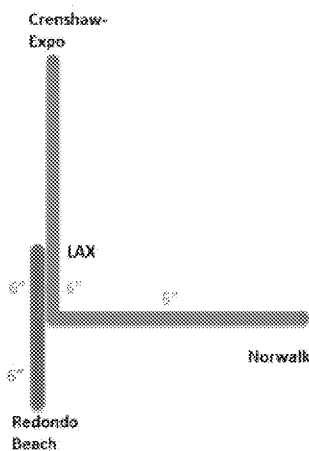
Alt B-2: Crenshaw/Green Line Branch



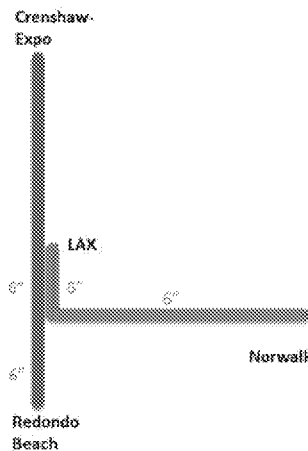
Alt B-3: Willowbrook/RP – Century/Aviation Shortline



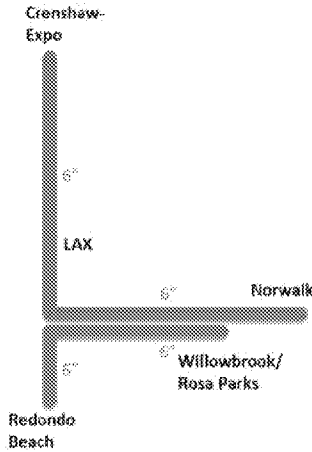
Alt C-1: Crenshaw/Norwalk Interline with Redondo Shuttle



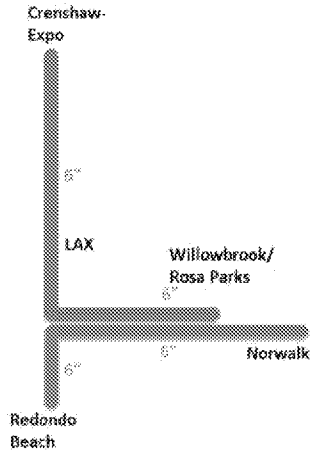
Alt C-2: Crenshaw/Redondo Interline, Norwalk Shortline



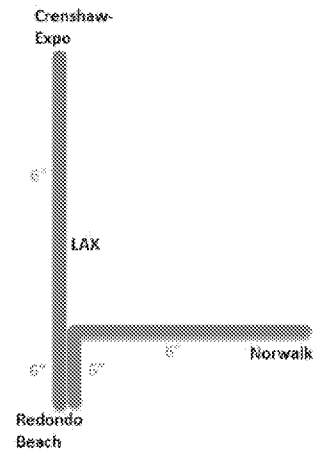
Alt C-3: Green Line shortline, Crenshaw to Norwalk



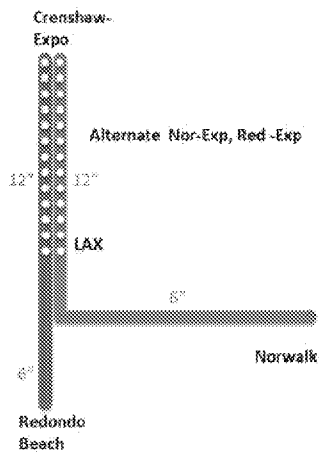
Alt C-4: Green Line, Crenshaw To Willowbrook/Rosa Parks



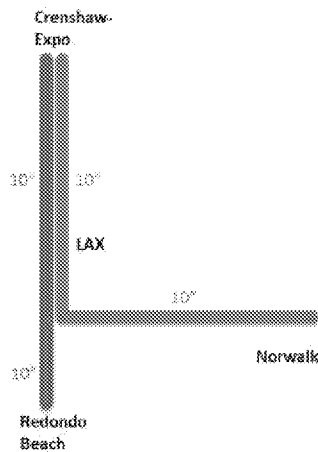
Alt C-5: Green Line, Crenshaw To Redondo Beach



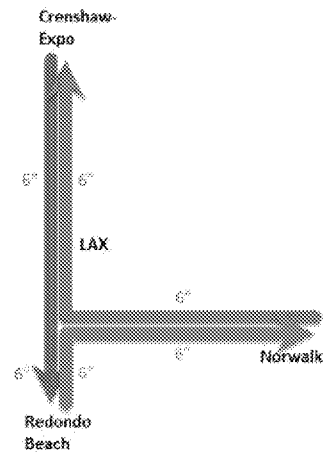
Alt D-1: Alternate Norwalk/ Crenshaw, Redondo/Crenshaw



Alt D-2: Alternate Norwalk/ Crenshaw, Redondo/Crenshaw



Alt D-3: One Way Operations



Each alternative service plan was evaluated using the following criteria:

- Connection to LAX

One primary goal of the Crenshaw/LAX Transit Project is to provide connectivity to LAX. Most bus connections, including the LAX Airport G Shuttle, will move from the current Aviation Station to the new Aviation/Century Station once Crenshaw/LAX opens. Therefore, the preferred service concept should ensure that a direct connection is provided between each of the three segments and the Aviation/Century and future 96th Street/AMC Station. Eight of the 11 alternatives achieve this criterion, including B-1, B-2, B-3, C-1, C-2, D-1, D-2, D-3.

- Current travel patterns – Figure 1-2 show the destinations of customers using the Green Line from each of the two segments (Norwalk – Aviation and Mariposa – Redondo Beach) based on TAP data. As shown in Figure 1, customers travelling along the Norwalk/I-105 Freeway segment are largely destined to central/south/southeast and downtown LA, along the Crenshaw Line corridor, and west along the Wilshire Corridor towards Santa Monica.

Figure 1
Transit Destinations from Norwalk/I-105 Freeway Segment



Figure 2
Transit Destinations from Redondo Beach Segment



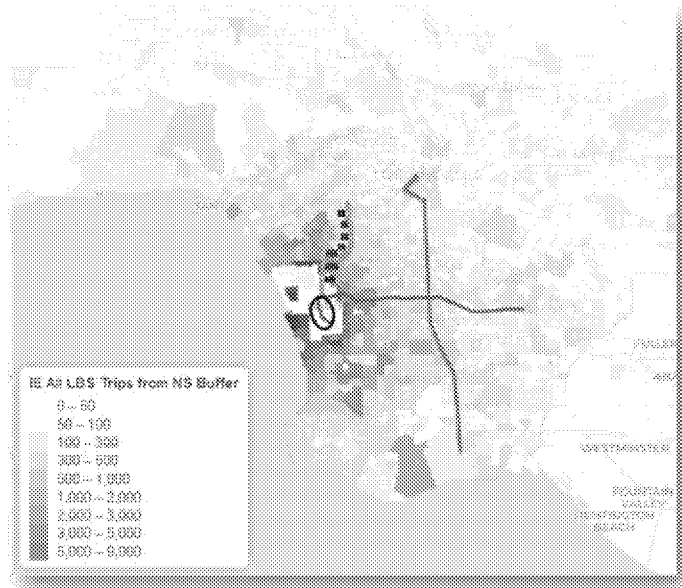
Customers boarding the Green Line along the Redondo Beach segment are largely travelling to destinations along the Blue Line. These are generally return trips for people working in the El Segundo business district.

Using Location Based Data from mobile devices, destinations of people travelling from a 1-mile buffer around the Norwalk/I-105 Freeway segment show similar results to the TAP data with more penetration south of the Green Line (Figure 3).

Figure 3
All Travel Destinations from Norwalk/I-105 Freeway Segment



Figure 4
All Travel Destinations from Redondo Beach Segment



Conversely, people starting their trips within a mile of the Redondo Beach segment are largely destined north and south along the I-405 corridor, and not east into the Crenshaw corridor nor the Green Line I-105 segment.

- Overall travel time for each of the six terminal-to-terminal moves

With the operating constraints from traction power and the wye junction, all scenarios have tradeoffs between providing one seat rides to and from all three terminals and frequency of service. If a transfer is required, the impact ranges between 3 and 7 minutes during the peak periods compared to a one seat ride. Transfers are required for some trips in all alternatives except for B-2. While B-2 provides a one seat ride to and from all three terminals, frequencies are reduced by 50% on each route from 6 to 12 minutes. Therefore, average wait time doubles from 3 to 6 minutes during the peak periods.

Based on the current Green Line travel demand, transfers between Norwalk and Expo/Crenshaw are likely to impact the most customers. Therefore, C-1 and C-3 provide the best overall travel time to the greatest number of customers with a 6 minute frequency and one seat ride between Norwalk and Expo/Crenshaw.

- Ridership demand for each of the three segments

It is important to consider current and future ridership along each of the three segments of the network to ensure that the appropriate capacity is provided to match demand. The Green Line currently carries about 33,000 average weekday boardings, with roughly 25,500 boardings on the I-105 Freeway segment between Norwalk and Aviation, and about 7,500 on the Redondo Beach – Aviation segment. The Crenshaw/LAX and Airport Metro Connector is expected to carry an additional 16,400 new boardings along the extension.

In addition, there is significant transfer activity currently occurring between the Green Line and major north/south bus corridors, such as Crenshaw Bl, Hawthorne Bl, and Vermont Av. Therefore, it is anticipated that many Green Line customers will migrate from these bus corridors to the Crenshaw/LAX Line, as experienced on the Expo Line from parallel bus services such as Wilshire Bl, Olympic Bl and Venice Bl.

Future ridership will include the Green Line Extension to Torrance anticipated in 2028. This segment plus the current Redondo Beach demand is expected to generate about 16,300 boardings, matching the ridership projections of the Crenshaw/LAX segment. Therefore, the service plan should be revisited at least one year prior to the Torrance Extension opening to determine if travel patterns and other relevant factors show a need for a change in the service plan.

- Consistent Headways

To ensure that customers have an even level of service along the entire Crenshaw/LAX – Green Line network, and passenger loads are even from train to train, both directions of each segment should operate at a consistent frequency. Service is anticipated to begin in the Fall of 2019 with 6 minute peak hour frequencies on all segments with a maximum design frequency of 5 minutes. This frequency is also consistent with the Blue and Expo Lines, ensuring transfer loads are balanced between all three rail lines.

All alternatives provide consistent headways except for B1, B-2, and D-1.

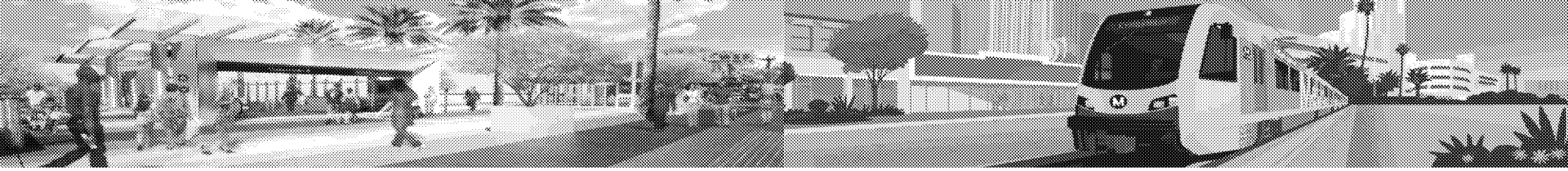
- Network Simplicity

Simplifying the network makes the rail service more intuitive and easy to navigate. Fewer variations in routing and frequencies reduce confusion and requires less pre-planning by the customer before making the trip. This is especially beneficial for airport service as some customers will be first time riders and many from different parts of the world. Alternatives C-1, C-2, C-3, C-4, C-5, and D-2 are the easiest to navigate given their consistent routing and headways.

CRENSHAW/LAX – GREEN LINE
FINAL 6 OPERATING SCENARIOS

ATTACHMENT C

Alternatives	Direct connection to LAX from all three terminals	Service on each segment matches ridership demand	Routing matches where most people want to go	Even spacing between trains	Minimize wait times and transfers				Network is easy to understand	Operating Cost/Year	
					Origin	Destination	Avg Wait	Xfer Cost			
B-2 				 Uneven frequencies on Green Line segments. Does not match Blue Line frequencies.	Origin	Destination	Avg Wait	Xfer Cost			\$93.5M
					Norwalk	Expo/Crenshaw	6 min				
					Norwalk	Redondo Beach	6 min				
					Expo/Crenshaw	Norwalk	6 min				
					Expo/Crenshaw	Redondo Beach	6 min				
					Redondo Beach	Norwalk	6 min				
					Redondo Beach	Expo/Crenshaw	6 min				
C-1 					Origin	Destination	Avg Wait	Xfer Cost			\$79.6M
					Norwalk	Expo/Crenshaw	3 min				
					Norwalk	Redondo Beach	3 min	7 min			
					Expo/Crenshaw	Norwalk	3 min				
					Expo/Crenshaw	Redondo Beach	3 min	3 min			
					Redondo Beach	Norwalk	3 min	7 min			
					Redondo Beach	Expo/Crenshaw	3 min	3 min			
C-2 					Origin	Destination	Avg Wait	Xfer Cost			\$76.0M
					Norwalk	Expo/Crenshaw	3 min				
					Norwalk	Redondo Beach	3 min	7 min			
					Expo/Crenshaw	Norwalk	3 min	3 min			
					Expo/Crenshaw	Redondo Beach	3 min				
					Redondo Beach	Norwalk	3 min	7 min			
					Redondo Beach	Expo/Crenshaw	3 min				
C-3 				 Does not match Blue Line frequencies.	Origin	Destination	Avg Wait	Xfer Cost			\$90.6M
		i-105/Norwalk segment overserved.			Norwalk	Expo/Crenshaw	3 min				
					Norwalk	Redondo Beach	3 min	3 min			
					Expo/Crenshaw	Norwalk	3 min				
					Expo/Crenshaw	Redondo Beach	3 min	7 min			
					Redondo Beach	Norwalk	3 min	3 min			
					Redondo Beach	Expo/Crenshaw	3 min	7 min			
C-4 				 Does not match Blue Line frequencies.	Origin	Destination	Avg Wait	Xfer Cost			\$90.6M
		i-105/Norwalk segment overserved.			Norwalk	Expo/Crenshaw	3 min	3 min			
					Norwalk	Redondo Beach	3 min				
					Expo/Crenshaw	Norwalk	3 min	3 min			
					Expo/Crenshaw	Redondo Beach	3 min	7 min			
					Redondo Beach	Norwalk	3 min				
					Redondo Beach	Expo/Crenshaw	3 min	7 min			
C-5 					Origin	Destination	Avg Wait	Xfer Cost			\$83.3M
		Redondo Beach segment overserved.			Norwalk	Expo/Crenshaw	3 min	7 min			
					Norwalk	Redondo Beach	3 min				
					Expo/Crenshaw	Norwalk	3 min	7 min			
					Expo/Crenshaw	Redondo Beach	3 min				
					Redondo Beach	Norwalk	3 min				
					Redondo Beach	Expo/Crenshaw	3 min				

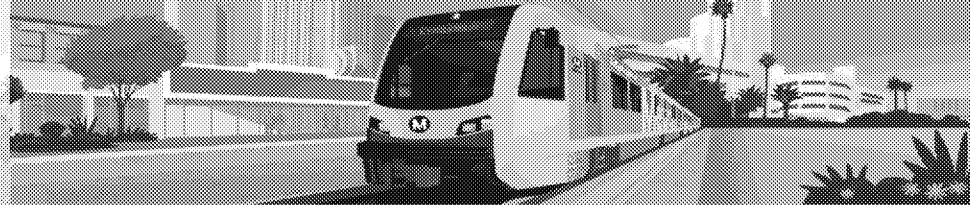


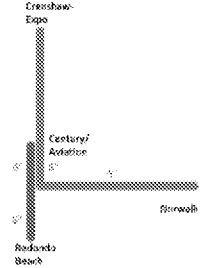
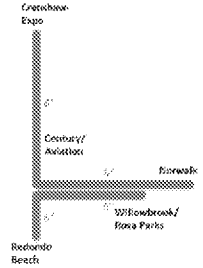
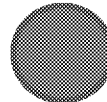
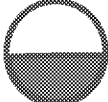
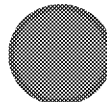
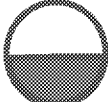
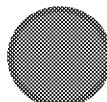
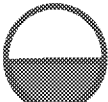
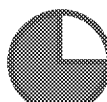
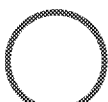
ITEM 28

CRENSHAW/GREEN LINE OPERATING PLAN

OPERATING PLAN OBJECTIVES

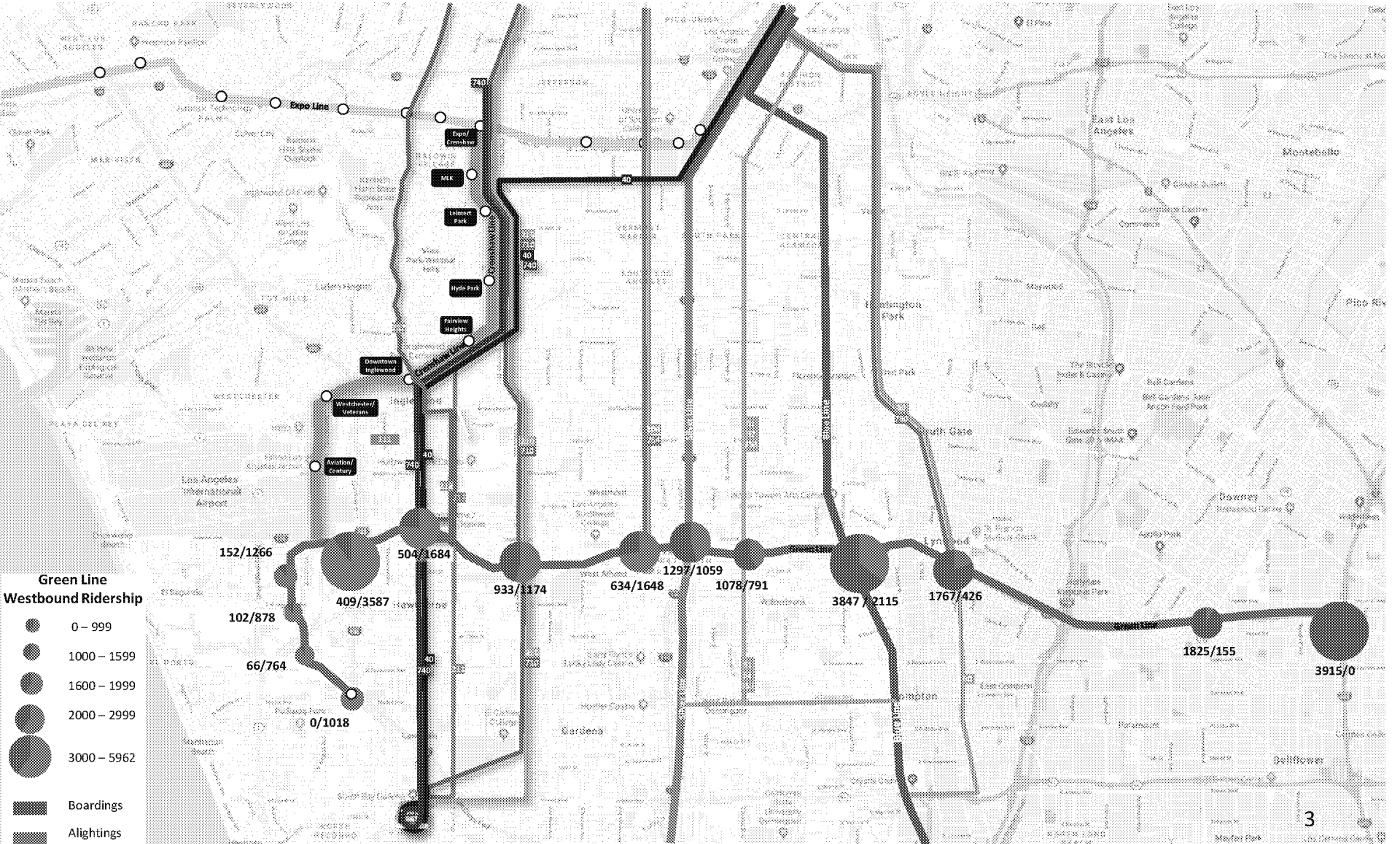
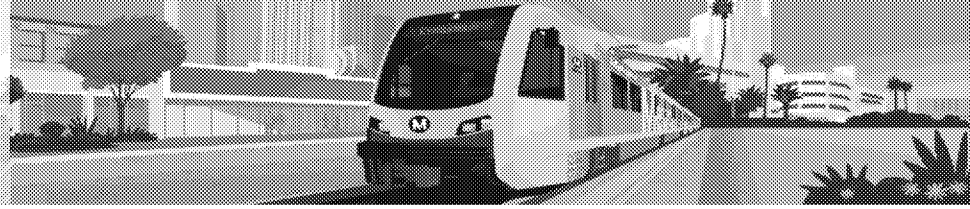
Evaluation of Final 2 Alternatives



	<p><u>C-1</u></p> <ul style="list-style-type: none"> Norwalk-Expo/Crenshaw Redondo Beach-LAX 	<p><u>C-3</u></p> <ul style="list-style-type: none"> Norwalk-Expo/Crenshaw Redondo Beach-Willowbrook 
Direct connections to LAX Airport from all directions	<ul style="list-style-type: none"> Direct service to 5th busiest airport in the world from all directions, and improving access to over 620K jobs within the LAX area 	<ul style="list-style-type: none"> No direct service to and from LAX from South Bay for visitors and workers 
Special event service to new NFL Stadium	<ul style="list-style-type: none"> Opportunity for special event service to Downtown Inglewood from all directions for NFL, Super Bowl, World Cup, Olympics, etc. 	<ul style="list-style-type: none"> No opportunity to route South Bay trains to Downtown Inglewood for special events 
Provides optimal capacity to meet current and future demand	<ul style="list-style-type: none"> Matches capacity with demand on all three segments Allows for 3-car trains along Crenshaw when ridership grows or for special events 	<ul style="list-style-type: none"> Overserves I-105 segment at a cost of \$10M/year Cannot expand to 3-car trains on Crenshaw due increased power consumption on I-105 segment 
New opportunities for South Bay residents	<ul style="list-style-type: none"> New opportunity to provide north/south service to take South Bay residents where they want to go 	<ul style="list-style-type: none"> Continues serving east/west alignment, which is very lightly used by South Bay residents 

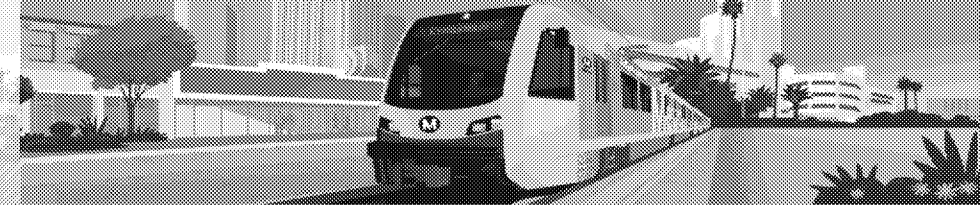
CRENSHAW/GREEN LINE

Bus/Rail Connections



GREEN LINE

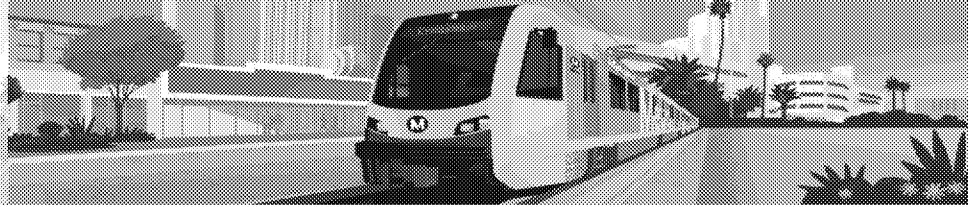
Average # People Travelling Each Segment



Between	Persons	Percent
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center; margin-right: 10px;"> 2 </div> <div style="font-size: 2em; margin: 0 10px;">↔</div> <div style="text-align: center; margin-left: 10px;"> 2 </div> </div> NOR NOR	12,240	77%
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center; margin-right: 10px;"> 1 </div> <div style="font-size: 2em; margin: 0 10px;">↔</div> <div style="text-align: center; margin-left: 10px;"> 2 </div> </div> SB NOR	3,392	21%
<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center; margin-right: 10px;"> 1 </div> <div style="font-size: 2em; margin: 0 10px;">↔</div> <div style="text-align: center; margin-left: 10px;"> 1 </div> </div> SB SB	197	1%
Total	15,828	100%



2. All Travel (cell phone data) RB-Mariposa Green Line Destinations

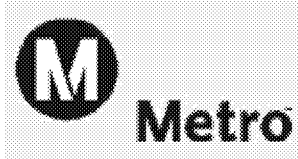
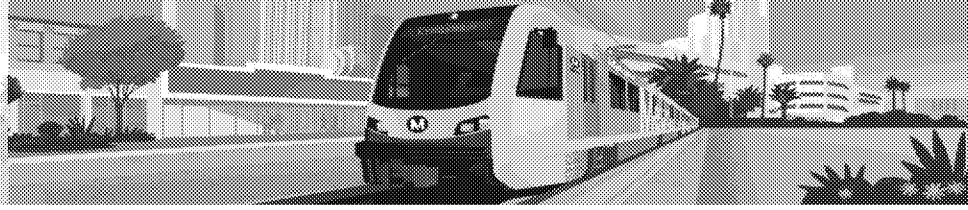


All Destinations from Redondo Beach Segment

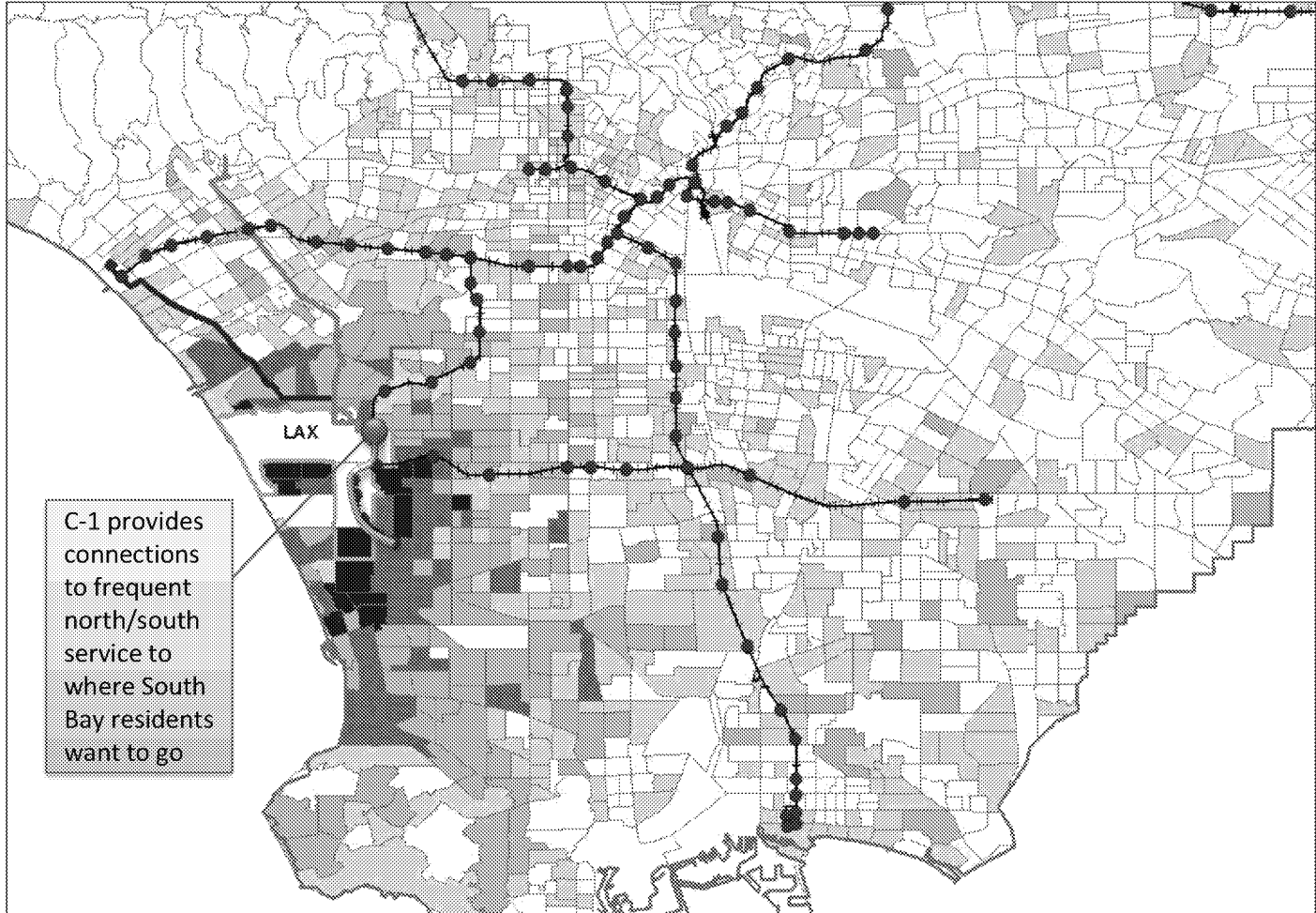


NEW OPPORTUNITIES FOR SOUTH BAY

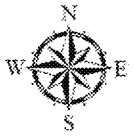
C-1 Provides Better Connections to Jobs



Commuter Work Flows to LAX-Aerospace Corridor From Los Angeles County Census Journey to Work 2006 - 2010 Survey

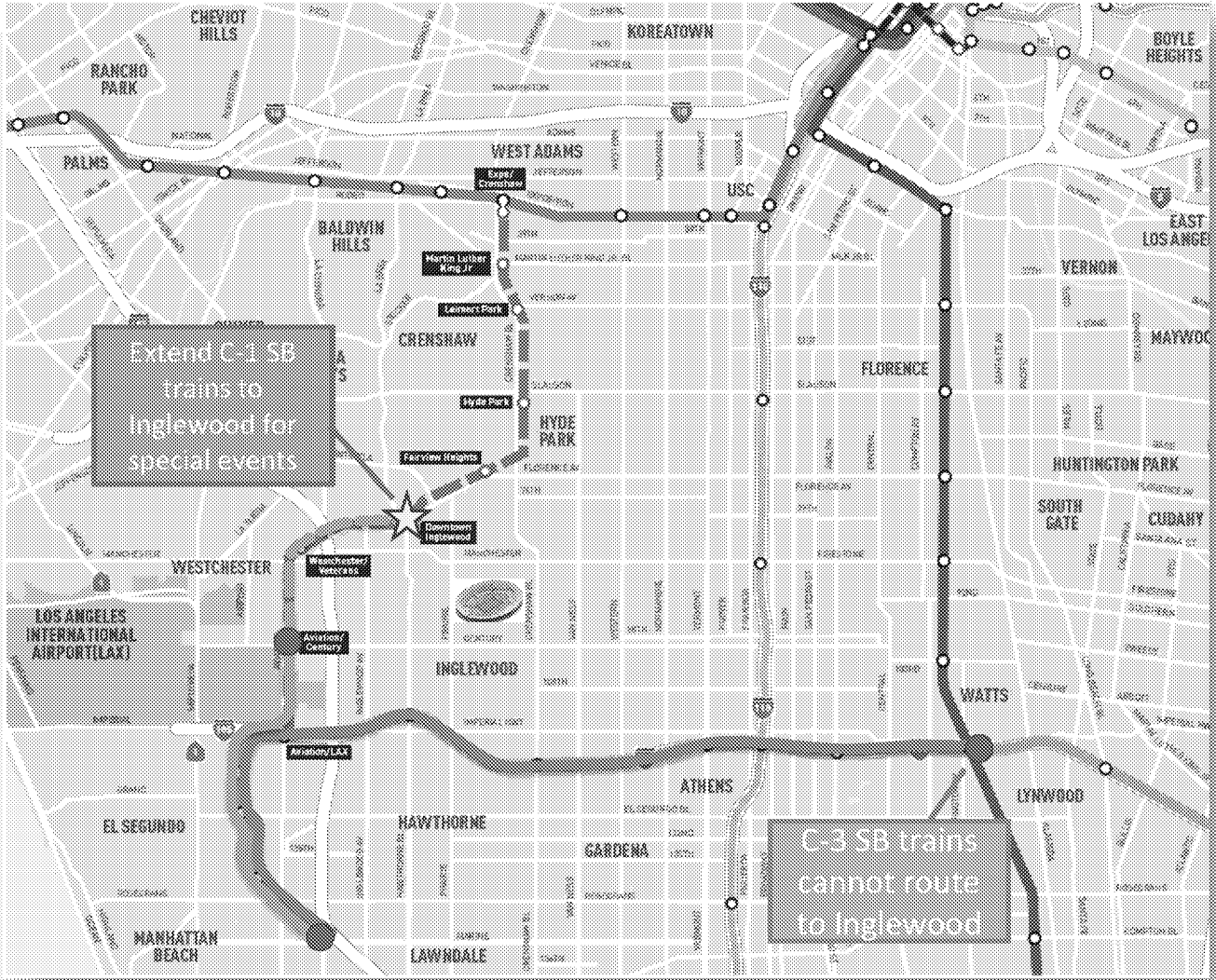
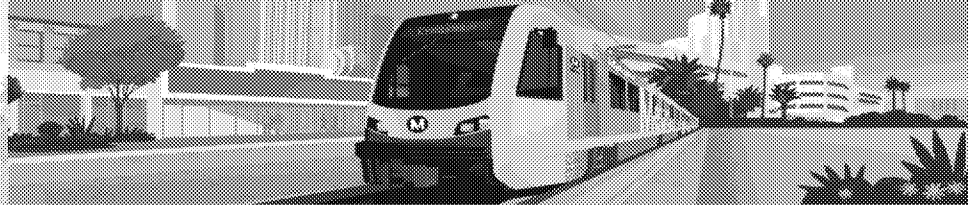


- Legend**
- Metro Rail Stations
 - Cuker City 6
 - Santa Monica 3
 - Metro Rail System
 - LAX - Aerospace Corridor
- Workers**
- 4 <= 45
 - 45 <= 110
 - 110 <= 230
 - 230 <= 415
 - 415 <= 765
 - Los Angeles County



ACCESS TO MAJOR SPECIAL EVENTS

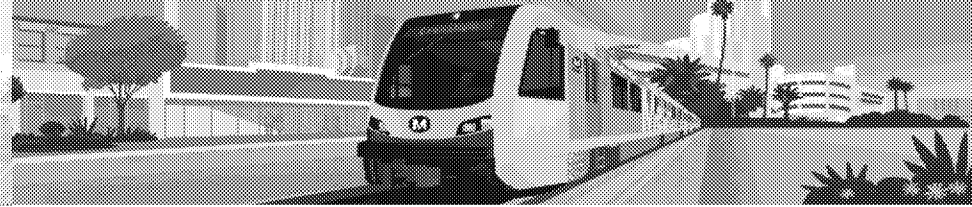
Inglewood Sports & Entertainment District



-  C-1 South Bay Route
-  C-1 Special Event Service
-  C-3 South Bay Route
-  Downtown Inglewood Station
-  22 NFL games per year
-  Super Bowl (2022)
-  NCAA Football Championship (2023)
-  FIFA World Cup (2026)
-  Olympics and Paralympics Games (2028)

TRACTION POWER CONSTRAINT

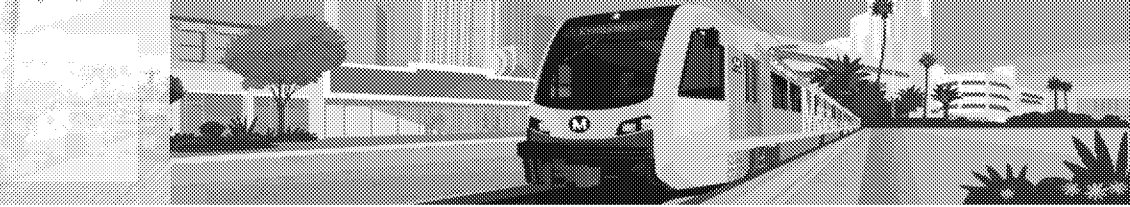
Impact to Train Performance with Alt C-3



- 2-car trains at 3 min headways on Green Line (Aviation – Willowbrook/Rosa Parks)
- Cars designed to operate at 750VDC for best sustainable performance (normal acceleration, HVAC, lighting, etc.)
 - 2-car trains at 3 min headways - power degrades to a **marginal level** (above 600vdc)
 - With one substation off-line and/or less than perfect train spacing - power degrades to an **unsustainable level** (below 600 vdc)
 - Alternating 2- and 3-car trains at 3 min headways; a substation off-line; and less than perfect train spacing - power degrades to an **unacceptable level** (below 500vdc)
- Impacts of unsustainable low voltage operations to customers:
 - Slow speed and delayed trains
- Impacts of unacceptable low voltage operations to customers:
 - Loss of HVAC
 - Loss of full body lighting (emergency lighting only)
 - Loss of power/stranded trains
- 2-car trains at 3 min headways on the green line poses service reliability risks;
- Alternating 2- and 3-car trains at 3 min headways poses clear service reliability risks.

RESOURCE REQUIREMENT

C1 vs C3



	Alt C-1	Alt C-3
Vehicle Requirement (Peak + Spares)	53	60
Ann Rev Vehicle Hrs	195,000	221,000
Ann Operating Cost	\$77M	\$87M

	Cost/RVH
Transportation	\$62
Maintenance	\$201
Other Operating	\$132
Total	\$395



QUESTIONS?