VTA Next Generation High-Capacity Transit Study

Executive Summary Report

October 14, 2021

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Submitted To:

Valley Transportation Authority

Santa Clara County
Transportation Authority (VTA)

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1.0 Introduction and Study Background

1.0 Introduction and Study Background

The VTA Next Generation High-Capacity Transit Study is intended to provide a comprehensive evaluation of existing and emerging high-capacity transit technologies to supplement or replace VTA's existing light rail transit system.

The purpose of this evaluation is to offer VTA's Board of Directors a range of options for addressing VTA's aging fleet of light rail vehicles. The range of possible actions include:

- refurbishing the current light rail fleet;
- replacing the fleet with a new generation of light rail vehicles; or
- replacing all or part of the light rail network with a different transit technology:
    - » Paving the light rail right-of-way to allow shared use by both light rail trains and buses
    - » Paving the light rail right-of-way to replace light rail trains with buses
    - » Eliminating light rail and replacing it with a fully-separated exclusive guideway transit system

VTA's light rail transit (LRT) system was born in an era of optimism about the new mode and its capabilities to increase transit ridership, reduce automobile congestion, and transform the metropolis. Unfortunately, this ideal has never been fully realized in Santa Clara County, largely because the built environment has evolved in ways that have undermined the demand for transit service. These include low-density development, dispersed patterns of trip making, and a large supply of roadways and inexpensive parking. As a result, VTA's 34-year old LRT system has struggled to attract ridership commensurate with the costs of its construction and operation. Light rail in Santa Clara County ranks in the lowest 10% of the country's 23 such systems in terms of passenger boardings per car-mile; it also has the highest operating cost per passenger of any U.S. light rail system.

An overarching goal of this study is to identify the most effective and financially sustainable path forward for VTA to economically provide high-quality service for the agency's high-capacity transit network. Any system revisions or enhancements should:

- Lower the cost of service
- Increase the frequency and flexibility of service
- Manage and justify capital costs
- Improve the passenger experience in order to grow ridership.

Summary of Findings - Any decision to completely replace the LRT network will realistically take 15 years or more for planning, permitting, funding, design, construction, and commissioning. In the meantime, it is assumed that VTA will continue operating its current LRT services. Considering the prospect of continuing LRT service for 15 years or more, it is fortunate that VTA's active fleet of 98 light rail vehicles is 17 to 19 years old. The fleet is in generally good condition and likely to continue operating beyond its 25-year expected minimum lifespan. **With its current mileage and level of utilization, the fleet should be sufficient to field 30 peak two-car trains until 2031.** At that point, unless cars have been rehabilitated or replaced, VTA's ability to provide a full complement of two-cars trains will be compromised. Since a rehab or replacement program will require about five years lead time, VTA has five years before that to decide on the future of its light rail service. **In order to continue full light rail service beyond 2031, a decision to rehab or replace cars should be made no later than 2026.**

A program of "right-sizing" the fleet, combined with a judicious program of refurbishments, could extend the life of the existing fleet to 2050 for as little as $32M in overhauls. During that time, VTA could more thoroughly evaluate a potential new technological investment to replace its light rail service.


DON'T BE ED...
TRASH YOUR TRASH.
936B

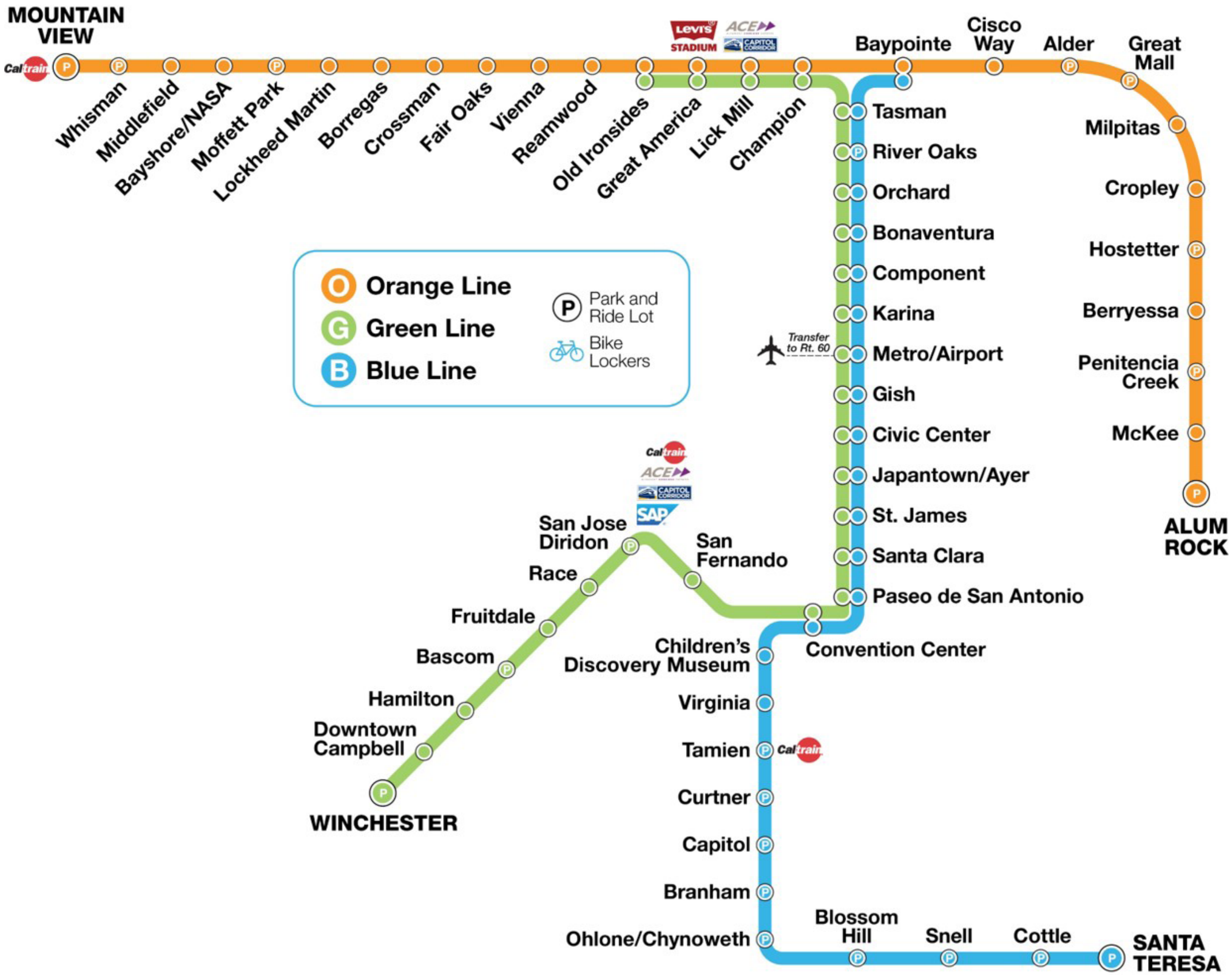
2.0 LRT System Summary

2.0 LRT System Summary

The Santa Clara Valley Transportation Authority (VTA) was formed in 1995 to conduct multimodal planning for transit, roadways, bicycles, and pedestrians. It also has the important responsibility of operating the local transit system. This system serves a 346-square-mile area of Santa Clara County, California, that includes the City of San Jose, 14 other municipalities, and unincorporated areas of the County.

VTA's transit system includes 505 buses operating on 50 routes, 98 light rail cars operating on three routes, seasonal vintage streetcar service, and ADA paratransit service. VTA is also a partner in intercounty bus and commuter rail service.

VTA's LRT system serves Santa Clara County with over 42 miles of standard gauge electrified railway. This network is largely double-tracked. LRT has operated here since 1987, with several substantial expansions. VTA has invested more than $2 billion building and expanding its light rail network. Today, that network serves 59 stations spaced an average of 0.7 miles apart with a fleet of 98 low-floor light rail vehicles, most operating in two-car trains. Prior to March 2020 (pre-pandemic), the system averaged 26,700 weekday passenger boardings. The end-to-end (commercial) velocity offered by VTA's light rail network is relatively fast compared with some

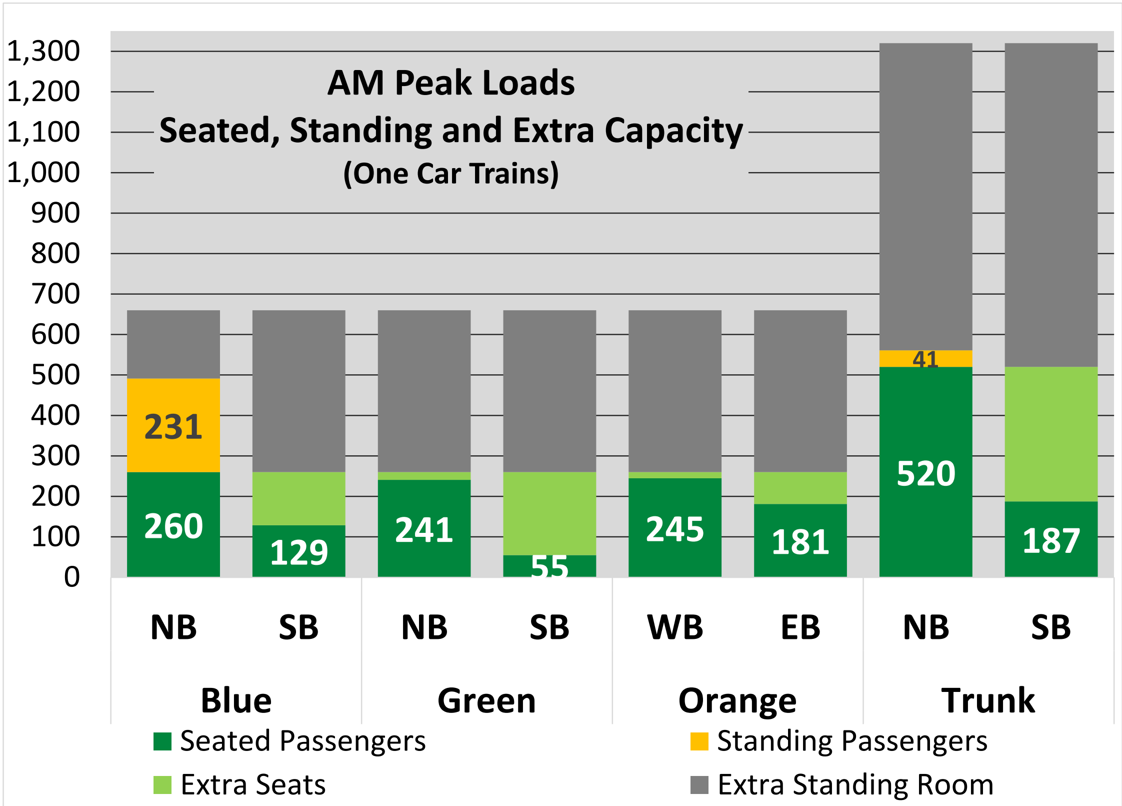

MOUNTAIN VIEW
Whisman
Middlefield
Bayshore/NASA
Moffett Park
Lockheed Martin
Borregas
Crossman
Fair Oaks
Vienna
Reamwood
Old Ironsides
Great America
Lick Mill
Champion
Levi's STADIUM
ACE
CAPITOL CORRIDOR
Baypointe
Cisco Way
Alder
Great Mall
Milpitas
Cropley
Hostetter
Berryessa
Penitencia Creek
McKee
ALUM ROCK
Tasman
River Oaks
Orchard
Bonaventura
Component
Karina
Transfer to Rt. 60
Metro/Airport
Gish
Civic Center
Japantown/Ayer
St. James
Santa Clara
Paseo de San Antonio
Convention Center
Orange Line
Green Line
Blue Line
Park and Ride Lot
Bike Lockers
Caltrain
SAP
San Jose Diridon
San Fernando
Race
Fruitdale
Bascom
Hamilton
Downtown Campbell
WINCHESTER
Children's Discovery Museum
Virginia
Tamien
Curtner
Capitol
Branham
Ohlone/Chynoweth
Blossom Hill
Snell
Cottle
SANTA TERESA

successful light rail systems, yet travel times remain slow compared to local auto alternatives. Operating with four trains per hour on each of its routes, VTA's LRT service is not as frequent as its more successful peers with similarly sized networks. But even with its existing service frequency, the current VTA light rail system offers a carrying capacity more than double its pre-pandemic peak demand.

High Capacity - The adjacent bar graph shows peak afternoon hourly loads relative to the seating and standing capacity of the VTA peak schedule, using one-car trains. (Note that in 2019, most peak VTA trains operated with two cars, so almost every passenger had a seat available to them. This practice resulted in twice the carrying capacity shown in the graph).

- During the peak hour, four trains ran in each direction on each branch, for a one-car capacity of 260 seats and 400 standees.
- On the combined Blue/Green line trunk, VTA ran eight trains per hour in each direction, to offer 520 seats and 800 standing spaces.

As noted above, VTA has generally been operating two-car peak trains. This doubles peak capacity to allow for 1,320 passengers per hour per direction (pphpd) on the branches and 2,640 pphpd on the trunk. No passengers are forced to stand for any portion their trip with this level of capacity.

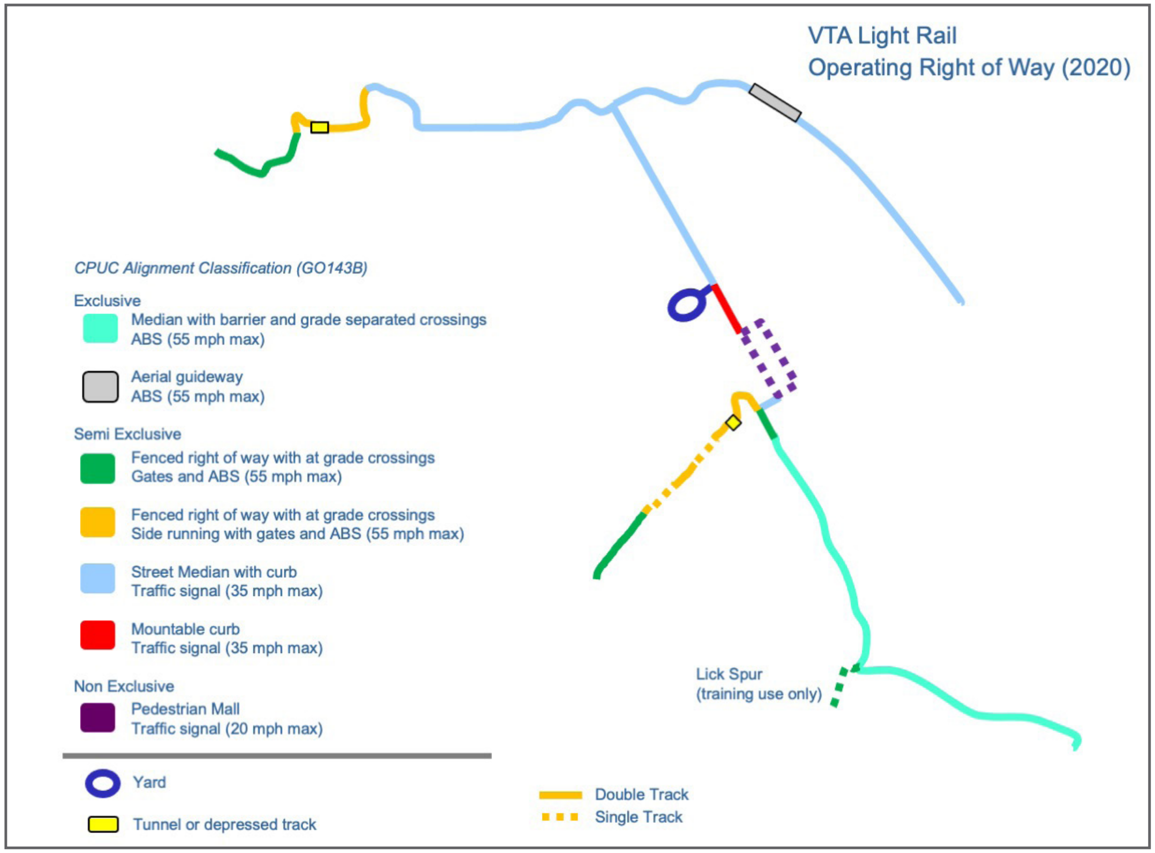


With one-car trains, the graph shows that almost 50% of the Blue Line's morning peak-hour northbound passengers at the peak load point (leaving Curtner Station) would have stood. But elsewhere on the network, no significant numbers of standees would be expected during the morning peak. Most passengers would be offered their choice of seats under typical operating conditions.

Since VTA has historically run its peak trains with a two-car consist, the network has huge capacity for ridership growth and to react to service perturbations and surges in demand.

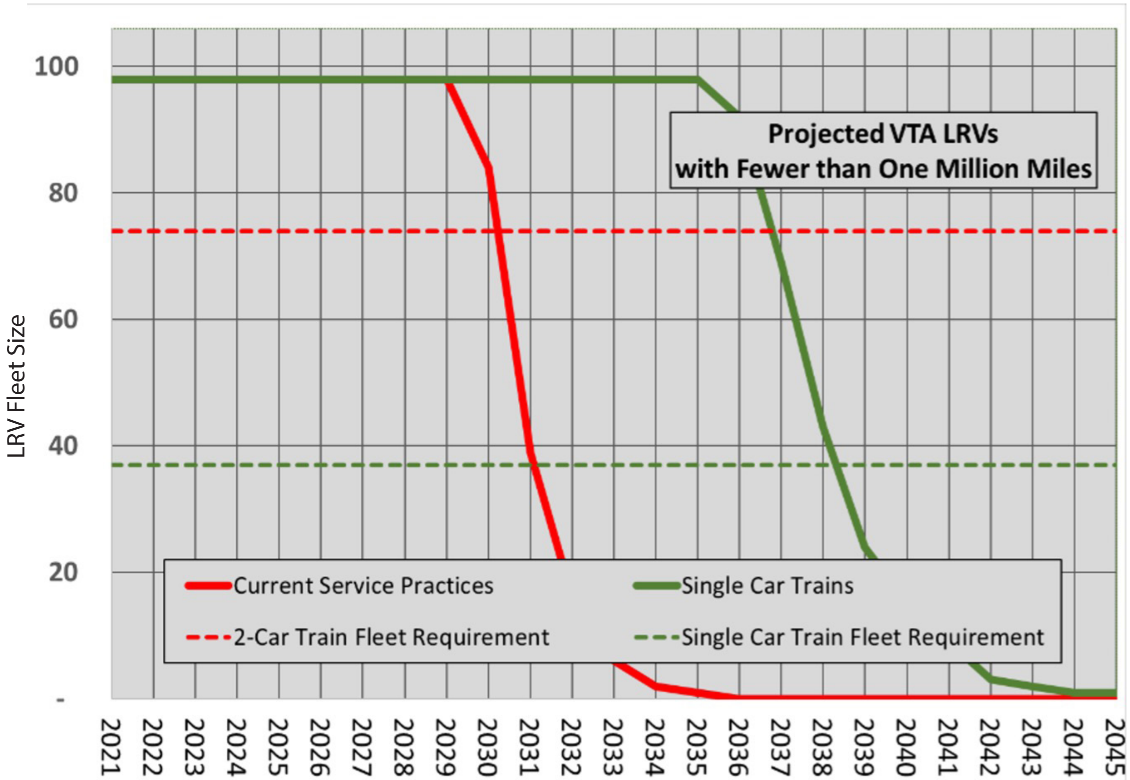
Track and Right-of-Way - With respect to infrastructure, LRT in Santa Clara County operates in a mix of exclusive and semi-exclusive rights-of-way, with various levels of priority over motorists and pedestrians:

- 25% of the overall LRT network operates in fully segregated right-of-way with no grade crossings, at a maximum allowable speed of 55 mph (shown in adjacent map as Exclusive).
- 29% of the overall LRT network has a right-of-way that is fenced and "protected" across roadways by railroad-style automatic highway crossing warning systems including gates, bells, and flashers, allowing a maximum speed of 55 mph (shown in adjacent map as Semi Exclusive).
- For several blocks downtown (1.4 miles or 3%), the system operates on a transit mall at a maximum speed of 10 mph; pedestrians are free to cross the tracks at any location, resulting in the LRVs running at the reduced speeds typical of a transit mall setting (shown in adjacent map as Non Exclusive).
- For the remaining 43% of the network, LRT operates at a maximum speed of 35 mph in the median of arterial roadways, separated from motorists by curbing (shown in adjacent map as Semi Exclusive).



Fleet Status - VTA's active fleet of 98 Light Rail Vehicles is 17 to 19 years old. The fleet is in generally good condition and should continue operating beyond its 25-year expected minimum lifespan. With VTA's mild operating conditions, low mileage, and relatively light loads, a life of 30 to 40 years is not unreasonable if the current program of maintenance and overhauls is sustained. The discussion below points out that the existing fleet, with its current mileage and level of utilization, should be sufficient to provide full peak two-car train service until 2031. At that point, with no car rehabilitation or replacement, VTA's ability to field a full 61 car-peak requirement will start to become more difficult. Assuming that a rehab or replacement program would require five years lead time, VTA would have to make a decision by 2026 to start rehabilitating or replacing cars.

Extending Vehicle Life - Propulsion system overhauls would be undertaken on an as-needed basis as each car approaches one million miles of service. This would extend life expectancy by ten years or more. As of June 2020, the 98-cars in the fleet averaged 575,000 miles of service. The typical VTA car has more than 40% of its anticipated lifetime mileage remaining before the next major overhaul. In 2019, the fleet averaged 38,500 annual miles per car, with the network operating an average of 1.65 cars per train. Assuming this same pace, VTA has until 2031 before it would have an insufficient number of cars (with fewer than one million lifetime miles) to be able to field 61 cars in the peak. This requires a fleet of 74 operable cars, including spares (which could be rounded up to 80 cars to provide for contingencies). However, if the typical train were shortened to only a single car, the peak vehicle requirement and rate of mileage accumulation would be reduced. With a minimum required fleet of 37 vehicles, including spares (which could be rounded up to 40 vehicles), the current fleet could be extended to the year 2036 before propulsion system overhauls were needed.

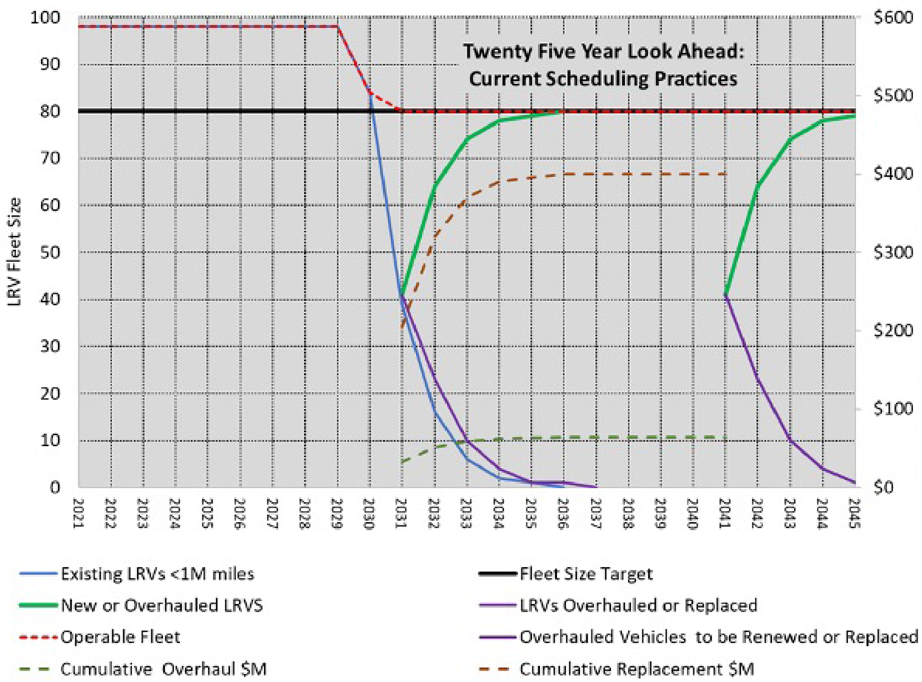


LRVS WITH FEWER THAN ONE MILLION MILES OF SERVICE PROJECTED BY YEAR AND SCHEDULING PRACTICE

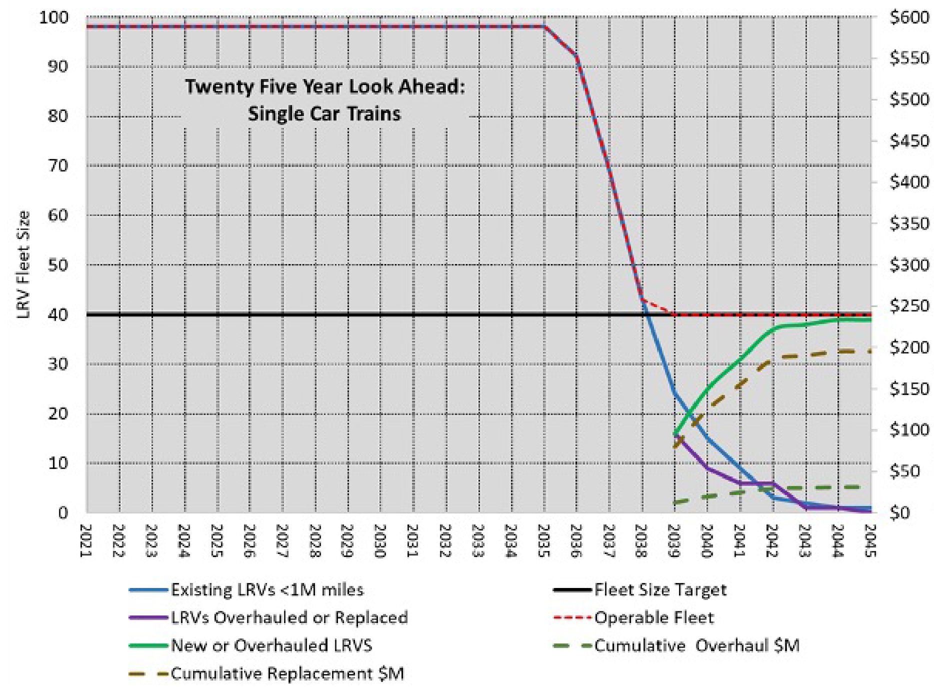
Thus, depending on schedule practices, VTA can defer any decision concerning overhaul or replacement of the current fleet until 2026 or 2031, allowing five years to complete a new car procurement or an overhaul program.

Costs to Overhaul or Replace Vehicles - VTA could decide to extend the lives of their current vehicles by starting a selective program of propulsion overhauls at an approximate cost of $800K per vehicle, in today's dollars. Overhauls for 40 cars could be expected to cost $32 million; an 80-car overhaul program would cost $64 million. Alternatively, replacement light rail vehicles would cost $5 million per car at today's prices. The replacement fleet would need to be roughly 40 vehicles for single-car trains, for a cost of $200 million. A replacement fleet of 80 cars would cost $400 million.

Fleet Timeline and Expenditures -As discussed above, VTA can wait five years to decide about an overhaul or procurement program. However, the



25-YEAR FORCAST OF REHABILITATION OR REPLACEMENT NEEDS FOR 2-CAR TRAIN SERVICE



25-YEAR FORCAST OF REHABILITATION OR REPLACEMENT NEEDS FOR 1-CAR TRAIN SERVICE

lead time for a new high-capacity transit system technology to replace the aging LRVs may be MUCH longer. Refurbishing a portion of the current fleet would be a reasonable fallback option if VTA decides to delay replacing the current vehicles or better understand its new technology options.

Replacing the existing light rail fleet with a fleet of new vehicles would be a costly capital investment for VTA. Alternatively, a program of "right-sizing" the fleet, combined with a judicious program of refurbishments, could extend the life of the existing fleet to 2050 for a capital cost of as little as $32M in overhauls. Over those three decades, VTA would be able to incrementally add vehicles to its fleet if ridership warrants. VTA could then use this additional time to consider its options for a potential new technological investment that might be more cost-effective for transit service in Santa Clara Valley.

The timing of introducing any new technology appears favorable. Given that, with single-car trains, the existing light rail fleet can be operated with few mechanical upgrades to 2045 or beyond, there should be sufficient time for the VTA Board to evaluate its options and formulate its plans.

However, if VTA plans to continue to reliably operate LRT service in the interim, by 2026 it will need to decide whether or not its interim service will use one-car or two-car trains and follow one of the following paths. :

1. Start the propulsion system overhauls of existing vehicles in the 2026-to-2031 timeframe, depending upon scheduling practices and required fleet size. This $32M to $64M investment could forestall any decisions concerning a replacement fleet to as late as 2046;

2. Begin planning for the delivery of replacement light rail vehicles at a cost of $200M to $400M in the 2026 to 2031 timeframe; or

3. Begin implementation of a new or revised mode of high-capacity transit. Right-sizing the existing fleet today and eventually refurbishing at least 40 vehicles would provide "breathing room" for VTA to thoughtfully consider its options and plan for a potential replacement system.

<table>
<tr><th colspan="5">Simplified Timelines for Retaining or Replacing VTA LRT Services</th></tr>
<tr><th rowspan="2">Year</th><th colspan="2">Keep Light Rail Transit</th><th colspan="2" rowspan="2">Replace Entire Light Rail Transit System</th></tr>
<tr><th>2-Car Trains</th><th>1-Car Trains</th></tr>
<tr><td>2021
2022
2023
2024
2025</td><td>Operate 2019 Service Frequencies with 2-Car Trains</td><td rowspan="2">Operate 2019 Service Frequencies with 1-Car Trains</td><td rowspan="3">Minimum Realistic Time to Select, Plan, Fund, Permit, Design, Construct Replacement System</td><td rowspan="5">Maximum Realistic Time to Select, Plan, Fund, Permit, Design, Construct Replacement System</td></tr>
<tr><td>2026
2027
2028
2029
2030</td><td>Start to Refurbish or Replace 80 cars</td></tr>
<tr><td>2031
2032
2033
2034
2035</td><td rowspan="2">80 Refurbished or New Cars in Service</td><td>Start to Refurbish or Replace 40 Cars</td></tr>
<tr><td>2036
2037
2038
2039
2040</td><td rowspan="2">40 Refurbished or New Cars in Services</td><td rowspan="3">Start Revenue Service of Replacement Technology</td></tr>
<tr><td>2041
2042
2043
2044
2045</td><td>Start to Refurbish 80 New Cars or Replace/Refurbish 80 Refurbished Cars</td></tr>
<tr><td>2046
2047
2048
2049
2050</td><td>80 Refurbished or Replacement Cars in Service</td><td>Start to Refurbish 40 New Cars or Replace/Refurbish 40 Refurbished Cars</td><td>Start Revenue Service of Replacement Technology</td></tr>
</table>

3.0 Screening the Universe of System Alternatives

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If a new mode of transit is to be considered to replace or supplement light rail, the universe of possible technologies should be reduced down to those with the most promise for success in Santa Clara County.

Modes of public transportation can be classified in various ways, according to the technologies they employ and the characteristics of their rights-of-way. Such classifications are useful for matching a mode of transit with the passenger demands it is expected to serve and the physical environment in which it will operate. For this analysis, new modes of transit were evaluated by technology family and not by each specific vendor's technology. The latter would be appropriate only if and when it were decided to adopt a new mode of transit to replace the light rail system.

Systems that run on streets shared with private automobiles are considered **street transit**. Light rail transit on segregated rights-of-way is generally classified as a form of **semi-rapid transit**; it currently serves as the basis of VTA's high-capacity transit system. Modes expected to carry higher passenger loads at faster speeds using fully exclusive rights-of-way are classified as **rapid transit**. There are also other modes, such as automated guideway systems and aerial cable systems, that can efficiently serve some urban transport markets. A variety of transit modes can operate within each right-of-way type, ranging from a standard urban bus in street operation to rapid transit metro, like BART, operating on an exclusive right-of-way.

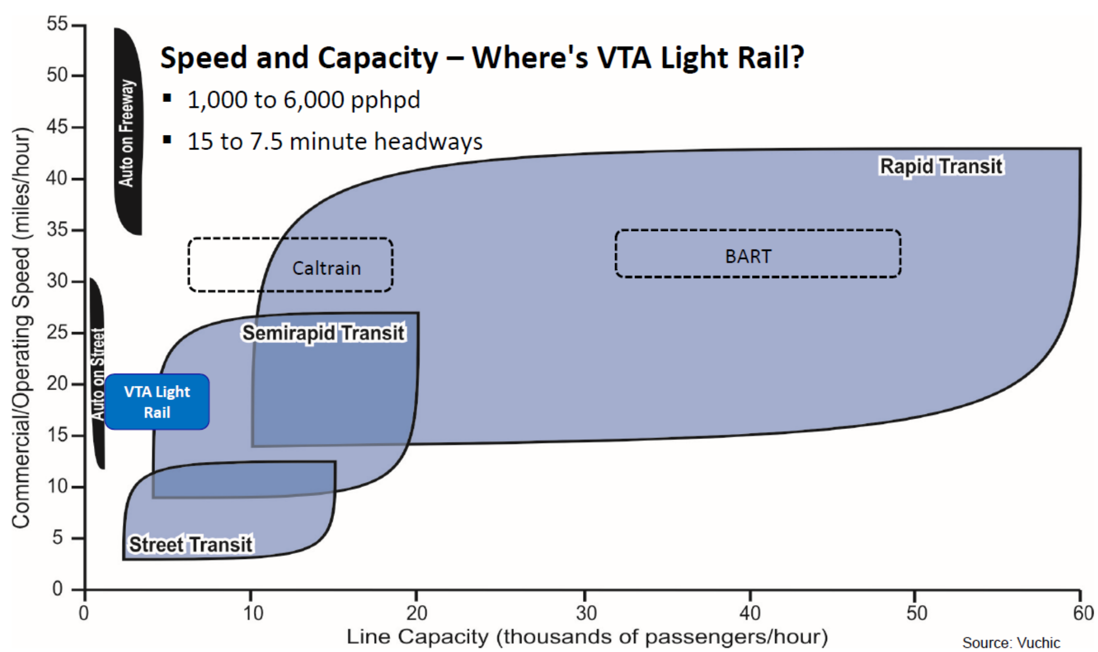
In general, semi-rapid transit systems offer service velocities in the range of 10 to 25 mph and can accommodate 3,000 to 20,000 passengers per hour. Within that general range, VTA light rail services offer velocities in the range of 16 to 21 mph. VTA is configured to carry up to 6,000 passengers per hour per direction. By way of comparison, the familiar BART and Caltrain systems are faster and higher-capacity rapid transit systems.

Customer Service and Transit Economics – Other factors beyond speed and capacity influence a traveler's choice of transport mode. Experienced travelers consider travel time, price, reliability, comfort, convenience, and courtesy as they choose the transport mode that offers what they consider the best mix of attributes for the trip they are making and their travel budget.

Hierarchy of Transit Modes	
Transit Mode Class	**Technology**
Street Transit	Standard Bus
	Trolleybus
	Streetcar or Tram
Semi-rapid Transit	Arterial Bus Rapid Transit (BRT)
	Light Rail Transit
Rapid Transit	Busway BRT
	Light Metro
	Metro
	Commuter or Suburban Rail
	Monorail
Other	Automated Guideway Transit (AGT)
	Aerial Cable Transit

Service and Demand - Passengers usually select modes that are fastest, most reliable, most comfortable, and fit within the budget they have available for the trip. If the traveler has ready access to an automobile, roads are not jammed, and parking is free, they will generally choose to travel in their automobile. In contrast, roadway congestion, high parking charges, high gasoline prices, and environmental concerns tend to encourage travelers to choose public transportation.

Waiting Time - One key advantage to travelling by private automobile is its spontaneity. A driver's personal vehicle is almost always ready for use. Travel by transit is more likely when the transit trip is fast and the wait for service is low. Travel time is a product of the actual time spent traveling and time spent waiting. Scientific studies indicate that travelers value time spent waiting 2 to 3 times more than time spent in the vehicle. In other



words, people hate to wait! Research summarized in the Transportation Research Board's publication concerning *Traveler Responses to Transit Service Changes* indicates that, on average, a 50% reduction in the interval between light rail trains would stimulate a 25% increase in ridership.

Service Velocity - Transit is a shared mode that raises revenues and lowers costs by serving multiple travelers on the same vehicle. To attract a diverse set of travelers for their shared journeys, the typical transit vehicle trip entails multiple stops for the various passengers to get on and off the vehicle. Each stop slows the trip and increases journey time for all passengers. Unless the roadways available for private automobiles are especially congested, the transit trip with multiple stops tends to be slower, even if using its own right-of-way.

Economies of Scale - High-capacity transit services take advantage of economies of scale by carrying large volumes of passengers on a shared vehicle with one (or two) operator(s) paid to operate the vehicle. High-capacity transit is not economically attractive unless it carries sufficiently large volumes of travelers—the reason why high-capacity transit services are often called "mass transit."

Capital, Labor, and Technology - The economic design and provision of public transport services represents a delicate balance between capital costs for vehicles, rights-of-way, and facilities, and the labor necessary to operate the service. Lower capital modes like buses tend to require more labor per seat-mile compared to higher capital modes. New technologies are constantly adapted to reduce the labor and capital required to offer transportation services.

Three classes of transportation modes—semi-rapid transit, rapid transit, and other--have been the focus of this study. Additional modes were considered but not analyzed in depth because they were deemed to be inappropriate for substitution for VTA's light rail system. The excluded modes are designed for longer distance trips and higher average speeds; these include modes such as intercity passenger rail, high-speed rail, and untested theoretical technologies like Hyperloop. Moreover, specialized applications like airport circulators have not been covered separately because they are encompassed within other technologies, such as automated guideway transit (AGT).

Beyond the transit modes discussed above, this study has evaluated industry trends in propulsion systems and operational control. California is leading a worldwide transition to clean, low-carbon Battery Electric Buses (BEBs). Unattended Train Operation for new metros is now the worldwide norm. Self-driving trams and trolleys are being demonstrated in Europe and Asia. Autonomous buses and shuttles are being tested in a number of domestic and foreign locations.

Minimum Thresholds for Consideration -To be considered a realistic alternative technology to supplant or supplement VTA's light rail system, a technology needs to be proven safe, reliable, and cost-effective for the transport of urban passengers at speeds and capacities that meet or exceed the performance delivered by the existing light rail service. The replacement technology must have a **proven record** serving the route lengths, service velocities, and passenger densities comparable to performance of the existing LRT network.

Service Attribute	Minimum Standard for Replacement Technology
Service Velocity	• 20 mph end-to-end travel speeds
Route Length	• Must support continuous uninterrupted end-to-end revenue service trips of 20 miles
Service Frequency	• Peak frequency of 8 trains per hour per direction (tphpd) in Downtown and 4 tphpd on all other service segments • Capable of 12 tphpd over entire network, with no upgrades to guideway
Average Peak Period Passenger Waiting Times	• 3.75 minutes in Downtown and 7.5 minutes on all other service segments • Capable of 2.5 minutes with no upgrades to guideway
Stop Density	• An average of three stations for every two route miles (one station per route kilometer)
Passenger Capacity	• 1,000 passengers per hour per direction (pphpd) • Capable of 5,000 pphpd by adding vechicles and operators but no upgrades to guideway or stations
Mature Technology	• Must provide infrastructure and vehicle technologies that have been fully built and tested in other similar environments beyond minor pilot installations • Should meet applicable regulations and safety standards

Airport-Diridon-Stevens Creek Connector Request for Information (RFI) - In July 2019, The City of San Jose, in coordination with VTA, invited interested parties to submit concepts to provide grade-separated mass transit infrastructure and operations at significantly lower cost than traditional transit projects for a connection between San Jose Diridon Station, Mineta San Jose International Airport (SJC), and Stevens Creek. Nineteen submissions recommended a specific transit solution for the Airport Connector. These proposals mostly focused on innovative automated technologies that would require a dedicated exclusive guideway: 14 technologies on an aerial guideway; four in a tunnel; and one a reserved surface right-of-way. All the proposals called for systems where vehicles would travel without a human operator and promised operating cost savings from automation and very small and light vehicles. ***None of these innovative technologies are appropriate or advanced enough to replace the 42-mile VTA light rail system because they have no track record of serving the route lengths, service velocities, or passenger densities that characterize the existing LRT network.***

What will work for VTA? -After careful consideration of a broad range of established and emerging transit technologies, the study moved to a more detailed evaluation of five alternative scenarios that would leverage VTA's investment in its LRT network, especially its expenditures for rights-of-way, stations, electric power supply, and track.

Four key considerations guided the study in defining the scenario options for more detailed evaluation:

1. Increased efficiency toward sustainable operating costs
2. Capital investment in scale with VTA's modest ridership
3. Rapid progress to electrification and a zero emissions fleet
4. Early entry on the industry trend toward automation

These considerations led the team to focus on electric buses, driver assistance features, and paths to eventual automation of operation. In addition, concerns about appropriate levels of capital investment commensurate with current ridership focused attention on options that would require less infrastructure investment and offer greater flexibility to respond to changing market conditions.

4.0 Alternative Scenarios

4.0 Alternative Scenarios

To assist the VTA Board in choosing among the wide array of alternative futures that could be envisioned for its present high-capacity transit system, five scenarios were developed.

Each scenario hypothesizes a way in which VTA's extensive investment in LRT could be sustained by continuing, augmenting, or replacing light rail technology. The alternative scenarios include: (1) refurbishing, and eventually replacing, the present fleet of light rail vehicles; (2) modernizing the light rail fleet with new technology; (3) integrating LRT and bus operation on the current light rail right-of-way; (4) replacing light rail with a busway in the same right-of-way; and (5) replacing light rail with a grade-separated rapid transit technology.

4.1 Status Quo – Right-Sizing and Refurbishing the Existing Light Rail Fleet

Retaining light rail in its present form can be considered the "base case" by which to compare the scenarios that augment or replace the system. The existing conditions analysis confirmed that the current fleet of 98 cars is larger than necessary to handle existing travel demands. Pre-pandemic, the peak vehicle requirement called for 61 cars (74 cars, with spares). A fleet of 80 cars instead of the current 98 would be more than sufficient to field 61 cars. Right-sizing the service to actual demand and using single-car trains would reduce the peak demand to 31 cars (37 cars, with spares). A fleet of only 40 cars could meet this service requirement. Right-sizing the trains in the 2021 operation would reduce mileage and wear and tear on the cars, extending their lives and forestalling the need to have new or refurbished cars before 2036. Right-sizing would also save approximately $10 million each year in reduced propulsion and maintenance costs.

If the number of cars operated in maximum service were reduced to 31 vehicles, the useful life of the existing fleet could be extended to 2038. VTA would need to make a decision about refurbishing or replacing a new smaller fleet of 40 cars in 2033, allowing time for overhauls or new car procurement. A rehab program would cost approximately **$32 million**. A new 40-car fleet would cost approximately **$200 million**.

Retaining light rail would require the upkeep of other system components. The buildings, culverts, and catenary support poles still have useful lives of many decades. Others components, such as tracks and overhead wires, require incremental maintenance, which currently costs about $33 million a year.

As discussed earlier, right-sizing the service and possibly refurbishing 40 cars starting in 2031 would extend the life of the existing fleet to 2045 or beyond. This would provide breathing room for VTA to consider its commitment to the light rail system and refine its understanding of alternatives. Since well over $2 billion has been invested in VTA's light rail system over the years, sound public policy dictates utilizing as much of it as possible. The following table summarizes some strengths and weaknesses of the Status Quo scenario.

Status Quo Scenario	
Strengths	**Weaknesses**
• Simplest scenario to implement • No changes required to operating procedures or corporate culture • Right-sizing capacity to demand will result in savings in vehicle maintenance and propulsion power (annual operational savings around $10 million)	• Refurbished light rail vehicles may appear outdated in future years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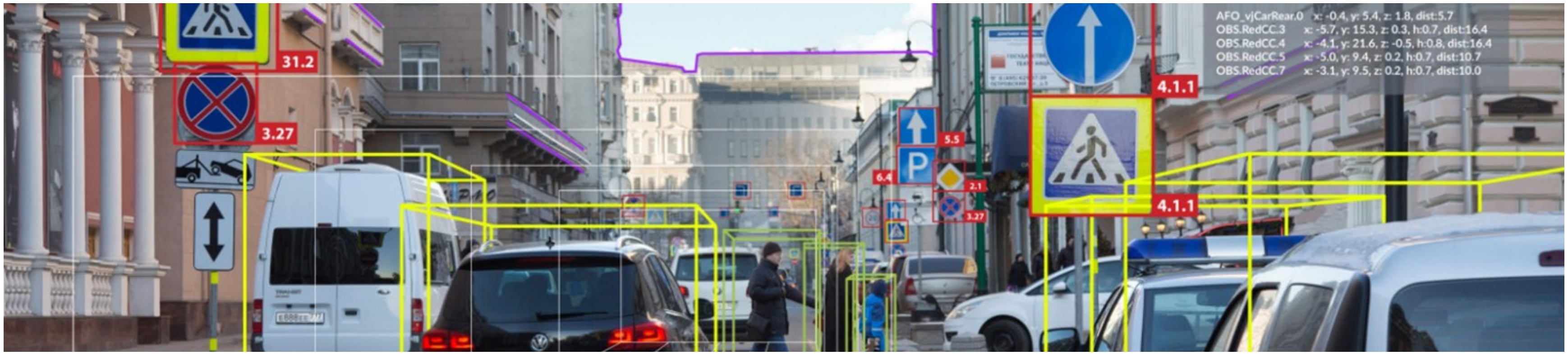
WINCHESTER
962A
Valley Transportation Authority
Solutions that move you
VTA



4.2 Scenario A – Light Rail Modernization

The Light Rail Modernization scenario is an extension of the base case. Should VTA choose to retain its light rail system for the next 20 years, this scenario explores how the existing cars could be modernized with "smart" car technologies that provide the sort of driver assistance that is common on 21st century automobiles. Advanced emergency braking systems (AEBS) are tied to detection systems that decelerate the vehicle to avoid or mitigate an impending collision. The technology has become so reliable and widespread that AEBS collision avoidance systems will soon be mandatory for new automobiles in most developed countries. Such a program would improve safety for the travelling public and reduce stress on VTA rail operators.

A positive experience with AEBS could lead to adoption of Advanced Driver Assistance Systems (ADAS) that help with other routine operating and safety functions, such as schedule adherence and confirming safety for opening and closing passenger doors. With experience, ADAS would provide a path to expanding the role of automated tools to offer full "self-driving tram" operation.

Demonstrations of self-driving light rail vehicles and trams have been successfully deployed in Germany, China, Russia, and Poland.   Other less publicized pilots are underway elsewhere. Full revenue service for these self-driving vehicles is not expected soon at any of these sites, but they are poised to take advantage of the flexibility and cost savings that should be available when the technology matures.

By 2048, the last of the existing cars would likely be replaced. The replacement cars would offer the same or better mechanisms to improve the safety and economy of operation.

The overall cost of Scenario A for improved train control for the existing fleet is estimated as **$57 million**. The following table lists strengths and weaknesses of modernizing the train control systems on the existing light rail fleet.

Scenario A - Light Rail Modernization		
Stages	**Strengths**	**Weaknesses**
Rationalization	• Better matches capacity with demand • Reduces wear and tear on equipment • Reduces vehicle maintenance, cleaning and propulsion costs • Annual operational savings around $10 million • Extends overall fleet life, creating more flexibility to embrace emerging technologies when they are more mature	• Potentially some peak-period standees on certain route segments
Autonomous Pilot and Demonstration	• Increases safety in driver-assist and fully automatic modes of operation. • Pathway to full autonomous driverless operation	• Risk associated with leading edge technology • Risks associated with workforce acceptance and support • Risks associated with regulatory approval and community acceptance • Distraction by the pilot from more urgent operating issues that may arise • Anticipated pilot costs in the range of $25 million
Full Revenue Service Deployment	• Reduced operational staffing costs • Increased safety with hypervigilant computer operations • Higher service frequencies possible at lower costs • Reduced wait time for transfers between bus and rail • Greater service flexibility • Greater capacity • With more frequent service, shorter dwell times leading to faster service • Improved utilization of valuable guideway real estate • Stimulated ridership from increased frequency, speed, reliability, and improved connections to other modes • Operator cost savings in the neighborhood of $14 million/year that could be reinvested to provide the propulsion power and maintenance expense necessary for increased service frequency	• Full deployment will require an additional $32 million in hardware and support costs

4.3 Scenario B – LRT/BRT Integration

Interweaving buses and rail cars on VTA's existing LRT network would involve paving segments of the LRT system's reserved guideway, resulting in the light rail tracks being embedded in a busway. This would allow buses to "hop on" the busway to avoid traffic congestion on the street. While on the light rail right-of-way, buses would stop at existing light rail stations, increasing service frequency and reducing wait time for some trips. This scenario would entail an iterative program of planning, testing, coordination, service design, engineering, procurement, and construction for the first segment. This would be followed by a similar sequence for subsequent segments. The overall program could require several decades to complete. Moreover, it could result in a variety of ultimate configurations for the network of services where buses and trains share right-of-way. Integration could proceed in three phases: in Phase 1, buses would share the LRT right-of-way with light rail vehicles; in Phase 2, battery electric buses (BEBs) would replace the combustion engine buses; in Phase 3, autonomous rubber-tired BEBs and shuttles could replace the manually-driven BEBs (still sharing the right-of-way with light rail).

The overall cost of Scenario B is about **$850 million**. The following table lists strengths and weaknesses for the LRT/BRT Integration scenario. Among the latter is the fact that this scenario my not be well suited to serving local transit ridership patterns.

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Scenario B - LRT/BRT Integration		
Stages	**Strengths**	**Weaknesses**
BRT Integration	• Increases service frequency for customers on the segments shared by both trains and buses • Increases commercial velocity and reliability for bus services on • shared segments • Improves utilization of valuable guideway real estate • Reduces bus service costs by reducing round trip travel times • Improves customer service and ridership by allowing VTA to offer more one-seat rides between key destinations (e.g., bus provides first- and last-mile connections without transfers between bus and rail)	• Cost, time and disruption required by infrastructure enhancements for track, catenary, and signal systems will be significant • Will require working through regulations and procedures to safely share trackway • Requires specialized buses with left-hand doors to serve center-island station configurations • Risk that VTA transit patterns may not provide much opportunity to overlap between light rail and bus routes. • May not yield sufficient additional ridership or cost savings to warrant the expense and inconvenience of conversion
Integration of Autonomous BEBS and Shuttles	• Increases utilization and mobility services on the light rail right-of-way • Reduces operating costs by substituting technology and capital for labor	• Risk associated with leading edge technology • Risks of public and regulatory acceptance • Will require technological integration over a diversity of modes and fleets

4.4 Scenario C – Busway Conversion

The Busway Conversion scenario would eliminate rail operations on VTA's light rail transit network and convert the rights-of-way to accommodate the operation of buses. In this scenario, the LRT infrastructure (track, signals, and stations) would be removed and the rights-of-way paved to serve as an exclusive roadway for VTA buses. The ability for buses to deviate off this exclusive guideway would allow VTA to potentially design services that provide more attractive one-seat rides; these would provide access to major trip attractors that had not been directly served by the light rail system. The overall cost of Scenario C is about **$1.5 billion**. The following table lists strengths and weaknesses for the Busway Conversion scenario.

Scenario C - Busway Conversion	
Strengths	**Weaknesses**
• Eliminating light rail transit reduces VTA's overall costs for vehicle and infrastructure maintenance • The existing overhead catenary system can be modified to power and charge BEBs travelling on the guideway, should BEBs be desired • Potentially stimulates ridership with increased frequency, fewer transfers, and shorter dwell times from more direct point-to-point service • Increased flexibility in the design of services, as buses can use local streets as well as the transit right-of-way • Potential migration path to all-autonomous electric bus service when autonomous self-driving buses become an economic reality	• Risk of public acceptance in replacing light rail with buses • As ridership grows, the economies of scale available from multiple-car trains will be lost • The person-moving capacity of the network will be reduced compared to rail • Average operator cost per unit of passenger capacity will be increased • A pilot project could cost almost $200 million, with full deployment estimated at roughly $1.5 billion in capital costs • Possible increase in noise impacts • Risks associated with service disruption • May not yield sufficient additional ridership or cost savings to warrant the expense and inconvenience of conversion • Cost, time, and disruption required by infrastructure enhancements for stations, running ways, catenary, and signal systems will be significant


THREE STAR
BUILDING


ONLY
BUS


008
Metro Local

4.5 Scenario D – Exclusive Rapid Transit

The Exclusive Rapid Transit scenario envisions replacing light rail with a totally grade-separated and fully automated rapid transit technology. The resulting system would utilize aerial guideways above most sections of the existing light rail rights-of-way. This scenario entails a program of design and construction that—based upon recent experience with similar projects—is likely to take well over a decade to complete, including planning, environmental analyses, design, procurement, construction, and testing. In the immediate term, VTA could take steps to rationalize its current LRT operations to reduce operating costs, as well as wear and tear on its fleet of light rail vehicles. This, combined with a rehab program in the 2030s, would provide LRT to the late 2040s or beyond.

VTA would need that time to develop plans for an aerial rapid transit system to take the place of the semi-exclusive portions of its existing LRT network. In these sections of the network, the footings for the aerial guideway would rest upon the present light rail reservations. The LRT tracks and infrastructure would first have to be removed, with some other form of transit—most likely buses—providing service along parallel streets until the rapid transit line were ready. This strategy could be deployed in phases until the entire light rail system were replaced. Needless to say, the cost of Scenario D would be considerable, estimated at over **$13 billion**. The following table lists strengths and weaknesses for the Exclusive Rapid Transit scenario.

Scenario D - Exclusive Rapid Transit	
Strengths	**Weaknesses**
• "Best and highest" use of the transit right-of-way • Operations staffing costs will be reduced with automated operations • Increased safety with reduced interactions between trains and automobiles • Higher service frequencies possible at lower unit operating costs • Reduced wait time for transfers between bus and rapid transit • Greater capacity • With more frequent service, shorter dwell times lead to faster service • Stimulates ridership with increased frequency, speed, reliability and improved connections to other modes	• Full deployment will require up to • $13 billion in capital costs • Risks associated with workforce acceptance • and support • Risks associated with community acceptance including visual and noise impacts • Risks associated with service disruption • Risks associated with project delivery and financing • Increase in overall operation and maintenance costs


PERFORMING
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5.0 Peers Forum

5.0 Peers Forum

On June 7, 2021, representatives from five western U.S. light rail systems generally similar to VTA's participated in a Peers Forum to discuss the future of light rail technology in their respective urban areas.

The aim was to highlight alternative ways of dealing with changing conditions in urban transit systems operating LRT. The five agencies and their representatives included the following:

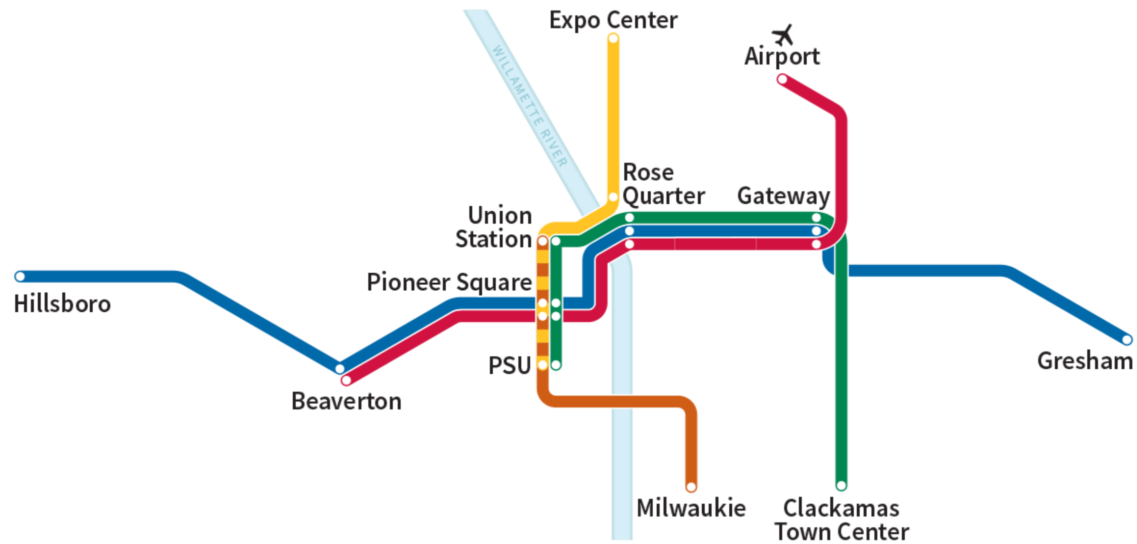
Los Angeles - Metro
Eve Moir, Transportation Planning Manager

Portland - TriMet
Alan Lehto, Director of Business Planning and Asset Management

Salt Lake City - UTA
Kerry Doane, Manager of Long Range and Strategic Planning

San Diego – MTS
Brent Boyd, Manager of Service Quality – Rail Division

San Francisco – SFMTA
Steve Boland, Transportation Planner – Transit Priority Group



PORTLAND LRT SYSTEM MAP


3009
3009
Metropolitan Transit System
San Diego Trolley
MTS
MTS
Rio Vista

From the outset of the Forum, it was clear that the five peer agencies have not experienced the same level of challenges with their light rail systems as VTA. Most are looking at some degree of LRT system expansion in the near future, adding new routes or extending existing routes, diverting routes from congested segments, and adjusting headways. Many agencies are currently working to improve systemwide performance by removing single-track segments that have created scheduling conflicts due to the existing bottlenecks. As a result of the COVID-19 pandemic, some agencies have shifted their focus on improving equity in their systems by increasing midday service. Several mentioned the importance of maintaining consistent headways, as riders can become frustrated when headways fluctuate too often.

A major concern for all agencies is how to run their fleets as efficiently as possible while still maintaining adequate capacity and frequent service intervals. Some continuously adjust the number of cars per train during service to reduce overall costs. While VTA mentioned that maintenance costs are a significant portion of their LRT operating budget, others noted that reducing the number of cars per train didn't significantly lower their overall operating costs.

Similar to VTA, the peer agencies are planning to, or in the process of, replacing their existing fleets. Most are replacing older light rail cars with similar vehicles, focusing on cars that are more efficient and reliable. Many expressed concern with making significant changes to their existing fleets due to apprehension about possible costs to modify maintenance facilities and train staff due to new technology.

While a few agencies have looked into alternative technologies such as automation, many felt that these are progressing slowly and are likely still a generation away from being realized. Furthermore, vehicle operator costs make up only a portion of an LRT system's operating budget. One agency determined that operator costs account for about 31 percent of its total operating costs; their outreach found that riders have concerns about the safety and reliability of any proposed automated system and want to see at least an attendant on each train. Most did agree that automated LRT would be safer and could save money by eliminating hostlers when trains entered or left their storage yards.

Several agencies expressed the importance of collaborating with local jurisdictions and regional planning agencies to match transit service to the built environment. The utility and cost-effectiveness of light rail are both improved when Transit Oriented Communities (TOCs) can be constructed near stations and first-mile/last-mile connections can be established where this is not possible.

6.0 Summary

6.0 Summary

This report has presented the pros and cons of five alternative scenarios with the potential of continuing, augmenting, or replacing VTA's current light rail transit system. Other scenarios could be considered, but those discussed here represent a range between modest and radical modification of Santa Clara County's high-capacity transit network.

The scenarios presented differ significantly in cost, difficulty of implementation, and benefits. The intent has been not to offer a recommendation but rather to present enough information to assist the VTA Board of Directors in making an informed choice.

The timing of a decision about the future of VTA's light rail system is critical if the agency wishes to retain its options. If it operates 2019 schedules with two-car trains, it will need to make a decision regarding refurbishing or replacing the existing cars in 2026. If it operates with single-car trains, the renewal or replacement decision can be delayed until 2031. In contrast, the lead time for implementing a new high-capacity transit technology to replace the aging light rail fleet is likely to be much longer than 5 to 10 years. Refurbishing a portion of the current fleet to extend its useful life may be a reasonable fallback if the Board decides to delay or better understand its options for a replacement technology. In either case, **it is recommended that VTA management chart a timeline so that this decision is not deferred until meaningful choices are no longer available.**