LIVERMORE AMADOR VALLEY TRANSIT AUTHORITY

STAFF REPORT

SUBJECT: Articulated Bus Feasibility Analysis

FROM: Tony McCaulay, Director of Planning and Marketing
Cyrus Sheik, Senior Transit Planner

DATE: April 22, 2019

Action Requested
None – Information Only

Background
As part of an effort to manage costs, reduce emissions, and best serve the client base, LAVTA staff has been asked to explore adding articulated vehicles to the fleet. In 2018, the Board of Directors requested a study as to the feasibility of adding in articulated buses as one possible solution to address overcrowding on its existing transit routes instead of growing the existing fleet of standard transit buses. This followed an earlier recommendation to add vehicles to the system over the next few years to address overcrowding on Wheels routes that serve area schools.

As a continuation of last year's Dublin Student Transit Service Plan, Nelson\Nygaard Consulting was asked to review LAVTA's current fleet relative to its routes and demand, and to explore the potential pros and cons of adding a subfleet of larger buses than the agency has operated up until now. The results of that analysis are outlined in the attached memo, and are summarized in this staff report.

Articulated Buses
Although the 40-foot (12m) bus is the typical length for almost any city bus transit operation, larger vehicle sizes exist and are operated by many transit providers in the U.S. and throughout the world. The most common configuration is that of a 60-foot (18m) vehicle, consisting of two chassis connected by an articulated joint in the center. The joint allows the bus to provide a turning radius that is similar to, or better than, a standard 40-foot bus.

Shown in the above inset is a New Flyer Industries low-floor articulated bus in a typical mainline configuration. They have also been deployed in special configurations to enhance the image and capacity of a service or service corridor.

Discussion
LAVTA currently operates 30-to-40-foot buses in its fixed route system. Today, trips where all seats are occupied and some riders are standing, occurs regularly on school-based trips serving middle- and high school students in Dublin and Pleasanton. On some routes, two or three buses pick up students and follow the same alignment to ensure that buses are below the maximum capacity approved by the agency.

Due to their significantly peak-oriented nature, the supplemental routes require a large proportion of the agency's overall capacity, both with regard to fleet as well as manpower resources. The need to provide overflow vehicles only adds further to this issue – particularly in the AM hours when school bell times overlap with peak commute times.

Demand Analysis
Per LAVTA's overflow policy, additional capacity should only be considered once a bus is at more than 150% of total seating capacity. In the case of the typical Wheels fixed-route 40ft bus, this threshold means a 60-passenger maximum capacity. The following table shows what the maximum capacities would be for different subfleet sizes, including articulated buses, using the same logic. It also shows the number of passengers that would cause each respective vehicle to be at 75% (of the maximum) capacity, an indicator that the trip could be at risk of an overflow situation intermittently or in the near future:

Bus Length	Maximum Capacity	75% Capacity
29 – 35'	45	34
Standard	60	45
Articulated	83	61

The analysis effort began with studying current LAVTA passenger load data to identify trips in the fixed-route system that are presently either at capacity or might be at risk of being at capacity by way of the 75% threshold.

All current crowding in the LAVTA system correlates to school bell times. The only mainline route that reached the threshold of 75% maximum load capacity over the course of three days was the 30R, on three trips out of 23 sample trips. All occurred in the afternoon and were directly related with school bell times.

In looking at ridership from the sampled trips, the study reports that routes 501, 504, and 611 would be immediate candidates for larger vehicles. In the case of Routes 501 and 504, adding five articulated buses would enable LAVTA to remove a net of two buses from the system. Route 611, however, is on the cusp of having overcrowding on the single vehicle it uses to meet demand. The following table summarizes this:

Route	Vehicles Needed in the Morning	Vehicles Needed in the Afternoon	Opportunity	Period Needed
501A	1	2	3 articulated from 4 total	PM
501B	2	2		
504	1	3	2 articulated	PM
611	1	1	1 artic, but no replacement	PM
Total Vehicles	5	8	6	

In addition to these, some trips of the AM service, as well as those of routes 502, 604, 605, and 608, might also benefit from articulated buses and reduce the number of needed vehicles due to capacity consolidation – over time. However, the report points out that loads as they stand right now wouldn't enable that because they'd require more capacity than a single articulated bus could provide.

Future conditions. For an estimate of future demand, the team looked at projections from existing reports about population and employment growth in the region, which are expected to upwardly affect demand for school-related transportation. The report states, however, that "the degree to which growth in LAVTA's service area translates into growth in ridership largely depends on the type and density of the development pattern. The existing, primarily [single-use] low-density development pattern would need to change to lead to extensive growth in demand for transit."

Feasibility

Adding a new type of vehicle to the LAVTA fleet means that it must be properly maintained and stored. The agency's main property is the maintenance, operations, and administration (MOA) facility on Rutan Court. Also, the agency's satellite facility at Atlantis Court provides additional bus parking, as well as a drivers' lounge and a fueling/washing station.

Based on an assessment of these properties, and on interviews with the operations contractor staff, the study group reported that there would be challenges in performing maintenance of articulated buses at the Rutan facility, primarily due to limitations of the steam bay, rack lift bays, and general bays. In a future phase, the Atlantis facility could be built to handle articulated vehicles.

Cost
The following table shows the cost - as estimated by the Metropolitan Transportation Commission - of acquiring city buses, by subfleet size, along with a breakdown of the 20/80 match (where the Federal Transit Administration provides the majority of capital costs) that is typical for agency bus purchases.

	30' bus		40' bus		60' bus	
	Diesel	Hybrid	Diesel	Hybrid	Diesel	Hybrid
Federal	$387,040	$595,320	$434,600	$632,221	$706,020	$865,100
Local	$84,960	$136,680	$95,400	$138,780	$154,980	$189,900
Total	$472,000	$726,000	530,000	$771,000	$861,000	$1,055,000

According to these figures, the added cost of acquiring a 60ft bus over a 40ft bus is relatively proportional to their respective differences in passenger capacity.

The analysis team also researched the market for used (pre-owned) articulated buses, but states that this market is limited, as agencies tend to hang on to them until they have reached the end of useful life.

The report finds that the cost to *operate and maintain* articulated buses is also relatively proportional to the added passenger capacity, stating that national experience shows fuel costs to be about 33% higher, and maintenance costs 43% higher than the standard 40ft bus. There are also costs associated with training and familiarizing drivers and mechanics with a new subfleet - although those aren't substantially different from that of introducing any other new subfleet such as an updated standard model bus with new features.

The Report's Recommendation
In its conclusion, the resulting suggestion from the analysis is for LAVTA to *not add articulated buses to its network at this time*, a recommendation primarily driven by cost considerations on the operating and capital side. The report points to the space constraints at the Rutan facility, and that the Atlantis facility could accommodate 60ft buses only if the system infrastructure is built and upgraded to accommodate the larger vehicles. It is also basing its recommendation upon the fact that "introduction of large buses would cause an increase in operating and capital costs."

Should the agency nonetheless decide to embark on the articulated bus path, the report recommends a subfleet of up to six (6) 60ft vehicles. As indicated above, initially, this new subfleet would reduce the peak pull by two (2) buses, based on how current passenger loads are distributed across existing scheduled trips. Over time, however, it is possible that the larger vehicles would be able to either reduce the peak pull further - or save the agency from having to increase its peak pull as school-related demand increases.

Budget
LAVTA has a fleet replacement program that is continually updated based on FTA-prescribed formulae for vehicle useful-life time spans. As indicated above, the FTA will typically provide an 80% match on transit bus fleet purchases, although this is also based on other factors such as the fleet that is being replaced. The next major replacement cycle is expected for 2021, in the run-up to which desired fleet size(s) would be applied, based on anticipated demand, the 10-year service plan, and direction from the Board.

Next Steps
Staff concurs with the recommendation from the Nelson\Nygaard study to not add articulated buses to our fleet at this time. That said, the scope of work of both the short and long range transit planning efforts that will begin later this year include the development of recommended fleet composition and deployment. The short range transit plan will cover a five year time span while the long range plan will look at a 20 year time span.

Recommendation
None – Information Only

Attachments:

1. LAVTA Articulated Bus Feasibility Memorandum by Nelson\Nygaard, 02/2019

NELSON
NYGAARD

MEMORANDUM

To: LAVTA

From: Nelson\Nygaard

Date: February 7, 2019

Subject: Articulated Bus Feasibility Analysis

1 INTRODUCTION

As part of an effort to manage costs, reduce emissions, and best serve the client base, the Livermore Amador Valley Transit Authority (LAVTA) is considering adding articulated vehicles to the fleet. The LAVTA Board of Directors requested a study of the feasibility of adding in articulated coaches as one possible solution to address overcrowding on its existing transit routes instead of growing the existing fleet of standard transit buses. This follows a recommendation to add vehicles to the system over the next few years to address overcrowding on routes that serve high schools in Dublin.

LAVTA currently operates 30-, 35- and 40-foot buses on its fixed route system. Today, overloads regularly occur on school-based trips serving middle and high school students in Dublin and Pleasanton. When overloads occur, LAVTA deploys extra buses to follow behind overloaded trips to pick up remaining customers. On some routes, two or three buses pick up students and follow the same alignment.

The purpose of this report is to determine whether adding articulated coaches to the vehicle fleet can:

- Improve cost efficiency by reducing the number of vehicles or operators needed to provide service
- Improve customer satisfaction by reducing crowding

This report provides analysis on:

- The current demand for larger vehicles
- Facilities and maintenance requirements
- Costs of introducing new service
- Recommendations for changes to the service

2 BACKGROUND

The LAVTA Wheels bus system includes a network of 33 routes serving the Dublin, Pleasanton, and Livermore areas, including two "Rapid" branded routes and 16 school-focused routes. There are currently 49 buses used to provide this service. The largest buses that LAVTA uses today are 40-feet long and hold up to 60 people, including standees, as set by Board of Director policy.

WHY NOT JUST ADD MORE BUSES?

Labor Costs Associated with Additional Drivers

With increased service, specifically during peak times, additional drivers must be hired to provide the service. With articulated coaches, the goal is to increase the supply of service without needing to hire additional drivers.

Storage Concerns

The LAVTA bus yard on Rutan Court is already at capacity.

Emissions

More vehicles on the road could mean more greenhouse gas and local air pollutant emissions if they are not right-sized. The Metropolitan Transportation Commission (MTC) and the California Air Rights Board (CARB) have mandates to keep emissions in check throughout the Bay Area.

Federal Transit Administration Requirements

Title VI

Title VI of the Civil Rights Act of 1964 protects people from discrimination based on race, color, and national origin in programs and activities receiving federal financial assistance. When a transit system operates 50 or more vehicles, the agency becomes responsible for meeting additional requirements to receive federal funding. Recipients must ensure that all transit services and related benefits are distributed in an equitable manner.

LAVTA currently operates 49 vehicles in peak service. Agencies that operate 50 or more fixed-route vehicles in peak service and are located in a UZA of 200,000 or more population have additional requirements. As a result, the purchase of one or more additional fleet vehicles will compel LAVTA to meet these additional requirements, including:

- Conduct equity analysis for any transit facilities it constructed or plans to construct in the current Federal fiscal year since the last Title VI Program submission.

- Equity evaluation for service changes.
- Provide meaningful access to Limited English Proficient persons (LEP).
- Notify the public of its rights under Title VI.
- Must implement complaint procedures as described in the Title VI Program.
- Implement a public participation plan from its Title VI Program.
- Monitor compliance by any sub-recipients.
- Ensure minority populations are being included/not excluded from procurement opportunities.
- Equity Analysis Elements of any New Fixed Guideway, New Starts, or Small Starts analyses must be conducted 6-months prior to the beginning of revenue service, proposed changes to parallel or connecting service also examined, comparison of service levels before and after, in a tabular format an analysis determining whether service changes due to the capital project would result in a disparate impact on minority populations, and a fare equity analysis was conducted for any fares that would change as a result of the capital project.
- There is also a monitoring element to be conducted at least every three years.

However, it should be noted that LAVTA is already complying with many of these requirements. LAVTA should evaluate what the expected additions to workload might be to maintain compliance.

BUS SIZE OVERVIEW

With increased vehicle size comes increased capacity, but also increased fixed and operating costs. Figure 1 illustrates the increase in costs by vehicle size. For school-based routes known to exhibit overcrowding, additional 40-foot buses are placed in service and noted in the published schedules with asterisks. Figure 2 is an example of what an articulated bus looks like and Figure 3 is a photo of LAVTA's newest 40-food buses. Figure 4 illustrates typical seating arrangements for 30-, 40-, and 60-foot vehicles that formed the basis for our passenger load assumptions for this report.

Figure 1 Overview of Vehicle Capacity and Costs[1] [2] [3]

Bus Type	Bus Length	Seated Capacity	Maximum Capacity	Fuel Use[1]	Purchase Cost [2]	Operating Cost (per hr)
Small	29 – 35'	22 - 30	45		$472,000	$115.88[3]
Standard	40'	35 to 40	60	---	$530,000	$115.88
Articulated	60'	60	83	133%	$861,000	$150.22

1 Fuel use is relative to a standard 40-foot bus. Actual fuel use depends on vehicle age, operating conditions, and whether or not it is a hybrid/electric model.

[2] Purchase cost is based on the diesel bus price from the Metropolitan Transportation Commission (MTC) New Vehicle Price List.

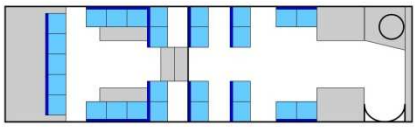
[3] Operating costs per revenue hour are not currently separated by vehicle type at LAVTA.

Figure 2 Articulated Bus in AC Transit's Fleet

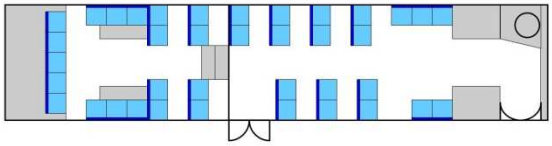
Figure 3 LAVTA's newest 40-foot vehicles

Figure 4 Example Bus Layouts

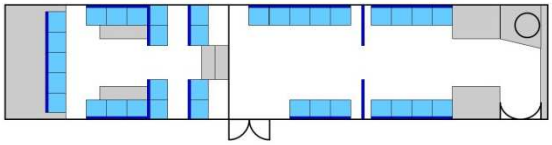
30-foot bus—27 seated + 10 standees = 37



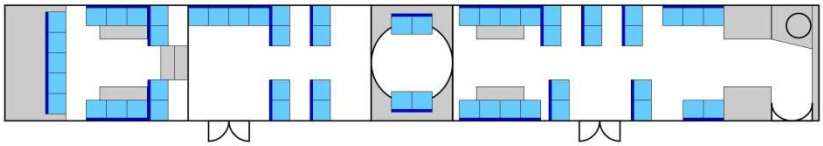
40-foot bus—38 seated + 15 standees = 53



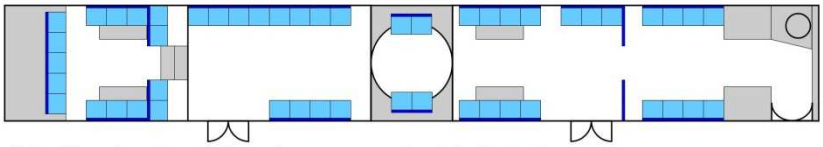
40-foot bus, perimeter seating—35 seated + 21 standees = 56



60-foot bus—54 seated + 25 standees = 79



60-foot bus, perimeter seating—50 seated + 33 standees = 83



Note: These layouts and dimensions are approximate for illustrative purposes. Actual seating layouts vary and the capacity for standees is approximate.

3 DEMAND ANALYSIS

Adding larger-capacity vehicles to the LAVTA fleet should be justified by current or projected passenger demand. The on-board maximum passenger load standards adopted by the LAVTA Board are shown in Figure 5. Local and school routes have load standards of 60 riders. The seating capacity of 40-foot buses is approximately 40 passengers, so a load of 60 would mean there are approximately 20 passengers standing, or 1.5 times the seated load. Regional Express routes operate for long distances on the freeway, making standing uncomfortable, so the load standards for those routes are at 40 passengers so that each passenger has a seat.

Figure 5 LAVTA Route-Level Overcrowding Standards

Category	Measure	Overcrowded Passenger Load
Regional Express	On-Board Load	Load greater than 40 riders (1x seated capacity)
Primary	On-Board Load	Load greater than 60 riders (1.5x seated capacity)
Neighborhood Feeder		
School Tripper		

It is common industry practice for an agency to start planning how to address projected overcrowding when a route consistently runs trips over 75% capacity. For articulated coaches, as shown in Figure 6, which can hold up to 83 total passengers, that threshold is 62 passengers. For standard 40-foot buses, that threshold is 45 passengers. However, with school-based routes, trips are timed with school bell times to meet the demand of riders at specific times, instead of having trips that depart with regular frequency. This also means a full bus, between 75% and 100% is ideal for efficiency for LAVTA.

Figure 6 Passenger Capacity by Vehicles Size

Bus Length	Maximum Capacity	75% Capacity
29 – 35’	45	34
Standard	60	45
Articulated	83	61

DATA COLLECTION PROCESS

This analysis relies on a small sample size due to data collection limitations. Trip-level ridership was collected via screenshots, and saved as jpegs for typical, mid-week, non-holiday weekday samples. Ridership from three weekdays and two weekend days were analyzed (10/17/2017, 8/23/2018, 8/25/2018, 8/26/2018, and 8/28/2018) for mainline routes. Analysis of school-focused routes was pulled from September 4-6th, 2018.

Because of the labor intensiveness of analyzing data from picture files, we chose an iterative process that first looked at route-level ridership across all routes to determine which routes and trips warranted further review. This process involved identifying:

1. **Trips with 45 passengers.** These trips are more likely than others to be at or above 75% rider capacity. For school-based routes that run multiple buses to cover the demand for a trip we also looked at total ridership on all the buses on one scheduled trip. This allows us to have a baseline for future capacity analysis. It is important to note that trip-level ridership does not equate to overcrowding unless all passengers are on board at the same time.
2. **Maximum load locations.** This information shows where routes experience overcrowding and for how long. Trips with high ridership, as indicated above, are not inherently crowded if passenger turnover is high. Similarly, a trip that reaches 61 people for just one stop may not justify a larger vehicle.
3. **Daily variation.** Loads vary on a daily basis. Trips that regularly cross a threshold warrant a more in-depth ridership trend analysis.

Limitations

- The reliability of Automatic Passenger Counters (APCs) can vary and is known to have errors. For example, people standing in the doorway can count a rider more than once. This is usually corrected manually looking at sample trips in post processing.
- The sample size of data was small. Although we suspect them to be representative, more data points over time would be useful.
- Routes that operate more than one bus at a time to cover the same trip must be evaluated differently than the method above – for these routes, all riders must be counted over the number of trips served.
- Data cannot show us why a trip is overcrowded or has very low ridership. Things such as on-time performance, missed trips, special events, and weather can impact ridership. Having as many data points as possible to account for ridership anomalies is critical for making decisions about the amount of service to provide.
- On school-based routes, trips that regularly hit the maximum load of 60 passengers triggers LAVTA to add another bus to the system.

Criteria for Running Articulated Buses

To justify putting a larger bus on a route, the following criteria should be satisfied:

- A pattern of high ridership (on the same trips every day)
- Many trips with high ridership (not just one trip during a whole day of service)
- The ability to keep the larger vehicle in service during off-peak hours
- Frequency that matches demand – overcrowding must not be merely a function of infrequent service.

ANALYSIS

All current overcrowding in the LAVTA system correlates to school bell times. The only mainline route that reached the threshold of 75% maximum load capacity over the course of three days was the 30R, , on three trips out of 23 sample trips. Those trips were selected from the iterative

process detailed in the data collection process section. All occurred in the afternoon and were directly related with school bell times.

School-based routes serving Dublin and Pleasanton middle and high schools have far fewer trips per day, but were more likely to have at least 45 passengers (75% maximum load) or exhibit overcrowding. LAVTA currently uses 19 40-foot vehicles to serve passengers on the school-based trip routes in the morning. In the afternoon that number grows to 26, as shown in Figure 7. Many of the school-based routes' departure times occur at about the same time, as shown in Figure 8, meaning that vehicles cannot make multiple trips as they could on a mainline route. The nature of school-based service is also such that multiple trips are not needed because the peak demand happens around the school bell times.

Figure 7 Number of Vehicles Used in School-Focused Service in 2018

Route	Route Description	Vehicles Needed in the Morning	Vehicles Needed in the Afternoon
501A	Positano Hill – Dublin	1	2
501B		2	2
502	Emerald Glen – Wells Middle – Dublin High	1	2
503*	Shannon Park – Wells Middle – Dublin High	1	1
504	Dublin Ranch – Dublin High	1	3
601*	Ruby Hill – Pleasanton Middle	1	1
602	Del Prado Park – Pleasanton Middle – Foothill High	2	2
603*	Muirwood Park – Hart Middle	1	1
604	Fairlands – Foothill High	1	2
604 variant	Fairlands – Foothill High	1	1
605	Fairlands – Amador Valley High	1	2
606	Vintage Hills – Pleasanton Middle	1	1
607	Laguna Oaks – Hart Middle	1	1
608	Amaral Park – Harvest Park Middle	1	1
608B		0	1
609*	Del Prado Park – Hart Middle	1	1
610	Fairlands – Hart Middle	1	1
611	Ruby Hill – Vintage Hills – Amador Valley High	1	1
Total Vehicles		**19**	**26**

Based on published schedule from fall 2018

Figure 8 Departure Times of Trips with High Ridership

Route	Morning	Afternoon
501	7:04, 7:08	3:40
502		3:40
504	7:08, 7:42*	3:40
602		3:08
604		3:08
605		3:12
606		3:11
608		3:11
610		3:17
611		3:12

* Wednesday bell time

Candidates for Articulated Buses

There are two scenarios during which an articulated bus should be considered to replace a 40' bus:

Capacity: When ridership hovers just above or around the maximum load capacity.

Consolidation: When adding a larger vehicle can reduce the number of vehicles in service.

Articulated buses can generally handle between 79 and 83 riders compared to 53 to 60 riders on standard buses. Figure 9 illustrates different capacity configurations.

Figure 9 Passenger Capacity of a Trip with Multiple Buses

	One Vehicle	Two Vehicles	Three Vehicles
Standard 40-foot bus	60	120	180
One standard bus, all other articulated	60	140	220
One articulated bus, all other standard buses	80	140	200
Articulated only	80	160	240

Looking at ridership over the three-day sample, Figure 10 illustrates that routes 501, 504, and 611 are candidates for larger vehicles. In the case of Routes 501 and 504, adding five articulated buses would enable LAVTA to remove a net of two buses from the system. Route 611, however, is on the cusp of having overcrowding on the one vehicle it uses to meet demand. No vehicles would be removed from the system with the introduction of an articulated vehicle.

Figure 10 School-based Routes with Potential for Vehicle-Size Change

Route	Vehicles Needed in the Morning	Vehicles Needed in the Afternoon	Opportunity	Period Needed
501A	1	2	3 articulated from 4 total	PM
501B	2	2		
504	1	3	2 articulated	PM
611	1	1	1 artic, but no replacement	PM
Total Vehicles	**5**	**8**	**6**	

Route 501 operates two route alignments. In the morning Route 501A is getting close to being able to utilize a larger vehicle, but it would not take a vehicle out of service. Route 501B uses two buses in the morning to carry the loads, but with 90 to 103 total riders, one articulated bus would not be enough to replace the two regular buses. In the afternoon, there was only one day of data, but it does appear that three articulated coaches could replace four regular buses between the two alignments, with 214 total riders combined.

Route 502 has two buses in the afternoon, but the combined load is more than the maximum load of an articulated bus, ranging between 90 and 112 students in two days.

Route 504 could only reduce a vehicle if two articulated coaches were put into service in the afternoon. One regular bus and one articulated bus would not handle the current loads.

Route 604 currently operates two buses on three different route alignments (patterns). One bus is able to make the last trip that serves all stops. The later trip does not have a crowding issue, and the first two are at 75% maximum capacity, but not full. Combining the two alignments into one to save a vehicle would not work because the total riders is over 83 riders, the maximum load. The current configuration makes the most operational sense.

Route 605 operates two buses to cover the afternoon demand. Total route ridership in that time period varied from 69 to 100. More data collection could be very useful here. Only on one of the three days sampled would one articulated bus been able to handle the loads. On the other days, two buses are still needed.

Route 608 operates two buses on two different route alignments in the afternoon. If they were consolidated, customers would not appreciate a longer ride and there would still be more demand than one articulated bus could carry; it would still need two buses.

Route 611 is the one school-based route that is hovering right at needing a second bus to handle the loads. Here an articulated coach would be useful in the afternoons, but it would only replace a regular bus instead of taking one out of the network.

Future Conditions

For an estimate of future demand, the team looked at projections from existing reports about population and employment growth in the region. The Tri-Valley region of Alameda and Contra

Costa County is expected to grow by 35% by 2040, raising the current population of 349,784 to 472,355.[4] The majority of this growth (59%) will occur in LAVTA's primary service area of Dublin, Pleasanton, and Livermore. Total employment is projected to increase by 31% from 183,600 jobs to 240,000. Jobs will continue to be concentrated in Dublin, Pleasanton, and Livermore in Alameda County and San Ramon in Contra Costa County. The degree to which growth in LAVTA's service area translates into growth in ridership largely depends on the type and density of the development pattern. The existing, primarily low-density development pattern would need to change to lead to extensive growth in demand for transit. The dense, transit oriented development around the East Dublin/Pleasanton Bay Area Rapid Transit Station is a good example of development that helps improve the usefulness of transit to residents and the efficiency for LAVTA to operate it.

The Dublin Transit Service Plan, completed in the summer of 2018, cited recommendations based on growth projections of students. Similar growth patterns are expected for Pleasanton schools. Therefore, if LAVTA is to meet the demand of multiple growing school districts, more resources will be needed.

RECOMMENDED NEXT STEPS:

- Develop a performance tracking method that looks at more data points to determine how often and by how much the loads vary on high-ridership trips
- Track the trends, quarterly, semi-annually, or annually
- Track the maximum passenger load locations
- Develop a policy to determine how often to evaluate bus size and distribution
- Develop a plan to monitor ridership projections

4 FEASIBILITY

Adding a new type of vehicle to the LAVTA fleet means that it must be properly maintained and stored. The purpose of this section is to document the physical aspects related to the feasibility of adding articulated coaches.

Particular attention was given to how larger articulated buses might be maintained, maneuvered, and stored within the facility. A phone interview was conducted on September 18, 2018 with Antonio Berastain, Maintenance Manager, and John Broxterman, Supervisor.

[4] Tri-Valley Transportation Plan and Action Plan for Routes of Regional Significance, 2017.

FACILITIES

Rutan Court

The LAVTA maintenance, operations, and administration (MOA) facility on Rutan Court was built in 1991. The facility is well situated within the overall Wheels service area and is near the I-580/Isabel Avenue interchange and Stanley Boulevard.

Atlantis Court Property

The Atlantis Court site provides overflow vehicle parking but has limited on-site facilities until construction is complete. Development of the Atlantis Facility has six phases and as of July 2018 Phase I and II are complete and the site includes a paved parking lot, fencing, lighting, a drivers' lounge, and a bus fueling and washing station. LAVTA is pursuing the option of potential funding sources to complete additional planned infrastructure at the Atlantis site, the estimated cost to finish the Atlantis facility is $23.6 million. LAVTA owns all fixed facilities and makes them available to MV Transportation for use in the operation and maintenance of Wheels service.

MAINTENANCE

Rutan Court

In discussions with the maintenance manager and facility supervisor about the ability of the current LAVTA Rutan Court MOA facility to accommodate larger sized buses, the following constraints were identified:

- **Steam bay**: Steam bays are used to raise the bus to steam the engine and other parts of the bus. There is not enough space for a 60' bus to fit in the existing steam room.
- **Rack lift bays:** Existing rack lifts are unable to safely raise articulated buses. Articulated buses would require a new lift or the use of a mobile lift set and potentially require raising the roof.
- **General bays:** There is not enough room for safe passage around buses larger than 40'. The facility is designed for working on 40' vehicles.

The existing maintenance equipment would not accommodate articulated buses without potentially expensive investments in modifying equipment and maintenance facilities.

A canopied outdoor area provides two lanes for fueling incoming buses that have returned to the yard from their runs. At that location, the vehicle fareboxes are emptied and the bus interiors are cleaned. Articulated 60' buses would be able to access the fuel island without modification to the existing structure and layout.

Atlantis Court Property

A second property on Atlantis Court does not provide any maintenance at this time.

VEHICLE STORAGE AND STAGING

Rutan Court

With a theoretical maximum capacity of 70 vehicles, the Rutan MOA facility is insufficient for the current daily staging and operation of the entire LAVTA revenue and support fleet. From conversations with LAVTA, the operational capacity is closer to 50 buses. There are currently unused vehicles (without Clipper readers) that are beyond the spare ratio that are stored at the Atlantis location.

Atlantis Court Property

At the time of this report, no vehicles are dispatched directly to or from the Atlantis facility, but given the capacity constraints of the Rutan facility, any notable increase in peak vehicle pull could require that some vehicles be staged from Atlantis. Therefore, the addition of articulated buses to the fleet could be accommodated between the two facilities, especially if other buses were phased out. Given vehicle storage and staging constraints, however, articulated buses would require additional dispatching efforts.

TAKEAWAY

LAVTA could not maintain articulated coaches at this time with the existing infrastructure at Rutan Court or Atlantis Court. The Atlantis Facility could be built to handle articulated vehicles.

5 COST

Costs can be broken down into purchase price of the vehicle, and operating and maintenance costs.

VEHICLE PURCHASE PRICE

Costs listed in Figure 11 are based on the Metropolitan Transportation Commission (MTC) price list. New articulated hybrid buses cost approximately 37% more in direct capital acquisition costs compared to its 40-foot counterpart. For diesel, although the overall costs are lower, the difference is over 62% more expensive for purchase of similar fuel systems. Moving from a hybrid 40-foot bus to a 60-foot diesel is an increase of almost 12%.

A rule passed in December 2018 by the California Air Resource Board states that by 2029 all cities must shift to electric vehicles during procurement. The program will be phased, and there is still clarification needed on whether LAVTA would qualify as an agency that must comply. The

agency's goal is to have 100% zero-emission bus fleets statewide by 2040.[5] LAVTA should track this ruling as it has major financial implications for the entire fleet.

Figure 11: MTC New Vehicle Price List

	30' bus		40' bus		60' bus	
	Diesel	Hybrid	Diesel	Hybrid	Diesel	Hybrid
Federal	$387,040	$595,320	$434,600	$632,221	$706,020	$865,100
Local	$84,960	$136,680	$95,400	$138,780	$154,980	$189,900
Total	**$472,000**	**$726,000**	**530,000**	**$771,000**	**$861,000**	**$1,055,000**

Used Vehicles

There are supply challenges to acquiring a used articulated bus, given low demand on the private market for articulated buses. The vast majority of articulated buses are owned by public agencies and most agencies will not sell them before the end of their useful life as that usually means paying back the FTA for the remaining life of the bus, unless the asset is transferred to another eligible FTA grantee.

OPERATING AND MAINTENANCE COSTS

National experience shows that there are additional costs associated with articulated buses compared to standard 40-foot vehicles, which includes:

- 33% higher fuel costs
- 43% higher maintenance costs.[6]

Baseline operating costs for LAVTA are based on data from the 2015 Short Range Transit Plan. Overall, the additional fuel and maintenance costs can translate to additional costs per hour, as shown in Figure 12 amounts to an 18% increase in operating costs each year.

[5] https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040

[6] Transit Cooperative Research Program and the Center for Urban Transit Research (CUTR)

Figure 12 Estimated Hourly Operating Cost

	LAVTA Costs for Existing Bus Fleet	Estimated Articulated Bus Costs
Fuel	$6.48	$8.62
Purchased transportation and maintenance	$43.02	$61.52
Other operating costs (includes personnel wages, benefits, administration, and other costs)	$65.84	$65.84
Total Cost per Revenue Hour	**$115.34**	**$135.98**

Source: Chapter 7 of the LAVTA 2016-2025 Short Range Transit Plan

VEHICLE LIFECYCLE COSTS

The lifecycle cost of standard and large vehicles was calculated using the purchase price for a heavy duty diesel bus, in Figure 11. Cumulative costs assume a 3.0% annual inflation rate. The lifecycle costs for each vehicle size are shown in Figure 13.

Operating costs estimates include fuel, maintenance, and operator wages and associated costs. The 12-year life cycle cost model includes the purchase price plus two operations scenarios: 12 platform hours per day, 260 days per year, and 18 platform hours per day operating 360 days per year, both with a 3% inflation rate. Articulated buses are 31 to 32% more expensive over the 12-year cycle, but if a large bus can replace two standard buses, there will be significant savings.

Figure 13 12-Year Life Cycle Cost by Vehicle Size

		40-foot bus	60-foot bus
	Platform Hours	Annual Costs	Annual Costs
Purchase Price		$530,000	$861,000
12 hours/day, 260 days/year	**3,120**	**$5,637,155**	**$6,881,944**
18 hours/day, 360 days	**6,480**	**$11,137,168**	**$13,366,037**

[1]Hourly operating cost increases 3% per year.

As noted in the Demand Analysis section, school-focused service is where the main demand lies for larger vehicles. However, school service is expensive to provide and while it is often very productive in terms of ridership, crowding is problematic because the demand spikes at bell times and drops significantly before and after. This means that multiple vehicles must be used to handle the loads and the buses are not needed outside that window, regardless of vehicle size.

TRAINING COSTS

Introducing new bus models and types into the fleet requires addition training for drivers as well as mechanics. California Education Code (CEC), Section 40083, requires at least 20 hours of behind-the-wheel training or driving experience, including driving vehicles comparable to those vehicles that will be used to transport passengers. As a new type of vehicle, articulated buses would require 20 hours of training for multiple drivers. Each new bus model, regardless of size, requires training for the

bus mechanics. The latest buses purchased for LAVTA's fleet required 120 hours of training over three months per mechanic[7].

PUBLIC PERCEPTION

Because routes with any trips meeting 75% passenger capacity only occur during peak times, when the most number of buses are in service, introducing a new vehicle type to the fleet is problematic because the buses would either be parked for a majority of the service day, or be put on a bus route mixed with buses of another size. Mixing bus sizes on one route at the same time can lead to bus bunching.

One tactic agencies have used to keep articulated coaches in revenue service past the peak hours is to use it on a route with 40-foot buses with 15-minute headways, for example, and stretch the service out to every 20 minutes. The 10R and 30R meet the criteria of operating at 15 minute headways throughout the day, however, reducing the frequency of service contradicts efforts to brand the service as "Rapid" and provide frequent transit. With the relatively low frequency of LAVTA's other mainline routes during the midday, reducing service levels further to justify using a larger vehicle is not recommended.

From the perspective of the passenger, what feels like a reduction in service also translates to a reduction in passenger satisfaction. We would only recommend reducing service frequency in a situation where articulated coaches were already in the system fleet and were needed to balance a budget.

6 RECOMMENDATIONS AND NEXT STEPS

It is not recommend adding articulated coaches to the LAVTA network. There are both operating and capital considerations that do not make it a financially sound decision at this time. There is an opportunity to introduce six articulated vehicles to the system for a very short span of service, and the net reduction to the fleet would only be two.

On the capital side, the critical issues that must be addressed before introducing articulated buses include:

- The space constraint at Rutan Court. The Atlantis facility could accommodate them, but the system infrastructure still needs to be built and upgraded to accommodate the larger vehicles.
- The introduction of large buses would cause an increase in operating and capital costs.

As for operations, based on population and job growth projections, the demand for bus service in the LAVTA service area will continue to grow in the coming years. With LAVTA already at the maximum

[7] From September 18, 2018 conversation with Maintenance Supervisor Antonio Berastain.

number of in-service buses before triggering more stringent Federal Transit Administration Title VI requirements, but only a handful of peak-hour trips being at capacity, LAVTA should seek other solutions before adding a new type of vehicle.

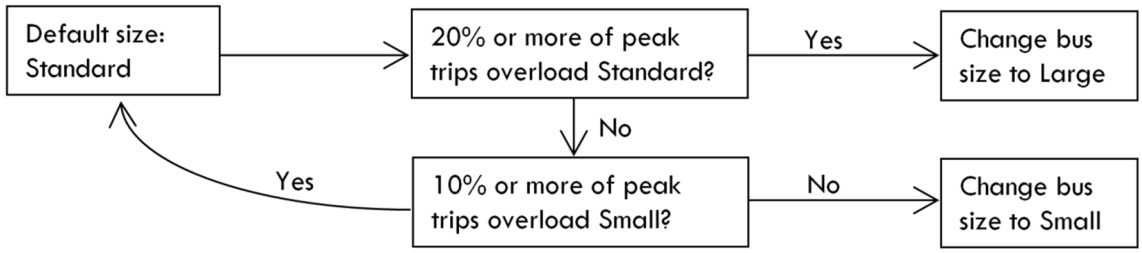
NEXT STEPS

Improve Data Collection Methods

Better data collection to track crowding would help LAVTA know when there is a trend occurring that needs attention. Finding a way to automate passenger boardings and alightings are getting easier with new technologies, and come at all price points. This would increase sample size while still minimizing the amount of labor that goes into analyzing the data.

LAVTA should also consider adding to its policy of when to add another vehicle to the system based on passenger loads, a consideration for the size of bus required.

Figure 14 Bus Size Decision Chart



Implement a Bus Size Decision Tree

Once more comprehensive data exists to evaluate the maximum passenger loads by trip, a decision tree can help LAVTA further evaluate whether to move forward with changes to bus sizes. The full decision tree could follow this path:

1. Data collection (detailed above)
2. Size criteria (Figure 14)
3. Staff review to ensure other considerations that quantitative data might miss
4. Interlining/blocking to ensure changes don't increase the fleet requirement
5. Evaluate costs
6. Fleet lifecycle evaluation to include operating and capital costs, changes to maintenance practices, industry trends, probability of use throughout life
7. Facilities impact evaluation to understand the degree to which bus stops and maintenance facilities can be adapted
8. Customer evaluation to ensure interlining or new blocks won't negatively impact customers

Check in with the Federal Transit Administration

Research and understand implications of operating a fleet of 50 or more vehicles. Your local FTA administrator will be able to tell you specifically what would change for LAVTA when the system requires 50 vehicles. The new requirements are likely to cost far less than procuring and operating articulated buses that must be parked and maintained at the Atlantis facility.

The next Short Range Transit Plan could include on-board survey for title VI with fare analysis components to meet the requirements for a fare equity analysis.

Ensure the build out of the Atlantis facility does not preclude LAVTA from using articulated buses in the future.

Costs associated with upgrading facilities to accommodate articulated buses and the small window in which overcrowding happens