Kimley»Horn

MEMORANDUM - DRAFT

To:	Ramses Madou City of San José
From:	Adam Dankberg, P.E. Kimley-Horn and Associates, Inc.
Date:	June 19, 2020
Subject:	San José New Transit Options RFI – Summary Assessment Technical Memo

Overview

The City of San José, in partnership with the Santa Clara County Valley Transportation Authority (VTA), City of Santa Clara, City of Cupertino, and County of Santa Clara issued a Request for Information (RFI) to develop new transit options connecting San José Diridon Station to Mineta San José International Airport (San José Airport) and to multiple destinations along the Stevens Creek Boulevard corridor.

Accommodating future growth in the region will require major changes in transportation infrastructure to allow more residents of San José and Santa Clara County to thrive without daily reliance on driving alone and the associated environmental impacts and personal costs. However, recent delivery of high-capacity mass transit has been characterized by projects costing hundreds of millions of dollars per mile and spending decades in planning and construction. These drawbacks have engendered an understandable skepticism that transit projects can be implemented quickly and can cost-efficiently achieve mode shift goals.

The City of San José and its partners issued the RFI to receive information from innovators in the field of transportation on how transformative transit projects might be completed more quickly and at lower costs. Submissions were requested that addressed new technologies, operational practices, and project delivery methods. The focus for this request was to solicit information on the opportunities for grade-separated transit solutions that could be constructed and operated at a significantly lower cost than existing and planned transit projects.

The RFI process generated a significant amount of interest and the proposals received by the City varied widely in level of detail and feasibility. Most of the proposals focused on technological solutions (with limited proposals for operational practices or project delivery methods), and the technologies ranged from products currently in operation to those that are still speculative. The RFI process succeeded in generating a cross-sectional assessment of emerging automated separated guideway solutions, ascertaining technological readiness, and promoting industry awareness of the specific opportunities and needs in Santa Clara County. The RFI process revealed that many technologies are still in their infancy and are a few years away from implementation readiness. It also highlighted that there are some technologies in operation and that the rapid pace of innovation and high level of international investment will likely lead to even more new transit solutions that will address the identified need being ready for deployment in the coming years.

Guide to this Document

As the goal of the RFI process was to learn about the state of the industry and the applicability of emerging technologies to two specific corridors in Santa Clara County, the summary assessment is not intended to select one or multiple technologies for deployment. This document rather summarizes the information received and identifies commonalities, trends, and areas for further consideration. The document is organized around categories that describe the proposed solutions, pivoting off of the questions asked of respondents in the RFI. This summary does not rank or score the responses received. A few notable proposals are highlighted near the end of the document to identify submissions that most closely aligned with the RFI's objectives and to give a snapshot of technologies generally closer to implementation. The main takeaways of the summary assessment are included in the Evaluation Summary section at the end of this document.

A summary of the characteristics of the reviewed proposals is included as **Attachment A**.

Proposals Received

The City of San José received a total of 23 proposals. Two of the proposals were from universities as part of student projects and were not intended to be developed into a working system. One proposal (4Dialog) suggested using the annual Podcar City Conference or other student competition to source a technology. Another proposal was from a signaling company (CRSC) not proposing a transit solution. The remaining 19 proposals recommended a specific transit solution for the Airport Connector and/or Stevens Creek Line. These proposals contained a variety of mass transit technologies, some already in operation and others still in development. While there is some overlap between technological categories, they may be roughly sorted into the following groups, described below with industry-accepted definitions.

Personal Rapid Transit (PRT)

Also known as "podcars," PRT vehicles typically seat a maximum of between three and six people and travel on an exclusive, automated guideway. Stations or stops are located on sidings allowing point-to-point travel.

Group Rapid Transit (GRT)

GRT systems function similar to PRT, traveling without an operator in an exclusive right-of-way, but with higher passenger capacity (up to 20, the size of a small bus).

Monorail

Monorail vehicles travel on an elevated guideway consisting of a single rail or beam. They typically operate without operators and most are powered by electric motors fed by contact wires in the guidance beam, rather than an overhead catenary cable (such as with Light Rail Transit).

Hyperloop

A relatively new technology, hyperloop is characterized by vehicles that travel within an enclosed and vacuum-sealed guideway, allowing them to travel at high speeds due to reduction in air resistance. The technology is still being developed and no hyperloop system is yet open for passenger service.

Automated People Mover (APM)

Typically found at airports or tourist attractions, APMs are essentially driverless trains traveling on exclusive guideways, composed of several cars and capable of transporting several dozen people. They may be powered by electric motor or traction.

Evaluation Methodology

Each of the 19 proposals was given an initial high-level review and assigned to a subject matter expert based on the general type of technology (e.g. tunnel boring, APM, PRT, etc.) for a more thorough review. At that point each project was evaluated with respect to several categories and sub-categories. The evaluation categories included:

- Technological Readiness
  - Infrastructure Readiness
  - Vehicle Capacity
  - System Capacity and Throughput
  - Scalability
  - Maintenance and Storage
- Cost
  - Capital Costs
  - Operating Costs
- Financing and Delivery
  - Funding Sources
  - Delivery and Risk Management
  - Regulatory Awareness
  - Timeline to Implementation

The proposal reviewers assigned to this effort were subject matter experts employed by Kimley-Horn and McMillen Jacobs. The reviewers summarized the information included in the proposals and documented themes and comparative attributes. No independent evaluation, verification, or assessment of the technology, costs, operational parameters, design feasibility, or any other aspect of the proposal was completed. Reviewers were limited to the information contained within the proposals and did not independently research or validate elements of the proposals. The opinions and judgments summarized below are not intended to be a warranty on any particular proposal, nor should they be considered to select any individual proposal for consideration or elimination.

The sections below describe the evaluation categories in greater detail and provide examples from the proposals received to illustrate the reviewers’ findings.

Technological Readiness

INFRASTRUCTURE READINESS LEVEL

The proposals received varied widely with respect to their readiness for implementation, ranging from those currently in operation elsewhere internationally to those that are purely conceptual at this stage. As part of the subject matter expert evaluation, a level of 1-5 was assigned to each technology, with 5 being the highest infrastructure readiness level. This section describes each of the levels of technological readiness, the number of proposals that were determined to fall into that category, and a representative proposal from that group. Note that the proposals described were selected as typical representations of each category but are not intended to imply preference or exclusivity within that category.

Description of Infrastructure Readiness Levels

- Level 5: Widespread technology with multiple implementations (2 proposals)
- Level 4: Proprietary technology with at least one implementation (1)
- Level 3: Full test track (6)
- Level 2: Scale model and ongoing testing (4)
- Level 0/1: Concept only or pre-concept (6)

Level 5	Level 4	Level 3	Level 2	Level 0/1
-Bombardier -BYD	-2getthere	-Chamara -Hyperloop -Miller Hudson/GA -moduTram -Primerail -The Boring Co.	-CyberTran -Plenary Glydways -Supraways -Virgin Hyperloop	-Citytram -Hotspur Design -JPods -SwiftAPM -The Gen. Tr. Fund -TriTrack Motors

Level 5 (2 proposals)

As one example within this category, Bombardier is a widely known manufacturer of both planes and trains. The proposal included information about its Monorail, APM, and LRT technologies, all of which are currently in operation in many cities around the world and consistent with technologies widely utilized in the industry.

Level 4 (1 proposal)

2getthere is the only company in this category. 2getthere manufactures automated, small-capacity GRT shuttles in a number of cities around the world. Their first-generation vehicle, which can carry eight seated passengers and four standees, has been operating as a parking lot shuttle at Schiphol

Airport, the main international airport in the Netherlands, since 1997. The proposal recommended its third-generation GRT, such as that operating at Rivium Business Park in Rotterdam, which would seat eight and permit 16 standees.

Level 3 (6 proposals)

The Boring Company (TBC) represent has constructed a 1.14-mile R&D test tunnel at its Hawthorne headquarters in Los Angeles County, and has been contracted to design, construct, and operate its Loop system for the Las Vegas Convention Center. The company claims to have drastically reduced the cost of tunneling, though the advantages over prior technology have not yet been thoroughly demonstrated in a project setting.

Level 2 (4 proposals)

Plenary Glydways Transit Solutions is an example within this category that proposed small automated PRT and GRT vehicles operating on an above-grade right-of-way. The technology is not currently in operation, but the company is currently in the process of implementing an indoor pilot and building an outdoor proof of concept. Glydways anticipates a full-scale system prototype by the end of 2020.

Level 0/1 (6 proposals)

Several of the proposals received (Citytram, Hotspur Design, JPods, SwiftAPM, The General Transportation Fund, and TriTrack Motors) either provided little detail about the current status of the technology or were in a very early conceptual stage of development.

VEHICLE CAPACITY

The RFI requested proposals for transit systems that would operate on a grade-separated guideway and would be able to be delivered and operated at a lower cost than traditional transit projects. The majority of the proposals presented technologies that would operate relatively small vehicles without human operators. This ranged from currently operational APMs with capacity for 20 or more passengers to small PRT vehicles in which fewer than five people could ride at a time. Below are examples of proposed vehicles grouped by vehicle size.

Description of Vehicle Capacities

- 10+ Person Capacity (10 proposals)
- 6-9 Person Capacity (3 proposals)
- 5 or Fewer Person Capacity (6 proposals)

10+ Person Capacity	6-9 Person Capacity	<6 Person Capacity
-2getthere -Bombardier -BYD -CyberTran -Hotspur Design -Hyperloop -Miller Hudson/GA -Primerail -SwiftAPM -Virgin Hyperloop	-Modutram -Supraways -The Boring Co.	-Chamara -Citytram -Jpods -Plenary Glydways -TriTrack Motors -The Gen. Tr. Fund

10+ Person Capacity (10 proposals)

For example, Hyperloop Transportation Technologies (HTT) proposed a version of its technology, called Urban Hyperloop (as distinct from Full-Speed Hyperloop). The vehicles would operate on wheels in a contained guideway, which could be upgraded to be vacuum-sealed to eliminate atmospheric friction. The vehicles, which HTS refers to as “capsules,” would fit inside a tube with a 13-foot diameter and would be able to carry 28-50 passengers with space for luggage. Passengers would have a similar amount of person space as if they were riding a bus. The vehicles’ top operating speed is 125 mph.

6-9 Person Capacity (3 proposals)

Modutram, one of the companies in this category, proposed a technology called AutoTrén, a system of driverless-mini-trains running on an elevated guideway. The GRT200 vehicles may accommodate up to eight seated passengers with several pieces of luggage or, if equipped with a luggage rack, six passengers and several large suitcases. Vehicles are powered by interchangeable battery packs, rather than an electrified guideway. They are able to reach a top speed of 45 mph, though the recommended cruising speed is 35 mph.

5 or Fewer Person Capacity (6 proposals)

One of the companies in this category, TriTrack Motors proposes dual-function, 3-wheeled vehicles that can operate in mixed traffic at speeds up to 40 mph, as well as autonomously on a separated guideway, on which they can would reach 180 mph. The vehicle has a weight limit of 920 lbs., allowing four adults and luggage. Batteries would be carried on the vehicles themselves and swapped between vehicle and charging infrastructure by “battery mules,” self-directed machines that would respond as needed to ensure all vehicles had sufficient charge.

SYSTEM THROUGHPUT

One of the benefits of transit is its ability to transport large numbers of people in the same direction efficiently within a constrained space. In traditional transit settings, this is due to the fact that many people travel within the same large transit vehicle. However, a similar total passenger throughput may be achieved by a system in which smaller vehicles arrive and depart more frequently, which has the advantage of decreasing total passenger waiting time. While several proposals assumed this model, these forms of very high-frequency PRT have not been fully realized in real-world transit settings to date. Many of the proposals received did not explicitly state a maximum passenger throughput; however, throughput could in some cases be inferred from the stated vehicle capacity and headways. It should be noted that subject matter experts found some of the throughput estimates to be unreasonably high, typically due to assumptions of very short vehicle headways and dwell time. Throughputs noted here are referenced directly or inferred from the proposals and do not reflect concurrence or independent assessment by the review team.

The proposals were grouped into categories of maximum passengers per hour per direction (pphpd). For context, the existing directional passenger throughput of existing Bay Area transit systems is also provided[1]:

- BART (through Transbay Tube): 46,000 pphpd
- VTA Light Rail (through downtown San José): 4,080 pphpd
- Coliseum-Oakland International Airport Line; 1,130 pphpd
- East Bay BRT: 960 pphpd

Stated Maximum Throughputs

- More than 20,000 pphpd (2 proposals)
- Between 10,000 and 20,000 pphpd (6 proposals)
- Between 5,000 and 10,000 pphpd (4 proposals)
- Between 2,500 and 5,000 pphpd (5 proposals)
- No throughput provided (2 proposals)

>20,000 pphpd	10,000 - 20,000 pphpd	5,000 - 10,000 pphpd	2,500 - 5,000 pphpd	Not provided
-Bombardier -Chamara	-BYD -Miller Hudson/GA -ModuTram -Primerail -TriTrack Motors -Virgin Hyperloop	-CyberTran -Hotspur Design -Plenary Glydways -Supraways	-2getthere -Citytram -Hyperloop -SwiftAPM -The Boring Co.	-Jpods -The Gen. Tr. Fund

More than 20,000 pphpd (2 proposals)

For example, Bombardier's proposal included several types of vehicles, all allowing high-capacity passenger throughput within large vehicles. The INNOVIA Monorail 300 system, an autonomous

[1] Throughput assumptions are as follows, assuming existing headways and current vehicle configurations. BART: 23 trains per hour, 10-car trains, 200 passengers per car. VTA Light Rail: 8 trains per hour, 3-car trains, 170 passengers per car. Oakland Airport Line: 10 trains per hour, 113 passengers per train. East Bay BRT: 8 buses per hour, 120 passengers per bus. Note that maximum throughput for these systems may be higher.

vehicle running on a separated guideway on rubber wheels, can move more than 40,000 passengers per hour per direction.

Between 10,000 and 20,000 pphpd (6 proposals)

An example of companies in this category is BYD (Build Your Dreams) widely known for manufacturing electric buses, proposed two technologies; an autonomous monorail called SkyRail; and the smaller APM, SkyShuttle. Both would operate on grade-separated elevated guideways and would be powered using on-board iron phosphate batteries. Cars have a capacity of 75-79 (SkyRail) and 50 passengers (SkyShuttle), between seated travelers and standees. The proposal suggests that the vehicles would run at two-minute headways during the peak hour and five-minute headways off-peak. Assuming 8-car configurations, this translates to a throughput of between 12,000 and 19,000 passengers per hour per direction.

Between 5,000 and 10,000 pphpd (4 proposals)

The company Supraways represents this group of companies. They proposes a system of suspended pods, called “Supras,” which would run on an overhead guideway. The vehicles are small and battery-powered, seating between seven and nine passengers, and would provide direct point-to-point transportation for riders. Assuming headways of five seconds, the system’s theoretical capacity would be between roughly 5,000 and 8,400 passengers per hour per direction.

Between 2,500 and 5,000 pphpd (5 proposals)

For example, SwiftAPM proposes running coaches suspended from an overhead guideway, powered by internal batteries charged at the boarding station. These vehicles are planned to have a passenger capacity of 20-25 people and their luggage. Assuming a typical dwell time of 10 seconds, single platform would allow 2,500 riders per direction per hour.

No throughput provided (2 proposals)

The proposals submitted for The General Transportation Fund and JPods included neither passenger throughput estimates nor headway and vehicle capacity assumptions that would allow throughput to be derived.

SCALABILITY

The RFI issued by the City of San José identified two deployments of the transit technology: 1) Diridon Station to San José Airport, and 2) Diridon Station to De Anza College via Stevens Creek Boulevard to the City and its partners are also interested in the ability to more broadly serve Silicon Valley with these technologies as part of future project phases. Therefore, the proposals were considered for their capability to expand deployment of the technology to additional to-be-determined corridors.

Scalability would be primarily influenced by the impact to the initial operating system as a result of expansion and whether a range of vendors could complete the expansion. Systems that require the initial vendor to execute all expansions as a result of proprietary technology associated with high-cost fixed infrastructure are generally considered less scalable than those where replacement or expansion of the vehicle fleet can be done by other vendors while continuing to use the initial system.

Ensuring that more than one vendor can complete an expansion is critical in reducing risk to the public agencies.

The proposals can be roughly divided into four groups, based on the difficulty of scaling up the technology to a wider deployment. The number of proposals that were assigned to each group, as well as a representative example from each group are shown below.

Scalability Categories

- Does Not Require Additional Infrastructure for Expansion and Operational Configuration Easily Replicated by Others (Assumed to be Highly Scalable) (2 proposals)
- Expansion Requires Additional Infrastructure but with Limited Impact to Initial Operational System and Operational Configuration Easily Replicated by Others (Assumed to be Reasonably Scalable) (6 proposals)
- Requires Additional Infrastructure and Modification to Initial Operational System and/or Proprietary Operational Technology (Assumed to be Less Scalable) (10 proposals)
- Not Described (1 proposal)

Does Not Require Additional Infrastructure for Expansion (Assumed to be Highly Scalable) (2 proposals)

Technologies that operate on existing streets are likely to be highly scalable. Existing example of this include a public bus system or TNCs such as Uber and Lyft. In either case, if the system sees particularly high demand, more vehicles can be brought online with little notice, allowing the system to carry more passengers. Expansion to new service areas can be completed with a new vehicle fleet, allowing for involvement from new vendors.

The 2getthere proposal identified a system that could operate at-grade or elevated. All of the propulsion and guidance is located within the vehicle. This flexibility would make it easier for expansion as the vehicles could operate in mixed-flow in additional corridors or take advantage of additional dedicated guideway. The service would not be limited to a certain network size or configuration.

Expansion Requires Additional Infrastructure but with Limited Impact to Initial Operational System and Operational Configuration Easily Replicated by Others (Assumed to be Reasonably Scalable) (6 proposals)

These systems require a new guideway (aerial or tunnel) for system expansion, but because the propulsion is on board the vehicle and the guideway is passive (it only provides physical support/guidance and does not transmit power or information to the vehicle), it both minimizes impact to the initial system and allows for greater flexibility selecting vendors for the expansion. An increase in frequency may be achievable but would be limited by the capabilities of the constructed guideway.

TBC proposed using twin-bore tunnels to create a dedicated transitway below grade. A number of access points could be created at various locations along the alignment, with different station configurations and sizes. This technology could be expanded to additional corridors through additional tunnel construction, dependent on the suitability of the soil and any below-grade obstructions.

Requires Additional Infrastructure and Modification to Initial Operational System and/or Proprietary Operational Technology (Assumed to be Less Scalable) (10 proposals)

These systems both require new guideway for expansion (all proposals in this category were aerial) and either the expansion would require re-configuration of the initial system or, because of a unique configuration of the guideway itself, would limit any expansion to be completed only by the initial vendor. These technologies in some cases had a powered track that would require an overall integrated technology system or had proprietary technology for the vehicle-guideway interaction.

Virgin Hyperloop would operate vehicles in a vacuum tube with offline stations feeding into a mainline tube. The ability to add vehicles or expand the system would require modifications to the tube itself as it is a single inter-connected system.

Not Described (1 proposal)

The proposal submitted by JPods did not contain sufficient detail to determine the level of scalability.

MAINTENANCE AND STORAGE

Transit systems typically require a centralized storage and maintenance facility to store vehicles when not in use and to perform regular repair and upkeep. Siting such a facility can often pose a challenge due to the space-intensive nature of vehicle storage and a maintenance floor. Additionally, for any transit vehicle that can only travel on its dedicated guideway (unlike a bus, which can run on public streets), the facility must be located at some point along the alignment, further limiting potential sites. Storage requirements can potentially be higher for systems relying on a large number of vehicles, particularly those offering point-to-point service on-demand with high frequencies. Some proposals provided more detail than others about the storage needs of their vehicles, though none went so far as to propose a specific site or size for a facility.

Maintenance and Storage Categories

- Off-line Storage and/or Maintenance Facility (15 proposals)
- Not Described (4 proposal)

Off-line Storage and Maintenance Facility (15 proposals)

Every proposal that described storage and maintenance accommodations noted the need for a maintenance facility and some form of off-line storage. The strategy for meeting storage needs varied significantly between proposals. The range of proposals included smaller distributed storage areas near stations, hubs of storage facilities near the alignment (such as in existing parking structures), and larger off-line storage/maintenance facilities. Because each proposal that covered the topic had a different approach to storage and maintenance, no further categorization was possible.

Unlike many of the other proposed technologies, ModuTram's GRT200 vehicles are not proposed for an off-site storage facility (the proposal suggests that the vehicles will be kept on parking tracks located within or close to stations). The network's control system adjusts the number of vehicles in operation to match current travel demand and routes any unneeded vehicles to parking tracks located within or near stations. An off-line maintenance facility is required, however, which would need to be connected to the guideway network, ideally at a central location. The design of the facility would be modular and could be expanded as needed with each module accommodating up to 40 vehicles. The facility would contain all necessary tools and machines required for full vehicle maintenance

Not Described (4 proposal)
Several proposals (Hotspur Design, JPods, General Atomics, and The General Transportation Fund) did not provide detail on how and where vehicle would be stored and maintained.

Costs

When considering the cost of a transit project, both capital costs (encompassing land acquisition, construction, and vehicle development) and operating costs must be considered.

CAPITAL COSTS

Capital costs varied widely across submissions, ranging from estimates of $0.5M per mile of guideway to $400M per mile. However, those proposals that both were sufficiently-documented and represented innovative and lower-cost technologies fell into a narrower range, typically between $20M to $50M per mile of grade-separated guideway. This is far lower than legacy technology capital projects now in planning or construction, such as San Francisco Central Subway Project (estimated at $940M per mile), the BART Silicon Valley Phase II (roughly estimated at $930M per mile) or the VTA Eastridge to BART Regional Connector-Capitol Expressway Light Rail Project (estimated at $190M per mile). The subject matter experts found some of the estimates received to be overly optimistic and should be considered with great caution.

Claimed capital cost savings over existing transit solutions were attributed to several factors, including:

- Passive track (non-powered) with self-propelled and intelligent battery-powered vehicles
- Very small vehicle sizes and lighter vehicles, requiring less structural infrastructure and ROW space
- For aerial guideway proposals, frequent column spacing (i.e. short spans) which would lower structural infrastructure requirements
- For tunneling proposals, a smaller diameter tunnel than is typical

It was not possible to categorize the proposals into specific cost categories. The proposals varied widely in how they accounted for capital costs. Some proposals itemized costs by guideway, stations, and vehicles, while others provided a comprehensive, all-inclusive estimate or didn't provide any estimate at all. Some included right-of-way acquisition, while others did not. Seven (7) proposals did not provide any capital cost estimate. Two examples with more thorough cost estimates are noted below.

Chamara Consulting

Chamara Consulting proposed an electromagnetic propulsion system on an elevated track with three to five person vehicles operating every three seconds. The proposal identified costs as $23M per mile for the guideway, $1M to $2M per station, and $2.4M for the entire vehicle fleet. The proposal pointed to smaller vehicles and more compact stations resulting in cost savings relative to existing transit options.

Plenary Glydways

Plenary Glydways proposed small automated PRT and GRT vehicles operating on an above-grade right-of-way. Propulsion would be on the vehicle with multi-level stations. Costs were estimated at $51M to $56M per mile for the guideway, $0.85M per station (smaller station with 8 bays), and $25k to $40k per vehicle. Cost savings relative to existing modes of transit were associated with a smaller vehicle allowing for a smaller guideway structure and autonomous, battery-powered vehicles.

OPERATING COSTS

All of the proposals received describe systems in which vehicles travel between origin and destination autonomously, i.e. without a human operator. The move toward autonomous transit could permit the deployment of smaller vehicles running at higher frequencies than is currently financially efficient. Only six of the proposals provided estimates of operating costs, which ranged from $1.6M per year to $21M year[2]. For context, the existing BART to OAK Automated Guideway Transit (AGT) connector has an annual operating cost of $6.5M[3]. Due to the insufficient amount of information provided, no categorization of the proposals was attempted. Below are examples of two proposals, describing their plan to minimize operating costs.

Swift APM

Swift Tram Inc. + Black & Veatch Inc. proposed an APM suspended from a cylindrical guideway and powered by on-board batteries, which would charge at boarding stations from roof-mounted solar PV panels. Annual operations and maintenance costs are estimated at $2.5M, with materials and supplies costing an additional $100K. Cost savings over traditional transit system were stated as attributable to several factors. The Swift system elevated guideway is constructed out of fabricated steel tubes with tracks welded to the interior of the tubes. The guideway is supported by 26 foot-tall towers poured in concrete. Because the vehicles themselves are self-powered, the guideway itself is purely mechanical with no wiring or utilities. The proposal states that maintenance costs would be very low and that the guideway would require inspection and cleaning once a year. The vehicles would be cleaned daily at the maintenance facility.

2getthere

Like Swift, 2getthere vehicles are self-powered, meaning the guideway itself would be less expensive to maintain than those for HRT or LRT systems, which require either third rail or catenary electrical systems. Unlike some of the other companies that submitted proposals, 2getthere already has

[2] These costs are not directly comparable, given that the different proposals imagine widely varying levels of service, and not enough information was provided for a meaningful comparison based on cost per service hour.
[3] BART Budget Pamphlet FY2019

working vehicles in operation, which should lead to greater in confidence of the company's estimates of operating and maintenance costs in any future submittals (though they did not estimate operating cost in this document).

Financing and Delivery

FUNDING SOURCES

The RFI asked proposers for innovative funding solutions. Traditional transit projects rely on heavy public-sector capital investment for design and construction with ongoing public investment for operations beyond what is recovered at the fares. Emerging trends are for cities to engage in public-private partnerships (P3) to finance transit through a mix of public and private money. Proposals received in this RFI included examples of both legacy and innovative funding models.

Public Finance	Private or Self-Finance	Public-Private Partnership	Not Indicated
-2getthere -Chamara -Citytram -CyberTran -Supraways -The Boring Co.	-TriTrack Motors -Jpods -Plenary Glydways -The Gen. Tr. Fund	-Bombardier -BYD -Hotspur Design -Miller Hudson/GA -ModuTram -Primerail -SwiftAPM -Virgin Hyperloop	-Hyperloop

Public Finance (6 proposals)

Six of the proposals suggested a system in which construction would be publicly financed using current typical public agency-led financing strategies.

Private or Self-Finance (4 proposals)

Four of the proposals stated that they would privately finance the construction and operation of the transit system. TriTrack Motors specifically stated that it would charge mileage tolls to fund the proposed system or would sell a monthly subscription allowing unlimited use (full financial details about whether the proposed $199/month would be sufficient to fund construction and operation was not included).

Public-Private Partnership (8 proposals)

The remainder of the proposals that included a discussion of funding sources recommended a P3 arrangement between a public entity and the private transit provider in which funding could be leveraged from both sides to provide necessary up-front costs.

No Funding Sources Indicated (1 proposals)

DELIVERY/RISK MANAGEMENT

The RFI requested proposals that identified innovative solutions not only for transit technology but also means of project delivery. However, generally, the proposals received did not propose new delivery strategies that would greatly accelerate schedule or reduce delivery costs. Many proposed a Design-Build-Operate-Maintain (DBOM) structure, in which the same entity would be responsible for all facets of the project from initiation and design through a pre-determined duration of system operations. The financing strategies included in most proposals represented a public-private partnership with significant risk borne by the public. However, a few included alternative strategies. The two with notable innovative delivery strategies discussed in their submission are noted below.

JPods

The proposal submitted by JPods imagines a network of self-driving vehicles carried overhead on a grade-separated guideway, traveling non-stop directly from origin to destination. The vehicles would be solar-powered by PV panels mounted on the top side of the elevated guideway. The ambitious proposal suggests that, rather than a simple linear track from Diridon Station to San José Airport and along the Stevens Creek Boulevard corridor, an entire network of JPods track could be built across Santa Clara County, funded by $6B in private investment without the need for additional public funds. Reviewers found these claims to be not fully substantiated through discussion of operational details or functional viability.

The Boring Company

TBC states that it will deliver projects on a firm-fixed price basis, meaning that any cost overruns are borne by the company rather than the public agencies. After that point, TBC would operate and maintain the system on an annual firm-fixed price. TBC suggest that it is amenable to other financing arrangements, but that that would depend on the nature of the eventual RFP.

REGULATORY AWARENESS

None of the entities submitting proposals operate a public system currently in California, which is notable given the complexity of the regulatory structure in the State. Several companies are currently developing test systems in the United States and/or have existing systems internationally, and others have yet to bring their proposed technology to market. Most of the proposals did not reference the many layers of environmental and regulatory review required for construction in California, though some were more thorough in their consideration of potential impacts than others. This is noteworthy because the robust environmental and regulatory review required in California is likely to dictate longer schedules and higher costs than the proposers may be considering. It also may preclude certain technologies from being implemented due to non-compliance. Three (3) of the proposals did not mention regulatory hurdles at all, with a number of other proposals from international firms with little to no United States experience. Below are examples of proposals that demonstrated a greater and lesser understanding of the regulatory environment present in the project area.

Plenary Glydways

The proposal’s section on key requirements for implementation demonstrated an understanding of the regulatory process, including the need to conduct a survey of soil conditions, underground and overhead utilities, as well as study the effect on nearby circulation and green space. The proposal also cataloged the potential negative impacts during construction, detailing the degree of impact on noise and vibration, dust and debris, parking constraint, road closures, pedestrian obstructions, and security. Other non-physical impacts that might occur were also listed, such as the interruption of sightlines and displacement of local TNC workers.

Primerail

The proposal submitted by Primerail described an APM called TieTran ROVE (standing for The Intelligent Electric TRANsit RObotic VEhicle). The system would be characterized by autonomous vehicles running on rubber tires in an enclosed elevated guideway. The shuttles would have a capacity of approximately 30 people with a guaranteed headway of 10 to 30 seconds between vehicles, providing a seven to nine-minute trip between Diridon Station and San José Airport. The company has a test track in Bangalore, India but has not yet developed a working system. Like many of the other proposals received, the proposal did not demonstrate a thorough understanding of California environmental regulations and glossed over some points that would likely present substantial barriers, such a community opposition and environmental impacts. Little detail was given about timelines for different steps of regulatory approval.

TIMELINE

Few of the entities that submitted proposals are currently able to deploy their proffered solution in the near term. Most proposals indicated that technology would be ready for use (ready for start of construction) within one to five years, but some of these estimates were deemed optimistic by reviewers. The timeline for implementation for many technologies generally fell in the range of four to eight years, though the subject matter experts noted that these estimates might be treated with some skepticism. Given the disparity in awareness and consideration of the hurdles for implementation, categorization of the timelines was not attempted. Seven (7) of the proposals didn't provide any estimate on timeframe. Below are representative examples of project timelines found in the proposals.

Virgin Hyperloop One

One of two proposals involving hyperloop technology, Virgin Hyperloop One (VHO) proposes an elevated or tunneled low-pressure tube which pods would travel through with little air resistance. The current design imagines pods carrying between 10-30 passengers autonomously. Turnouts would allow pods to divert from the main trunk, allowing passengers to travel point-to-point from the station of origin to the station of destination without stopping at intermediate stations.

VHO completed a full-scale prototype in Nevada in 2017 and has been refining the system since then. Because the technology has yet to be deployed in a real-world setting, VHO is working with several states to establish a hyperloop certification center. Though VHO states that it sees support from the federal government, the proposal estimates that the Virgin Hyperloop System would be ready for deployment in five to seven years, assuming that regulatory and safety milestones are achieved.

BYD

BYD provided a relatively detailed breakdown of their proposed timeline, estimating 44 months from NTP until operation, encompassing final design, train manufacture, guideway and station construction, systems installation, and testing. This schedule assumes no delays due to litigation, funding shortages, or unforeseen technical challenges. .

CyberTran

Headquartered in the Bay Area city of Richmond, CyberTran proposes Ultralight Rail Transit (ULRT), which would serve as a point-to-point transportation system with stations off-line or installed in buildings such as airport terminals, allowing users to travel to their destination without having to stop at intermediate stations.

CyberTran has built three physical test tracks and has conducted computer simulations of proposed operations. After environmental clearance and right-of-way acquisitions (a process which commonly takes several years), CyberTran estimates that the system can be deployed within five years using a DBOM framework. This would include 1.5 years for 65% design; 2 years for final design, utility relocation, and guideway construction; and 1 year for testing and construction of the maintenance facility.

Areas of Uncertainty

The solutions proposed are generally not currently in operation in the United States. All of the proposals carry significant uncertainty in their ability to deliver in the time and budget proposed. A general theme found in the proposals was a limited understanding of the regulatory environment . This resulted in timeframes and costs that the proposal reviewers frequently found to be unrealistic. Additionally, there was little consideration given to system failure or emergency management protocols .

Notable Proposals

The 19 proposals received by the City and reviewed by the subject matter experts comprised a wide range of vehicle type, technological readiness, and ability to meet the needs of the region. Several of these proposals appeared to represent a promising combination of technology, delivery innovation, and readiness and are noted below.

The proposals noted in this section are not endorsed in any way by the reviewers nor are they identified at being more cost effective or implementable than other proposals received, or other technologies in the marketplace that were not proposed as part of the RFI. Proposal content was not independently verified for accuracy. This section highlights several proposals that, in the opinions of the reviewers, most closely aligned with the City’s objectives; however, these are not necessarily the only proposals that would meet the City’s stated objectives.

The five notable proposals are as follows (listed alphabetically):

- 2getthere
- BYD
- Modutram

- Plenary Glydways
- The Boring Company

2getthere
2getthere currently operates four permanent deployments internationally, with several more planned in the coming years. Vehicles operate using existing technology, operate at relatively low speeds, and without drivers. This proposal was the only one submitted by a company that has an existing GRT/PRT deployment and experience operating and maintaining such a system. As such, the cost and timeline estimates were considered by proposal reviewers as being reasonable.

BYD
Known in the US primarily for its work with battery-electric buses, BYD is currently operating three APM systems internationally, with several more in development and testing. Driverless vehicles would run on an elevated guideway with columns at roughly 100-foot intervals. Because the system would operate with on-board batteries, track electrification would not be necessary, decreasing cost and complexity of development. The proposal was deemed aggressive but possible depending on environmental clearance and litigation.

Modutram
ModuTram proposes a system called AutoTrén, a system it calls an Automated Transit Network (ATN) providing high-capacity transit for up to six seated passengers riding in driverless battery-powered electric mini-trains on elevated guideways. Passengers would indicate their destination upon boarding and would be taken directly to their destination station without the need for intermediate stops. The company currently operates a full-scale test facility in Mexico. Due to the fact that the system does not have any real-world deployments yet, there is some uncertainty about the system cost as well as the assertion that the company could privately finance construction.

Plenary Glydways
Plenary Glydways Transit Solutions (PGTS) would develop a system consisting of a fleet of autonomous electric vehicles operating on a dedicated guideway. The vehicles would be small but would operate at high frequency, with the proposal promising up to 10,000 persons/hour in each direction at a low cost. PGTS proposes a DBOM model in which the company would take on responsibility for all aspects of the project including financing for a 30 to 40-year term. Proposal reviewers found the submission to be reasonably comprehensive and well-articulated. However, the company does not yet have a physical test facility, and feasibility of vehicle storage was not fully addressed. Therefore, the technology has great uncertainty regarding readiness and cost.

The Boring Company
TBC has stated that its tunneling technology operates at a fraction of the cost of existing models. The proposal for San José would construct a small dual-bore tunnel with driverless electric vehicles operating on rubber tires. Stations would be located on siding tracks, allowing riders to experience point-to-point service as the vehicle would skip any intermediate stations. The vehicles themselves would be Tesla Model X or a modified version of existing production vehicles. Stations would be below-grade and accessed via vehicle elevator. The company currently operates a test track at its

Hawthorne headquarters in Los Angeles County and is currently developing a working facility at the Las Vegas Convention Center. The proposal lacked details for how the tunneling cost savings were realized. Several other aspects of the proposal were deemed questionable, such as including tunnels with radii not currently achievable by TBMs and vehicle operating speeds that are likely infeasible in a transit environment. Additionally, there are concerns regarding the ADA accessibility of the proposed vehicles. However, the proposal suggests a firm-fixed price proposal that would potentially limit agency risk and add potentially significant cost savings.

Evaluation Summary

Below are some general themes from the 19 proposals reviewed:

- There was a significant emphasis on vehicle technology itself, detailing the specifications and dimensions of the vehicles.
- While many of the proposals had not yet demonstrated the capabilities of their technology through real-world implementation, the proposals included a range of transit service technologies with high frequency and high throughput.
- The proposals claimed substantial cost savings relative to legacy transit systems through a variety of means. These claims deserve further investigation to confirm the magnitude of savings and ensure compliance with local standards and regulations.
- Comparatively little innovation was demonstrated with respect to project delivery, which was one of the goals of the RFI. Many of the proposed projects suggested a DBOM framework with public financing.
- Many of the proposals relied entirely on untested technologies that do not exist beyond scale model form. With the technology being thus far untested, many of the cost estimates should be considered with some level of caution. It is likely that when considering California's rigorous regulatory environment, actual costs will be higher.
- Almost none of the proposals included a thorough discussion of capital risk management, namely which entity would be responsible in the event of cost overruns, a significant concern given the untested nature of many of the proposed technologies.
- Few of the proposals gave a great deal of consideration to emergency preparedness or made more than passing reference to ADA.

Attachment A: Summary Assessment Table