COUNCIL REPORT

CITY OF MOUNTAIN VIEW

DATE: February 27, 2018

CATEGORY: New Business

DEPT.: Public Works

TITLE: **Automated Guideway Transit Study**

RECOMMENDATION

Approve the Automated Transit Guideway (AGT) Feasibility Study Report and direct staff to develop a work plan and budget for a Phase 2 Feasibility Study that focuses on the evaluation of alternative route alignments for an Autonomous Transit AGT system.

BACKGROUND

At its June 16, 2015 meeting, the City Council directed staff to initiate a multi-year process in conjunction with other cities and agencies to improve last-mile connections. During an October 27, 2015 Study Session, the City Council provided the following additional direction: (1) focus on the development of an off-street AGT system (e.g., automated people mover, group rapid transit, personal rapid transit, etc.); and (2) give priority to the corridor linking the Downtown Transit Center to the City's North Bayshore Area.

The City Council also directed staff to monitor the North Bayshore Transportation Access Study that Google has contracted with the Valley Transportation Authority (VTA) to conduct.

On February 2, 2016, the City Council provided input regarding a proposed process to explore the development of an AGT system for the Downtown Transit Center to North Bayshore, and on December 6, 2016, the City Council authorized the City Manager or his designee to execute a professional services agreement with Lea+Elliott, Inc. (Lea+Elliott) to prepare the study. The Lea+Elliott consultant team's scope of work included the identification of candidate technologies, development of passenger market and demand estimates, identification of system requirements, and evaluation of technologies to meet system needs. The consultant team's scope of work also included community meetings, business outreach, a project website, and partner agency discussions (see Attachment 1).

On May 23, 2017, the City Council provided input on the proposed technology groups, the study corridor, and the recommended evaluation criteria. This input was used to continue the evaluation of technology options. On October 17, 2017, the City Council held a Study Session to review the evaluation of the technology groups and discuss preliminary conclusions. A synopsis of the technology evaluation and key conclusions, as presented at the October 17, 2017 Study Session, is as follows:

Technology Options

Four AGT technology groups were evaluated (see Figure 1).

Figure 1—Technology Options

Aerial Cable Transportation This type of transit system uses one or more cables for propulsion and stability, carrying passengers in suspended cabins above the ground. There are different types of aerial cable transportation technologies such as gondolas and aerial trams. The smaller-sized gondolas can transport about 2,000 people per hour per direction. The larger aerial trams can transport up to 6,000 passengers per hour. They generally operate in the 10 mph to 20 mph range.	 Roosevelt Island Tramway, Aerial Tram (NYC, NY)
Automated People Movers (APM) This technology is best described as an automated transit system with large-capacity vehicles operating on a fixed guideway. Propulsion can be of several methods, such as cable, electrically powered, or magnetic levitation. This grouping includes rubber-tire and steel-wheel APM, Monorails and Maglevs. These technologies can reach greater speeds compared to the other technology groups and have larger vehicles and greater system capacity.	 Mitsubishi: Crystal Mover APM (Miami International Airport, FL)

Automated Transit Network (ATN) Smaller automated vehicles operating on a network of guideways and providing point-to-point service for passengers characterize this technology group. ATN guideways can use sensors and other technology to provide guidance, rather than tracks or cables. Personal Rapid Transit (PRT) and Group Rapid Transit (GRT) technologies were included in this group as they both have smaller capacities and similar operation. Multiple vehicles can be located at stations and are deployed when called on by passengers leading to shorter wait times.	 Ultra Global PRT (Heathrow, England)  2getthere GRT
Autonomous Transit This technology group consists of automated vehicles on a mapped network, preferably with dedicated lanes, but capable of operating in mixed-flow traffic. Equipped with sensors and GPS, guidance is provided by the vehicle rather than the guideway. Capacity is similar to Automated Transit Network, although there is potential for higher-capacity vehicles to be developed. While current pilot operations involve lower speeds, average speed of the vehicles has the potential to increase in the future as the technology becomes more mature and service proven.	 EasyMile:  Navya: Arma

Evaluation Methodology

The methodology for the evaluation included updating the demand estimate for sizing the system, developing representative alignments, evaluating each technology group based on data gained from operational stimulations, and developing order-of-magnitude capital and operations and maintenance (O&M) cost estimates.

- **Demand Estimate**—Ridership projections based on existing and future jobs and housing in the study area, including North Bayshore and NASA/Ames, was in the range of 4,000 to 8,500 daily riders. Demand was also estimated for a peak 10-minute period to ensure that the system would be able to handle overlapping demands from multiple peak-hour Caltrain arrivals. The estimated system capacity need was estimated at 330 riders in the peak 10-minute period.

- **Representative Alignments**—The study team developed two representative alignments as shown in Figures 2 and 3 for use in the evaluation. The "T Alignment" features a line-haul type service with two routes: one to Intuit and one to NASA/Ames. The "Loop Alignment" features a dual lane bidirectional alignment for line-haul service and assumes a supplemental network-type system will provide further connections within North Bayshore. For this initial evaluation, a fully elevated guideway was assumed. The route alternatives were used as a basis to compare the technology options.

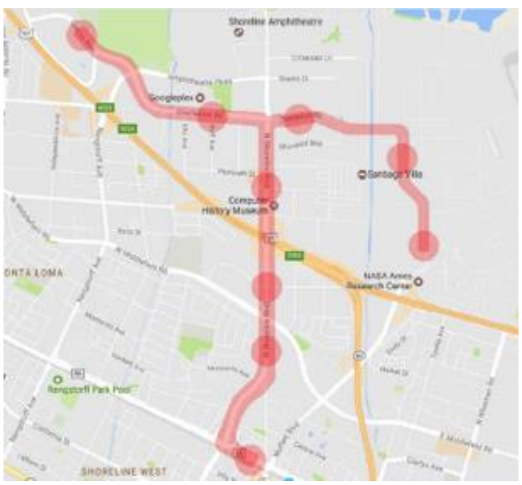


Figure 2: T Alignment

Figure 3: Loop Alignment

- **Operational Simulations and Service Characteristics**—Simulations of how the different technology groups could provide the peak period demand were performed. Simulation inputs included factors such as alignment geometry, station locations, dwell times, vehicle/passenger comfort parameters, and car capacity. The simulated travel time was then used to calculate operating fleet sizes needed to meet the demand, passenger trip times, passenger wait times, and vehicle frequency.

Table 1 summarizes the resulting operational characteristics for each technological group based on the travel time simulations.

Table 1: Operational Characteristics

Operational Characteristics	Aerial Cable	APM	ATN (PRT/GRT)	Autonomous Transit
Vehicle Capacity (passengers)	14 to 32	80	3 / 20	10 to 20
Travel Time to North Bayshore (minutes)	11	7	6 / 7	6 to 7
Frequency to North Bayshore During Peak Period	30 sec to 1 min	4 min	10 sec / 45 sec	30 sec to 1 min
Operating Fleet (vehicles)	22 to 48	8 x 2-car trains	135 to 140 / 25 to 30	35 to 80

- **Costs**—Cost estimates were developed for each technology, including both capital cost (on a per-mile basis) and operations and maintenance (O&M) costs. Rough order-of-magnitude costs for each technology group are provided in Table 2.

Table 2: Preliminary Cost Estimate Summary

	Aerial Cable	APM	ATN (Assumes GRT)	Autonomous Transit
Capital Cost (per mile)	$35M to $50M	$130M to $195M	$85M to $130M	$85M to $135M
O&M Cost (per year)	$9M to $13M	$15M to $22M	$7M to $10M	$5M to $8M

The capital cost per mile estimate includes systems equipment (e.g., vehicles, guidance, power, communications, train control, etc.) and facilities (e.g., civil works for stations, guideway, and maintenance facility). For purposes of this study, a fully elevated system and typical viaduct configuration for the APM, ATN, and Autonomous Transit technology groups were assumed. Constructing a fully elevated system in conformance with California structural seismic requirements is a substantial element of the capital costs. Costs could be lower if the guideway provided only a single (possibly reversible) lane or if (for Autonomous Transit) some of the guideway could be at street level.

The annual O&M cost estimate addresses labor, power and material (i.e., parts and consumables) costs for the system operations and estimated fleet size. O&M costs include vehicle and guideway maintenance, system controls, fare collection and roving staff that can respond to mechanical problems and emergencies.

Evaluation Summary

Based on the evaluation of the technology alternatives, as well as community input, the study made the following conclusions regarding the potential AGT service characteristics and technology options:

- **Passenger Experience**—The estimated travel time of less than 10 minutes from the Transit Center to the heart of North Bayshore would be attractive for users. Aerial cable would have a longer travel time than other options. Small-capacity vehicles (ATN/PRT) would need to operate much more frequently (as low as every 10 seconds), which will be difficult to achieve. GRT and Autonomous Transit were estimated to have peak frequencies of about 30-45 seconds.

- **Infrastructure**—Established AGT technologies have been fully grade-separated, usually elevated. Of the options studied, Aerial Cable towers, while spaced more widely, would have the largest ground footprint. Aerial Cable would also the most potential for personal privacy concerns. While similar to the structures for ATN and Autonomous Transit, the APM structure would be larger due to the larger size and weight of the vehicles.

- **Assessment of Technology Options**—Key conclusions about the individual technology groups are discussed below:

  — <u>Aerial Cable and Automated People Mover (APM)</u>—Both are well-established and proven technologies. However, Aerial Cable systems are generally deployed where there are topographic barriers, not usually in urban areas. APM is often developed in self-contained areas such as airports, where the elevated structure is less intrusive. Both Aerial Cable and APM have higher operating costs and are less flexible in integrating into a built-up environment, adapting to extensions or conversion to other technologies.

  — <u>Automated Transit Network (ATN)</u>—Although ATN is not a new technology, it has only been fully deployed in a few locations. To meet demand in the North Bayshore corridor, Personal Rapid Transit (PRT) with small-capacity vehicles may not be feasible, due to the large number of vehicles and very high service frequency. The Group Rapid Transit (GRT) variation, with larger vehicles, could be a better fit to serve the corridor demand, while retaining a reasonable midday service level.

- <u>Autonomous Transit</u>—The newest technology, Autonomous Transit, would be operationally similar to ATN and could operate on a fully grade-separated guideway. The guidance systems are provided in the vehicles simplifying the guideway segments to be just structural elements. In addition, this technology offers the potential to reduce costs by operating partially at-grade in dedicated lanes. The technology is not fully developed yet and there are no operating systems, only limited pilots. However, systems that could operate autonomously may be viable in the next 5 to 10 years.

Of the technologies explored, the ATN/GRT and Autonomous Transit technologies were found to be most applicable to Mountain View's needs and environment. It was also noted that a hybrid Autonomous Transit alternative, combining at-grade, fully dedicated lanes (or a single reversible lane) with some elevated or depressed segments crossing key traffic arterials could reduce the capital costs, visual impacts, and environmental impacts substantially while maintaining comparable travel times. This alternative could also provide opportunities to make more effective use of existing and planned infrastructure. The Shoreline Boulevard reversible bus lane and a potential similar lane in the median of Moffett Boulevard are examples of such opportunities.

At the October 17, 2017 Study Session, Council concurred with focusing further evaluation on the GRT and Autonomous Transit technology options. The Council also requested more information on how to integrate an AGT station into the Transit Center Master Plan.

<u>ANALYSIS</u>

The Draft Final Report, prepared by the Lea+Elliott consultant team, describes the evaluation of potential AGT technologies and presents key conclusions and recommendations in greater detail (see Attachment 2). Described below are the additional findings and conclusions developed since the October 17, 2017 Council Study Session.

Further Research on Group Rapid Transit (GRT) and Autonomous Transit

Additional research into these technologies has identified that the two options are essentially merging into a single technology relying primarily on autonomous vehicle guidance. This research included meetings and discussions with key individuals representing agencies, companies, and research organizations (see Attachment 3) and compilation of studies, news reports, and other recent documents.

From this research, it is apparent that this emerging AGT industry is still evolving in terms of both technology and social/regulatory issues. Estimates of the time that Autonomous Transit can be widely deployed range from a few years to a decade or more. Following are some key observations and conclusions from this research:

- There are a small number of GRT systems that have been deployed and have proven technologies. None of these newer systems are in the United States. While the companies that developed these systems are still active, few new systems are being developed. It appears that their focus is shifting to fully autonomous vehicles linked to their system control capability. Examples are Ultra and 2getthere, which have GRT operating systems in Europe. Ultra is piloting Autonomous Transit vehicles modeled on the vehicles they operate at Heathrow Airport. 2getthere is also designing autonomous vehicles for projects under development.

- In contrast to GRT, a significant number of companies and agencies are exploring Autonomous Transit. However, these developments are all currently in the testing and pilot operation phase. Tests of small, first-generation, partially autonomous shuttles are becoming common. This accelerating activity has been driven, in part, by increased interest and investment from traditional auto and transit vehicle manufacturers. Examples include pilots operated by Easy Mile in San Ramon and Navya in Las Vegas. Jacksonville, Florida is looking to convert their Skyway monorail guideway into an Autonomous Transit guideway and has a test guideway section in operation.

- While the current pilot shuttle demonstrations are in controlled environments and require some operator intervention, second- and third-generation vehicles and systems are under active development. A deployable Autonomous Transit system will require Level 4 autonomy, which is fully autonomous in a limited or controlled environment, such as a guideway or exclusive lane. Many in the industry believe this technology will be available in four to five years.

- While the technology development is proceeding strongly, there is a good deal of uncertainty in terms of regulatory approval, safety certification, insurance, liability, and other related issues. These issues are beginning to be addressed, but the actual responsibilities and timing are in question.

- At the Federal level, the National Highway Traffic-Safety Administration (NHTSA) is responsible for setting vehicle safety standards; although their focus to-date has been on individual vehicles, not transit service. The Federal Transit Administration (FTA) has just announced a five-year research and demonstration project that will address key operating issues and conduct pilots (e.g., Autonomous Bus Rapid Transit).

- At the State level, the California Department of Motor Vehicles has been issuing permits for pilot shuttle projects and is expected to allow limited tests with general traffic. The California Public Utilities Commission (CPUC) has historically been responsible for safety certifications for transit systems, such as rail transit and Automated People Movers. However, at this time, CPUC has no direction to develop guidance on Autonomous Transit systems.

- These regulatory and safety issues create significant uncertainty regarding the timeline for deployment of autonomous vehicles on public roads, including transit vehicles. Rapid advancements in technology may accelerate the development of standards and certifications. On the other hand, public safety concerns or other unforeseen issues could lengthen the process.

- There also appears to be a general view that Autonomous Transit, operated with Level 4 autonomy in a controlled environment and by a single agency, is likely to receive regulatory approval sooner than autonomous vehicles operating in a mixed traffic environment.

The consultant's study report continues to conclude that both GRT and Autonomous Transit are the most appropriate technology options for the Transit Center to North Bayshore corridor while also acknowledging that the two technologies are evolving into a single technology using autonomous vehicles. The status and advantages of the Autonomous Transit technology are more fully described on pages 10 to 14 of the report and the evolution of GRT into Autonomous Transit is discussed on page 36. Based on the analysis and the current state of technology development, staff recommends the City plan for an Autonomous Transit system with the flexibility to operate on both a separate guideway and dedicated roadway lanes.

Proposed AGT Objectives and Characteristics

The consultant study helps to define the type of system needed for the study area. In general, the desired system should be one that can:

- Connect major transit stations with nearby employment and residential areas (first/last mile connection).

- Provide highly competitive travel times compared to auto or traditional transit service.

- Provide a nonauto mobility option for local trips of all types.

- Serve moderately high passenger demand during peak conditions (e.g., transfers from Caltrain).

- Provide frequent cost-effective service throughout the day.

- Has flexibility in its infrastructure to fit within and maneuver through the existing environment.

- Provide a flexible system that can operate direct service between origins and destinations, particularly in off-peak hours.

These objectives help to better define the key elements that would be needed for operational service, with a focus on Autonomous Transit. The desired elements for this potential system include:

- Vehicles specifications:
  - Battery-powered, rubber-tired vehicle.
  - Level 4 autonomy (fully self-driving in a controlled environment).
  - Capable of speeds up to 30+ miles per hour.
  - Capacity of 20 to 30 persons, including standees.
  - Size = 20′ to 30′; capable of operating in platoons.

- Peak service frequency of up to 30 seconds (or 1 to 2 minutes if operated in multi-vehicle platoons); off-peak frequency 5 minutes or less.

- Capability to operate on dedicated guideway and/or in exclusive at-grade lanes with minimal interaction with regular traffic and pedestrians.

- Off-line stations at intermediate locations.

- Control systems and facilities that support transit service operation, including:
  - Operating control system (vehicle dispatching, customer information, trip routing, door controls, fare collection, vehicle platooning).
  - Operating and maintenance facility—staffing and equipment.
  - Safety and security provisions—emergency response.
  - ADA compliance—precision docking, level boarding at stations.
- Staffing and equipment for guideway, station, and vehicle maintenance.

VTA North Bayshore Transportation Study

Project staff met several times with VTA to coordinate the Google-funded North Bayshore Transportation Access Study with the AGT Study. Public release of this study is expected in March. While the two studies looked at different, but overlapping, corridors and a slightly different set of potential technologies, the two studies have similar conclusions about the potential for Autonomous Transit as a future transit mode.

Potential Transit Center Integration

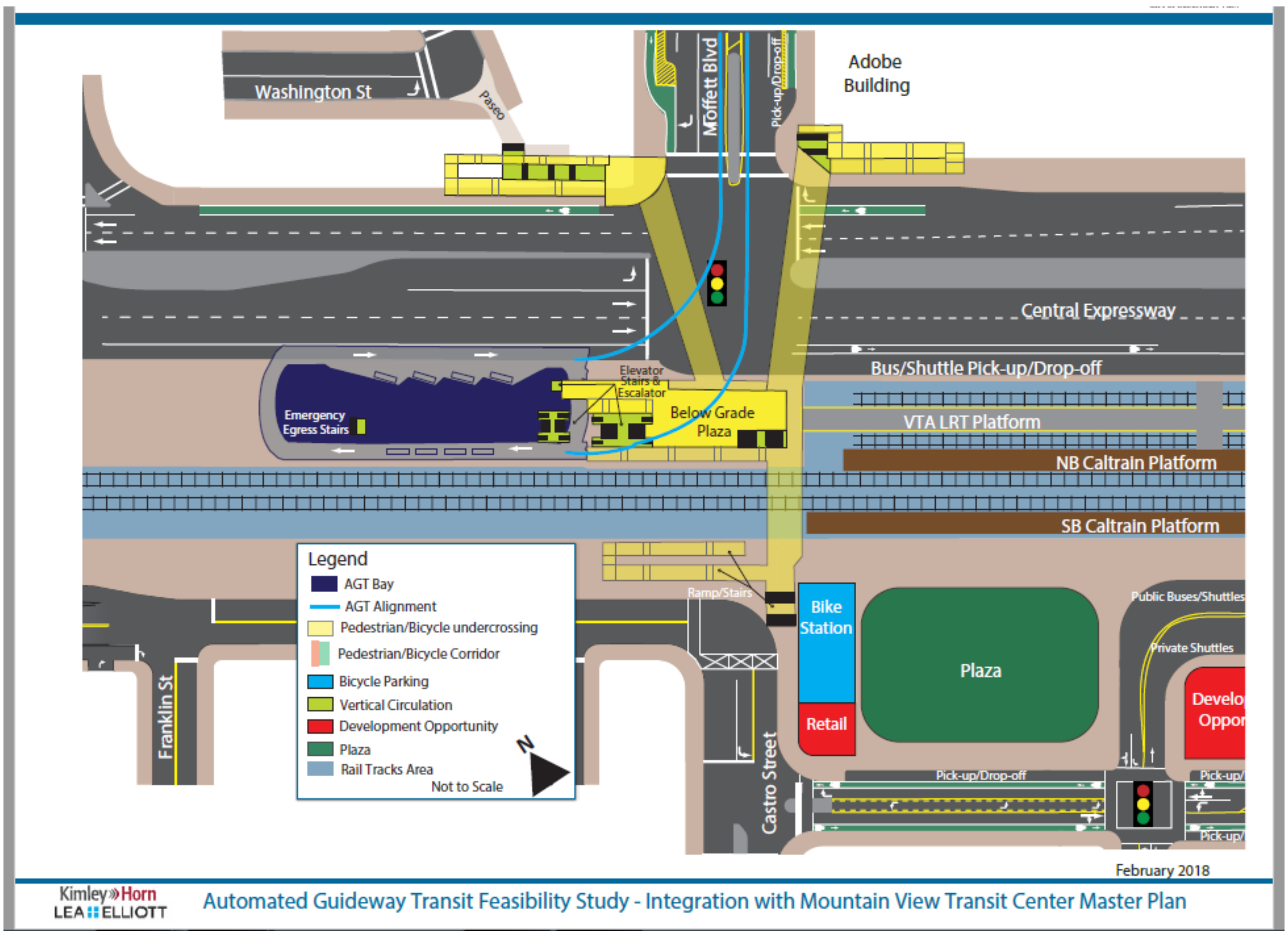
To respond to questions about how a potential AGT station would integrate with the Mountain View Transit Center Master Plan, the consultant team investigated the general size and potential layout of an integrated station.

Key assumptions in this analysis included separate vehicle deboarding and boarding platforms, including four separate saw-tooth boarding bays (in order to accommodate short headways and high peak passenger volumes). The platform width was estimated to handle the queues associated with peak boarding flows. To allow for flexibility, the individual bays are sized to accommodate 30′ vehicles. This allows for the use of existing shuttle vehicles in the near term and preserves the possibility of longer Automated Transit vehicles with higher capacities in the future.

This Transit Center station concept is treated as an end-of-the-line station, but has the potential to be an intermediate station if the system is expanded in the future. Some widening might be required to allow through movements in the future.

An elevated station located on the southwest corner of the Castro Street-Central Expressway intersection between the Caltrain tracks and Central Expressway is proposed. The station entrance is assumed to be integrated with the access provisions proposed as part of the Transit Center Master Plan. To accommodate the estimated station width, the station will likely need to extend slightly over the eastbound lanes of Central Expressway, as shown in Figure 4.

Figure 4 — Transit Center AGT Station Concept



Next Steps

Staff recommends a Phase 2 Feasibility Study that focuses on the evaluation of alternative route alignments for an Autonomous Transit system with the characteristics described above. Specific recommended tasks include:

- Evaluation of potential alignment alternatives—vertical and horizontal alignment options; guideway design concepts; station concepts and footprint; maintenance facility requirements; right-of-way, roadway, and traffic impacts; potential phasing, including interim uses ahead of fully automated operation; coordination with North Bayshore and NASA development plans.

- Refined evaluation of the desired operating system, including vehicle characteristics, fleet size, service plan, control systems, and operating protocols.

- Additional community and stakeholder outreach.

- Further development of cost estimates, projected ridership, and analysis of cost-effectiveness.

- Identification of potential funding, implementation, and operating strategies.

In parallel with the above tasks, project staff could continue to track the status and evolution of Autonomous Transit technologies. This would include a better understanding of vehicle and system technologies, commercial viability, the development of potential suppliers and manufacturers, and the timeline for deployment. A key tracking issue will be the development of regulatory policies and procedures, including Federal, State and local responsibilities. There may also be opportunities for the City to participate in multi-city consortiums and demonstration projects.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

CEQA recognizes the need for agencies to engage in long-range planning for large projects and provides a specific statutory exemption for planning and feasibility studies. CEQA Guidelines, Section 15262, statutorily exempts from CEQA review actions consisting of "feasibility or planning studies for possible future actions which the agency has not approved, adopted, or funded." The AGT Feasibility Study is a planning study that does not approve, adopt, or fund the actual construction of any improvements. Approval of the study does not commit the City to a course of action. Any specific projects or individual elements of a potential future project still require approval and funding. Additionally, none of the identified elements have been approved or funded in the City's Capital Improvement Program. At such time as they are, comprehensive CEQA review will be performed. Thus, the City finds the proposed action to be statutorily exempt from CEQA pursuant to Guidelines Section 15262.

FISCAL IMPACT

There is no fiscal impact associated with approving the AGT Feasibility Study. If the Council approves the next step of developing a Phase 2 of the Feasibility Study to evaluate alternative route alignments, staff will prepare a work plan with a timeline and cost estimate and submit a CIP request for funding. The preliminary estimated cost for the Phase 2 study is in the range of $750,000 to $1,000,000. As part of developing the work plan, staff would explore potential funding partners.

CONCLUSION

The AGT Feasibility Study provides an analysis of Automated Guideway Transit technologies for potential development in the Downtown Mountain View to North Bayshore corridor. Based on the study's findings, Autonomous Transit is identified as best suited to the corridor in terms of demand, community acceptance, flexibility, and adaptability. The study also defines the desired characteristics of the AGT service. Next steps would be to conduct Phase 2 of the Feasibility Study to evaluate specific alignment alternatives.

ALTERNATIVES

1. Direct staff to explore additional issues and revise the AGT Feasibility Study.

2. Do not direct staff to develop a work plan for a Phase 2 Study.

3. Provide other direction.

PUBLIC NOTICING

In addition to the City's standard agenda posting requirements, notices regarding this Study Session discussion were distributed to the persons who have signed up on the project website for updates and information, previous business and/or community meeting participants, representatives of VTA, Caltrain, and Mountain View TMA, and other interested parties, as well as on social media.

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DSC-JL/TS/2/CAM
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Attachments:
1. Community and Agency Outreach
2. Draft Final Report
3. Research Contacts