Response to RFI 2019-DOT-PPD-4 New Transit Options: Airport-Diridon-Stevens Creek Transit Connection

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Summary Sheet

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High level description of concept: 2getthere realizes automated transit systems, which can operate on a segregated infrastructure, on dedicated lanes or in mixed traffic. The technology is based on 30+ years of experience with automated vehicles in various demanding environments. Flexibility is the keyword as there is:

- no need for a fixed guideway (rail and switches) and a human driver, as driverless electric (using on-board battery) vehicles are used;
- vehicles can be deployed as single unit or be part of a platoon of multiple virtually coupled vehicles when higher capacities are required;
- operational fleet size can vary during the day, following the actual transport demand;
- application and fleet size can are easily expandable;
- depending on transit demand service can change between on-schedule and on-demand, point-to-point to fixed route.

For the Airport Connector and the Stevens Creek line, 2getthere will develop applications operating on segregated guideway infrastructure (elevated/underground), with multiple stations along their routes. Ideally, both systems are connected in order to gain synergy effects by sharing the fleet of vehicles and maintenance, storage and control room facilities. This can greatly reduces capital investments.

The integration of both application into the environment will be based on the requirements in terms of capacity relative to any spatial restrictions and the business case. Both applications will allow for implementation in phases, enhancing the system capacity of the applications by merely adding vehicles or enlarging the service area of the applications by extending the routes.

High level description of business plan: 2getthere proposes to jointly work with the city, a financing group and the operator on an acceptable business case for all stakeholders involved. Revenues for the system could come from (a combination of) ride fares, parking fees and advertisement. Additional funding could come from housing/office/commerce developers, as they will greatly benefit. 2getthere advises to consider not charging ride fares at all, instead increasing parking fees at the locations served. This would both stimulate the use of public transit, while discouraging the use of the personal car.

Maximize ridership can be achieved having an attractive system to use. This can be achieved by ensuring high system availability, short waiting times, short trip times excellent ride comfort, a pleasant travel experience and by not charging the passengers. It also requires the involvement of the operator and/with knowledge of the local culture and a marketing agency to create a message to the community to sell the system with. Shared transit is increasingly gaining popularity and will play an ever-increasingly bigger role in the future of large cities.

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1. Introduction

1.1 Context

As automobile-focused transportation in Silicon Valley is reaching its limits, the City of San José (City) and its partners, Valley Transportation Authority (VTA), City of Cupertino, and City of Santa Clara, are approaching the market in order to gain insight in new transit solutions for the following two major routes/corridors:

1. Diridon Transit Station to Mineta San José International Airport (Airport Connector)
2. Diridon Transit Station along the Stevens Creek Blvd Corridor to De Anza College (Stevens Creek Line)

2getthere, a company of ZF, as a turn-key supplier of automated transit systems, is confident that its formal response to the City's RFI will reflect 2getthere's experience, knowledge and capability to deliver a solution tailored to the needs of both the Airport Connector application and the Stevens Creek application.

1.2 Understanding the City's vision & objectives

In order to eventually supply transit solutions that perfectly match the City's requirements and expectations, it is important understand the City's vision and objectives. For the transit solution the following objectives have been determined:

Objective	Consideration
High Quality Guest Experience	Quick and intuitive transfers to/from Diridon station Meet ADA requirements
High Quality Performance & Service	Reliable and predictable service Short headways Short travel times between stops Grade separated, high capacity & high speed transit
Costs	Lower costs for Construction and Operations & Maintenance than traditional systems Have viable financial outlooks
Project execution	Faster deployment than traditional projects
Benefits on a wider scale	Reduce roadway vehicle traffic and air pollutant emissions

Table 1: Transit solution objectives

For the two corridors, specific objectives have been determined:

1. Airport Connector

Objective	Consideration
High Quality Guest Experience	Integrate Diridon Station and the airport as a single facility from the passenger's perspective Provide airport passengers and employees with link to local and regional transit systems. Allow for quick, level boarding for passengers with luggage. Provisions for airport baggage handling and other amenities at Diridon for airport passengers is desirable.
Benefits on a wider scale	Expand the airport's geographic market reach, in turn mitigating capacity constraints at the two other major Bay Area airports Serve as a national showcase of a state-of-the-art transit link between airport and rail service hubs.

Table 2: Airport connector objectives

2. Stevens Creek line

Objective	Consideration
High Quality Guest Experience	Link major sites in the corridor to each other and to the rest of the Bay Area and to Diridon station.
Benefits on a wider scale	Support higher-density development in the corridor by providing the transit capacity needed to attract mode shift away from private vehicle usage Support urban integration and human scale activation of Stevens Creek Blvd by attracting users to walk, bike, and transit to stops on the corridor.

Table 3: Stevens Creek line objectives

In order to deliver on each of these objectives, 2getthere will design and supply a turn-key tailormade solution based on its proven and reliable technology.

1.3 Reference Documents

Below are several documents that are available as reference. With the exception of RD-1 they require a Non-Disclosure Agreement to be signed as they contain commercially sensitive information that we don't want to become publicly available.

[RD-1] 8002.010_Reference list 2getthere projects_v4.0
[RD-2] 8002.006 Functional Description TOMS_v2.0
[RD-3] 8002.004 Design Description GRT Vehicle_v3.0
[RD-4] 8002.008_Project_Approach v3.0
[RD-5] 8002.002 Safety Approach_v3.0
[RD-6] Example Maintenance scheme

2. Response Information

2.1 Respondent Profile

Please refer to the cover and summary sheets.

2.2 Proposed Concept

2getthere proposes to use automated vehicles for both the Airport Connector and the Stevens Creek line. The chosen technology has safely delivered over 14,000,000 passengers, and has been 'in control' over 60 million miles in applications such as the Schiphol Airport (1997), the Rivium business park (since 1999), and Masdar City (2010) as well as applications in other demanding environments. Several other projects are currently in production and are destined for installation over the next two years. For more information, please refer to the Reference list [RD-1].

Systems featuring automated vehicles offer high levels of flexibility for operations since vehicles can automatically be called to operation depending on the actual demand. During peak hours short headways can be realized and off peak excess vehicles automatically return to charging or buffer locations to offer a fleet size in line with the actual transport demand. In order to realize the full potential of this flexibility, all vehicles are integrated into one system that offers a transportation service.

The system's main components are the vehicles, the supervisory system, a maintenance facility, charging equipment and station interfaces. The following figure provides a schematized overview of commonly used system components and their communication lines.

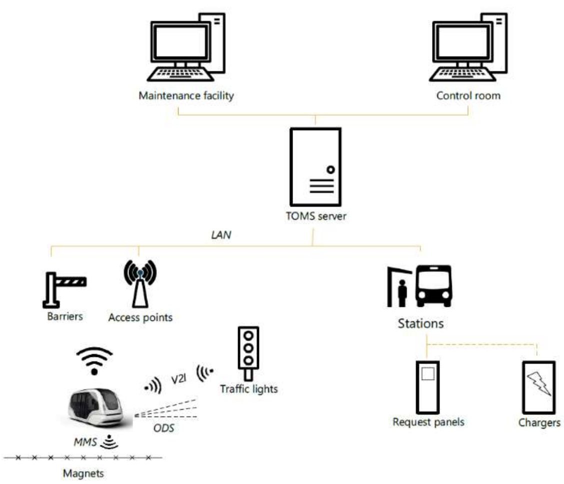

Figure 1: Overview of a typical communication architecture

The Transit Operation Monitoring and Supervision (TOMS) system keeps an overview of all operations in the system and manages the fleet. TOMS is connected to the maintenance facility, control room, barriers (if applicable) and stations by a LAN network. Communication with the vehicles is wireless. All vehicles are equipped with advanced Obstacle Detection Sensors (ODS) to detect (moving) objects around the vehicle.

TOMS communicates continuously with all vehicles in the system and is continuously aware of their status and location. The task of TOMS is to schedule and execute transport orders using the currently available vehicle fleet. Upon generation of a transport order, TOMS inquires which vehicle meets the correct requirements and what its availability and distance from the intended origin are. Available vehicles respond, and the order is assigned to the vehicle with the most optimal profile.

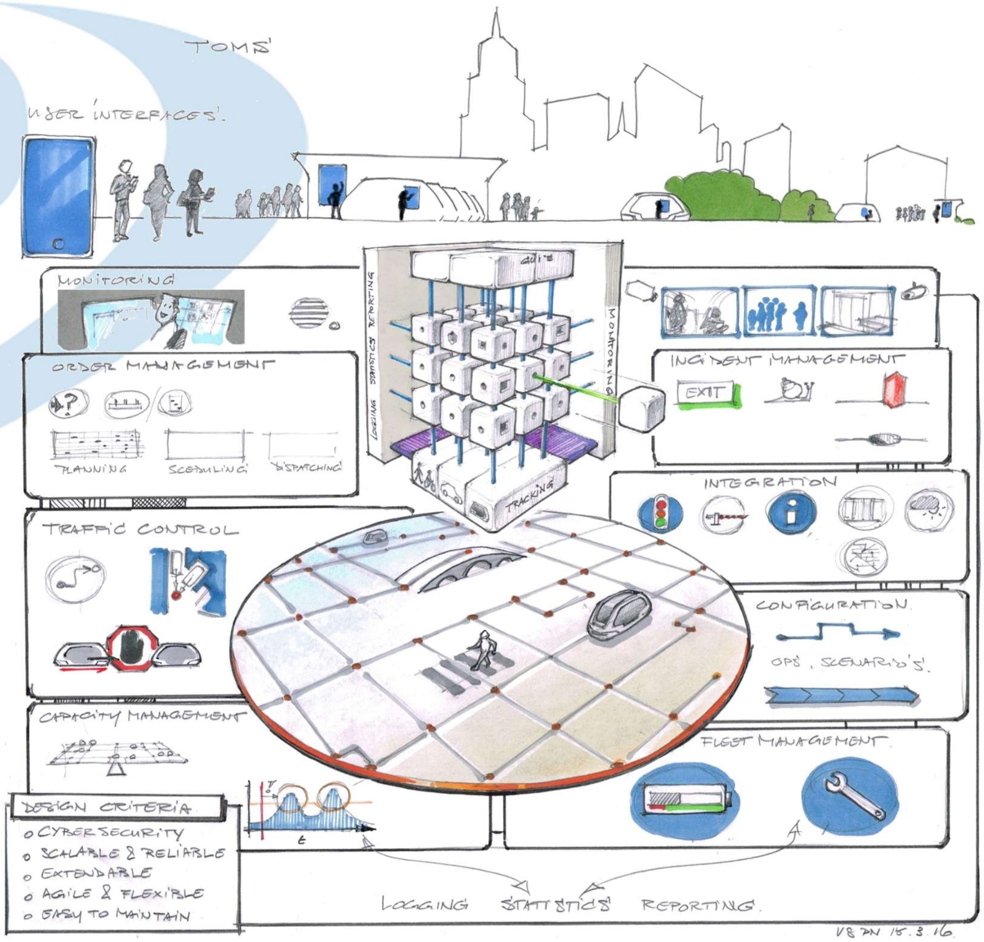

Figure 2: Impression of TOMS functionality

If there are no vehicles present at a station, passengers can request transportation at stations. Alternatively, TOMS can generate transit requests for vehicles to ensure their presence at specific stations. These requests can be based on logged transit patterns or to synchronize the availability of multiple vehicles with the arrival of other modes of transit.

TOMS is also in control of fleet management. This includes ensuring timely recharging of the batteries and keeping log files of all system events and transportation requests. The log files can be retrieved for statistical processing at any time.

The necessary communication to and from vehicles is done via a wireless link. Vehicles are in frequent contact to update the information. With TOMS the vehicle fleet is easily expandable, requiring only the updating of TOMS as to how many additional vehicles are active in the system, requiring no costly software alterations.

TOMS is capable of supporting traffic and/or bus schedules. Different schedules can be supported throughout the day, optimizing the system to the needs at any particular time.

For more information on TOMS, please refer to the TOMS specification document [RD-2], available subject to signing a NDA.

2.3 Physical Elements

i. <u>Guideway</u>

- <u>What does it look like for a person walking by and/or using the system?</u>

Figure 3: Impressions of the guideway (elevated/at grade):

2getthere's systems can be installed grade separated, on a dedicated lane and in mixed traffic. For a grade separated, high capacity & high speed transit system, the guideway is typically dual lane, with middle and side barriers for separation.

2getthere's system only requires a flat solid surface in order to operate. It's vehicle navigation system utilizes embedded artificial landmarks which function as reference points to determine relative vehicle position, which completely eliminates the need for a physical track or guideway system (a flat road surface suffices). The use of artificial landmarks is based on robust, proven technology and provides the most reliable method to provide safe vehicle navigation.

- <u>How is it grade-separated?</u>

The system allows for different kinds of grade-separation. This can be elevation, at grade and underground (tunnel), or a mixture. As stated in the RFI, for both the Airport Connector as the Steven Creek line elevation or tunnel both are considered. Depending on the requirements of the stakeholders involved a decision regarding elevation/tunnel can be made. This needs to be done in a next phase when stakeholders and requirements are known.

- <u>What are its right-of-way needs?</u>

The applications for the Airport Connector and the Steven Creek line require grade-separation, meaning that no interference with other traffic will occur. The only right-of-way ‘needs’ would be amongst the vehicles of the system. This is handled by the supervisory system TOMS. However, in an application where mixed traffic would occur, different possibilities exits, e.g. right of way (with/without signage), (controlled) traffic lights with/without barriers, etc.

ii. Stations

- What does it look like for a person walking by and/or using the system?

In general, three different types of stations exits:

- Main station: often a main node in a transit network, close by to a large attractor within the area, often leading to high passenger flows to/from the station.
- End station: a station at the end of a route or line within a network.
- Intermediate station: a station along the route or node.

Depending on amongst others capacity requirements, stations are sized with one or multiple berths to embark/disembark the vehicle. Station and berth information screens are used to inform passengers of shuttle arrival, departure and destination information. When required, platform screen doors can be used to guide passengers into the vehicle and to prevent unwanted access of the guideway by passengers. Details regarding the station setup will be determined in the next phase when system requirements will be known.

Figure 4: Impression of an intermediate station

Regarding station setup, 2 berth configurations can be chosen:

- Angled berth stations. The optimum design for higher intensity stations is based on independent entry and exit of multiple berths.
- Longitudinal berth stations. The longitudinal berth station is simple, but has one disadvantage: The gas-station problem. This means that the second vehicle can’t exit the station.

Please see an indicative example below:

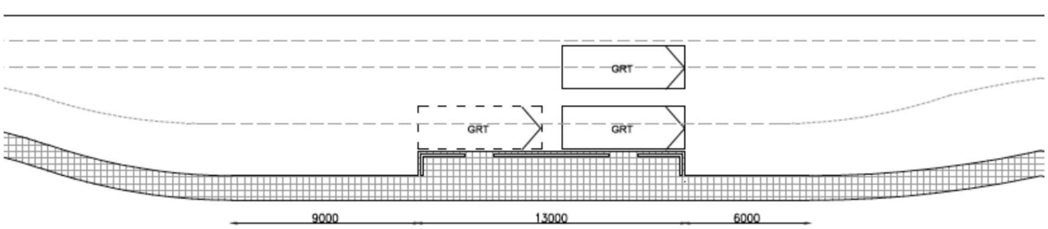

Figure 5: Impression of an ‘longitudinal’ berth intermediate station

- What are the right-of-way and land needs of a station?

The applications for the Airport Connector and the Steven Creek line require grade-separation, meaning that no interference with other traffic will occur. The only right-of-way ‘needs’ would be amongst the vehicles of the system. This is handled by the supervisory system TOMS.

The land needs will be based on station requirements. The throughput required per station will determine its size (number of berths, platform size, number of guideways, stairs, elevator, escalator, ticketing, etc.). During a next phase, when system requirements will be clear, station size estimation can be made.

- <u>How will stations integrate with the surrounding urban fabric on the Stevens Creek line?</u>

The actual design of stations will need to be made based on the local spatial constraints, requirements of the application and the desired look-and-feel. Architectural efforts can made in order align the design with the surrounding urban fabric. Please note that all stations can be different from each other.

- <u>How will the system integrate with the existing transit system?</u>

In order to integrate systems, requirements of all stakeholders involved need to be clear early on in the projects. Items, such as ticketing methods, ticket pricing, look-and-feel of vehicles/stations, travel information screens, distances and accessibility between transit systems, system operators, system maintenance crews, maintenance areas, etc. are all to be discussed and possibly aligned/integrated. An integration concept can be developed, which can be part of the design requirements of the new transit systems.

- <u>How will the proposed system connect with rail platforms (either BART or other heavy rail) at Diridon station?</u>

See previous answer (d). Stakeholder requirements need to be known and spatial restrictions need to be clear. Important is to consider, a.o., short travel distances between rail and new transit system, ticketing requirements, travel information, enough space to comfortably handle the crossing flows of passengers and their luggage (especially for airport passengers), clear signing and ADA requirements. This needs to be further developed in a next stage, when more is known requirements and restrictions.

- <u>How will the system connect with airport facilities and parking at SJC?</u>

The inherent flexibility of the system allows for integration at any site based on the requirements and the local spatial restrictions. However, it is vital that this is established in the engineering stage. This needs to be further developed in a next stage, when more is known requirements and restrictions. Also see previous answer (d and e).

- <u>How do the system's vehicles operate within the network?</u>

Autonomous vehicles drive around as ordered by the supervisory system TOMS on a network based of predefined routes. TOMS dispatches transit orders (based on timetables or based on-demand requests) to vehicles. TOMS manages route section reservation for the vehicles.

The vehicles use several types of sensing technology in order to drive precisely and safely to its next destination. Vehicles calibrate their position using artificial landmarks that are insensitive to all weather conditions. They continuously calculate their position by measuring the wheel travel, the steering angles and the planar rotation. Furthermore, it uses different techniques for obstacle detection in order to prevent collisions.

- <u>Is there level boarding?</u>

Yes. Stations are designed in such a way that there is level boarding with a minimum gap between station platform and vehicle (ADA compliant). This will especially be useful for passengers in wheel chairs and passengers with heavy luggage heading to/coming from the airport.

- <u>How will the system be designed to be compatible with "complete streets" if the system is aerial?</u>

It could be argued that aerial (or tunnelled) guideways contribute to "complete streets", as first of all an efficient public transit system replaces a congesting inefficient automobile system, literally creating more space on the streets as less vehicles and vehicle movements are required to achieve the same passenger flows. Then, by shifting these public transit movements from the streets in the air (or tunnel), it will provide even more space on street level to accommodate pedestrians and bicycles, parcs and green areas. Entries and exits to the system must be designed in such ways that they align with the "complete street" requirements.

- If the main guideway is aerial or underground, how do passengers get to grade level?

Typically, (a combination of) zigzag ramps, stairs, escalator and/or elevators can be used to transfer passengers from grade level to either aerial or underground level. A.o., space restrictions, station capacity, ADA requirements, look-and-feel, will determine which means will be selected.

iii. Vehicles

- What does it look like for a person walking by and/or using the system?

The 3rd generation GRT vehicle utilizes proven technologies to offer safe, efficient, zero-emissions (battery-driven) transportation without the labor burdens of driver-based systems. It is bi-directional, ideally for manoeuvring without need for much space (like turning loop). It has doors at both sides, so it can dock at both side of the guideway which can simplify guideway and station design. It can drive up to 40 kph (25mph).

Figure 6: Impression of the 3rd generation GRT vehicle

Figure 7: Impression of the 3rd generation GRT vehicle's interior.

For more detailed information about the vehicles, please refer to the GRT Vehicle design document [RD-3], available subject to signing a NDA.

- How many passengers and how much baggage can fit in the vehicle?

The GRT is capable of transport 22 passengers, of which 8 are seated and 14 are standing. If required, a GRT can be configured to contain more seats, which will go at the expense of the capacity of standing passengers. The GRT is capable of transporting 1 passenger using a wheelchair. Due to its level access at stations with a raised platform, the GRT offers easy access and egress for all types of passengers.

Figure 8: Impression of alternative seating arrangement, including wheelchair provision

For airport applications, typically a capacity of 16 passengers is used, in order to take into account their luggage (this figure can be set differently based on requirements).

- <u>How do passengers board and alight? How long does it take?</u>

Boarding and alighting is a process that takes a minimum time only. Typically 20 seconds are taken into account at an intermediate station only, as only a few people are likely to get in and out. At larger stations a dwell time of 60 seconds can be used. The values are typically determined during the engineering phase of the project.

Please note that a dwell time of 60 seconds (or longer) can be applied for end-of-line stations, to allow opportunity charging during the stop. The length of the dwell time at these stations depends on the charging strategy specific for these application.

- <u>What is the top speed and how quickly is it achieved?</u>

A vehicle can drive up to 40 kph (25mph). The acceleration is comfortable and jerk controlled. Taking passenger comfort in mind, especially of standing passengers, acceleration from 0 to 40 kph requires ca. 17s.

- <u>Are vehicles autonomously operated?</u>

Yes.

- <u>What do vehicles do when they are not operating?</u>

When the system is not operational vehicles can be safely stored at storage/charge positions to be recharged. In theory, the storage positions can be near the maintenance facility, but also at a different location or (distributed) at stations or at other positions along the guideway.

When the system is operational, a vehicle can be ‘out of operation’ as it is under maintenance or it is serving as a standby vehicle. A vehicle can also be ‘out of operation’ as it requires charging. The vehicles’ batteries are designed to be quickly recharged. A full operational charge takes ca. 11 minutes. By making use of ‘opportunity charging’, which means a vehicle is charged during its dwell time at stations, the need to take a vehicle out of operation for charging is reduced or sometimes even eliminated.

- <u>Do the vehicles require space off the guideway for storage?</u>

See previous answer.

- <u>How are the vehicles powered (e.g. battery, catenary, third rail, etc.)?</u>

In order to make the deployment of a GRT in automated transport system as efficient as possible, it is equipped with an on-board Li-Ion nano NMC battery, that is known for its durability and its fast charging capabilities. This enables opportunity charging (as earlier described). For more details, please refer to the GRT vehicle design document [RD-3], available subject to signing a NDA.

- Do the vehicles require a maintenance facility? If so, describe the facility requirements (e.g. number of facilities, connection to the system, size of facility, etc.)?

Yes. Typically, the facilities for the autonomous vehicles application consist of a maintenance facility, control room, server room and charging facilities.

The control room, with server room (for TOMS), can be located at a strategic position (e.g. one control room can be used for both the Airport Connector and the Stevens Creek line, near Diridon station). The operator interface consists of multiple screens showing the TOMS supervisory system and CCTV, enabling operators to interact if necessary based on provided status information, warnings and errors, and video images of stations and the interior of selected vehicles.

The maintenance facility needs connection to the guideways and a test track. The maintenance facility can include a secondary control room, with servers required for running the system, allowing for operations to be taken over from there whenever required or alternatively provide insight to maintenance personnel for analysing system disturbances and failures. The maintenance facility requires a repair and maintenance position, to do all the regular preventive maintenance and replacement repairs. In order to do so, the service personnel need to have sufficient free space around the vehicle to access the maintenance components, such as brakes, tires, electric components and traction parts. For this reason, a lifting bridge is essential to have access to the parts underneath the vehicle. The number of required maintenance position depends of total fleet size. This can be determined in a next phase, when the requirements for the system are known.

As mentioned before, the vehicles can be stored and/charged at the charging facility. As mentioned, several options are possible. This can be determined in a next phase, when the requirements for the system are known.

- Do the vehicles need to move or be moved in order to be redistributed to meet demand on a regular basis? Describe how this is performed (by operator, autonomously, by user, etc.) and how often.

All regular operations regarding fulfilling transit demand and vehicle charging demand are automated and taken care of by TOMS. During the system design phase, possible operational scenario's based on the transit demand and its distribution, are programmed into TOMS. The scenario can change automatically during the day/week or can be selected/adapted by the operator.

2.4 Operational Elements

i. Operational model

- Can the vehicle travel outside the grade-separated guideway (e.g. provide point-to-point service utilizing city streets)?

Yes. The system can be designed to include city streets (mixed traffic situation). As long as the routes are predefined in TOMS and are supported by the required wayside technology (e.g. reference points for localisation, communication connection along the route) this is possible. Integration on existing roads requires a thorough assessment of possible risks and interactions with other traffic. Bases on this assessment the system design and/or civil infrastructure can be adapted to ensure system performance and safety.

- What is the potential travel time from SJC to Diridon?

This needs to be evaluated in a next stage, when more is known regarding requirements and restrictions, but a rough estimate leads to single trip time of approximately 10-12 minutes.

- What is the potential frequency of the service?

Frequency will depend on required system capacity and (if applied) platoon sizes. High-level calculations show the following indications (for the Airport Connector):

Platoon size	Headway (s) system capacity: 1000 pphpd	Headway (s) system capacity: 2500 pphpd	Headway (s) system capacity: 5000 pphpd
1	56	23	12
2	113	45	23
4	224	90	45

Table 4: High level calculations on vehicle headway (in grey: station design requires extra attention to achieve these headways)

These figures are based on a vehicle occupancy of 16 persons and luggage (in total 4 pieces of full size suitcases and 4 pieces of hand luggage), as it will service airport passengers. For a regular system (e.g. Stevens Creek line), a vehicle occupancy of 22 persons is normally taken into account.

Needless to say is that these figures need to be evaluated in a next stage, when more is known regarding requirements and restrictions.

- What is the potential passenger carrying capacity?

This will depend on the system requirements and restrictions, but in general the 2gethere system can have a system capacity up to ca. 5,700 pphpd (with a minimum vehicle headway of 10s). Higher capacities require platooning technology to be implemented.

- How can capacity scale up if demand exceeds initial supply?

If the system starts with a lower capacity, it can be expanded by simply adding more vehicles to the system, and (when required) changing platoon size (e.g. from 1 to 2 vehicles per platoon). Also, stations, berths and guideway can be added at a later stage.

It will be best if the initial system, station design and guideway design take into account a future system expansion, regarding number of berths at station, etc. This doesn't mean that they need to be constructed already, but the design should be such that they can be added: a modularly expandable building.

- What is the dwell time of vehicle at a station?.

This is closely related to number of passengers getting in and out. At intermediate stations the time passengers needed for boarding/alighting from the vehicle will be shorter in comparison to stations a major attractors or stations at the end of the line (e.g. the airport). Another factor that influences this is whether or not the vehicles are charging at the station. If this is the case, a higher dwell time can be desirable.

Typically the following dwell times can be considered for the initial design:
Intermediate station: 20-30 s
Main station: 30-60 s
End station: 60-90 s

Application specific values can be determined in a next phase, when the requirements for the system are known.

- What is the reliability of the service?

The system will be designed based on the performance requirements, since this will impact especially the IT and communication configuration. 2getthere's current applications have a reliability exceeding 99%. This is achieved by using proven and reliable technology that is based on +30 years of experience.

- <u>Can the service be ticketless? If so, how will fares be collected?</u>

There are several ways to create a ticketless system. The first one is to not collect fare at all. This avoids the need for extensive infrastructure and encourages the use of public transit. The costs for operating the system could be covered by increasing parking fees (e.g. at the airport) or the costs per square foot (for shops and offices) – or a combination of both.

Another possibility is by means of electronic fare collection. Passenger will buy a pass with an electronic chip, and loads an amount of money (credit) on the chip. Before and after a trip, the passenger needs to check in and out, and the trip fare is taken from credit available on the card. Checking in and out can be arranged by check-in/out gates or validators near entries/exits of stations or on the station platforms. It is even possible to place a validator inside a vehicle (near the doors), where passengers can check in/out during boarding/alighting from the vehicle.

2.5 Current Status of Concept Technology

i. <u>Provide a description of the current development status of your concept (e.g. conceptual, design, development, pre-production, testing or production)?</u>

With permanent applications under its belt (see also document Reference list [RD-1]), the development status of 2getthere's concept has been in operation for years. The new generation, GRT III, is in 'production'.

Where there are many announcements with regards to autonomous vehicles and autonomous vehicle technology for mixed operations, the number of applications is growing more slowly. This is directly related with the complexity of traffic patterns and the behaviour of existing road users, as well as the inability of technology to anticipate in similar fashion to humans. Where there is a desire to use existing infrastructures to the degree possible, dedicated lanes allow for a higher throughput.

2getthere identifies 4 main elements of complexity for these mixed operations: Speed, Intersections, Access and Behavior. Depending on the degree of 'control' over one or more of these elements, an automated system will be easier or more difficult to realize. The easy ones are applications that can be installed today, the difficult ones require (much) longer to develop. With its systems and applications, 2getthere searches to grow into scenarios of increased complexity, incrementally shifting into higher degrees of mixed operations, from applications in fully controlled environments towards semi-controlled environments.

In pursuit of this roadmap, 2getthere needs to enhance the technology so as to ensure the safety and capacity under mixed operations. 2getthere's R&D efforts consists of concepting, designing, developing and testing new technologies, which will be part of applications that are already commissioned (production) but also for future applications. Some examples of the technologies 2getthere is currently developing:

- Platooning: cooperative driving, where multiple vehicles are linked virtually and drive closely after each other thus operating as a train.
- V2X: cities and road authorities are boosting the developments of smart infrastructure. In order for autonomous vehicles to interact with smart infrastructure, such as smart traffic lights, V2I communication is required. V2V communication is required for platooning functionality.
- Dynamic path planning: current path planning for vehicles is based on using predefined routes. In mixed traffic conditions, unexpected situations can occur that require temporarily rerouting of a vehicle (e.g. circumvent a

parked car). Dynamic path planning should enable the vehicle to safely navigate around objects.

ii. <u>Include a schedule for development a fully deployable system, if applicable. Identify key assumptions for this schedule.</u>

Depending on the fleet size, customizations and customer requirements overall, the delivery schedule for an application typically ranges between 18 and 36 months. The image below illustrates the various phases from engineering through systems hand-over and the ranges between an "All Standard" and "All New" system.

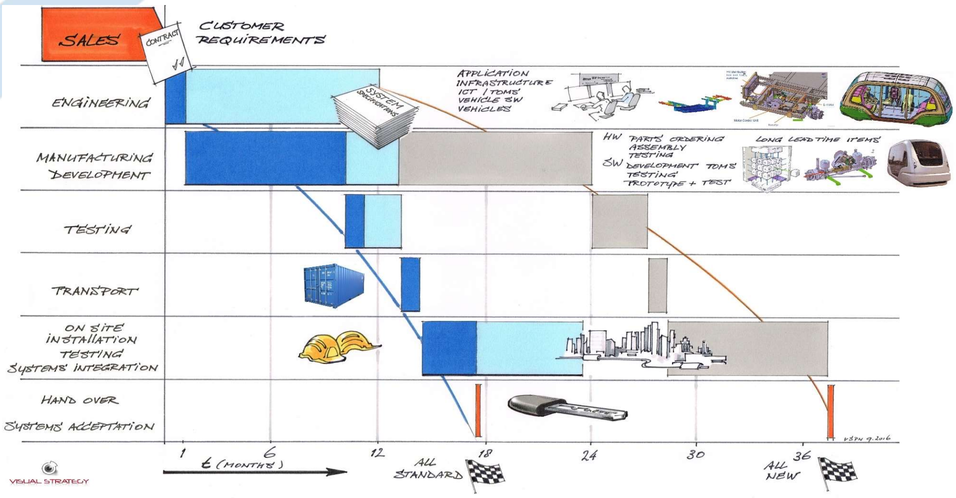

Figure 9: Impression of delivery schedule of the 2getthere system

In parallel to the above schedule any civil works would need to be engineered and constructed, with the construction needing to be complete before installation of the system on site can commence ahead of testing.

iii. <u>Include examples of successful similar implementations if applicable.</u>

See document Reference list [RD-1]), which provides a description of projects delivered by 2getthere.

iv. <u>Identify areas of notable risk that would be investigated further.</u>

Regarding the technology required for applications the Airport Connector and Stevens Creek line, both acting on segregated lanes, from a technology point of view, no notable risks are identified.

The platooning technology, which might be required for both systems, is currently under development, and it is expected that will be completed ahead of the schedule for the San Jose's applications.

When the stakeholder requirements of each the two applications become clear, more can be said on potential risks regarding technology.

In 2getthere's experience, regulatory risks can have an impact on this project. A regulatory risk comes from the absence of an existing regulatory/legal framework for autonomous vehicles and/or automated transport systems using autonomous vehicles. When stakeholders and their requirements with respect to regulations are unknown/incomplete/ fuzzy at the start of the project, it could potentially impact the project at later stages (e.g. design alterations, delays, costs, etc.).

Regarding regulatory/policy requirements, for a segregated track (which is likely for both applications) it is expected that existing standards for people mover applications would apply. At present, there is no specific current standard against which autonomous vehicles can be certified. There are several standards that apply partly to electronically guided systems (e.g. the ASCE APM Standards), autonomous vehicles (e.g. ISO26262) or to specific aspects of it (NFPA 130 Standard for Fixed Pathway Transit and Passenger Rail Systems). These standards are taken into account during the implementation of the 2getthere system.

Thanks to its Project and Safety Approach (please refer to documents [RD-4] and [RD-5], available subject to signing a NDA), 2getthere has been granted certification by the Abu Dhabi Department of Transportation for the Masdar PRT System on November 23rd, based on the Letters of No Objection as issued by the Independent Safety Assessor (Lloyd's Rail Register) and Independent Health Assessor (Bureau Veritas). The key will be to work closely with the local regulatory authorities to understand the applicable certification process prior to progressing the design phases too far.

2.6 Concept Requirements

i. Describe key requirements for implementation of the system (e.g. infrastructure, utilities, regulatory and/or policy) and estimated length of time required to implement the system.

During the definition phase of the project all system requirements will be defined, including the exported constrains for civil infrastructure, utilities etc.

For the implementation schedule, please refer to section 2.5.ii

ii. Could the system function in either aerial or underground configuration? Could it transition between aerial and underground? What are the allowable grades for the system in the future?
The system can operate in both aerial or underground configuration. A transition between underground and aerial is possible. For a speed of 40 kph, the slope should not exceed 5%. From operational point of view the track shall be free of obstacles, accumulation of sand, snow and ice.

iii. Could the system be extended in the future?
Yes.

iv. Could stations be added in the future?
Yes.

v. What are the maintenance requirements for the guideway, vehicles, stations?
The requirements with regard to the civil infrastructure will need to be provided by the civil contractor. The requirements for the system elements are indicated in document [RD-6], available subject to signing a NDA. All these will be taken into account in the maintenance contract that 2getthere will sign with the operating company.

2.7 Costs

i. What is the cost per mile to deliver the fixed infrastructure needed to operate the system, not including stations and land acquisition costs?
Please note 2getthere is not a civil engineering engineer or contractor. As such the civil works are not our area of expertise. The data we have available is specific to the applications it was calculated for and hence might not be a correct indication for a California application where pricing tends to be higher to reflect the higher local (labor) costs and possible seismic conditions. This also holds for other station costs estimations.

Furthermore, there is a large difference between a guideway constructed at grade and elevated. As 2getthere is capable of running at grade the cost savings that result can be substantial.

There are some rules of thumb that can be applied though. The costs per mile for the infrastructure (dual lane guideway) at grade are likely to range between $2,000,000,- and $3,000,000,-. For an elevated mile these are typically between $17,500,000,- and $25,000,000,-.

ii. <u>What is the incremental cost of a station?</u>
The incremental costs of a station are highly dependent on the size, lay-out and topology of the station. A station at-grade is much more affordable in comparison to an elevated station which requires escalators and elevators to be ADA-compliant. 2getthere has created stations at the Rivium application, which are simple open-air stations. With just a single berth position and located on-line, rather than off-line, the costs of the station are approximately $100,000,-. This amount includes the civil works, some fencing as well as the station request module displaying passenger information.

Figure 10: Rivium station

2getthere has also created the stations at grade for the Masdar application, which feature 4 and 6 berths respectively. Even though these are created at grade, the costs are estimated to range between $600,000,- and $1,800,000,- each as a result of elaborate screens, Platform Screen Doors, air conditioning and passenger information systems, as well as elevators and a designer staircase and an artificial waterfall.

Figure 11: Masdar station

An elevated station, without such excessive amenities as featured at Masdar, is likely to range between $3,000,000,- and $6,000,000,- depending on the number of berths that are required for the throughput faced per hour.

Figure 12: Rendering elevated station

It should be noted that 2getthere is not a civil contractor, and as such is not familiar with the pricing levels in California. We have understood that cost might be higher as a result of the higher labor costs and seismic conditions. We strongly advise to involve an engineering firm that can provide a realistic estimate based on the system requirements which can be provided by 2getthere.

iii. <u>What is the cost of the vehicle fleet needed to begin operations?</u>
Based on the current data, lacking an Origin-to-Destination matrix, 2getthere is unable to estimate the required fleet size for the initial operations. However, based on several assumed system capacities (see section 2.4.i.c), indications can be given. They will be included om the capital system costs (as requested in the section).

iv. <u>Summarize the capital costs for delivering the full system for each potential project (Airport Connector and Stevens Creek Line). Assume six stations on the Stevens Creek Line and three stations on the Airport Connector, plus the Diridon station for both routes.</u>
To be able to set up a good cost overview, a civil contractor would need to be involved. Based on data from other projects, which is not necessarily applicable to this project, we have roughly estimated the costs:

- Airport Connector

Description		System with capacity: 1000 pphpd	
Range		Low	High
Civil infrastructure			
	Costs of 2 end stations	$ 6.000.000,-	$ 12.000.000,-
	Costs of 2 intermediate stations	$ 6.000.000,-	$ 12.000.000,-
	Costs of ca. 5.7 km (3.55 miles) aerial dual lane track	$62,000,000,-	$89,000,000,-
Automated transit system			
	Total fleetsize	32	
	Total system costs	$ 36.000.000,-	$ 44.000.000,-
Total costs		$ 98.000.000,-	$ 133.000.000,-

Table 5: High level cost indications

- Stevens Creek line (2 end stations, 5 intermediate stations, ca. 14 km aerial dual lane track)

Description		System with capacity: 1000 pphpd	
Range		Low	High
Civil infrastructure			
	Costs of 2 end stations	$ 6.000.000,-	$ 12.000.000,-
	Costs of 5 intermediate stations	$ 15.000.000,-	$ 30.000.000,-
	Costs of ca. 14 km (8.70 miles) aerial dual lane track	$152,000,000,-	$218,000,000,-
Automated transit system			
	Total fleetsize	51	
	Total system costs	$ 57.000.000,-	$ 68.000.000,-
Total costs		$ 230.000.000,-	$ 328.000.000,-

Table 6: High level cost indications

Needless to say is that all these figures are indicative and need to be evaluated in a next stage, when more is known regarding requirements and restrictions, to provide a more accurate budget calculation. If system price indications are required for higher capacity systems, please inform us and we shall update the indications.

v. Provide a high-level estimate of the ongoing operations and maintenance costs, as well as equipment replacement costs and schedules.

The costs per year range between 6-10% of the initial system investment, depending on the hours of operation and the type of contract. This could be influenced by local labor rates.

The maintenance interval is indicated in document [RD-6], available subject to signing a NDA.

In order to get an indication for the maintenance costs of the civil infrastructure, a civil contractor would need to be involved.

2.8 Business Plan

i. Describe the business plan to deliver and operate the proposed project. The city is looking for innovative ways to fund and operate new transit systems.

2getthere is a system supplier, not an operator and as such will seek the collaboration with an operator for the project. This could be the VTA, or alternatively another operator. Similarly, in the delivery, 2getthere will seek to work together with a civil engineering firm to set up the design of the infrastructure needed. Based on this design the city would be able to contract with a civil works constructor. 2getthere envisions these to be separate contracts, as the civil works contract is likely to be larger than 2getthere's scope and 2getthere is not able to manage civil construction projects in the USA. Alternatively, the civil contractor could be the main contractor, with 2getthere as a subcontractor. We note though that his might be undesired with 2getthere's experience being that civil contractors due to their unfamiliarity with new transit technologies, calculate a risk premium over 2getthere's costs that is not necessary.

2getthere has been working together with independent parties that invest, develop and manage public infrastructure. The San Jose applications could be discussed to see whether they have an interest in these projects. The interest is likely to depend strongly on the yearly business case and the guarantees there are for the revenue generated. If the payback is linked to ridership this obviously is less attractive in comparison to a revenue stream that is related to parking fees or guaranteed by the city.

We would propose working on the business case jointly with a financing group, the operator and the city, determining which mix of ride fares, parking fees and possibly advertisement and investments from housing/office developers in the area ultimately provides an acceptable business case for all stakeholders involved.

ii. <u>Who will operate the system once constructed (VTA, the builder, PPP, other)?</u>
Although 2getthere has operations experience – we are the operator of the Masdar system in Abu Dhabi -, we have no interest in operating the system. Public transit operations is an extremely competitive market, with experience and established local presence being key elements of optimizing the service level that can be provided. 2getthere does want – and in the first years of operations even requires – to be involved in the maintenance and support of the system operations. The day-to-day operations should be managed by an operations company of the customers preference.

iii. <u>What is the passenger fares strategy?</u>
The fare strategy should be determined by the operating company. 2getthere advises to consider not charging ride fares at all, instead increasing parking fees at the locations served. This would both stimulate the use of public transit, while discouraging the use of the personal car. The city will see the largest impact in this way, while this also provides a more stable source of income for the operator as it is independent on the number of users.

iv. <u>What are the expected fares for passengers to use the system?</u>
No statement on this can be made at this time due to insufficient data.

v. <u>What is the strategy to maximize ridership?</u>
First and foremost ridership can be stimulated by providing an attractive , safe, comfortable, high frequent and reliable system, which in easy to use. This is closely followed by not charging passengers at all as suggested under section 2.9 (iii), charging parking instead. Based on an Origin-to-Destination matrix, express connections can be created ensuring shorter travel times, making the system more attractive to use.

Ultimately, the strategy to maximize ridership requires the involvement of the transit operator and/with knowledge of the local culture and a marketing agency to create a message to the market to sell the system with. Shared transit is increasingly gaining popularity, but in car-oriented society it can remain a challenge.

vi. <u>Can capital and operations costs be funded through passenger fares?</u>
No statement on this can be made at this time due to insufficient data.

vii. <u>Describe opportunities or strategies to maximize farebox recovery and/or offset operations and maintenance costs.</u>
Obviously the system will need to be designed for passenger convenience: the farebox revenue will be maximized when the added value experienced by a passenger is highest. This translates to short waiting times, short trip times and excellent ride comfort. For example, this means that for the airport connector we should be operational early to get people to the airport before the first flights depart and well after the last one arrives, but also accommodate sufficient space in the vehicle for luggage.

In operations and maintenance, the search is for combination of activities with what is already locally present. This will mainly concern the operations monitoring of the system, which can be done from a central control room for public transit operations or alternatively a similar facility at the airport. However, it could also involve certain services aspects. What is possible will need to be established between the customer and the different project partners.

2.9 Impacts

i. <u>What are potential negative impacts during constructions?</u>
During construction, negative impacts can come from nuisance for the general public due to extra traffic, noise, delays, accessibility issues in the area(s), etc., all in the area of where the applications are going to be build. This mainly regards the required civil infrastructure: the building of an aerial construction or tunnel.

ii. <u>What are potential negative impacts during operations?</u>
When the system is operating normally, no negative impacts are expected, since the vehicle are fully electrical and are driving on rubber tires. The visual impact of the elevated guideway can be minimized, since the vehicles are relative light comparing to trains and metro's and the do not need any overhead power line. The station design should be well integrated in the surroundings. Should the system have a disturbance, there could be a negative impact with people complaining about the service, similar to any transit system.

iii. <u>How can negative impacts be mitigated?</u>
The best way to mitigate negative impacts is to prevent them from happening, and in the event they happen, have plans to minimize the impact (e.g. through clear communications).

A typical approach would be for the project team to identify all stakeholders for a project and to involve them from the start of the project by having discussions with them in order to explore and get clarity on their requirements. Then, during the next stages of the design and plan process, design and plan documentation by is submitted to stakeholders for review. Also, special plans can be developed that focus on preventing and/or minimizing negative project impacts. By doing so, stakeholders' interest are taken into account during the design and plan stages of the project, which should lead to better executing of the project with minimum chance of negative impacts. Also, stakeholders will be better informed share and some of the responsibility when the project is executed.

iv. <u>What might be community outreach and engagement strategy look like?</u>
This is not 2getthere's area of expertise. We typically cooperate with the civil contractor, the transit operator and the customer to determine these types of plans.