Response to RFI 2019-DOT-PPD-4

NEW TRANSIT OPTION FOR AIRPORT – DIRIDON – STEVENS CREEK TRANSIT CONNECTION

Contents

ModuTram

A. Respondent Profile

Legal name of company:	MODUTRAM MEXICO, S.A.P.I. DE C.V.
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High level description of concept:	A modular mass transit system, called Autotrén™, composed of: 1) a fleet of driverless mini-trains with state-of-the-art electric automotive technology; 2) a lean – and less costly – elevated or underground guideway network with no moving parts; 3) an automatic train control system that enables demand-responsive service, optimizes traffic flow and fleet usage; and 4) a smart passenger grouping system that eliminates unnecessary intermediate stops.
High level description of business plan:	A public-private partnership, in which the government invests in the required infrastructure (guideway, passenger stations, and maintenance facility), while a private entity invests in the rolling stock and the control system. Farebox (plus advertising) revenue fully covers operating expenses and also allows the private investor to recover original investment with a reasonable return, within the respective lifetimes of the trains and the control equipment.

B. Proposed Concept

Autotrén™ (combination of auto and train) is a complete mass transportation system known as an Automated Transit Network (ATN). It provides on-demand service at up to 3 times rush-hour traffic speed, with all passengers seated. It offers high capacity (over 10,000 passengers per hour per track), costs much less than a conventional rail-based solution, can be installed faster, and fits in places where conventional mass tranit is not feasible. It consists of a prefabricated, usually elevated guideway; a fleet of light-weight, driverless electric mini-trains; modular, prefabricated stations; a state-of-the-art Communications-Based Train Control (CBTC) system that controls train movements with very short headways, adapting routes and schedules to instantaneous demand on the fully interconnected network; and an intelligent passenger grouping system that minimizes intermediate stops. Autotrén™ is not based on new propulsion technology; it is an innovative combination of proven technologies using an open architecture. With an energy efficiency that rivals the most efficient trains on the market (under 0.03 kWh per passenger-km), Autotrén can be operated profitably in Private-Public Partnerships (PPPs) without subsidies.

Rolling stock:
Autotrén™ trains are made up of individual vehicles that can be coupled and uncoupled automatically, to form trains of different sizes as needed. Each vehicle carries 8 seated passengers (no standees), or 6 seated passengers plus a luggage rack. Each vehicle has a state-of-the-art automotive electric powertrain that allows it to reach speeds of up to 72 km/h (45 mph), and an interchangeable battery pack. In operation, there are 2 battery packs per vehicle: one on the vehicle (getting discharged), and the other at a recharging station (getting re-charged).

Track network:
The mini-trains run on a dedicated track network, separated from mixed traffic. In this network, every station has: a) a by-pass track so that mini-trains don't need to stop at each station; b) U-turn tracks so that mini-trains don't need to travel the length of an entire corridor before returning in the opposite direction; and c) a parking track, where mini-trains can park temporarily whenever they are not serving demand.

Automatic train control system:
The automatic train control system is a state-of-the-art Communications-Based Train Control (CBTC) system, with Automatic Train Operation (ATO), Automatic Train Protection (ATP), and Automatic Train Supervision (ATS) functions. The CBTC system was designed specifically for small trains travelling at very short headways.

System operation:
Passengers indicate their destination at the origin station, before boarding. This allows the system to operate in demand-responsive mode. The computer system groups passengers travelling to the same destination, maximizing mini-train occupancy but also respecting a (configurable) maximum wait time. Throughout the day, as demand increases and decreases, mini-trains are dispatched automatically or parked as needed. When necessary, the computer system automatically sends a mini-train for battery pack replacement or vehicle maintenance. The CBTC system can also couple mini-trains to form longer trains when demand peaks, and relocate empty mini-trains to make them available at stations where demand is increasing or expected to peak.

C. Physical Elements

C.1. Guideway

C.1.1. What does it look like for a person walking by and for a person using the system?

The Autotrén™ guideway can be either elevated, at-grade (with dedicated right-of-way), underground, or any combination of these. The following rendering shows what the elevated guideway would look like for a person walking by:

The following rendering shows what the guideway would look like for a person using the system (on board a vehicle):

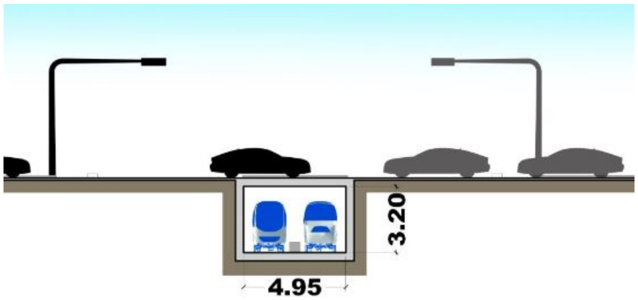
ModuTram has considered the following factors in the Autotrén™ guideway design:

- Clean look
- Structural modularity
- Standard, prefabricated sections to the greatest extent possible
- Ease of expansion

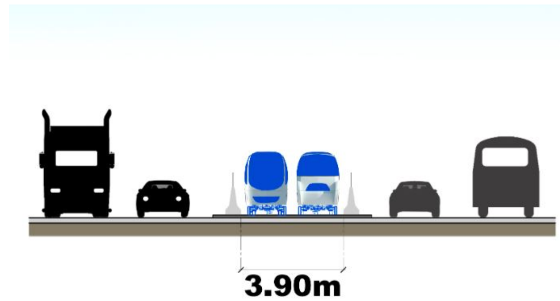
C.1.2. How is it grade-separated?

The following figures of guideway cross sections show how separation from mixed traffic is achieved:

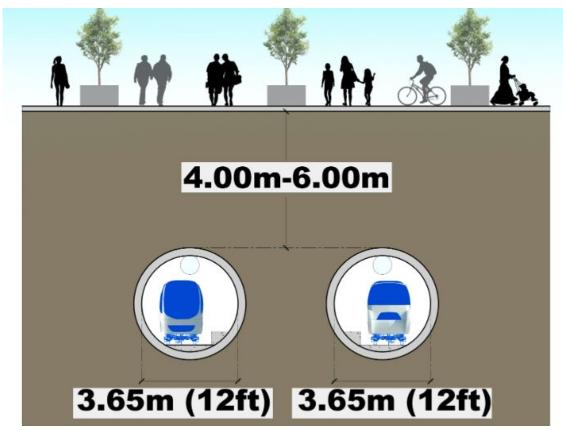
Underground, "cut-and-cover":



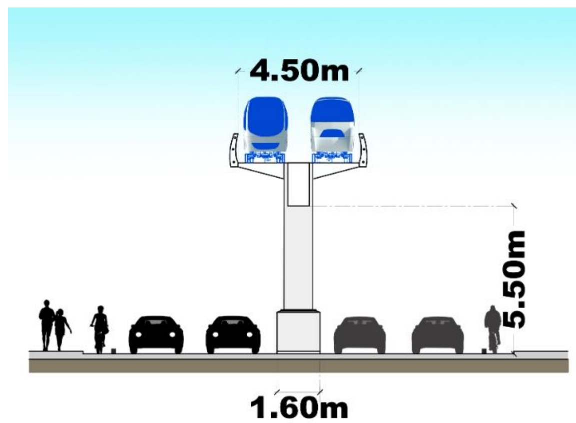
At grade:



Underground, "mini-tunnels":



Elevated:

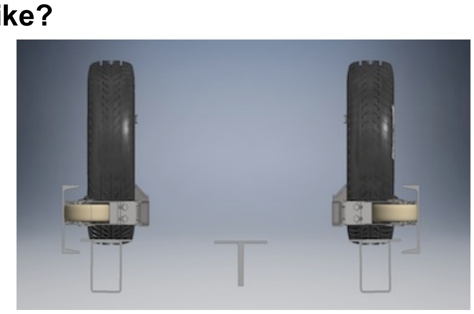


C.1.3. What are its right-of-way needs?

A single track plus vehicle clearance envelope requires 75 x 95 inches (W x H) in straight sections, and up to 83 x 95 inches (W x H) in curved sections.

A double (bidirectional) track plus vehicle clearance envelope requires 154 x 95 inches (W x H) in straight sections, and up to 168 x 95 inches in curved sections.

C.1.4. What does the guideway–vehicle interface look like?



The Autotrén™ rails are based on an open, non-proprietary, guideway-vehicle interface design. This interface is suited to both captive and non-captive vehicles alike.

The rails consist of standard, widely available structural steel sections. By design, the rails minimize water or snow/ice accumulation. Also, the C-channels used as guide rails provide a very cost-effective anti-derailment feature, which is important on elevated guideways.

C.2. Passenger Stations

C.2.1. What do stations look like for a person walking by, and for a person using the system?

The following rendering shows what a medium-to-high-capacity passenger station (up to 4800 passengers per hour) would look like for a person walking by:

The following rendering shows what the inside of a passenger station would look like for a person using the system:

C.2.2. What are the right-of-way needs of a passenger station?

Autotrén™ stations are modular and can be sized according to the required capacity. Each module has a boarding/alighting platform with a capacity of up to 2400 passengers per hour. As capacity requirements increase, additional modules can be added to each station.

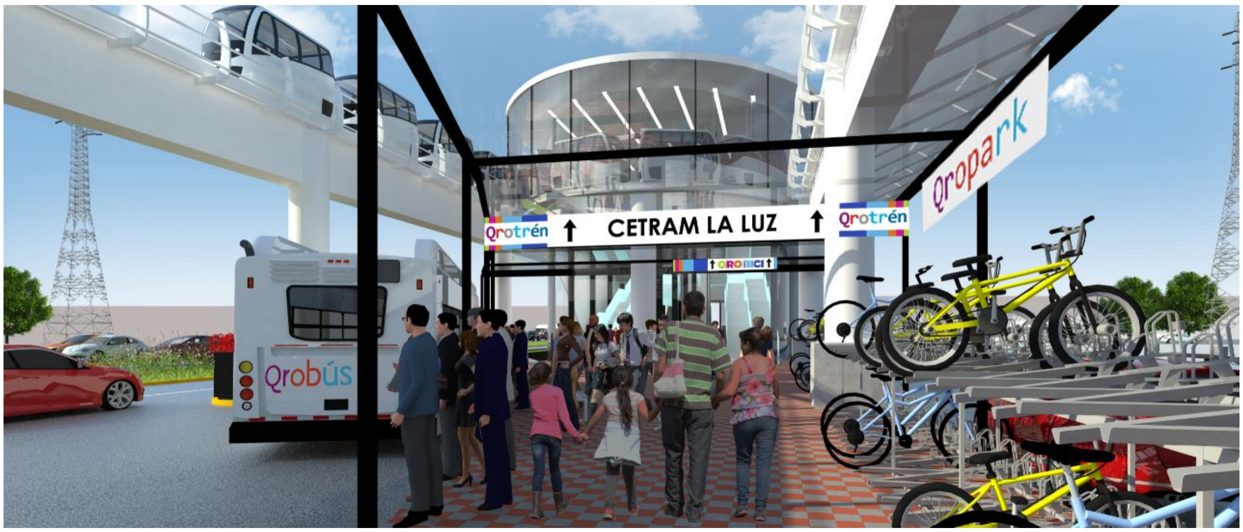
Wide-footprint modules have a footprint of 82 x 43 feet (L x W). Narrow-footprint modules have a footprint of 115 x 10 feet (L x W).

C.2.3. How will stations integrate with the surrounding urban fabric on the Stevens Creek Line?

Although this is subjective, ModuTram considers that the stations as shown in these renderings will fit into the surrounding urban fabric on Stevens Creek Boulevard very well.

C.2.4. How will the system integrate with existing transit systems?

Autotrén™ has been designed to work in multi-modal transit networks. The following rendering shows an example of an intermodal transfer station:



C.2.5. How will the proposed system connect with rail platforms at Diridon Station?

ModuTram's proposal is to place the Autotrén™ station directly above the existing rail platforms.

C.2.6. How will the proposed system connect with airport facilities and parking at SJC?

ModuTram's proposal is to follow the recommendations outlined in previous studies carried out by renown consulting companies to implement an ATN system at SJC airport.

C.2.7. How do the system's vehicles operate within the network?

The way in which the vehicles, or trains, operate within the network is irrelevant to the passenger. Passengers just select their destination, and then they are guided to the appropriate boarding platform and to the appropriate train by displays that indicate that destination. Within the control system software, the system's vehicles are dynamically assigned to certain routes, according to real-time demand and historic data. These routes are either express (non-stop) routes between high-demand origin-destination pairs, semi-express routes (with one or two intermediate stops), and local routes that serve low-demand stations as needed.

C.2.8. Is there level boarding?

Yes.

C.2.9. How will the system be designed to be compatible with "complete streets" if the system is aerial?

Autotrén™ has been designed with "complete streets" in mind. The following renderings show examples of "complete streets" with Autotrén™:

C.2.10. If the main guideway is aerial or underground, how do passengers get to grade level?

Stations have escalators and elevators to provide vertical circulation between street level and platform level.

C.3. Vehicles

C.3.1. What do they look like for a person walking by, and for a person using the system?

The following renderings and photographs show what a vehicle would look like for a person walking by and for a passenger:

C.3.2. How many passengers and how much baggage can fit in a vehicle?

ModuTram's GRT200 vehicles can accommodate up to 8 seated passengers plus a few pieces of carry-on luggage, or, if equipped with a luggage rack instead of the two fold-up seats opposite the doorway, up to 6 seated passengers plus 4 large suitcases and several pieces of carry-on luggage.

C.3.3. How do passengers board and alight from the vehicle?

GRT200 vehicles have automatic slide-and-plug doors, designed for mass transit applications. Passengers board and alight from the trains by walking in and walking out, as in a subway system. The doorway is wide enough to allow 2 passengers to enter or exit simultaneously.

C.3.4. What is the top speed, and how quickly is it achieved?

Vehicle top speed is 45 mph (20 m/s), and is reached within 16 seconds. Recommended cruising speed is 35 mph (15.6 m/s).

C.3.5. Are vehicles autonomously operated?

Yes.

C.3.6. What do vehicles do when they are not operating?

The control system continuously adjusts the number of vehicles in operation to match travel demand. When vehicles are not operating, they are parked on parking tracks located within or close to passenger stations.

C.3.7. Do vehicles require space off the guideway for storage?

No.

C.3.8. How are vehicles powered?

Vehicles have interchangeable battery packs. The battery pack exchange process is carried out at special battery exchange and recharging stations that can be placed at various locations throughout the guideway network. The fully automated exchange process takes under 3 minutes.

There are various reasons for using interchangeable battery packs. The most important is that it maximizes availability of vehicles for passenger service. Additionally, re-charging can take place under well-controlled conditions (important for safety). Finally, because battery technology is evolving quickly, it allows technical upgrades related to the batteries to be implemented much more easily.

C.3.9. Do the vehicles require a maintenance facility? If so, describe the facility requirements.

Yes, the vehicles do require a maintenance facility. ModuTram's maintenance facility design is modular and can be expanded as needed. Each maintenance module has the capacity to service a fleet of 40 vehicles, and includes a vehicle lift, a diagnostic scanner (used to read and clear fault codes from the vehicles' memories), a workbench with toolkit, a set of industrial cordless screwdrivers, an air compressor, and a 12-ton hydraulic press.

The maintenance facility needs to be connected to the guideway network, preferably at a relatively centralized location.

C.3.10. 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 and how often.

The control system automatically pulls vehicles from the parking tracks and sends them to those passenger stations where demand is increasing.

C.4. Control System

The ATN control system is a very important element of the overall transit system. Even though it is largely invisible, the control system plays a huge role in keeping vehicles and passengers flowing through stations and along guideways smoothly and safely.

The Autotrén™ system utilizes ModuTram's internally designed Communication-Based Train Control (CBTC) system.

C.4.1. Control Center

The Control Center requires an IT site and a System Operators' work area with at least 2 desks and sufficient space for a dozen flat-panel displays. Electrical power to the IT site must be properly conditioned and uninterrupted. Integration with an existing transit control center is possible and even recommended.

C.4.2. Telecommunications Equipment

ModuTram uses off-the-shelf industrial grade telecommunication equipment designed specifically for train-to-ground applications and communications-based train control (CBTC). Further analysis is necessary to determine the most appropriate frequencies for the ATN's wireless communications in this particular application.

C.4.3. Safety

ModuTram's CTBC system is undergoing an independent safety assessment to demonstrate compliance with European railway safety standards EN 50126, EN 50128, and EN 50129. Based on the results of the assessment to date, Moduram is confident that the CBTC system will be certified with safety functions that achieve safety integrity level 4 (SIL4), which is the highest level possible and is required in driverless metro systems.

D. Operational Elements

D.1. Operational model

D.1.1. Can the vehicle travel outside the grade-separated guideway?

Initially, in the first phase of the guideway network and with the first set of transit vehicles, operation would be entirely within the grade-separated guideway. In a second phase and beyond, with new transit vehicles, dual-mode operation (both on and off the grade-separated guideway) would be possible.

Dual-mode operation has pros and cons. Our conclusion, based on internal analyses and simulations, is that dual-mode operation makes sense under specific circumstances but not as a general solution. In the majority of situations, the last-mile problem is better solved (i.e. the average overall trip times are shorter and the average overall trip costs are lower) with automated shuttles that operate as feeders/distributors to/from the rapid transit stations rather than with dual-mode systems.

D.1.2. What is the potential travel time from SJC to Diridon?

Approximately 7 minutes.

D.1.3. What is the potential frequency of the service?

Based on an estimated peak demand of 1200 trips per hour per direction between SJC and Diridon Station, using 24-passenger trains the potential service interval would be 1.2 minutes. During low-demand hours, the service interval would depend on the programmed maximum wait time (e.g. 5 minutes), and service would be provided with smaller trains or even individual vehicles.

D.1.4. What is the potential passenger carrying capacity?

The potential passenger carrying capacity of the Autotrén system is 19,200 passengers per hour per direction (with 32-passenger trains at 6-second headways). This applies to the capacity on the main guideway, along the section with the heaviest load.

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D.1.6. What is the dwell time of a vehicle at a station?

Typically, 20 seconds from door opening to door closed, at stations where passengers have little or no luggage. At stations where passengers typically have luggage, dwell time will be 10-15 seconds longer.

D.1.7. What is the reliability of the service?

Service availability, as defined in the Automated People Mover standard ASCE 21-13, is at least 99.5%.

D.1.8. Can the service be ticketless? If so, how will fares be collected?

Service can certainly be paperless, but not really ticketless. Electronic ticketing and fare collection are realized via a smartphone app and/or via prepaid RFID cards. If a passenger uses the smartphone app, he/she will select the trip origin and destination on the app and pay with the registered credit card. The passenger will then receive a QR-code on the smartphone, which must be scanned at a turnstile in order to be granted access to the boarding platform at the origin station. Alternatively, if a passenger does not have a smartphone or the app, he/she can purchase or reload a contactless pre-paid card at the origin station, select the desired destination at a self-service kiosk using the card, and then pass the card by the scanner at the turnstile to be granted access to the boarding platform.

In either case, monthly passes or other discounted fares can be handled.

E. Current Status of Concept Technology

E.1.1. Current development status of the concept:

Pre-production testing

E.1.2. Schedule for development of a fully-deployable system:

The Autotrén™ system is ready for initial deployment in Mexico. For an application in the U.S., approximately 18 months are required to develop modifications to be fully compliant with standards such as NFPA 130.

E.1.3. Examples of successful similar implementations:

ModuTram's full-scale test and demo facility in Guadalajara, Mexico, is an example of a successful implementation, albeit on a much smaller scale than the San José project. This facility is the most comprehensive of its kind worldwide, incorporating the following features:

- 600 meters track, thereof 200m at grade and 400m elevated with spans of up to 24m in length;
- 90-degree and 180-degree curves with a centerline turning radius of 3.0 m (minimum radius turn);
- 15% uphill and 15% downhill gradients (maximum inclines);
- 10m and 25m-radius curves with superelevation;
- 5 diverges (forks) and 5 merges;
- 2 variants of elevated guideway structure (to demonstrate different design options);
- An equipped maintenance facility with a battery exchange and recharging station;
- A passenger station equipped with ticketing machines, self-service kiosks for destination selection, turnstiles, and information displays;
- A fleet of 7 vehicles that can be coupled to form mini-trains, designed for urban transit applications;
- A state-of-the-art Communications-Based Train Control (CBTC) system; and
- An intelligent passenger grouping system that enables high-capacity, demand-responsive service.

This facility is operated every day for 4 hours, as if it were a commercial application. To date, the fleet at this facility has accumulated over 70,000 km and has completed over 175,000 passenger trips (both real and virtual).

E.1.4. Areas of notable risk that would be investigated further:

The San José application may require a higher operating speed than applications that ModuTram is working on in Mexico. Although Autotrén™ vehicles are technically capable of higher speeds, the impact on operating costs (maintenance, battery life) would need to be investigated further.

F. Concept Requirements

F.1.1. Key requirements for implementation of a system:

Obviously, right-of-ways and property rights for stations and central facilities need to be secured.

Battery exchange and recharging stations require a reliable high-voltage electrical power supply.

Estimated length of time to implement is 24-30 months.

F.1.2. Could the system function in either aerial or underground configuration? Could it transition between aerial and underground? What are the maximum allowable grades?

Yes, the Autotrén system can function in either aerial or underground configuration, and can also transition between aerial and underground. Maximum allowable gradient is 15% (ascent or descent).

F.1.3. Could the system be extended in the future?

Certainly, in terms of guideway length, guideway branches, number of stations, station size/capacity, fleet size, and vehicle technology.

F.1.4. Could stations be added to the system in the future?

Yes.

F.1.5. What are the maintenance requirements for the guideway, vehicles, stations, etc.?

Guideway: As the guideway has no moving parts, it only requires annual inspections for corrosion, and painting as needed (frequency depends on paint used).

Vehicles: ModuTram has developed a full maintenance plan for the Autotrén vehicles, which is similar to an automobile maintenance plan (preventive maintenance every 10,000 km). Vehicle cleaning is done at least once a day, during the battery exchange operation.

Stations: Escalators and/or elevators require maintenance as prescribed by the manufacturer. Otherwise, normal maintenance for public buildings with medium to high traffic.

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G. Costs

G.1.1. Cost per mile:

ModuTram respectfully declines to provide detailed cost information at this stage, but will do so in a subsequent project phase.

G.1.2. Incremental cost per station:

G.1.3. Cost of the vehicle fleet:

G.1.4. Summary of capital cost – Airport Connector:

Element	Unit cost	Quantity	Total cost
Guideway (per mile)			
Passenger station		4	
Vehicles			

Summary of capital cost – Steven Creek Line:

Element	Unit cost	Quantity	Total cost
Guideway (per mile)			
Passenger station		7	
Vehicles			

G.1.5. High-level estimate of ongoing operations and maintenance costs:

G.1.6. Equipment replacement costs and schedules:

H. Business Plan

H.1.1. Describe the business plan:

A realistic and feasible business plan for this project is based on some type of public-private partnership, in which the government invests in the required infrastructure (guideway, passenger stations, and maintenance facility), while the private sector invests in the rolling stock (including battery packs and recharging equipment) and the control system. The idea behind this split is that the government invests in those elements which can be considered “fixed” (i.e. independent of ridership), while the private sector invests in elements which can be considered mostly “variable”.

Farebox revenue (plus advertising revenue) has to cover operating expenses and allow the private investor(s) to recover their original investment with a reasonable return on investment, within the respective lifetimes of the trains and the control equipment. Autotrén™ trains have a useful life of 1 million km, which translates to 8 years of operation. This means that within 8 years, the private investor(s) need to recover the investment in the trains, in order to renew the train fleet. This benefits users and the community because the fleet is kept technologically up-to-date and always looking sharp. The control system electronics have a useful life of 15 years, and the same applies here.

Should farebox revenue exceed initial projections and provide the private investor(s) with a higher than planned ROI, the government could charge a fee for use of the infrastructure. Income to the government from this fee could then be allocated to future extensions of the rapid transit network (or at least to partially offset the cost of the additional infrastructure). This would make the transit network more attractive and would increase ridership further, thus creating a virtuous cycle.

H.1.2. Who will operate?

ModuTram recommends that the Autotrén™ system be operated either by the VTA or by a private, professional operator of public transport having experience in operating rapid transit systems, with contracted technical support from ModuTram (e.g. for major maintenance on trains) and with appropriate government oversight.

Based on ModuTram’s experience in Mexico, the private operator can also be the private investor.

H.1.3. What is the passenger fares strategy?

In general, ModuTram recommends that fares be based on distance travelled. Fares can be a bit higher than bus transit fares, because the service is far superior to ordinary bus service, but should be lower than the corresponding ride-hailing service fare. Special discounts can of course be offered to certain user groups such as students and elderly citizens.

H.1.4. What are the expected fares?

This information will be provided in a subsequent project phase.

H.1.5. What is the strategy to maximize ridership?

To maximize ridership, it is important to consider transit-oriented development (TOD). Passenger stations need to placed almost directly at the doorstep of major origin/destination points, and spaced at no more that 800 yards apart along stretches that don’t have major origin/destination points.

An additional strategy is to offer a high service level. In the same way that ride-hailing services have offered improved versions of conventional taxi services, Autotrén™ offers an improved version of conventional transit service.

H.1.6. Can capital and operations costs be funded through passenger fares?

As explained in H.1.1, capital costs for rolling stock and the control system, as well as operating costs, can be funded through passenger fares. Although it might be possible to fund capital costs for infrastructure through passenger fares, this is not likely.

H.1.7. Opportunities and strategies to maximize farebox recovery?

Strategies to maximize farebox recovery include: different pricing for regular/daily users (commuters) and non-regular users (e.g. travelers to/from airport); a price premium for shorter waiting times or passenger grouping preferences; and special offers for travel at off-peak hours.

I. Impacts

I.1.1. Potential negative impacts during construction?

The main potential negative impacts during construction are road closures along the stretches of elevated guideway and around the new stations. Construction noise is not expected to be higher than for a typical construction site. Depending on the final guideway alignment and station placement, certain elements of existing infrastructure (e.g. lamp posts, utility lines) may need to be relocated. The space required for the maintenance facility may reduce existing green area at the selected site.

I.1.2. Potential negative impacts during operations?

The main potential negative impacts during operation are: increased traffic congestion around the new stations (related to modal transfers), and a certain number of “depleted” lithium-ion batteries at their end-of-life.

I.1.3. How can negative impacts be mitigated?

Road closures can be mitigated with short construction times, using prefabricated elements for the elevated portions of the guideway to the greatest extent possible. Traffic congestion around the new stations can be mitigated by appropriate planning for modal transfers. The environmental impact of lithium-ion batteries at their end-of-life, which will be much smaller than the equivalent impact from privately-owned electric automobiles, will have to be mitigated within the context of recycling used automotive lithium-ion battery packs in general. If there is sufficient ridership to justify electrifying the guideway, this is also a possible mitigation measure supported by the Autotrén™ system.

I.1.4. What might the community outreach and engagement strategy look like?

The strategy should include some or all of the following elements: determining and articulating how the project will change/improve the lives of the people in the community; finding a few champions for the project (not just politicians but also celebrities and respected activists); hosting a series of town hall meetings with these champions in attendance, to present the project, describe its benefits and impacts, and address community concerns; and organizing contests to allow community members to decorate the stations with locally-designed murals and/or locally-produced artwork.