



Jacksonville
Transportation
Authority



JTA Skyway Modernization Program

Technical Memorandum IV: Capital Cost Estimate

Final Report, April 2017

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1.0 Executive Summary

As part of the Skyway Modernization Program, JTA has prepared conceptual estimates of an Automated People Mover (APM) on an elevated, fixed track and Autonomous Vehicles (AV) that can operate elevated or at street level. JTA has prepared the cost estimates to provide a rough order of magnitude comparison of three vehicle options and at grade or elevated extension scenarios. Actual costs could vary significantly depending on a variety of factors including right of way costs.

The AV option may be 25% to 50% less expensive than the APM option, depending on the extension scenario. The AV is likely less expensive due to expected lower vehicle and operating system costs. It is also likely to require lower infrastructure investment, since the AV can feasibly operate at street level.

Estimates for the APM option tend to be higher primarily due to higher vehicle costs, and the likelihood that extensions would have to be elevated. Elevated extensions accommodate a fixed guideway. The fixed guideway creates a traffic obstruction at street level.

AV is an emerging technology. Significant uncertainties persist related to the cost of operating systems, charging stations, modifications and additions to the existing Operations and Maintenance Center, and long term operations and maintenance requirements, among other factors.

Refined estimates will be prepared during future project development stages. These will include development of more detailed plans, environmental assessments, evaluation of right of way requirements and other factors. Findings from these efforts could significantly affect project cost estimates.

An important part of cost analysis includes not only up front capital costs but also long term annual operations and maintenance costs which are likely to be funded by JTA. A life cycle cost analysis should be performed as part of further project development

Further limitations, assumptions and uncertainties are discussed in the following sections.

2.0 Introduction

Conceptual estimates for the components of the Skyway Modernization Program were prepared to compare rough order of magnitude costs for vehicle options and extension scenarios to assist with developing a project implementation plan identifying potential funding options. They are not intended to be definitive estimates for final procurement or construction.

Estimates will be refined throughout the course of the Skyway Modernization Program. These estimates are updated from those prepared during earlier project stages, (i.e. technology assessment and life cycle cost analysis).

Estimates were prepared for the options deemed to be most feasible:

- » Autonomous Vehicle (AV)
- » Modernizing and extending with the existing Automated People Mover (APM X) vehicle or;
- » Replace and extend with new APM similar to Bombardier Innovia 256 (APM N)

Less feasible options including Personal Rapid Transit (PRT), Monorail, Cable Propelled APM, and Streetcar options were evaluated in earlier project stages but were not included in the updated cost analysis.

In future phases of effort, JTA will develop more detailed plans, perform environmental assessments, and evaluate right of way requirements and other factors that could significantly affect project costs. Refined cost estimates will be prepared during subsequent project development stages based on information derived from these tasks. It is possible that updated estimates and actual costs could vary significantly from the estimates provided in this report.

It is important to note that estimates are shown in present day values and do not consider inflation factors to account for the planned year of construction.

The estimates include capital costs for modernization and extension only and an estimate of current operations and maintenance costs. Costs to maintain or rehabilitate the existing infrastructure are not included.

The following sections provide a summary of the basis of estimates, definitions of Skyway Modernization Program vehicle options and extension scenarios, assumptions and uncertainties guiding component cost estimates and a summary of results.

3.0 Basis of Estimates

Cost estimates were prepared using available data from:

- » FDOT six month moving statewide averages 5/1/16 to 10/31/1/6
- » FDOT Generic Cost Per Mile Models 8/2/16
- » FDOT BDR Bridge Costs for New Construction
- » Input from manufacturers
- » Where cost data is not available, engineering judgement was used to develop cost ranges.

AV is an emerging technology and cost data is not readily available. Estimated costs used in this memorandum for AVs and associated components, such as operating systems, could vary significantly.

4.0 Definitions

4.1 Vehicle Option Definitions

- » **AV1:** Autonomous Vehicle (AV): Emerging technology with extensions elevated
- » **AV2:** Autonomous Vehicle (AV): Emerging technology with extensions at street level
- » **APM X:** Automated People Mover (APM X) similar to the existing vehicle and operating on existing infrastructure with elevated extensions.
- » **APM N:** A new APM such as the Bombardier Innovia 256 that would require removal of concrete guidebeam and replacement with a steel I-Beam guiderail and installation of running plinths with elevated extension.

5.0 Project Component Estimates

Estimates were developed for the various project components and are summarized in Table 1 at the end of this section. These estimates were developed based on the following considerations:

5.1 Vehicle Estimates

- » **AV1 and AV2:** Based on input from manufacturers, costs will vary depending on the size and capacity of the vehicle. For example the Olli and EZ 10 with a capacity of 10-12 passengers are estimated at \$250k while the larger 2getthere (16-24) is estimated at \$1M per vehicle. It is important to consider that AV is an emerging technology and actual vehicles costs could vary significantly. Option AV1 assumes elevated extension and AV2 at-grade extensions.

- » **APM X:** Input received through the request for information from industry indicate that a new vehicle similar to existing could cost \$3-\$5M.
- » **APM N:** A new APM N vehicle is estimated at \$3-\$5M.

5.2 Infrastructure Conversion

AV 1 and AV 2: To accommodate a new AV, significant modifications to the existing infrastructure will be required including:

- » Removal of existing guidebeam
- » Installation of smooth running surface
- » Modifications at stations to accommodate lower vehicle floor
- » Reinforcement or replacement of barrier wall
- » Modifications to switch gear
- » Modifications of maintenance facility
- » Modifications for charging stations

This will be required for both the AV1 and AV2 options.

APM X:

- » Modifications to the existing infrastructure will not be required for the APM X vehicle.

APM N: To accommodate a new APM that operates with a steel guiderail in lieu of a concrete guidebeam the following modifications are anticipated:

- » Removal of concrete guidebeam
- » Installation of running plinths
- » Installation of a steel I-beam
- » Possible strengthening or replacement of significant portions of the superstructure due to additional weight of vehicle

It is important to note that modifications to the existing infrastructure will require the system to be taken out of operation for a period of up to two years. While structural modifications will not be required for the APM X option, for the other options, confirmation of the feasibility of the structural modifications required for the preferred vehicle option AV1 and AV2 or APM N will be performed during subsequent project stages. Structural modifications could require significant modifications up to partial or complete replacement of superstructure as well as extensive modifications to stations resulting in significantly higher estimates. A structural analysis will be performed during next stages of project development to confirm extent of modifications required.

5.3 At-Grade Extensions

AV 2: At-grade extensions with the Autonomous vehicle, assume that the existing elevated structure is converted and that all extensions are at-grade. Per mile estimates were developed using FDOT LRE per mile costs and assume that an existing parking or travel lane can be converted to a transit lane within existing right of way to accommodate the AV with resurfacing, minimal widening, curb and gutter, pedestrian enhancements, pavement markings and transit signal priority systems. The estimate does not include right of way.

5.4 Elevated Extensions

Cost per mile estimates were developed for elevated extensions for all vehicle options assuming the following:

- » Quantity estimates were prepared assuming the elevated extensions would be similar to existing pre-stressed concrete double T-Beam superstructure and concrete substructure.
- » Unit costs from latest FDOT data.

Estimates accounting for variations to superstructure for the different vehicle options were developed:

- » **AV1** with smooth running surface and barrier walls.
- » **APM X** with concrete guidebeam and barrier walls.
- » **APM N** with steel I-beam, running plinths and barrier walls.

5.5 Stations

Estimates for street level and elevated stations were developed not including right of way and are assumed to be similar for each of the vehicle options. New elevated stations are assumed to be similar to existing elevated skyway stations in design and at-grade stations similar to those recently installed as part of BRT System.

5.6 Operating System

For all options it is assumed that the existing operating systems will be replaced to bring the skyway system up to current standards and improve operating efficiency and flexibility.

AV1 and AV2: As this is an emerging technology and there are no current systems in operation no cost data is available. It is assumed that the AV operating system will include on board and wayside communications linked to a central operating center. The assumption is that much of the communication will be wireless and that the costs will be less than for an APM operating system, but greater than required for a BRT System. The costs provided are assumed values and could vary significantly from ultimate costs.

APMX and APMN: Operating system costs provided are based on current industry data for similar APM operating systems.

5.7 Elevated to At-Grade Transition

AV2: It is assumed that at least a portion of the extensions for the AV2 option will be at-grade and will therefore require a transition from elevated to street level that could require a transitional structure length of 400-500 feet at an 8% grade. The actual costs will be dependent on the location of the transitions and other considerations such as geotechnical requirements, effect on existing roadway and sidewalk, etc.

5.8 Operations and Maintenance Facility

With the conversion and expansion of the system, the existing operations and maintenance facilities will have to be modified and / or expanded. The extent of the modifications or expansion is uncertain at this time due to the following variables:

- » number of vehicles
- » modifications to Operating and Control Center
- » number, location and size of charging stations
- » extent of land or right of way required

For the AV 1 and AV2 options significant modifications may be necessary, including possible expansion of the existing operations and maintenance facility. The extent of modifications will depend on the number of vehicles and length of extensions, among other factors.

For APM X option it is expected that minimal modifications will be required initially, however as extensions are added and the fleet size increased, it is reasonable to expect that an increase in facility size would be warranted.

For the APM N options, moderate modifications to the existing facility will be needed to convert to the different vehicle that operates on steel rail instead of existing concrete guidebeam. As with the APM X option, expansion may be required as the system grows.

5.9 River Crossing

An estimate for a new river crossing was developed for the AV option only. It was developed using FDOT BDR data, assuming a .75 mile crossing with ramped connections at both banks. A bridge width of 40' was assumed to accommodate a two way transit lane and shared-use bike-pedestrian path. A height and navigable clearance similar to the Acosta Bridge is assumed. The estimate does not include right of way costs that might be required at each bank. The actual alignment and height is conceptual only and will be refined during subsequent project development stages. It is possible that US Coast Guard, US Army Corps of Engineers and St Johns River Water Management District requirements could significantly impact locations, alignment and height of the structure, thereby affecting actual costs.

5.10 Operation and Maintenance Estimates

Annual operating and maintenance costs for the existing system are \$6.5 to \$7M per year. If the selected alternative is an APM vehicle, then operating costs should decrease in near term for APM and APM X options (e.g. \$5 - \$6.5 M), since vehicles will be replaced with new models. Operations and maintenance costs are not available for AV vehicles. However, costs are expected to be higher than BRT (\$3.0 M), but less than APM.

The estimates provided are for the existing 2.5 mi system with a similar number of vehicles. However, O&M will increase proportionally with increased length of systems and fleet size.

It is important to note that the results of the Life Cycle Cost Analysis performed previously indicate that annual operating and maintenance costs over the long term compose the most significant portion of system costs which are typically the responsibility of the owning agency.

6.0 Summary

The AV2 option with extensions operating at-grade may be 25% to 50% less expensive than the APMX or APM N options, depending on the extension scenario. The AV is likely less expensive due to lower vehicle costs and expected lower operating system costs. It is also likely to require lower infrastructure investment, since the AV can feasibly operate at street level.

Estimates for the APM option tend to be higher primarily due to higher vehicle costs, and the likelihood that extensions would have to be elevated. These vehicles require a fixed guideway (concrete or steel) which make at-grade extensions difficult due to the fact that the guideway will create traffic obstructions at intersecting streets.

AV is an emerging technology. Significant uncertainties persist related to the cost of operating systems, charging stations, modifications and additions to the existing Operation and Maintenance Center, and long term operations and maintenance requirements, among other factors.

It is important that detailed capital cost estimates and long term operations and maintenance cost be evaluated as part of further project development including a detailed life cycle cost analysis.

Table 1: Capital Cost Estimates Range by Component

Estimated Cost Summary by Component January 2017				
Component	AV 1 Elevated	AV 2 0 At- Grade	APM X	APM N
Vehicles (Each) ^{1,2}	\$0.25-\$1M	\$0.25-\$1M	\$3-\$5M	\$3-\$5M
Infrastructure Conversion ³	\$15-\$25M	\$15-\$25M	0	\$15-\$25M
Extensions (per Mile) ^{4,5}	\$20-\$30M	\$2-\$5M	\$20-\$30M	\$20-\$30M
New Stations (Each)	\$4-\$6M	\$0.5-\$0.75M	\$4M-\$6M	\$4M-\$6M
Operating System (per Mile) ^{6,7}	\$5M-\$10M	\$5-10M	\$25-\$40M	\$25-\$40M
Elevated to at-grade transition (Each)	N/A	\$3-\$5M	N/A	N/A
Operations and Maintenance Facility ^{8,9}	\$10-\$25M	\$10-\$25M	\$5-\$10M	\$10-\$15M
New River Crossing ¹⁰	\$100-\$125M	\$100-\$125M	\$100-\$125M	\$100-\$125M
Annual O&M Costs ^{11,12}	\$3.0-\$5.5 M	\$3.0-\$5.5 M	\$5.5-\$6.5M	\$5.5-\$6.5M

General Notes:

- » Estimates are conceptual and are provided solely to compare options.
- » Estimates should not be used to infer detail project level cost estimates.
- » Actual costs could vary significantly from the estimates provided.
- » More detailed estimates, including a life cycle cost analysis, will be prepared during project development.
- » AV 1, APM X and APM N all assume elevated extensions. AV 2 assumes At-grade extensions.
- » Estimates do not include right of way.
- » AV is an emerging technology and availability of reliable cost data is limited.
- » Please refer to Technical Memo 4 for additional information on basis of estimates.

Footnotes:

1. AV vehicle costs are less than APM. However, AV may have less capacity and therefore the system may require more AV vehicles.
2. AV vehicles may have a shorter useful life than APM, resulting in increased life cycle costs.
3. Conversion includes removal of guidebeam, station platform modifications and assessment of safety issues (including evaluation of the emergency evacuation walkway and crashworthiness of barrier walls).
4. Elevated extensions costs are equivalent for AV and APM in the current estimate. Further analysis may show that elevated AV extensions (AV1) are less costly than APM X and N, since an AV vehicle may be lighter.
5. AV At-grade extensions are similar to BRT with dedicated lanes and Transit Signal Priority.
6. The AV option will likely be battery powered. Charging requirements and locations are currently uncertain and could increase costs significantly.
7. The cost of the AV Operating System is uncertain. It could be less than estimated. For example, one manufacturer indicates a significant portion of operating system is captured in vehicle cost.
8. Operations and Maintenance Facility Modification costs will increase as a function of the number of vehicles and the length of extensions.
9. APM X O&M facilities will require minimal modification. Modifications for APM N and AV will be moderate and extensive, respectively.
10. The river crossing estimate assumes a two way transit lane with pedestrian and bicycle facilities. It does not include provision for other vehicles.
11. O&M costs are based on an existing 2.5 mile system.
12. O&M costs for AV options are assumed to be greater than BRT (\$3.0M) and less than APM.