Jacksonville Transportation Authority

FINAL SKYWAY TECHNOLOGY ASSESSMENT REPORT

August 2015

LEA + ELLIOTT

In association with:
RS&H, Inc. | Fit Engineering | Civil Services, Inc.
G. M. Hill Engineering, Inc. | The Ohmega Group, LLC

Revision Log

Revision	Date	Description of Changes
Draft	06/03/2015	First issue
Final Draft	07/15/2015	Edited Executive Summary Moved Condition Assessment Operating System and Infrastructure to Appendices A and B Modified Section Numbers Amended RFIF section 3.0 to include additional discussion/observations of industry feedback Added Recommendations on Option 1-3 to Table 4-12 Added Option 1 ROM Cost estimate Added Option 2 ROM Cost estimate Revised sections 4.1.3.1 and 4.1.3.2 for Infrastructure near and mid-term estimates Amended Section 5.0 "Recommendations, Policy Consideration and Next Steps" to include: • Street car options 3A, 3B and 3C • Modifying the existing guideway to accommodate an alternate vehicle Appendix B: Revised infrastructure section of Conclusions and Recommendations
Final	08/05/2015	Edited sections 4.0, 4.1.2.1 and 4.2.2 Corrected and adjusted Table 4-4 Rounded off numbers in Tables 4-1, 4-4 and 4-13 Corrected numbering in Section 5.0 Adjusted formatting

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EXECUTIVE SUMMARY

General

In an effort to bolster transportation service in downtown Jacksonville, the Jacksonville Transportation Authority (JTA) has issued Request for Proposal (RFP) No. P-14-014 for the JTA Skyway Technology Assessment on February 6, 2014. Proposals from qualified firms were received on April 7, 2014. The competitive procurement process resulted in the selection of the Lea+Elliott Team to perform the following activities:

- Condition Assessment of:
    - Skyway Operating System
    - Skyway Infrastructure (including Load Rating of a typical span).
- Technology Assessment
- Evaluation of Alternatives:
    - retained alternatives were examined at a concept level to establish viability and implications.
    - retained alternatives included a concept level description/discussion of:
        - The category of modifications (system and infrastructure) required
        - Policy considerations and implications
        - Cost per mile

The condition assessments and the technology assessment were completed in November 2014 and presented to the JTA on December 19, 2014. During the presentation, the Lea+Elliott Team also reviewed, families of alternatives identifying some of the inherent policy implications/decisions. The JTA staff then met internally, identified additional options and requested the Lea+Elliott Team to perform a "Pros-Cons" comparison. The options were discussed at a meeting held on January 21st. Subsequently, the JTA staff focused their attention on the following three alternatives and requested that they be discussed in the Draft Skyway Technology Assessment Report:

Option 1: Mid-Life Overhaul Operating System and Infrastructure,

Option 2: Replacement in-kind with a similar vehicle and Overhaul of the Infrastructure

Option 3: Street-car as a complete replacement of the Skyway

In parallel, the JTA determined to assess the industry's interest in the following options as part of a Request for Industry Feedback (RFIF):

RFIF Option 1: Overhaul of the Jacksonville Skyway Monorail Operating System,

RFIF Option 2: a) The Replacement in-kind of the Jacksonville Skyway Monorail vehicles and b) The overhaul of the wayside Operating System elements.

RFIF Option 3: a) the replacement of the existing Skyway vehicles with new vehicles "allowing infrastructure modifications that do not alter the existing beam structure, with no net increase in weight stress on guideway infrastructure" and b) the replacement, as required, of the wayside Operating System (train control, power distribution, guideway switches etc.)

The Structure of this report, the Draft Skyway Technology Assessment Report, consists of the following:

- a brief presentation of the initial options and provide a Pros-Cons comparison,
- a discussion of the RFIF process,
- a discussion of the JTA-retained three options with a conceptual discussion of street-cars as a possible "one-for-one" replacement of the Skyway,
- a discussion of recommendations (JTA policy decisions and next steps), and
- a highlight of the major findings of the Condition Assessments.

Request for Industry Feedback

The JTA issued a Request for Industry Feedback (RFIF) to 18 selected operating system suppliers/manufacturers with the intent to gauge the industry interest in the following three options:

RFIF Option 1: Overhaul of the Jacksonville Skyway Monorail Operating System,

RFIF Option 2: a) The Replacement in-kind of the Jacksonville Skyway Monorail vehicles and b) The overhaul of the wayside Operating System elements.

RFIF Option 3: a) the replacement of the existing Skyway vehicles with new vehicles "allowing infrastructure modifications that do not alter the existing beam structure, with no net increase in weight stress on guideway infrastructure" and b) the replacement, as required, of the wayside Operating System (train control, power distribution, guideway switches etc.)

RFIF responses were received by the JTA on May 6, 2015. The respondents were Schwager Davis (SDI), Bombardier, Skyweb Express and Thales.

RFIF Option 1: Operating System Overhaul

Only SDI considered that this option may be implemented. It is suggested that detailed meetings be held with SDI to clarify the project specific constraints and to ensure that SDI is capable of performing the overhaul.

RFIF Option 2: Replacement in-kind of the Jacksonville Skyway Monorail Vehicle

None of the four respondents provided a positive response. Based on industry response, it does not appear that this option warrants further analysis.

RFIF Option 3: Replacement of the Skyway vehicles with new vehicles "allowing infrastructure modifications"

This is the only option that all four respondents offered proposed solutions for. However, each of them comes with its own risk that must be carefully evaluated by the JTA.

Streetcar

Streetcar as a "one-for-one" replacement of the Skyway monorail was also examined on a conceptual basis.

For this preliminary evaluation, the proposed streetcar alignment follows the current Skyway alignment and therefore, crosses the St. Johns River using the Acosta Bridge. Conceptual typical sections were developed for the Acosta Bridge crossing.

Three sub-options were considered:

Option 3A: Use of existing Skyway alignment

- This option requires considering the transitions from the at-grade alignment on each bank to the elevated existing Skyway structure in the center of the bridge.
- This option also requires considering the load rating on the existing Skyway structure for a heavier streetcar vehicle.

Option 3B: Use of outside travel lane

- This option requires modification to the existing bridge deck to accommodate the streetcar rails, either embedded in the existing deck or using a new raised platform.
    - The assessment of a raised platform option requires considering the added weight and load ratings of the concrete platform for rails and streetcar vehicle.
- This option limits the use of the outside travel lane for other vehicles and hence reduces existing vehicular capacity.

Option 3C: Expansion of bridge structure for additional streetcar lane/corridor on new structure

- This option requires considering construction of a new bridge structure to carry the streetcar alignment on each side of the existing bridge structure; or one side of the bridge as a two-way operation.
- Additional right-of-way for the bridge expansion in order to accommodate the ramps to the at-grade alignment should be considered.
- Adjacent land uses, accessibility to bridge structure and other site conditions should be reviewed in greater detail to determine if further consideration is warranted.

The assessment of the three options listed above is presented to provide potential concepts to consider as part of a more detailed streetcar study. Options 3A, B and C are viable for further investigation, as is the modification of the existing guideway to accommodate an alternate vehicle.

As part of a future project development, it is recommended that an in-depth structural analysis be performed for all spans. Each structure span and type, and vehicle type under consideration will require a specific analysis. It is also important to note that any modifications to the Acosta Bridge including the existing skyway support must be coordinated with FDOT and City of Jacksonville due to both operational and structural impacts.

Recommendations (Policy and Next Steps)

The JTA has engaged in a planning effort and has examined a variety of options. This study is a first step in this planning process that should include involvement of the City of Jacksonville, the citizen community and the various stakeholders.

In order to support the JTA planning effort, the Lea+Elliott Team has developed a list of recommendations for the JTA's consideration.

1. **Pursue the process** initiated with the Request for Industry Feedback to ascertain with greater certainty the feasibility of RFIF Options 1 and 3 (hold detailed discussions with manufacturers and obtain a firm commitment prior to selecting an approach to pursue.)
    a. On the overhaul option:
        i. Consider not proceeding without having **firm assurance and guarantee** that a replacement propulsion system has been identified, or that the propulsion system can be overhauled. Based on Bombardier's response to the RFIF, investigate whether bogie parts could be manufactured, if required.
        ii. Consider requesting that **Bombardier provide the design details of the Main Propulsion Controller Board** (Part #3MUP0000001-0016 (DMC-120) considering that it will no longer be supported by Bombardier.
    b. On the replacement with a new vehicle "in-kind":
        i. Given the lack of interest noted as part of the RFIF, this options does not appear viable and it **is recommended that it be dropped from further consideration**.
    c. On the replacement with a new vehicle with no net weight increase on the existing infrastructure:
        i. **Engage discussions with SDI, Bombardier and Skyweb express.** For SDI, the JTA should ensure that the original technical project requirements are understood and can be met.
        ii. For Bombardier, **investigate whether the existing structure is adequate to support the loads of the heavier VAL 256**.
        iii. The Skyweb express proposed solution i.e. **PRT requires a detailed planning effort, risk assessment and development of a business case**. The risk assessment is necessary since there is, at this time, no PRT system that would match the complexity and scale of the system proposed by Skyweb Express.
    d. On Streetcar:
        i. A **business case** needs to be elaborated to justify the migration from the Skyway to this technology.
        ii. The existing guideway structure is unlikely to support a heavier streetcar system.
        iii. Three Options were considered:
            1. **Option 3A:** Street Car Crossing at same location of existing guideway:
            2. **Option 3B:** Street Car Crossing on Acosta Bridge
            3. **Option 3C:** New Structure on a new alignment
        iv. The assessment of the options listed above is presented to provide potential concepts to consider during a more detailed streetcar study. **Options 3A, B and C are viable for further investigation** It is also important to note that any

modifications to the Acosta Bridge including the existing skyway support must be coordinated with **FDOT and City of Jacksonville** due to both operational and structural impacts.

2. Modifying the existing guideway to accommodate an **alternate** vehicle may be viable. As part of subsequent project development **it is recommended that an in-depth structural analysis be performed for all spans. Each structure span and type and vehicle type under consideration will require its own analysis.**
3. Develop a **business case** for all options under consideration. The business case should include ridership, fare structure, capital and O&M costs.
4. As part of any business plan, determine the required **FTA payback amount** if the vehicles or infrastructure will not be used for the design life agreed upon with the FTA.
5. Implement the **recommendations** listed in the Operating System **condition assessment** report and the Infrastructure **condition assessment** report.
6. Determine the **short term** course of action for the Skyway; i.e.: the JTA should consider initiating repairs that could have an impact on safety (such as Guideway Intrusion System), or availability of the system (such as loop cable, water accumulation, conduits and cables affected by water accumulation etc.).
7. The JTA should consider the implementation with other stakeholders of a **transportation plan** and consolidate the transportation systems in operation today (bus, etc...) with those under planning or design (Street Car, BRT, others)
8. **Conduct a forum** to share results of the Skyway Technology Assessment with key stakeholders to initiate a dialogue regarding:
    - long term transportation planning;
    - the essential connection between transportation and land use;
    - secure advocates;
    - and possible funding partners and programs.

   The forum should include representatives of:
    - DIA
    - City Council
    - Shipyards Development
    - Downtown Business Leaders
    - Urban Design specialists
    - FDOT Urban Office
    - North Florida TPO Board
    - JTA Board of Directors
9. JTA LRPSD staff Advance collaborative efforts for the redevelopment of **Lavilla District**. Streetcar projects typically promote economic development adjacent to the rail line.
10. Develop **Implementation Plan** for selected alternative considering:
    - Planning and Design Effort
    - Schedule
    - Estimated costs
    - Funding Availability
    - Stakeholder Coordination
    - FTA / FDOT/NEPA Requirements
    - Public Involvement

1.0 BACKGROUND

In an effort to bolster transportation service in downtown Jacksonville, the Jacksonville Transportation Authority (JTA) has issued Request for Proposal (RFP) No. P-14-014 for the JTA Skyway Technology Assessment on February 6, 2014. Proposals from qualified firms were received on April 7, 2014. The competitive procurement process resulted in the selection of the Lea+Elliott Team to perform the following activities:

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The condition assessments and the technology assessment were completed in November 2014 and presented to the JTA on December 19, 2014. During the presentation, the Lea+Elliott Team also reviewed, families of alternatives, identifying some of the inherent policy implications/decisions. The JTA staff met internally identified additional options and requested the Lea+Elliott Team to perform a "Pros-Cons" comparison. The options were discussed at a meeting held on January 21st. Subsequently, the JTA staff focused their attention on the following three alternatives and requested that they be discussed in the Draft Skyway Technology Assessment Report:

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- a brief presentation of the initial options and a Pros-Cons comparison,
- a discussion of the RFIF process,
- a discussion of the JTA-retained three options with a conceptual discussion of street-cars as a possible "one-for-one" replacement of the Skyway,
- a discussion of recommendations (JTA policy decisions and next steps), and
- a highlight of the major findings of the Condition Assessments.

This study is not a transportation planning study, but rather a technology study focused on describing the current state of the Skyway, investigating potential replacement technologies and performing a conceptual evaluation of alternatives retained by the JTA. This study should be viewed as an integral part of a comprehensive planning effort in the City of Jacksonville. Such effort should include an overall transportation plan designed to rationalize transportation modes, provide clarity on passenger demand and an estimate of future public transit ridership. This effort should also result in providing a satisfactory response to the transportation questions facing citizens and visitors of the City of Jacksonville.

2.0 POTENTIAL OPTIONS DISCUSSIONS

This section includes a summary of the various options discussions.

2.1 PRELIMINARY OPTIONS

At the conclusion of the Technology Assessment, a preliminary set of options was discussed qualitatively with the JTA on December 19, 2014 (see below).

Criterion / Option	Do Nothing	Overhaul	Replace System Using Existing Infrastructure (similar vehicle)	Replace System Using Existing Infrastructure (different vehicle)	Replace System - Abandon Existing Infrastructure
Long Term Viability	◔	◕	●	●	●
Impact to Existing Infrastructure	●	●	●	◔	N/A
Urban Insertion Impact	●	●	●	◕	◔
Federal Obligation/Grant Management	●	●	◕	◕	◔
Cost	●	◕	◑ *	◔	◔
Business Case	◑	●	◑	◑	◔

● =1,Best
◕
◑
◔ =4,Worst

* Sole Source

Table 2-1: Comparative Options Evaluation

During the discussion, the following facts were highlighted:

- The "Do Nothing" Option serves a baseline and may be explored further depending on the findings of the study.
- Federal payback obligation have to determined and part of the overall comparison/evaluation in case the JTA elects to proceed with an option that either requires replacing the existing vehicles with new vehicles or that replaces the Skyway with another system: PRT, Streetcar etc.
- Business Case: Except perhaps for the Overhaul option, all options require that a business case be established by the JTA. Such business case should consider projected ridership, fare structure, operating revenues, operating costs, federal obligations etc.

The discussion led to internal JTA staff meetings and consultations aimed at the elaboration of a move-forward strategy.

2.2 REVISED OPTIONS

2.2.1 <u>General</u>

A second discussion with the JTA upper management was held at the end of January 2015. The Lea+Elliott Team prepared responses to JTA questions and performed a “Pros-Cons” comparison of some of the alternatives under consideration by the JTA.

The Pros-Cons comparison was performed on a set of JTA initial options and subsequently on a set of JTA refined options. Both comparisons are included in Tables 2.2.2 and 2.2.3 below.

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2.2.2 Initial Options

The JTA options considered in this analysis are:

- Overhaul,
- Replace existing vehicle with same (new) vehicle
- Replace existing system with Alternate APM technology
- Replace the Skyway with a Light Rail (LRT) System

JTA INITIAL OPTIONS	Overhaul	Replace with Same Vehicle	Replace with Alternate APM Technology	LRT
Pros	• Lowest relative Cost of the options • Keep/maintain existing infrastructure (Guideway/Stations/Infrastructure) • No/Minor staff Learning curve -Maintenance -MMIS -Inventory/Parts • No FTA obligation/payback • Improved System Availability	• 25 years vehicle life • Improved System Availability	• 25 years vehicle life • Vehicle in operation on other properties o Supplier support o Spare parts availability • Improved System Availability	• 25 years vehicle design Life • Appeal of a new system • Catalyst for downtown re-development
Cons	• Propulsion Replacement uncertainty • Aging Infrastructure • Unique vehicle (obsolescence)	• Mid-range Cost of the options • Unique, custom made, vehicle/long term support • Staff learning Curve o Maintenance o Maintenance Management Information System (MMIS) o Inventory, parts • Limited procurement competition (sole source), hence higher cost • Infrastructure approaching midpoint of useful design life • FTA obligation/payback	• Higher capital cost • Staff learning Curve o Maintenance o MMIS o Inventory, parts • Complete Structural Analysis of Infrastructure system required • Impact to Infrastructure o Guideway o MSF o Switches o Height of vehicle and this impact on skyway stations o Loading of new vehicles differ from existing (axle spacing, etc.) • Alignment concerns/grade (6% max, radius of curvature) • Possible reconstruction of low radius spans to accommodate new vehicle • Infrastructure approaching midpoint of useful design life • Impacts during construction • FTA obligation/payback	• Higher Capital Cost • Highest O&M Cost • FTA obligation/payback • Compete with road traffic • Decreased performance • Urban Insertion/Environmental impact • Planning consideration (BRT) • Demolition of existing infrastructure

Table 2-2: Initial Options- Qualitative Comparison

2.2.3 Refined Options

The JTA options considered in this analysis are:

1. Run Skyway until it stops and replace with a Streetcar or a Bus Rapid Transit (BRT) system,
2. Overhaul the Skyway, run for 10 to 15 years and develop replacement system in the meantime
3. a) Replace vehicle with one that can run on existing infrastructure; extend the system using an elevated structure
3. b) Replace vehicle with one that can run on existing infrastructure; extend the system using an alternative mode, streetcar or BRT

JTA REFINED OPTIONS	1. Run Skyway until it stops and replace with Streetcar or BRT	2. Overhaul vehicle and run for 10 to 15 years and develop replacement system in meantime	3a. Replace vehicle with one that can run on existing infrastructure Extensions using elevated structure	3b. Replace vehicle with one that can run on existing infrastructure Extension with alternative mode – Streetcar or BRT
Pros	• Lowest relative cost of the options • Take time to do proper planning	• Second Lowest relative Cost of the options • Keep/maintain existing infrastructure (Guideway/Stations/Infrastructure) • No Learning curve • No FTA obligation/payback • Improved System Availability • Allows significant time for development of future transportation plan	• 25 years vehicle life • Improved System Availability • Possibility of Extensions using similar technology • Potential increased attractiveness of the Skyway using transit-oriented development • Extension Could Provide service to emission generators	• 25 years vehicle life • Improved System Availability • Integrate the Skyway with planned BRT transportation modes • Greater flexibility integrating with future transportation plan
Cons	• Planning uncertainty/ gap between skyway and Street Car/BRT operation • Impact to Passenger Service During the transition to the new replacement mode • FTA payback for vehicle and Infrastructure • Demolition of existing infrastructure- cost and impact • Skyway Operations and Maintenance costs increase with time	• Propulsion Replacement uncertainty • Infrastructure approaching midpoint of useful design life • Requires infrastructure capital investment • Unique vehicle (obsolescence) • Limited fleet -> Limited capacity of extension • Minor Passenger Service Interruption	• Higher Relative Cost • Unique, custom made, vehicle/long term support • Staff Learning Curve o Maintenance o Inventory, parts • Limited procurement competition (sole source), hence higher cost • Infrastructure approaching midpoint of useful design life • Requires infrastructure capital investment • System Operation to be considered (Y-junction) • FTA obligation/payback for vehicles • Major Passenger Service Interruption • Limited flexibility with integration with future transportation plan	• BRT costs already considered • Unique, custom made, vehicle/long term support • Staff Learning Curve o Maintenance o Inventory, parts • Limited procurement competition (sole source), hence higher cost • Infrastructure approaching midpoint of useful design life • Requires infrastructure capital investment • FTA obligation/payback for vehicles • Major Passenger Service Interruption • Transfer between modes

Table 2-3: REFINED OPTIONS- Qualitative Comparison

2.2.4 Summary

During the discussion it became apparent that both the "Overhaul" and the "Replace in-kind with a new vehicle" options include a non-negligible element of uncertainty. For the overhaul, the replacement of the propulsion system may prove to be challenging based on initial discussions with a major propulsion supplier (ABB), while the replacement with a new vehicle may not attract the interest of the major vehicle manufacturers, implying either that there is no interested party, or a very high sole source cost if one supplier only expresses interest. **It was then suggested to the JTA to engage in discussions with Bombardier upper management and request that design information of the main propulsion controller board be provided (see Appendix 1).** If such information were to be provided by Bombardier, it would give the JTA a greater assurance on the overhaul of the propulsion system, lead time and cost for repair.

3.0 REQUEST FOR INDUSTRY FEEDBACK

Given the uncertainty surrounding some of the options, and in order to obtain more precise information, the JTA elected to issue a Request for Industry Feedback (RFIF) to 18 selected operating system suppliers/manufacturers regarding the Jacksonville Skyway Monorail Operating System. The RFIF intent was to gauge the industry interest in the following three options:

RFIF Option 1: Overhaul of the Jacksonville Skyway Monorail System,

RFIF Option 2: a) The Replacement in-kind of the Jacksonville Skyway Monorail vehicles and b) The overhaul of the wayside Operating System elements.

RFIF Option 3: a) the replacement of the existing Skyway vehicles with new vehicles "allowing infrastructure modifications that do not alter the existing beam structure, with no net increase in weight stress on guideway infrastructure" and b) the replacement, as required, of the wayside Operating System (train control, power distribution, guideway switches etc.)

The RFIF included a note that the Fixed Facilities (guideway, stations) overhaul (drainage, structure repair etc.) would be addressed separately by the JTA. After receipt of the RFIF responses, Lea+Elliott generated an Executive Summary and a fact sheet (see references). Additional thoughts and considerations on the RFIF responses are provided below.

The replacement with a vehicle that minimizes impact to the existing infrastructure presents its challenges as the competition is limited given that the majority of the Automated People Mover (APM) vehicles are heavier than the existing Skyway Monorail.

The replacement "in-kind" also appears uncertain since it is doubtful that major APM suppliers would build a new vehicle knowing that it takes years to do so; and that it takes a few more years to attain an acceptable level of reliability. Major APM Suppliers had recently deployed new vehicles such as the Innovia 300 APM for Bombardier or the CityVal by Siemens and would not be, in all likelihood, interested in building a new vehicle given that the fleet size for Jacksonville is small as compared to other urban systems, and the market for such small monorail may not be attractive.

To our knowledge, the most recent case of a supplier manufacturing a vehicle that fits within the physical constraints of a system built for another vehicle, would be Bombardier for the Muzha Line in Taipei, Taiwan. The original Muzha Line system was deployed by Matra Transit, since acquired by Siemens a few years ago. Bombardier was a successful bidder in the replacement of the Matra system requested by the transit authority in Taipei (DORTS) for the Muzha Line and the new extension, the Wenshan line. Bombardier car order was 202 Innovia 256 trains, in addition to the retrofit of the VAL 256 with CityFlo 650, Bombardier moving block CBTC system. The large car order, and contract value, was probably instrumental in having Bombardier compete for the project.

Building on the development of the Innovia 256, Bombardier has recently been awarded the Chicago O'Hare International Airport APM contract intended to replace the VAL 256 by Matra Transit with the Innovia APM 256.

By comparison, the differences between the Innovia Platform (100 and 200) and the VAL 256 were not as considerable, for example, as the ones between say the Innovia Monorail and the UMIII monorail. This is an important consideration in understanding the lack of response to RFIF Option 2.

3.1 RFIF OPTION 1- OVERHAUL

Even though most of the overhaul elements discussed in the Operating System Condition Assessment report are feasible and manageable, the propulsion system replacements stands out as problematic.

The JTA has held discussions with ABB, a major propulsion supplier, who reviewed the existing propulsion system design, characteristics and space requirements. ABB indicated that they have identified a replacement for the brushless DC motor, but were experiencing difficulties with a) the interface between the propulsion controller and the DC motor, and b) finding space for a replacement propulsion drive. Decision was then made to widen the search and request feedback from the industry. The RFIF is obviously only a first step in assessing feasibility. Subsequent discussions, meetings and site visits may be necessary to be sure whether the propulsion system could be overhauled or replaced.

In order to increase the probability of a successful propulsion overhaul, the JTA may elect, as recommended by Lea+Elliott, to request Bombardier Transportation to provide the main propulsion controller board design details allowing the JTA to have it manufactured and tested by qualified suppliers.

3.2 RFIF OPTION 2- REPLACE VEHICLE “IN-KIND”

The vehicle replacement “in-kind” also offers significant challenges. The first challenge is that in order for a vehicle to be designed, built, tested and made reliable, it takes time; it may take years. It appears likely that the major car manufacturers will not be interested in this option.

Let us consider three suppliers as a case study: a) Siemens, 2) Mitsubishi Heavy Industries and 3) Bombardier.

Siemens (Matra, at the time) technology, VAL for Vehicle Automatique Leger, was the technology in use on the Jacksonville Skyway starter line, between the Convention Center and Central stations. As mentioned in section 3.0, Siemens has recently developed the NeoVal vehicle and has made numerous attempts in the last few years to market the product. Siemens has been recently awarded a contract in Rennes (France) where it will deploy the NeoVal (CityVal) in 2018. It seems therefore unlikely that Siemens would be interested in Option 2.

Bombardier is also deploying the new Innovia APM 300 on several sites, but this product is not in passenger service yet. It is therefore unlikely that Bombardier would be interested in Option 2.

The Mitsubishi Crystal Mover, deployed by Mitsubishi Heavy Industries on several sites around the world is a careful evolution of the Japanese APMs, and the Hong Kong Airport APM, both smaller versions of the Crystal Mover. Given the Japanese regulatory requirements for the manufacture and deployment of a new vehicle, it seems unlikely that MHI would be interested in Option 2.

3.3 RFIF OPTION 3- REPLACEMENT OF EXISTING SKYWAY VEHICLE WITH A NEW VEHICLE WITH NO NET INCREASE ON THE GUIDEWAY INFRASTRUCTURE

As mentioned in section 2.0, this option limits competition as it appears doubtful that major APM suppliers would not be interested in building a new vehicle to fit within the existing infrastructure constraints knowing that it takes years to do so and a few more years to achieve a reliable product. Further most APM suppliers are deploying new vehicles and would, probably, not be interested in building a new vehicle given that the Jacksonville Skyway System fleet size is small as compared to other urban systems and the market for such small monorails may not be attractive.

3.4 RFIF RESPONSES

3.4.1 General

RFIF responses were received by the JTA on May 6, 2015. The following includes a summary of the four responses by Schwager Davis (SDI), Bombardier, Skyweb Express and Thales.

3.4.2 RFIF Executive Summary Conclusions and Considerations

3.4.2.1 Option 1 – Operating System Overhaul

3.4.2.1.1 General

Based on the RFIF responses it appears that only SDI considers this option to be viable and also points out that it could extend the service life of the system by 15 years. SDI also points out that this option would tend to be the least disruptive to the existing Skyway operations. SDI recommended that the vehicles' propulsion and braking system be upgraded to resolve the problems experienced by the Skyway (due to obsolete parts and other possible operating issues).

Bombardier, on the other hand, recommends against this option citing that it would be difficult and costly to locate suppliers and vendors willing to "recreate" the very specialized components contained within the drive train and bogies of the UMIII vehicles and it would be necessary to purchase all spares with the main order.

The other two suppliers (Thales and Skyweb Express) did not address this option.

Based on the RFIF responses SDI's response appears to be the most promising as it extends the service life of the system by 15 years but most importantly could provide a solution that minimizes disruption to the existing Skytrain operations. It is however not certain that this option is feasible since the detailed project constraints have not been shared with SDI, nor have the propulsion issues. It is recommended to pursue this option in order to ascertain its feasibility. To that effect, **it is suggested that detailed meetings be held with SDI to clarify the issues (project specific constraints) and to gain confidence and a higher level of comfort that SDI is capable of performing the overhaul considering all the risks involved.**

3.4.2.1.2 Disruption to Existing Skyway Operation

The Vehicle Overhaul will be carried out at the manufacturer's facility and the Skyway vehicles (2 cars at a time) will be lifted off the guideway as per an agreed rehab schedule. After each vehicle is overhauled, it will be brought back to Jacksonville, lifted on the guideway and commissioned. This process may take several months. This implies that for a period of time, the Skyway will operate without a full fleet and will need to consider the testing and commissioning program of the new cars. The time to overhaul a vehicle will be longer for the first vehicle and will tend to be shorter as the manufacturer develops proficiency and knowledge. If the vehicle manufacturer does not have a test track at its facility, testing of the vehicles will be performed in Jacksonville, will take longer and will be less efficient. The complete process will take a few years to complete.

3.4.2.2 Option 2 –Replacement of Vehicle "In-Kind"

3.4.2.2.1 General

For Option 2 none of the four respondents provided a positive response. SDI stated that it would extend the service life of the Skyway by 30 years but also cited that this does not come without challenges specifically related to replacement of the propulsion motor and controller.
Bombardier also did not recommend Option 2 stating that it would be difficult and costly to locate suppliers and vendors willing to "recreate" the very specialized components contained within the drive train and bogies of the UMIII VAL vehicles.

The other two suppliers (Thales and Skyweb Express) did not address this option completely or at all.
Based on the RFIF responses, it is noted that although replacing the system and vehicles in-kind could provide for an extended service life of 30 years and beyond the JTA must consider that a specialized vehicle to replace the Skytrain vehicles would be a one-of-a-kind vehicle and would present potential issues in the future to obtain support and spare parts, etc. and would have some major impacts on existing Skytrain operations.

Based on industry response, it does not appear that this option warrants further analysis.

3.4.2.2.2 Disruption to Existing Skyway Operation

The Vehicle manufacturing will be carried out at the supplier's facility. Given that this is a new vehicle, the interface between subsystems should be carefully considered (train control, brake, propulsion) for compatibility with the existing system and track block layout. It is recommended that Thales be the supplier of the on-board train control, for compatibility with the existing wayside train control system. Vehicles will be manufactured one at a time, shipped to Jacksonville, lifted on the guideway and commission. A detailed testing and commissioning program should be developed, including the phasing out of the existing fleet. The migration from the existing vehicles to the new vehicles will take several years. The time to manufacture the first vehicle may be up to two years, or longer. The manufacture of the subsequent vehicles will follow in short order since the jigs and manufacturing stations will already be in place, and proficiency would have been gained by the manufacturer. The manufacturer should have a test track at the plant to test the vehicles prior to shipment. If the vehicle manufacturer does not have a test track at its facility, testing of the vehicles will be performed in Jacksonville, will take longer and will be less efficient. The complete process will take a few years to complete.

3.4.2.3 Option 3 – System Replacement with Minimal Infrastructure Modifications

Option 3 was the only option that all four respondents offered proposed solutions for. However, each of them comes with its own risk that must be considered by the JTA when evaluating the proposed options. Each of these proposed solutions would also have major impact to existing Skyway operations and would likely need to shut down the system for an extended duration to implement.

Bombardier suggests that the monorail beam be removed and that they propose to use a vehicle technology that would closely match the original Skyway system technology, the Matra VAL 256. Bombardier states that they have experience in replacement of the Matra VAL 256 with their Innovia APM 256 vehicle technology in Taipei and are currently under contract to replace it again at Chicago O'Hare International Airport. Bombardier's experience with previously performing this work and utilizing a standard Bombardier APM vehicle should be noted as a benefit.

A potential concern with this proposed solution is that Bombardier would need to verify and confirm that the entire Skyway guideway (original/starter line and all extensions & MSF) is designed and constructed for the heavier Innovia APM 256 technology. If not, there may be extensive infrastructure re-design and reinforcement requirements that must be considered. The JTA would need to do a complete cost benefit analysis on this proposed solution.

SDI recommends Option 3 and state that they could adapt their technology, vehicle and system and that will have minimal impact on the existing infrastructure and provide for a 30 year service life. **It is suggested that detailed meetings be held with SDI to gain confidence and a higher level of comfort that SDI is capable of performing the replacement and to understand the extent of the required changes to the Infrastructure and to the Operating System.** Also the JTA could consider sharing the technical contractual requirements of the Jacksonville Skyway monorail with SDI. Some of the project constraints are somewhat challenging (such as 8% grade, Y-junction) and it would be advisable that the JTA makes sure that SDI fully understands the project requirement and is capable of delivering a reliable system.

Thales proposed to replace the ATC and communications system but offers no solution for the vehicle replacement. This is understandable given that Thales is a train control supplier.

Skyweb Express proposes a Personal Rapid Transit (PRT) System to replace the current trains with lighter, more private single vehicles. Skyweb Express strongly believes that the JTA's short-term and long-term solution (extending into historic neighborhoods) lie with a solution such as PRT. Skyweb Express discusses comparative cost per mile benefits **that should be verified**. Skyweb indicates that the Conversion of the current system would require alteration only at Rosa Park, King Street and Prime Osborn stations by allowing a balloon track to move cars from one side to the other on a two-way track.

Skyweb express discussion of System capacity appears optimistic as the advertised headways may not have been proven in passenger service (see Lea+Elliott note on PRT headway included in Lea+Elliott Technology Assessment Report dated November 2014).

It is recommended that detailed discussions be held with Skyweb Express to determine the extent of the proposed changes, their impact on the infrastructure and the operations of the proposed system. Furthermore, the decision to implement a PRT requires a complete separate study by the JTA to determine alignment, station locations, fleet size, ridership, business case etc.

4.0 RETAINED OPTIONS

The options retained by the JTA to conclude this study are **slightly different** from the ones in the RFIF. These options are listed below (see also section 1.0):

Option 1: Mid-Life Overhaul Operating System and Infrastructure,

Option 2: Replacement in-kind with a similar vehicle and Overhaul of the Infrastructure

Option 3: Streetcar as a possible "one-for-one" replacement of the Skyway

Note: RFIF Options 1 and 2 are identical to the JTA retained options 1 and 2; RFIF Option 3 is different from JTA Option 3. In this report, when referring to options 1 and 2, we are also referring to RFIF options 1 and 2. Option 3 refers to "Streetcar as a possible "one-for-one" replacement of the Skyway", while RFIF Option 3, on the other hand, refers to "System Replacement with Minimal Infrastructure Modifications".

These options are discussed in the following sections.

4.1 OPTION 1- OVERHAUL

4.1.1 General

Option 1 "Overhaul" was discussed in depth in section 3.0 "RFIF". In this section we will discuss the cost estimate for this option.

4.1.2 Operating System Cost Estimate

4.1.2.1 General

Estimating the cost of the overhaul presents a challenge mainly due to the uncertainty of:

- Propulsion overhaul (see 3 and Appendix A),
- Bogie overhaul (see Section 3 and assessment by Bombardier Transportation)

In addition to the above challenges, the cost of an overhaul is a function of the market interest for the work since competition compels competing suppliers to lower their proposed cost. Based on the RFIF responses, there is only one supplier that has shown interest for this work; namely SDI. As discussed in Section 3.0, the feasibility of the overhaul should be assessed further by the JTA by holding detailed discussions, showing design documents, organizing a site visit and sharing the issues related to the vehicle propulsion and the vehicle bogie.

The Lea+Elliott Team generally uses its proprietary cost model to estimate System overhaul costs, assuming competitive procurement and not sole source. Some of the items such as Train Control estimate are based on discussions with Thales (see Condition Assessment Operating System). It is important to note that a sole source supplier can essentially "dictate" its price. In addition, terms and conditions and other requirements of the contract have also a significant impact on the supplier prices. Finally, typical cost estimates are based on a regular propulsion system overhaul where a replacement is readily available, and that there are no issues of space, interface or otherwise. Given the high uncertainty associated with the replacement of the propulsion system it appears premature to develop the Operating System Overhaul cost estimate. Noting the above, the JTA requested that a cost estimate be presented even if the feasibility of the overhaul has not been ascertained. It appears appropriate to engage in the estimating process in the following steps:

1) Step 1: determine the economic feasibility of the overhaul by holding detailed working sessions with SDI (see section 3.0, above),
2) Step 2: Determine the framework of the overhaul using the Lea+Elliott Team condition assessment reports,
3) Step 3: Developing performance-based design/build procurement documents, including detailed scope and the JTA project specific terms and conditions,
4) Step 4: Establishing an allowance account to cover potential unforeseen costs needed to address items uncovered during a due diligence exercise, including reliability and obsolescence analysis,
5) Establishing an overall budget.

Based on the above, the ROM cost estimate presented below is very tentative.

JTA Skyway Mid-Life Overhaul
OPERATING SYSTEM ROM COST ESTIMATE

Estimated for Year:	7/13/2015
Bid Date:	7/13/2015
Date Estimate Prepared:	7/13/2015

ITEM	DESCRIPTION	ESTIMATE BASED ON HISTORICAL PROJECTS	COMMENTS
BID ESTIMATE SUMMARY			
2.1	GUIDEWAY EQUIPMENT	$ 3,037,000	
2.2	STATION EQUIPMENT	$ 937,000	
2.3	MAINTENANCE AND STORAGE FACILITY EQUIPMENT	$ 1,664,000	
2.4	POWER DISTRIBUTION SYSTEM EQUIPMENT	$ 600,000	
2.5	AUTOMATIC TRAIN CONTROL EQUIPMENT	$ 1,500,000	
2.6	COMMUNICATIONS EQUIPMENT	$ 150,000	
2.7	CARS	$ 17,865,000	
2.8	OTHER OPERATING SYSTEM EQUIPMENT OR FACILITIES	$ 2,968,000	
2.9	OPERATING SYSTEM VERIFICATION AND ACCEPTANCE	$ 1,330,000	
2.10	OPERATING SYSTEM CONTRACTOR'S PROJECT MANAGEMENT AND ADMINISTRATION	$ 9,570,000	
SYSTEM TOTAL		$ 39,620,000	
30% CONTINGENCY FACTOR		$ 12,250,000	
TOTAL (ESTIMATE YEAR)		**$ 51,870,000**	
Escalation from Current Date to Bid Date		1	
TOTAL		**$ 51,870,000**	

NOTE: This ROM estimate should be considered with caution, is only indicative, and should not be used to establish a budget.
JTA should first confirm that Overhaul is possible (see RFIF). Uncertainties are 1) uncertainty of the propulsion overhaul;
2) potential sole source procurement; ' 3) Performance procurement documents, terms and condition and detailed scope of work.

Table 4-1: Option 1- Operating System Tentative Overhaul ROM Cost estimate (see discussion above)

4.1.3 Infrastructure Cost Estimates

The Infrastructure cost estimates for Options 1 and 2 are identical. These cost estimates have been developed for the rehabilitation, extension, and demolition of the Skyway System. The following summary will briefly outline the findings for the Near, Mid, and Long term for the Skyway system. It is important to note, that these costs are for infrastructure only, and do not include the costs of electrical, mechanical, vehicle costs, etc. These cost estimates also do not include the additional costs associated with right-of-way, environmental impacts, alternative means of transportation, or land repurposing. A more detailed study will be required for both the Skyway extension and the Skyway demolition in order to capture all of these additional costs.

4.1.3.1 Infrastructure Near Term Estimate

The Near term estimates associated with the Skyway rehabilitation include routine maintenance costs and recommended near term repairs only. The routine maintenance costs were not included in this analysis, as they are current and ongoing for the life of the structure. It is assumed that the current maintenance costs will remain the same for the next 0-5 years.

The L+E Team recommended near term Repairs for the infrastructure include items identified during our assessment as well as items included in the JTA Mini Rehabilitation Plan as shown in the table 4.1.3.1 below. We recommend that these items be performed in the near term regardless of selected alternative.

The total estimate for these items is $2.8M to $3.4M. This is in addition to normal routine maintenance costs. The estimates provided are conceptual and are for planning purposes only, as the actual cost will be dependent on the actual scope of services performed and on whether the work is performed by JTA or contracted forces and if so the actual bid prices received. We recommend that a detailed plan and estimate be prepared prior to the implementation of any of the near term recommended repairs.

Infrastructure Health Map Estimates for Rehabilitation Near Term (0-5 Years)		
Item Description	**Low**	**High**
Guideway Infrastructure:		
Drainage Repairs and Maintenance	$ 50,000	$ 60,000
Vegetation Trimming	$ 50,000	$ 60,000
Cleaning and Repairing Spalls in Deck & Piers	$ 1,000,000	$ 1,200,000
Expansion Joint Repair	$ 30,000	$ 40,000
Steel Beam Spot Painting	$ 280,000	$ 340,000
Steel Beam Maintenance Access Locks	$ 1,000	$ 2,000
Skyway Stations:		
Cleaning and Repairing Spalls in Concrete	$ 150,000	$ 180,000
Drainage Repairs and Waterproofing*	$ 80,000	$ 100,000
Fire Alarm and Security System*	$ 600,000	$ 720,000
Contingency & Misc. Elements (25%)	$ 570,000	$ 690,000
Total Estimate Near Term	**$ 2,820,000**	**$ 3,400,000**

Table 4-2: Near Term Infrastructure Cost Estimate

4.1.3.2 Mid Term Estimate

The Mid Term recommended rehabilitation estimates are based upon the findings and recommendations from the site inspection reports provided by G.M. Hill Engineering, Inc. and FIT Engineering, LLC. With these findings, we have extrapolated a cost by utilizing FDOT standard pay items. We have also included items identified in the JTA Mini Rehabilitation plan that are recommended for implementation if the selected alternative is Option 1 (Overhaul) or Option 2 (Replace the existing vehicles using existing infrastructure). These items and estimated low and high range are shown in table 4.1.3.2 below.

It is important to note that if an alternate is selected that requires modification of the existing infrastructure an updated estimate should be prepared based on a detailed engineering study.
The total estimated cost for these items is $26.1M to $31.4M. This is in addition to normal routine maintenance costs. The estimates provided are conceptual and are for planning purposes only, the actual cost will be dependent on the actual scope of services performed and on whether the work is performed by JTA or contracted forces and if so the actual bid prices received.

We recommend that a detailed implementation plan and estimate be prepared as part of an annual capital improvement program prior to implementation of any of the mid-term recommended repairs. This plan and estimate should be revised and updated regularly using information from regular inspections and the skyway rehabilitation plan. Also the implementation plan should consider available budget and scheduling of other activities such as vehicle refurbishment and special events. In order to pro-long the life of the system it is recommended that all of the mid-term recommendations be performed as soon as feasible if options 1 or 2 are selected.

Infrastructure Health Map - Estimates for Rehabilitation Mid Term (5-15 Years)		
Item Description	**Low**	**High**
Guideway Infrastructure:		
Drainage Repairs - Engineered Solution	$ 210,000	$ 260,000
Vegetation Trimming	$ 50,000	$ 60,000
Walkway Galvanic Coating	$ 670,000	$ 810,000
Expansion Joint - Engineered Solution	$ 2,220,000	$ 2,670,000
Steel Beam Coating	$ 2,730,000	$ 3,280,000
Load Rating of Existing Structure	$ 2,000,000	$ 2,400,000
Map and monitoring the Cracks in Pier Elements	$ 200,000	$ 240,000
Skyway Stations:		
Repair/Replace Corroded Elements	$ 800,000	$ 960,000
Painting of Metal Elements	$ 340,000	$ 410,000
Replace Failed Expansion Joints	$ 800,000	$ 960,000
Maintenance to Concrete Spalls	$ 150,000	$ 180,000
Drainage Repairs and Waterproofing	$ 240,000	$ 290,000
Elevator Rehabilitation	$ 550,000	$ 660,000
San Marco Escalator Replacement	$ 1,800,000	$ 2,160,000
Station and O&M Center Roof Replacement	$ 1,500,000	$ 1,800,000
Station Lighting	$ 1,900,000	$ 2,280,000
Station Public Address (PA) System	$ 190,000	$ 230,000
Station Translucent Roof Replacement	$ 2,000,000	$ 2,400,000
Other		
Acosta Bridge Lighting	$ 2,000,000	$ 2,400,000
Temporary Maintenance Facility Enclosure	$ 250,000	$ 300,000
Maintenance Facility Expansion	$ 300,000	$ 360,000
Contingency & Misc. Element (25%)	$ 5,230,000	$ 6,280,000
Total Estimate Mid Term	**$ 26,130,000**	**$ 31,390,000**

Table 4-3: Mid Term Infrastructure Cost Estimate

4.1.3.3 Long-Term Costs

The Long-term cost for the Skyway rehabilitation has not been provided, as this value cannot be satisfactorily quantified with any level of confidence. As the Skyway system ages, additional structural elements may deteriorate and require replacement. This structural repair will inevitably lead to time out-of-service, which could incur additional costs. It can be surmised that as the Skyway system reaches the end of its service life, the associated costs will continue to rise at an ever increasing rate.

4.1.4 Infrastructure Skyway Extension Cost Per Mile

The Skyway extension costs are given on a per mile basis for an in-kind system. The cost estimate provided is based on two guideways, each with a concrete double tee superstructure, both of which are supported on a single hammerhead or "T" shaped pier. It is also assumed that for every mile of Skyway extension, there will be an additional Skyway station.

Quantities for the track have been developed using the As-Built Drawings of the South Line Extension dated October 23, 2001. The cost is based on the FDOT Listing of Master Pay items, LRE Reference Price (8/28/14 – 10/26/17) for each of the calculated quantities.

The per mile cost for the Skyway extension is for the infrastructure of the new track and new stations only. This per mile estimate does not include the additional cost required to rehabilitate the existing portions of the Skyway system. For example, the cost of an additional five miles of track will be

$$(5\ miles\ of\ track\ extension) \times \$30M/mile = \$150M$$

$$Rehabilitation\ of\ existing = \$13M$$

$$Total = \$150M + \$13M$$

$$\underline{Total = \$163M}$$

4.1.5 Skyway Demolition

4.1.5.1 General

The JTA requested the Lea+Elliott Team to evaluate the cost of demolition for the Skyway. The Judiciousness of demolishing the existing Skyway structure is a JTA decision in consultation with the City of Jacksonville and other stakeholders. **The Lea+Elliott Team assignment is limited to the performance of a technology assessment and as such the recommendation of demolition or not of the Skyway structure is not part of its scope of work.** The rough costing estimate is presented below.

4.1.5.2 Demolition Cost

The estimated cost of demolition for the Skyway including the guideways and stations is $20-$25M. This is based on the estimates provided in the FDOT Bridge Development Report (BDR), which has been extrapolated to provide a cost per mile and assuming a total system length of 3 miles. The cost of station removal has been estimated as a lump sum value of $750,000 to $862,500 each.

The estimate does not include demolition of the main river crossing which is integral to the Acosta Bridge and which could affect the integrity of the structure. There are additional cost implications that will be incurred by abandoning the system which are not included in this analysis. These include the costs related to environmental impacts, alternative means of transportation to those affected by the Skyway closure, and the costs associated with land repurposing/sale. Also the estimate does not consider any salvage values or sale value of surplus right of way and property. In order to capture all of these associated costs, a detailed study should be performed.

4.2 OPTION 2- REPLACEMENT WITH A SIMILAR VEHICLE "IN-KIND"

4.2.1 General

Option 2: "Replacement in-kind with a similar vehicle and Overhaul of the Infrastructure" was discussed in depth in section 3.0 "RFIF".

4.2.2 Operating System Cost estimate

Given that no supplier has shown interest in this option, and the high level of uncertainty, there is no historical basis to price this option. The JTA felt that it was important nonetheless to present a cost estimate even if the feasibility of Option is in question.

Based on the above, the estimate presented below appears to be an academic exercise and should be considered as such.

The assumptions used to derive this "tentative" ROM cost estimate are listed below:

1. Use the Overhaul cost estimate for all subsystems, except Vehicle and Train Control,
2. For Vehicle costs consider the following: a new APM car costs between $2 Million and $3 Million; say, $2.0 Million for a low end estimate, and $4.5 Million for a high end estimate (considering a 50% premium on $3 Million). The range of $2 Million to $4.5 Million would also include the cost of a vehicle that is modified to fit the Skyway infrastructure (see RFIF Option 3).
3. For Train control, the assumption is that the supplier will be Thales (formerly Alcatel, original provider for the Jacksonville Monorail); consider all interface between new vehicle and train control supplier; design reviews, EMC, block design etc. Add about $2 Million in engineering and Test and commissioning costs.

OPTION 2- REPLACEMENT OF EXISTING VEHICLE IN-KIND
OPERATING SYSTEM COST ESTIMATE

Estimated for Year:	July 13 2015
Bid Date:	July 13 2015
Date Estimate Prepared:	July 13 2015

ITEM	DESCRIPTION	ESTIMATE BASED ON HISTORICAL PROJECTS LOW	ESTIMATE BASED ON HISTORICAL PROJECTS HIGH
BID ESTIMATE SUMMARY			
2.1	GUIDEWAY EQUIPMENT	$ 3,037,000	$ 3,037,000
2.2	STATION EQUIPMENT	$ 937,000	$ 937,000
2.3	MAINTENANCE AND STORAGE FACILITY EQUIPMENT	$ 1,664,000	$ 1,664,000
2.4	POWER DISTRIBUTION SYSTEM EQUIPMENT	$ 600,000	$ 200,000
2.5	AUTOMATIC TRAIN CONTROL EQUIPMENT	$ 3,500,000	$ 3,500,000
2.6	COMMUNICATIONS EQUIPMENT	$ 150,000	$ 150,000
2.7	CARS	$ 40,000,000	$ 90,000,000
2.8	OTHER OPERATING SYSTEM EQUIPMENT OR FACILITIES	$ 2,968,000	$ 2,968,000
2.9	OPERATING SYSTEM VERIFICATION AND ACCEPTANCE	$ 133,000	$ 1,330,000
2.10	OPERATING SYSTEM CONTRACTOR'S PROJECT MANAGEMENT AND ADMINISTRATION	$ 9,275,000	$ 9,275,000
SYSTEM TOTAL		$ 62,260,000	$ 113,060,000
30% CONTINGENCY FACTOR FOR LOW ESTIMATE AND 20% FOR HIGH ESTIMATE		$ 18,670,600	$ 22,610,000
TOTAL (ESTIMATE YEAR)		**$ 80,930,000**	**$ 135,670,000**
Escalation from Current Date to Bid Date		1	1
TOTAL		**$ 80,930,000**	**$ 135,670,000**

NOTE: This estimate should be considered with caution and is only indicative. No interest was expressed as part of the RFIF process.

Table 4-4: Option 2- Replacement of vehicle "in-kind" ROM (see discussion above)

4.2.3 Infrastructure Cost Estimate

The Infrastructure Cost estimate for Option 2 is identical to that of Option 1. Please refer to Section 4.1.3 for details.

4.3 OPTION 3- STREETCAR

4.3.1 General

Option 3 selected by the JTA includes streetcars on a dedicated lane as a replacement of the existing Skyway Monorail System.

In order to provide a reasonable understanding of the nature of streetcars, we have researched the literature and identified two references where streetcars are defined.

- *TCRP 86, "Relationship between Streetcar and the built Environment" includes a discussion about the definition of a streetcar. In the report, the following is stated: "A challenge in considering Streetcars is the lack of a common and consistent definition of what constitutes a streetcar as opposed to a light rail system. Furthermore, some systems blend characteristics of these two modes. For example, the LINK system in Tacoma, Washington, is termed "light rail" by SoundTransit, its operator, even though its vehicles are the same as those used in the Portland and Seattle streetcar systems. For this synthesis, a broad definition of streetcar systems was used that builds on rail advocacy organization Reconnecting America's typology of streetcars. Streetcar systems typically run in the street at grade on embedded rails, stop every several blocks, operate at average speeds of less than 12 mph, and have lower construction cost per mile than light or commuter rail."*

- *APTA's brochure: "Light Rail and Street Car System, How They Differ; How They Overlap" dated October 2014 includes an attempt to differentiate LRT and Streetcar Systems.*

For the purpose of this study, we will consider a wide definition of streetcars. In Section 4.3.2, vehicle products are described that could be used in the City of Jacksonville along with their technical characteristics

4.3.2 Light Rail Transit (LRT) / Tram / Streetcar- Technology Overview

4.3.2.1 Alstom Citadis 402

Alstom, headquartered in France, has implemented its self-propelled, steel-wheeled Citadis tram in over 40 cities around the world of varying models. These systems are guided by steel rails, utilize on board rotary electric motors and can operate as trains of 3- to 7-cars. Power is supplied via overhead catenary, a power rail embedded in the guideway (called APS) or by on board batteries (for recovery only). They are typically manually operated.

Examples of system implementations of the Alstom Citadis tram are provided further below.

Alstom Citadis Tram Characteristic	Value
Vehicle length	143.4 ft. (7 cars)
Vehicle width	7.5 – 8.7 ft.
Vehicle weight (unloaded)	20,000 – 25,000 lb./axle
Vehicle capacity	300 (7 cars)
Vehicle range	Unlimited (system has continuous power)
Maximum speed	31 mph
Minimum horizontal curve radius	82 ft.

Table 4-5 Alstom Citadis tram vehicle specifications

Figure 4-1: Alstom Citadis 402, Bordeaux, France

Figure 4-2: Alstom Citadis 402, Paris, France

Figure 4-3: Alstom Citadis 402 vehicle interior

Figure 4-4: Alstom Citadis guide rails and APS embedded power rail, Tours, France (Image: Alstom, www.raillynews.com)

4.3.2.2 Bombardier Flexity 2

Bombardier has implemented its self-propelled, steel-wheeled Flexity tram in over 40 cities around the world. These systems are guided by steel rails, utilize on board rotary electric motors and can operate as trains of 3- to 7-cars. Power is supplied via overhead catenary wire or by contactless, wireless charging using inductive energy transfer between underground components and receiving equipment beneath the vehicle (called Primove). They are typically manually operated.

An example of a system implementation of the Bombardier Flexity 2 tram is provided further below.

Bombardier Flexity 2 tram characteristic	Value
Vehicle length	105.6 ft. (5 cars)
Vehicle width	7.5 – 8.7 ft.
Vehicle height	11.2 ft.
Vehicle weight (unloaded)	81,791 lb. (5 cars)
Vehicle capacity (@ 4 pax/m^2)	222 (5 cars)
Vehicle door opening (clear width)	4.3 ft.
Vehicle range	Unlimited for catenary power (system has continuous power); determined by charging system spacing for Primove
Maximum speed	43 mph
Minimum horizontal curve radius	82 ft.

Table 4-6: Bombardier Flexity 2 tram vehicle specifications

Figure 4-5: Bombardier Flexity 2, Blackpool, England, UK

Figure 4-6: Bombardier Flexity 2, Blackpool, England, UK (Image: Bombardier)

Figure 4-7: Bombardier Flexity 2 vehicle interior, Blackpool, England, UK (Image: Bombardier)

Figure 4-8: Bombardier Flexity guidance system (Image: Bombardier)

4.3.2.3 Brookville Liberty Modern Streetcar

Brookville Equipment Corporation, headquartered in the United States, introduced its self-propelled, steel-wheeled Liberty Modern Streetcar in 2011. This system is guided by steel rails, utilizes on board rotary electric motors and operates as trains of 3-cars. Power is supplied via overhead catenary or by on board batteries. They are manually operated.

An example of a system implementation of the Liberty Modern Streetcar is provided further below.

Brookville Liberty Modern Streetcar Characteristics	Value
Vehicle length	66.4 ft. (3 cars)
Vehicle width	8.0 – 8.7 ft.
Vehicle weight (unloaded)	63,960 lb. (without off-wire capability)
Vehicle capacity	135 - 149 (3 cars, AW3)
Vehicle range	Unlimited (on-wire), not available (off-wire)
Maximum speed	44 mph
Minimum horizontal curve radius	59 ft.

Table 4-7: Brookville Liberty Modern Streetcar vehicle specifications

Figure 4-9: Brookville Liberty Modern Streetcar, Dallas, Texas, USA (Image: DART)

Figure 4-10: Brookville Liberty Modern Streetcar vehicle interior (Image: Brookville)

4.3.3 United Modern Streetcar

United Streetcar, headquartered in the United States, is a division of Oregon Iron Works, Inc. It introduced its self-propelled, steel-wheeled modern streetcar in 2009. This system is guided by steel rails, utilizes on board rotary electric motors and operates as trains of 3-cars. Power is supplied via overhead catenary or by on board batteries. They are manually operated. It has been reported that United Streetcar was dissolved in February 2015.

Examples of system implementations of the United Modern Streetcar are provided further below.

United Modern Streetcar vehicle Characteristic	Value
Vehicle length	66 ft. (3 cars)
Vehicle width	8.0 ft.
Vehicle weight (unloaded)	71,000 lb.
Vehicle capacity	157 (3 cars, AW3)
Vehicle range	Unlimited (on-wire), not available (off-wire)
Maximum speed	44 mph
Minimum horizontal curve radius	59 ft.

Table 4-8: United Modern Streetcar vehicle specifications

Figure 4-11: United Modern Streetcar, Portland, Oregon, USA (Image: United Streetcar)

Figure 4-12: United Modern Streetcar, Tucson, Arizona, USA (Image: Tucson.com)

Figure 4-13: United Modern Streetcar vehicle interior, Portland, Oregon, USA

4.3.4 Summary of LRT / Tram / Streetcar Systems

Table 4-5 below provides a summary of four representative tram and streetcar systems: Bordeaux, France (Alstom), Blackpool, England, UK (Bombardier), Dallas, TX, USA and Portland, OR, USA.

	Bordeaux Tram	Blackpool Tram	Dallas Streetcar	Portland Streetcar
Developer/Manufacturer	Alstom	Bombardier	Brookville	United Streetcar
Development Status	Operating	Operating	Operating	Operating
Guidance system	Steel rail, embedded	Steel rail, embedded	Steel rail, embedded	Steel rail, embedded
Current System Length	27.3 mi.	11.2 mi.	1.6 mi.	7.2 mi.
Fleet Size	74 trainsets	16 trainsets	2 trainsets	17 trainsets
Vehicle Capacity	300 (7 cars)	222 (5 cars)	135-149 (3 cars)	157 (3 cars
Max. Estimated Speed	37 mph	43 mph	44 mph	44 mph

Table 4-9: Summary of LRT / Tram / Streetcar Systems

4.4 STREET CAR ROUTES AND EXISTING PLANNING

4.4.1 Streetcar Study Background

As the JTA moved forward with the planning and design of its bus rapid transit (BRT) system providing premium transit service along four primary corridors, additional multimodal studies were initiated to further explore the transportation options to augment connectivity to the BRT and enhance mobility to all areas of Jacksonville.

The JTA Streetcar Pre-Feasibility Study (Pre-Feasibility Study) was one of those studies launched in 2008 to examine the feasibility of streetcar technology to connect the BRT corridors to downtown employment and adjacent activity areas; serving as both a downtown circulator and the "last mile of a trip."

Since project development processes can be costly and timely, the "pre-feasibility" study level was conducted as a means to evaluate streetcar technology at a conceptual level; yet with a high degree of engagement with multiple stakeholders groups in order to narrow the focus of more detailed subsequent project studies.

The following paragraphs provide an overview of the Pre-Feasibility Study as background information for consideration in the streetcar option.

The Pre-Feasibility Study was a conceptual level study based on limited data and evaluation. The primary goals of the Pre-Feasibility Study were to:

- Define Potential Streetcar Districts
- Develop a District Concept
- Define a Basic Implementation Strategy
- Define Next Steps for Future Streetcar Exploration

Streetcar technologies typically serve a defined area or districts, with shorter trips. Additionally, in many cities, streetcars are contributing to redevelopment of urban areas spurring economic opportunities along or adjacent to an alignment. The Pre-Feasibility Study identified potential “candidate” districts within the Northbank and Southbank areas of Downtown Jacksonville and evaluated those districts on a conceptual level using general criteria essential to a implementing a streetcar project as described below.

Following the initial district boundary evaluation, the following were identified as the candidate, recommended districts for the application of the streetcar district criteria.

- Core (identified as a common area between the districts, not a stand-alone district)
- Riverside/Avondale
- 5 Points/Brooklyn + Core
- LaVilla + Core
- Springfield + Core
- Sports Complex + Core
- South/San Marco + Core

The evaluation of the districts used weight factors and ranking process for each of the key streetcar district criteria. None of the streetcar district boundaries cross the St. Johns River, thus no alignments consider a connection across the river at this time. It was anticipated that the Skyway and the BRT would serve these river crossing needs as envisioned at the time of the Streetcar Pre-Feasibility Study.

4.4.2 Recommended District and Conceptual Streetcar Alignments

Based on the district assessment, the 5 Points/Brooklyn/Core was identified as the potential initial streetcar district for further review in the Streetcar Pre-Feasibility Study. Subsequent evaluation considered general streetcar characteristics, as well as, available streetcar technologies as outlined below.

Evaluating the possible linkages of activity centers, connectivity to committed projects and development potential within the district, two possible alignment options were considered for the 5 Points/Brooklyn/Core district – one using the Riverside Avenue Bridge and one using the Park Street Bridge. These possible alignments include both single track and double track options.

The Pre-Feasibility Study concluded with a dialogue concerning potential funding strategies and financing options for the construction and long term operation of the streetcar system. These funding and finance options are continually changing and various funding sources would be evaluated again in each subsequent phase of study.

4.4.3 Existing Planning Efforts

JTA's transit system has been undergoing a major transformation. A recent route optimization initiative in December 2014 has modified every existing bus route in the system and altered the way some services are integrated, such as the community shuttle and the Skyway.

As part of the transit service integration, JTA has continued to look at multiple modes since the Streetcar Pre-Feasibility Study in 2008. In addition to advancing the BRT program which commenced in 2000, JTA has conducted a Waterborne Transportation Feasibility Study and is now in the next phases of the Commuter Rail Feasibility Study, having recently completed a Commuter Rail System Plan and advancing to the next phase of project development with a preferred corridor.

Additionally, for several years JTA has been evaluating the nexus of all of these transit services, considering the redevelopment of the area surrounding the Prime Osborn Convention Center and Convention Center Skyway Station along Bay Street for a new regional transportation center. The Jacksonville Regional Transportation Center (JRTC) would serve connections of all modes, including intercity bus, such as Greyhound, and bringing passenger rail back to its Downtown, with the relocation of the Amtrak service to the proposed JRTC.

The recent route optimization effort was essential to provide more efficient and accessible transit options for the community; and was essential to readying the existing system for the integration of premium transportation services such as BRT and commuter rail.

The Alternatives Analysis for the BRT was completed in 2006. The BRT program includes four corridors which extend more than 12 miles into the various quadrants of the city and the surrounding communities. These corridors are known as:

- North Corridor (primarily along Lem Turner Road)
- Southeast Corridor (primarily along US 1, south of Downtown)
- East Corridor (primarily Arlington Expressway/Beach Blvd connecting to the Beaches communities)
- Southwest Corridor (primarily along SR 21 Blanding Boulevard)

Connecting these four corridors is the north-south Downtown alignment currently under construction, along the one-way pair system of Broad Street and Jefferson Street, and a key connection point at the Convention Center Skyway Station.

It is recommended that more detailed study should be advanced to fully consider the streetcar technology integration as a possible option to provide the connectivity to the existing bus, BRT and future transit modes under consideration by the JTA.

4.4.4 Other Planning Considerations

The implementation of the streetcar technology and its integration into the existing transit system, as a potential replacement of the automated people mover system in Downtown, the Skyway, will require consideration and assessment of the following key roadway environment features.

Existing Roadway Network

- Effect on Traffic
- Right of way requirements / restrictions
- Roadway pavement, drainage, lighting, etc.

Traffic Conditions

- Traffic Volumes and Capacity
    - Travel speeds
    - Future projections for corridor
    - One way versus two way operations
- Signalized Intersections
- Safety Issues
    - Accident Data
- Truck Volumes and Travel Patterns

Parking

- Curbside parking areas
- Meter locations
- Parking garage access points

Transit Interface

- Existing Bus Routes
- Existing Bus Stop Locations
- Integration with BRT routes and facilities
- Transit Stop/Shelter locations
- Terminal station Areas – Rosa Parks transit Station, Kings Avenue Station and Convention Center Station
- Future regional transportation center integration

Pedestrian Facilities

- Sidewalks
- Pedestrian Signalized Crosswalks

Bicycle Facilities and Usage

- City of Jacksonville Bicycle Plan
- Bike Share Program

Streetscape and Aesthetics

- Integration and Coordination with Downtown and Neighborhood plans

Existing Skyway

- Disposition of existing skyway infrastructure
- Redevelopment or re-purpose of Skyway station areas

Urban Design Requirements

- Stakeholder Criteria
    - City of Jacksonville Codes & Ordinances
    - FDOT
    - DIA
    - DDRB
- Historical Considerations
- Compatibility with Adjacent Land Use
    - Predominant types of land uses
    - Outdoor dining locations
- Wayfinding/Transit Signage

Redevelopment and Economic Development

- Consideration of effect on economic development
- Integration with zoning / planning
- Downtown redevelopment efforts (Shipyards, The Landing, etc.)

Project Implementation Considerations

Coordination of project implementation with work programs of partner agencies.

- City of Jacksonville
    - Public Works projects
- FDOT
    - Resurfacing/
    - Traffic Signal and Safety Upgrades
- JTA
    - JTAMobilityWorks Transit Enhancements
    - JTAMobilityWorks Complete Streets
    - JTAMobilityWorks Roadway projects
- Utility Coordination
- Traffic Management Center

4.5 STREETCAR CHARACTERISTICS (OPERATING SYSTEM)

Streetcars exhibit the following typical characteristics:

Characteristics	Streetcar
Operation	Operation in mixed traffic or dedicated lanes
Track	
Maximum grade	9%
Minimum curves	60 ft.
Type	Embedded rails in street surface
Stations	
Size	Single-car length
Spacing	Several city blocks
Location	Sidewalk extension
Amenities	Pedestrian access, minimal shelter, minimal seating, nearby street lighting
Power Supply	
Substations	< 1MW spaced less than one mile apart
Overhead Wire	Simple trolley wire with pole supports, span wire connected to poles on sidewalks or attached to adjacent buildings
Embedded Power rail	Electronic or Electromagnetic control
Signals	
Train Separation	Line of sight
Traffic Priority	Pre-emption. Interface with traffic signal controllers
Central Control	Streetcar location display from external systems
Communications	
Operator Dispatch	Radio channels or cell phone
Passenger Information	Active Signage
Passenger Security	Sidewalk, line of sight
Fare Collection	Simple ticket machines at stops and/or on-board; onboard fareboxes Operator monitor or proof-of-payment with inspection

Table 4-10: Typical Characteristics of Streetcar Systems (source: APTA)

4.6 STREET CAR INSERTION INFRASTRUCTURE

This preliminary investigation examined the conceptual insertion of the streetcar in the anticipated routes: available clearances, spaces, modification to roadway and traffic, and anticipated challenges. Important issues to consider include streetcar in dedicated vs shared traffic lane, overhead catenary vs underground power systems, one-way vs two way operation, consideration of environmental and right of way impacts, underground conflicts, streetcar stops and motorist and passenger access and safety.

4.6.1 Description of Streetcar Option

This section of the report outlines key assumptions and considerations for the implementation of streetcar technology along the existing Skyway alignment. This streetcar option assessment is preliminary and additional more detailed technical analyses will be required to further define the design parameters, alignment, implementation and operational requirements; and potential impacts on the existing road network and adjacent land uses. Specifically, this section of the report addresses:

- Conceptual Design and Vehicle Assumptions
- Conceptual Streetcar Alignment
- Conceptual Typical Sections
- Future Analysis and Operations Considerations

4.6.2 Conceptual Streetcar Option Design and Vehicle Assumptions

For the purposes of this preliminary streetcar evaluation, the conceptual streetcar alignment follows the general alignment of the existing Skyway system. General design assumptions for the conceptual streetcar alignment include:

- Dedicated lane along curb
- Two-way operation
- Underground power versus overhead catenary
- Minimum 11 foot wide travel lane
- Utilization of existing parking lane or existing traffic lanes depending on road facility

Preliminary design assumptions and alignment considerations identified for this conceptual study are based on references from the document, *DC Streetcar Criteria*, developed by the District Department of Transportation (DDOT), June 2012; and the previous *JTA Streetcar Pre-Feasibility Study*, prepared in 2008. The conceptual alignment is discussed in more detail later in this section.

Assumed Vehicle - Brookville Liberty Modern Streetcar

The streetcar vehicle identified for this preliminary assessment is the Brookville Liberty Modern Streetcar (see Section 4.3.2.3).

4.6.3 Design Vehicle Parameters and Operating Environment

- 30 mph maximum design speed
- Station stops via curb extensions to accommodate all doors on streetcar (3 car)

Additional design parameters for the vehicles are depicted in the following *Comparison of Current and Future Vehicles* table.

Comparison of Current and Future Vehicles						
Vehicle Identification	**Existing (2- car)[1] Bombardier UMII**	**Existing (3- car)[1] Bombardier UMII**	**Bombardier Flexity 2 (5-car)**	**Brookville Liberty Modern (3-car)**	**United Modern (3-car)**	**Portland Street Car (5-car)**
Guidance System:	Center Concrete Beam	Center Concrete Beam	Street Car	Street Car	Street Car	Street Car
Vehicle Length (ft.)	48	68	70	66.4	66	90
Vehicle Width (ft.)	7.0	7.0	8.0	8.5	8	8.75
Vehicle Height (ft.)	9.0	9.0	11.2			11
Unloaded Vehicle Weight (lb.)	26,100	33,100	81,791	63,960	71,000	92,150
Normal Vehicle Weight (lb.)	35,188	46,732	106,879	80,760	88,536	112,950
Crush Vehicle Weight (lb.)	39,540	53,260	111,658	83,960	91,907	118,710
Vehicle Capacity (persons, AW1)	56	84	140	149	157	211
Vehicle Door Opening (clear width)			4.3			4.33
Vehicle Range	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
Maximum Speed (mph)	35	35	43	44	44	44
Minimum Curve Radius (ft.)	100.0	100.0	82.0	59.0	59.0	82.0

Note 1 : Data Shown Represents Total System

Table 4-11: Vehicle Comparison

4.6.4 Conceptual Streetcar Alignment

The conceptual streetcar alignment for this preliminary evaluation generally follows the existing Skyway alignment. An overview of the conceptual streetcar alignment is depicted in the figure titled *Conceptual Streetcar Overview.* This option is different than the recommended streetcar alignment identified in the *2008 JTA Pre-Feasibility Streetcar Study.* The recommended streetcar alignment in the *Pre-Feasibility Study* was the 5 Points/Brooklyn/Core alignment.

Beginning on the Southbank at the southern terminus at the Kings Avenue Garage/existing Skyway Station, the conceptual streetcar alignment proceeds north from the Kings Avenue Station area along to Prudential Drive, then continues west along Prudential Drive, as a two-way operation, using the curbside travel lane in each direction. The alignment continues west on Prudential Drive and turns north on San Marco Blvd accessing the Acosta Bridge at Mary Street.

The streetcar alignment traverses the Acosta Bridge and exits to the east onto the Northbank of Downtown Jacksonville at Water Street. The alignment proceeds east along Water Street to Hogan Street; then turns north along Hogan Street to Rosa Parks Transit Station. The streetcar alignment would circle the transit station then continues along the route to Pearl Street.

The alignment then proceeds south on Pearl Street, continuing to Bay Street. Then west on Bay Street, continuing on Bay Street, then turns into the Convention Center Station.

The alignment then exits Convention Center Station on the north side of the property traveling east on Forsyth Street to Park Street then south on Park Street to Water Street. The alignment would then travel east on Water Street to the Acosta Bridge, crossing to the Southbank, returning to Prudential Drive, and east to Kings Avenue, entering the Kings Avenue Station.

Alignment Section	Track Route Limits	Estimated Track Miles
Southbank	Prudential Dr. to Onyx St. to Kings Ave. to Prudential Dr. to San Marco Blvd. to Mary St.	~1.3
River Crossing Northbound	Mary St. to Water St.	~0.7
River Crossing Southbound	Water St. to Prudential Dr.	~0.8
Northbank	Water St. to Hogan St. to Pearl St. to Bay St. to Water St.	~2.6
Total	Streetcar Route Loop	~5.4

The alignment described herein is for illustrative purposes only. One could also envisage two streetcar lines, similar to the ones in use on the Jacksonville Monorail System. Such operation would require a merge in the area of Water, where the two lines merge. Such merge will require special trackwork to ensure that all requirements streetcar movements (merge, diverge, straight/tangent) are possible.

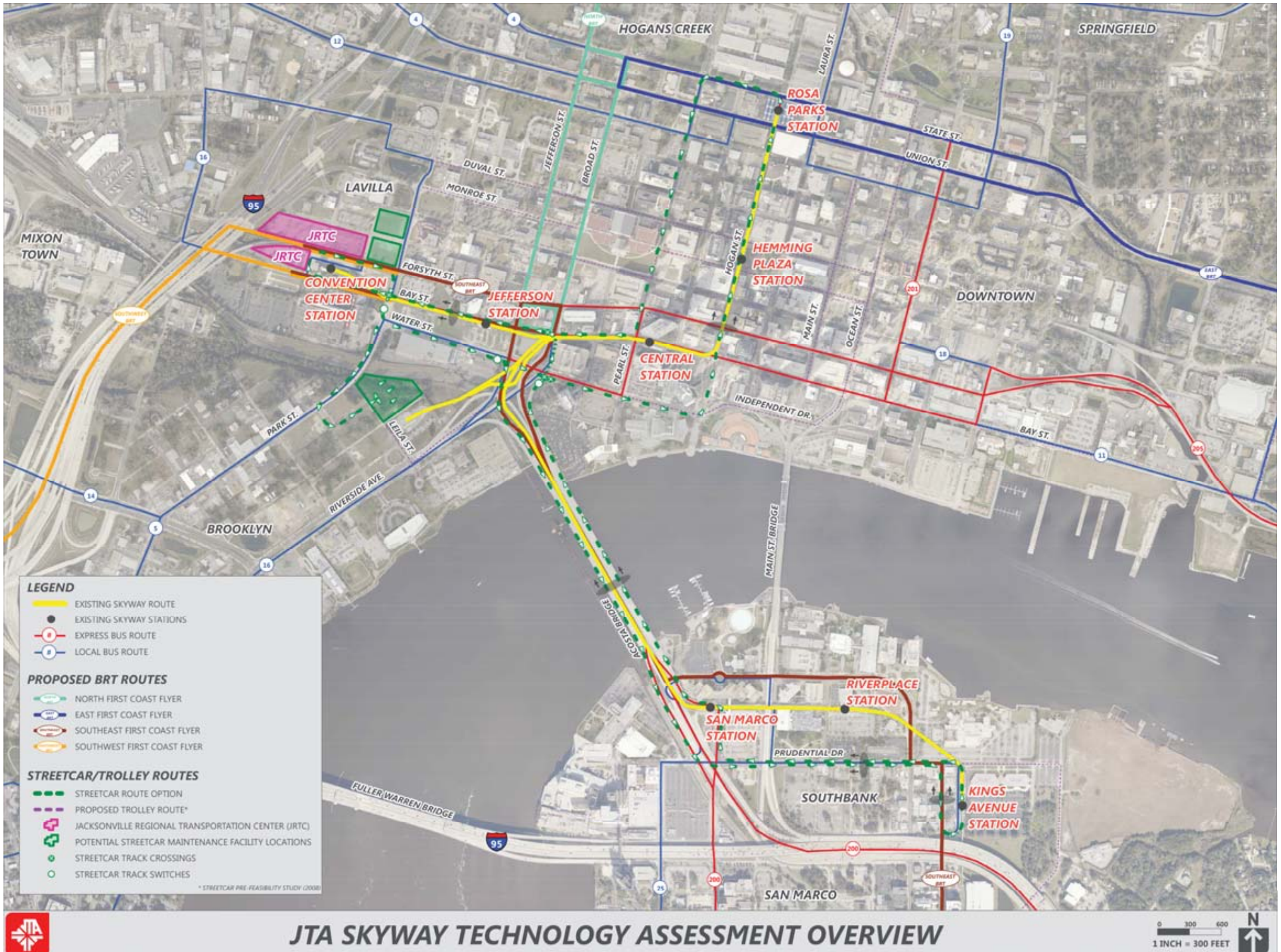
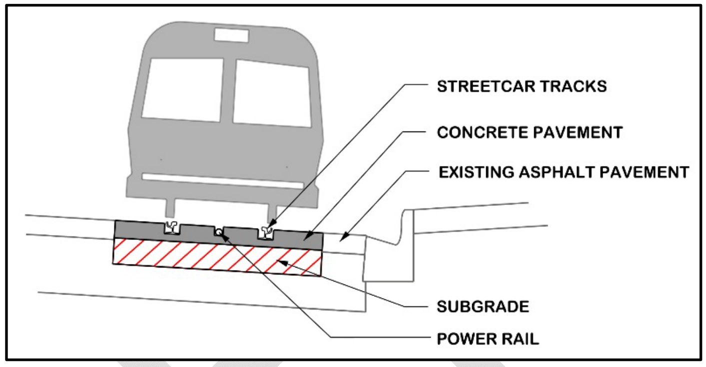


Figure 4-14: Streetcar Alignment

4.6.5 <u>Conceptual Typical Sections</u>

Based on the current alignment of the Skyway and the previously stated design assumptions, conceptual typical sections have been developed along the following roadway segments. The conceptual typical sections assume that the streetcar would occupy the curbside travel lane, or parking lane, if available. The following detail illustrates the assumed typical section.

- Kings Avenue, south of Prudential Drive and immediately west of the Kings Avenue Skyway Station
- Prudential Drive, east of Main Street
- Bay Street, west of Jefferson
- Hogan Street, north of Forsyth Street



Pearl Street was identified as the southbound route, opposite of Hogan Street northbound route, due to its transit use of the existing bus system. An option for Hogan Street would be to analyze it as a "transit only" corridor, providing the two way operation in one corridor versus the Hogan Street-Pear Street pair.

The typical sections are conceptual, and further analysis and evaluation of adjacent land uses, driveways, utility locations, etc. would determine the necessary modifications to the proposed concepts. The conceptual typical sections are illustrated in schematics following this discussion. Consideration was also given to an option along Mary Street in the vicinity of the existing Riverplace Skyway Station below the existing Skyway alignment. The Mary Street alignment could possibly considered for a transit only corridor, providing direct access to the Acosta Bridge.

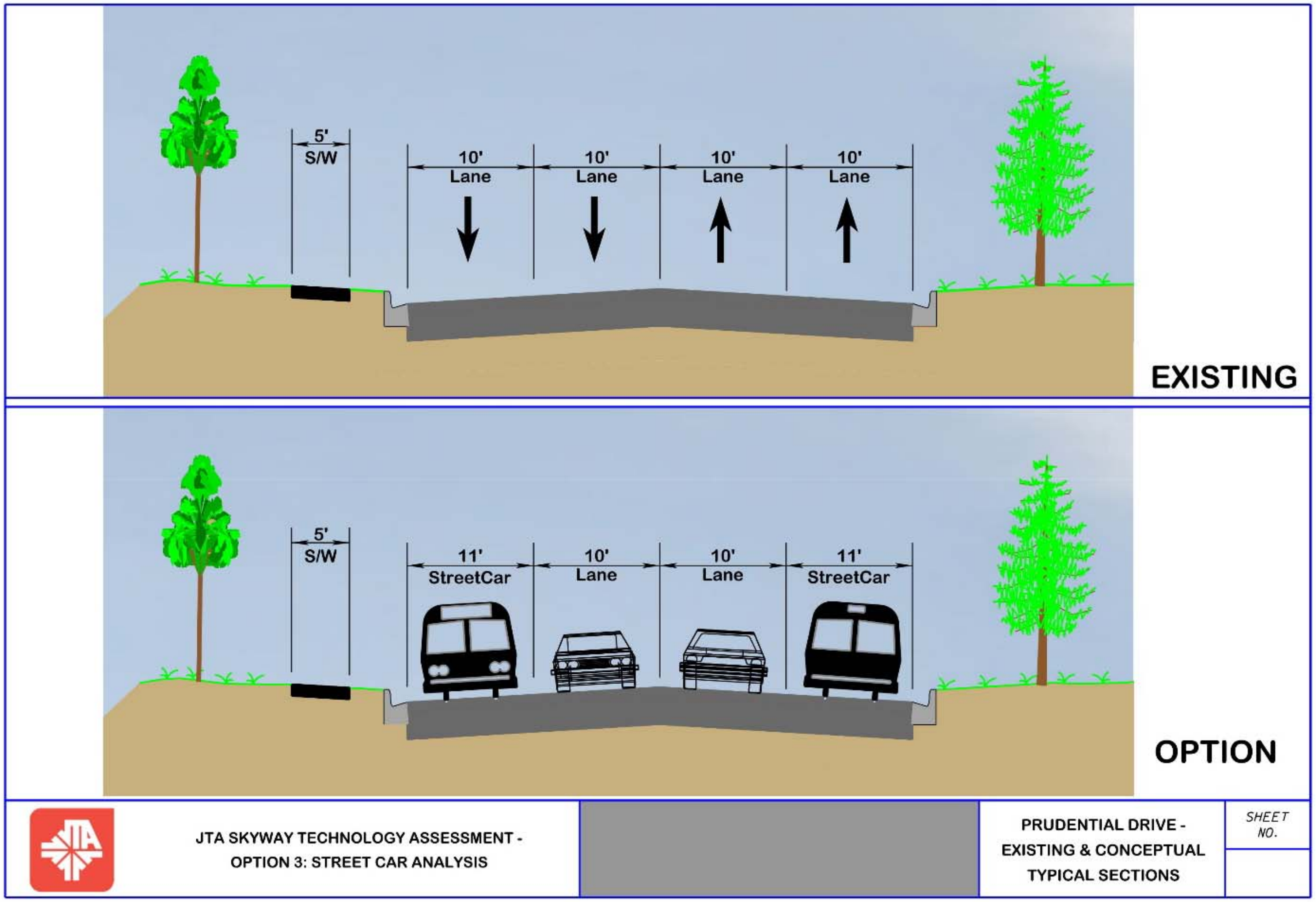


Figure 4-15: Prudential Drive, Typical Sections

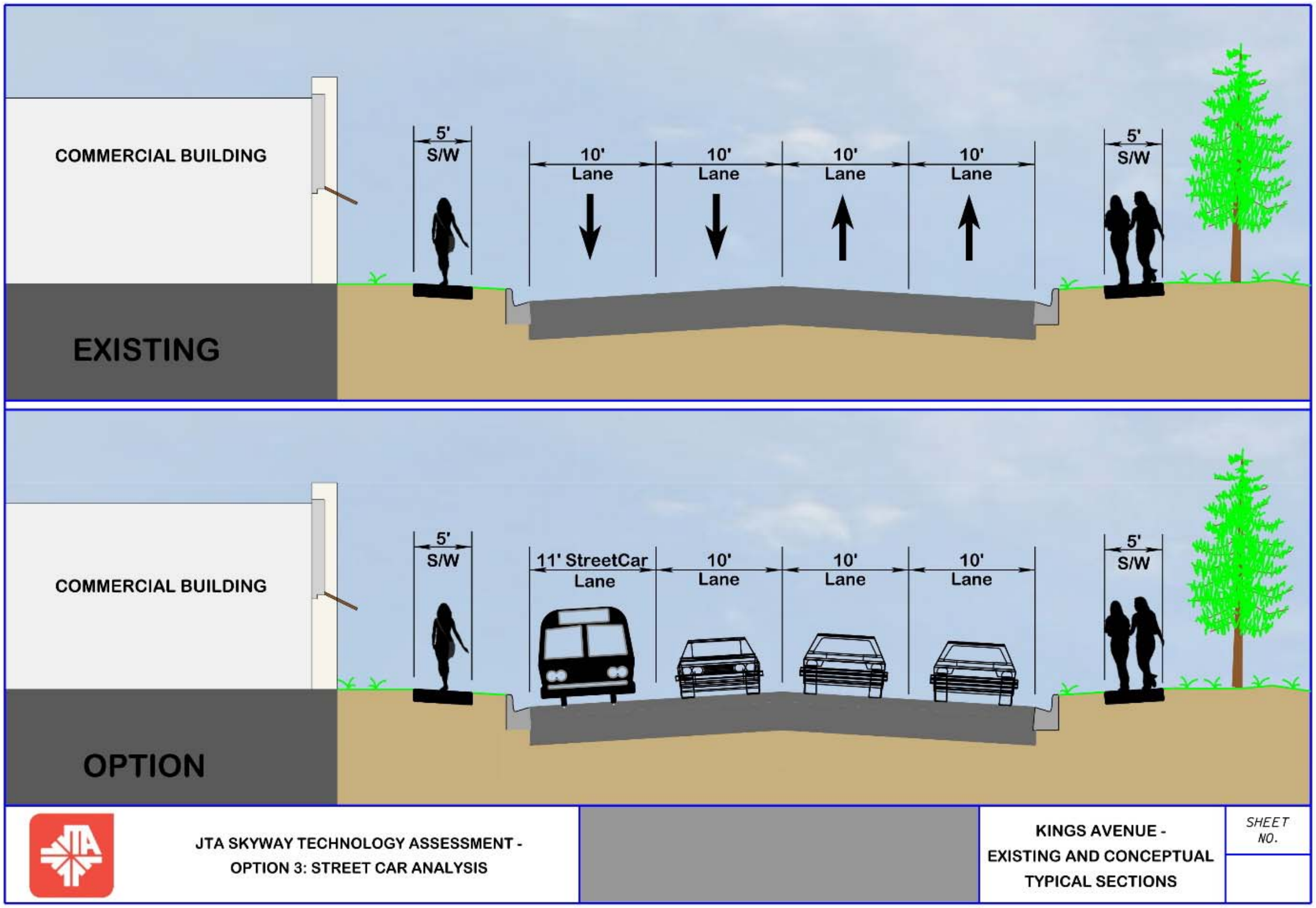


Figure 4-16: Kings Avenue Typical Sections

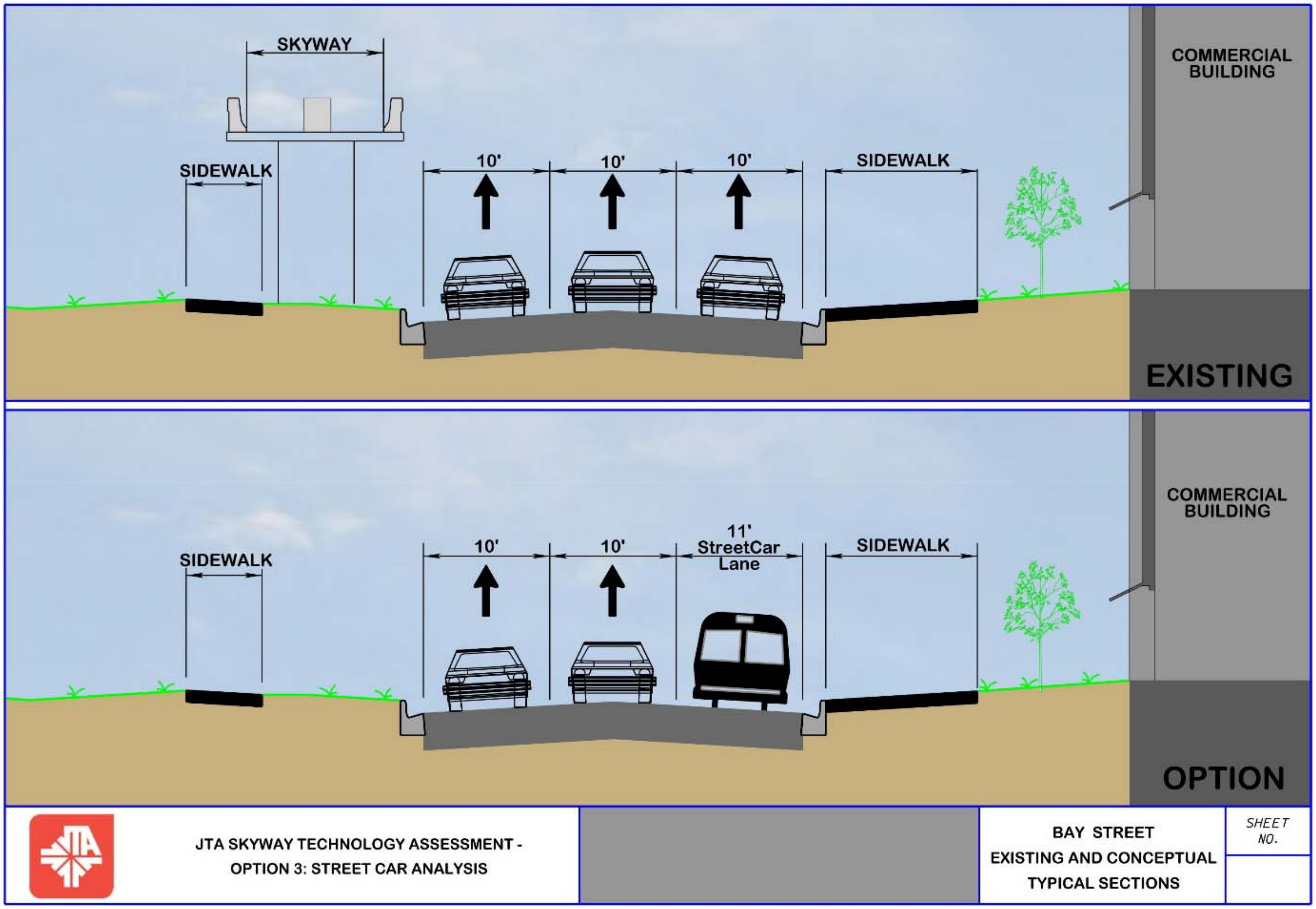


Figure 4-17: Bay Street Typical Sections

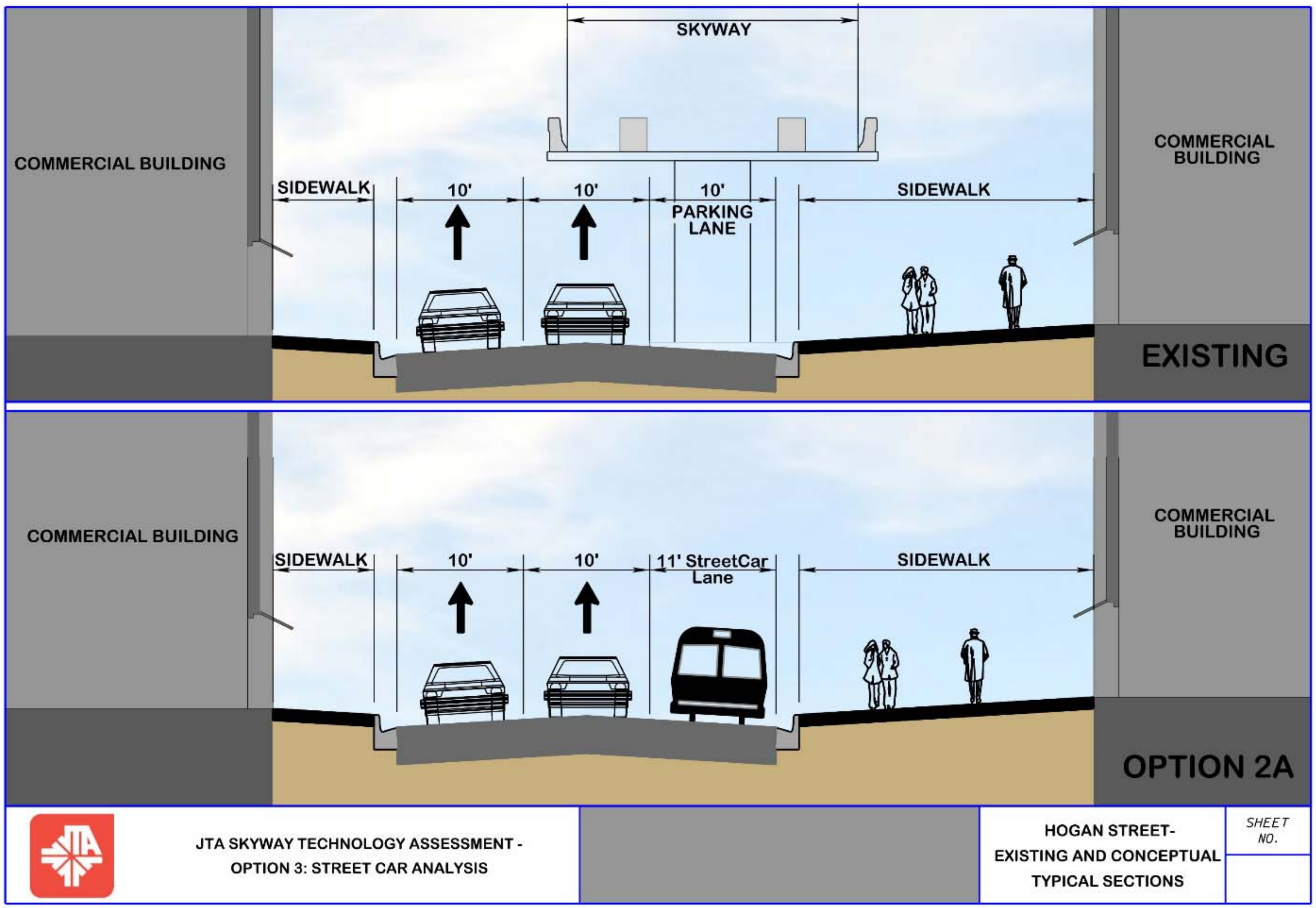


Figure 4-18: Hogan Street: Typical Sections

4.6.6 River Crossing Considerations

Connectivity between the North and South banks of Downtown Jacksonville metropolitan area would require a crossing of the St. Johns River; likely coincident with either the existing Main Street Bridge or the Acosta Bridge crossings. The current Skyway System crosses the Acosta Bridge.

The JTA's 2008 *Streetcar Pre-Feasibility Study* did not recommend a streetcar connection across the St. Johns River due to the increased costs associated with anticipated complex track work, specifically for the Main Street Bridge alignment that was under consideration. The Acosta Bridge was not discussed in the *Streetcar Pre-Feasibility Study* due to the presumed existing transit service provided along the Acosta Bridge by the existing Skyway and the proposed BRT system which was under development at the time of the 2008 Streetcar Study.

For this preliminary evaluation, the proposed streetcar alignment follows the current Skyway alignment and therefore, crosses the St. Johns River using the Acosta Bridge. For this reason, conceptual typical sections were developed for the Acosta Bridge crossing.

4.6.7 Conceptual Bridge Typical Sections

The following conceptual typical section options have been developed for consideration for the Acosta Bridge crossing and have been used for the preliminary cost estimates in a subsequent section of this report.

Option 3A: Use of existing Skyway alignment

- This option would need to consider the transition from the at-grade alignment on each bank to the elevated existing Skyway structure in the center of the bridge.
- This option would also need to consider the load rating on the existing Skyway structure for a heavier streetcar vehicle.

Option 3B: Use of outside travel lane

- This option would require modification to the existing bridge deck in or to accommodate the streetcar rails, either embedded in the existing deck or a new raised platform.
- The assessment of a raised platform option would need to consider the added weight and load ratings for the concrete platform for rails and streetcar vehicle.
- This option would also limit the use of the outside travel lane for other vehicles.

Option 3C: Expansion of bridge structure for additional streetcar lane/corridor on new structure

- This option would need to consider construction of a new bridge structure to carry the streetcar alignment on each side of the existing bridge structure; or one side of the bridge as a two-way operation.
- Additional right-of-way for the bridge expansion in order to accommodate the ramps to the at-grade alignment would need to be considered.
- Adjacent land uses, accessibility to bridge structure and other site conditions would need to be reviewed in greater detail to determine if further consideration is warranted.

There are assumed structural limitations for Acosta Bridge, such as the existing Skyway technology, the monorail guide beam, and existing bridge profile, which will affect the conversion to streetcar technology. The structural analysis is described in more detail later in this section.

4.6.8 Track Switches

The conceptual streetcar alternative route option identified as part of the JTA Skyway Assessment includes design considerations for two track switch locations. In order to resemble the existing Skyway routes and provide streetcar loop options track switches would have to be designed for the following intersections:

- Broad Street at Water Street (on the off-ramp from Acosta Bridge)
- Water Street at Jefferson Street (for the on-ramp to Acosta Bridge)
- Lee Street at Water Street (for the maintenance facility)

The location of the track switches provides an option of having two streetcar loops: Convention Center Station to Kings Avenue Station; and Convention Center Station to Rosa Parks Station. The Broad Street track switch provides an option to continue along Broad Street and connect to Bay Street or to make a right on Water Street and continue towards Hogan Street. Similarly, The Water Street track switch would provide an option to get on the on-ramp for Acosta Bridge or continue straight on Water St. towards Hogan Street.

Figure 4-19, illustrates an embedded track switch for streetcar route. Power operated track switches use train-to-wayside communication systems. These systems allow for a train-to-wayside controller to have the option of manual entry of code or for pre-determined automatic track switch routes. The power switch machines should be equipped with both point locking and point detection. The minimum length of a tangent track preceding a point of switch should be 10 feet with an absolute minimum of 5 feet. Documentation and justification should be prepared for instances where the absolute minimum is used.

Figure 4-19 Embedded Track Switch

4.6.9 Track Crossings

The conceptual streetcar alternative route option identified as part of the JTA Skyway Assessment also includes design consideration for track crossings. Track crossings for the conceptual streetcar route are identified at the following intersections:

- Broad Street at Water Street (track diamond)
- Water Street (track frog)
- Bay Street (track frog)
- Lee Street at Bay Street (track diamond)

Figures 4-20 and 4-21 illustrate an embedded track diamond and track frog crossings, respectively.

Figure 4-20: Embedded Track Diamond

Figure 4-21: Embedded Track Frog

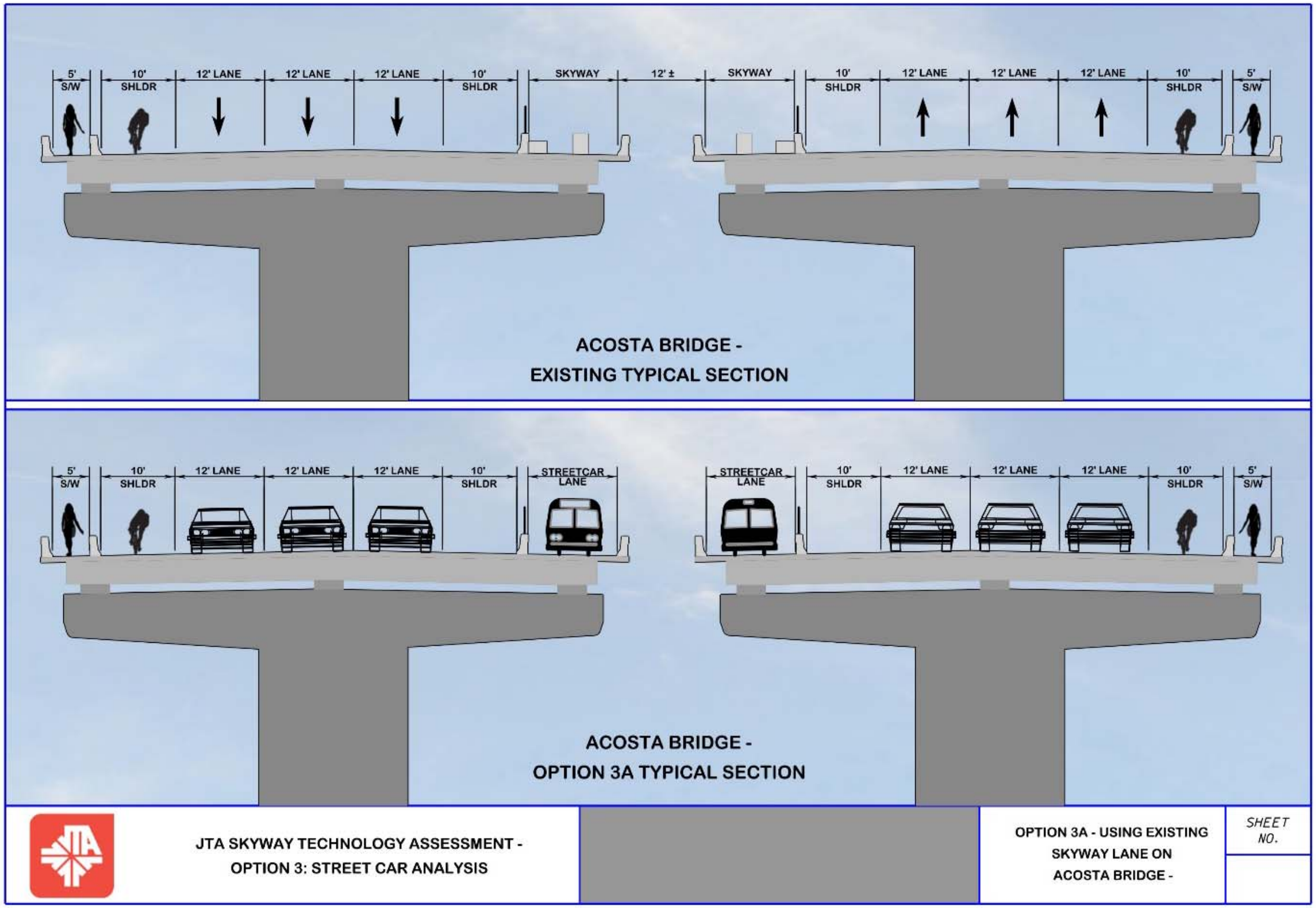


Figure 4-22: Option 3A

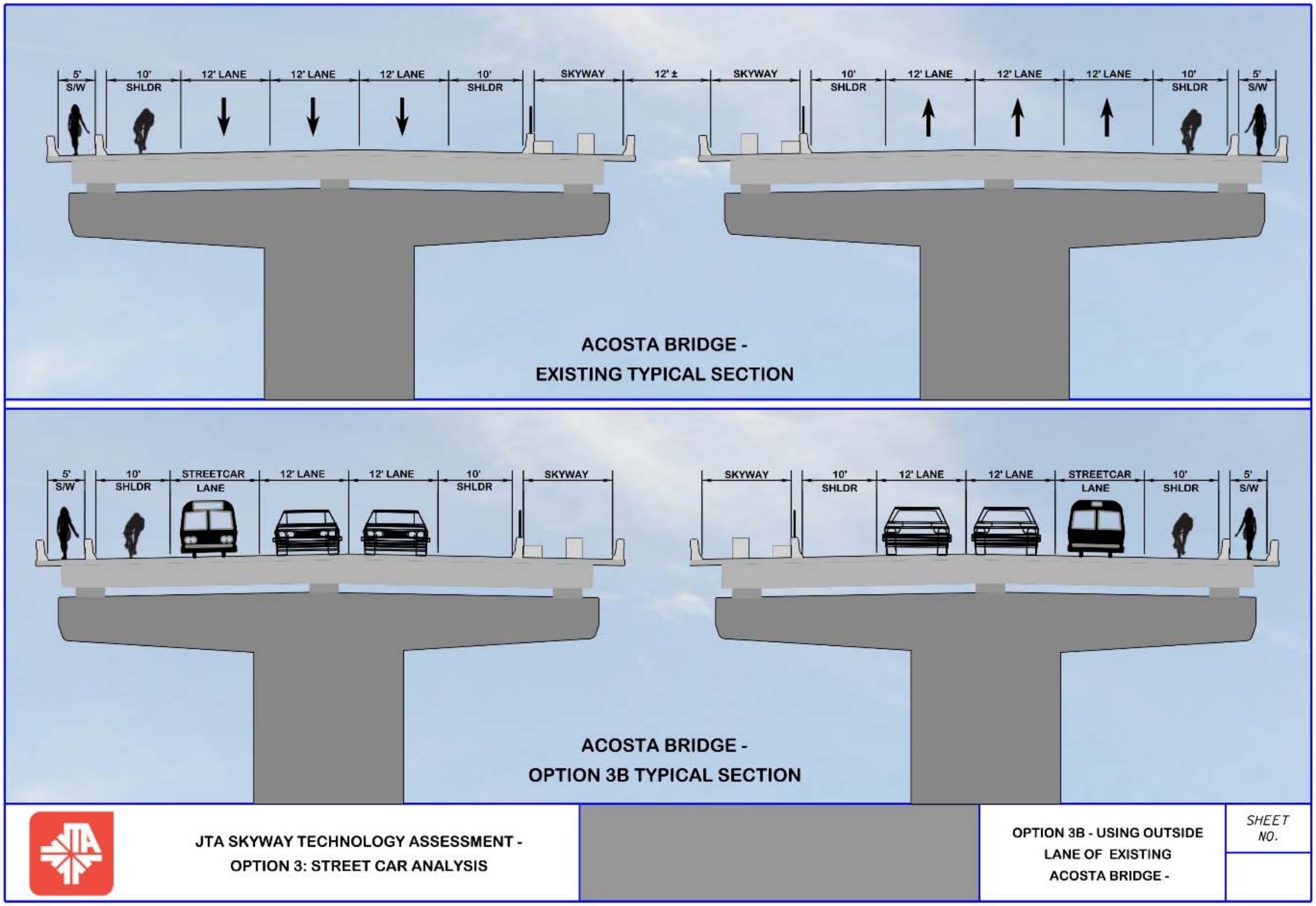


Figure 4-23: Option 3B

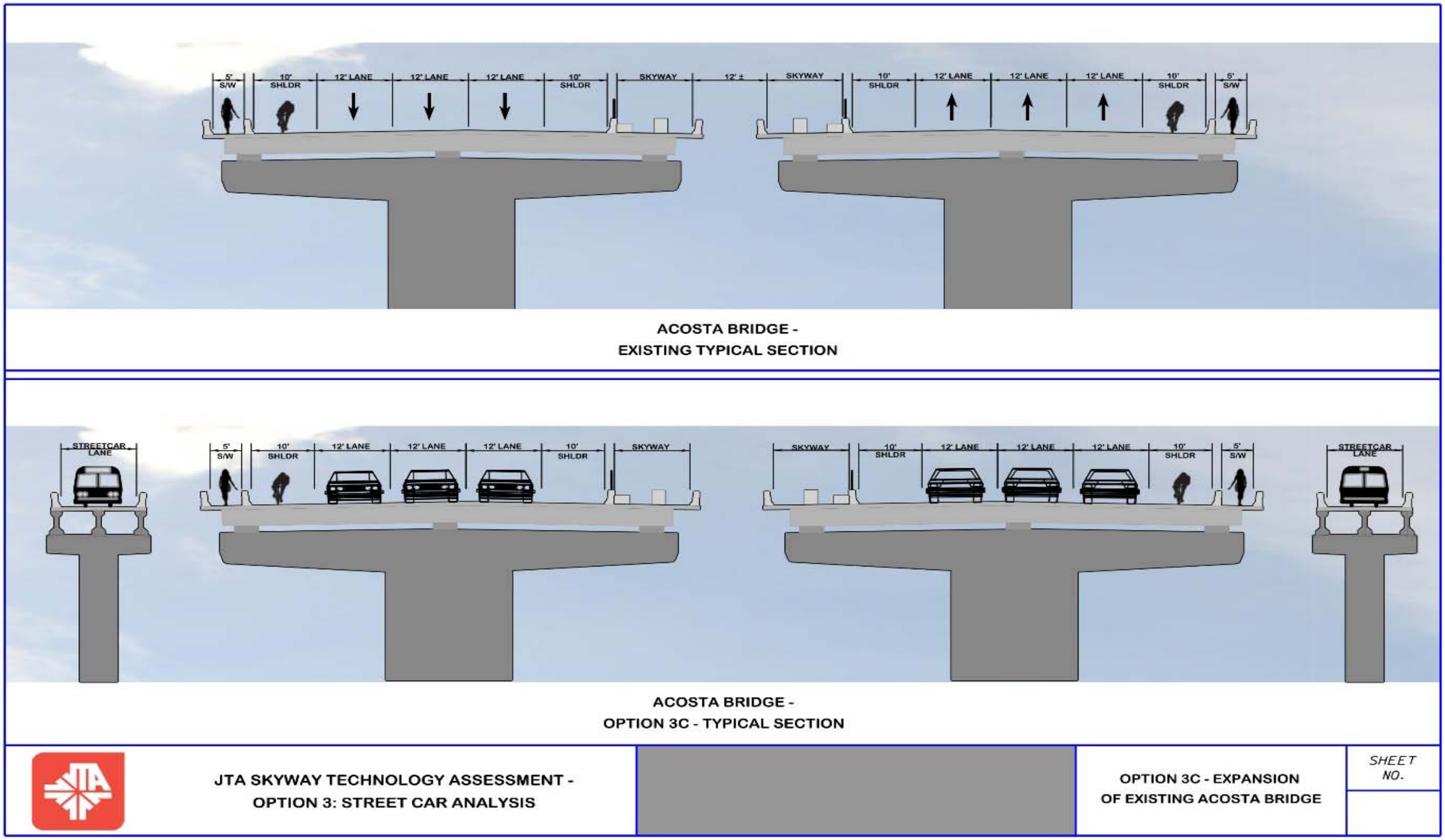


Figure 4-24: Option 3C

4.6.10 Structural Analysis

This section summarizes results of the structural analysis for the existing skyway guideway; and for three river crossing options for the streetcar; and a discussion on feasibility of modifying existing guideway system to accommodate an alternate to be determined vehicle.

4.6.10.1 Existing Skyway Guideway

During the initial phase of this project, a load rating was performed for a representative span consisting of pre-stressed post tensioned concrete double T-Beams which represents approximately 70% of the skyway system. The load rating indicated that the system was designed to accommodate the current skyway vehicle with the 3 car configuration with a crush weight of 53,260 lb. Therefore there is very little reserve capacity to accommodate heavier vehicles. The crush weight of the Brookville liberty (one of the lightest streetcars in production) is 83,960lbs. **Therefore, the existing guideway structure is unlikely to support a heavier streetcar system.**

4.6.10.2 River Crossing Options 3A, B and C

Civil Services Inc. (CSI) has performed additional analysis to assess the feasibility of a streetcar operating on the existing guideway and at the river crossing for Options 3 A,B and C. The analysis indicates that it may be feasible for the existing guideway river crossing to accommodate the streetcar with some structural modification and similarly the existing Acosta Bridge may have the capacity. Both 3A and 3B are viable options for further investigation.

Following is a discussion for each option for the river crossing:

4.6.10.2.1 Option 3A – Street Car Crossing at same location of existing guideway.

This option would require connecting the streetcar to the existing river crossing alignment at the center of the Acosta Bridge. There are two primary structure types to consider; the main span and approach spans.

The main span support for the guideway consists of a cantilevered deck section that was designed and constructed integral with the Acosta Bridge. **The structural analysis indicates that it may be feasible to carry the streetcar on this section with some modification and that this option is a candidate for further analysis.**

The approach spans consist of a steel box beam. Our analysis indicates that these sections could possibly accommodate a streetcar with some modification, and that this option is a candidate for further analysis.

It is important to note that additional structures will be required to connect the at-grade streetcar to the bridge approaches. For this option the approach ramps will need to be elevated to enable the streetcar connection over vehicular traffic approaching the Acosta Bridge.

The estimate for this section assumes modification of bridge main span unit, re-use of the box beam approaches and construction of new elevated ramps to provide connection from at-grade street connection to the bridge approaches.

4.6.10.2.2 Option 3B – Street Car Crossing on Acosta Bridge

Analysis indicates that that the existing Acosta Bridge **may accommodate** the street car loading since it was designed for the HL-93 truck and the streetcar is lighter. However, the streetcar would have to be located **over the main superstructure** and not the cantilevered sections that currently support the shoulder and pedestrian facility. In addition, the bridge deck would have to be modified to accommodate the streetcar rails and power systems.

This option will require construction of ramps from the at-grade streetcar in the roadway to connect to the bridge. The cost estimate for this option assumes modification of the Acosta Bridge and reconstruction of approach spans and ramps.

It is also important to note that with a dedicated streetcar lane the capacity for vehicular traffic on the bridge will be reduced.

4.6.10.2.3 Option 3C - New Structure on a new alignment

This option offers the most flexibility with the design of the streetcar system. We have assumed that the crossing would be parallel and to the outside of the existing Acosta Bridge; the location should be however optimized during a more detailed evaluation of a potential streetcar route. If the new crossing is built adjacent to the existing bridge, impacts to the FEC Railroad Bridge and property on each river bank would have to be considered when selecting the optimum route.

For this option the cost estimate assumption is for a new structure with new ramps, required to connect the streetcar from the roadway to the bridge.

4.6.10.3 Additional Option Modification of Guideway to Accommodate an Alternate Vehicle

We have reviewed the as-built plans for the guideway and determined that **it is feasible to remove the guidebeam to accommodate an alternate vehicle.** The guidebeam on the original North bank section was added to the original structure so removal should, in all likelihood, not present a problem. For the newer sections of the guideway on the Southbank, the guidebeam was constructed with the initial construction but appears to have been a separate concrete pour and therefore should be able to be removed. Additional work for the rebar removal and deck re-finishing will be required.

By removing the dead load of the guidebeam it is expected that additional capacity would be available to possibly accommodate a slightly heavier vehicle. **This capacity should be determined by a detailed load rating analysis for a specific vehicle. In addition to structural capacity, factors such as turning radius, vertical and horizontal clearances, floor height, vehicle width, axle spacing, passenger loading etc. should be considered.**

4.6.10.4 Summary of Streetcar Structural Analysis

The assessment of the options listed above is presented to provide potential concepts to consider during a more detailed streetcar study. **Options 3A, B and C are viable for further investigation as is**

modifying the existing guideway to accommodate an alternate vehicle. As part of subsequent project development it is recommended that an in-depth structural analysis be performed for all spans. Each structure span and type and vehicle type under consideration will require its own analysis**. It is also important to note that any modifications to the Acosta Bridge including the existing skyway support must be coordinated with FDOT and City of Jacksonville due to both operational and structural impacts.**

4.6.11 Existing Skyway Terminal Station Areas

There are three primary terminal Skyway Station areas along the current Skyway alignment. These terminal stations, Rosa Parks Transit Station, Kings Avenue Transit Station and Convention Center Station provide connectivity with JTA's transit system including the local bus, community shuttles and the proposed BRT, First Coast Flyer.

The Convention Center Station, adjacent to the Prime Osborn Convention Center and conveniently located near I-95, also accommodates connections with other intercity and regional travel through Megabus. Greyhound bus operations are currently in downtown, several blocks from this location. In the future, Greyhound will also operate from a facility adjacent to the Convention Center Station.

The Convention Center Station is also the site of the proposed Jacksonville Regional Transportation Center (JRTC). The proposed JRTC plan includes a new bus transfer facility as well as JTA administrative offices. JTA is also exploring the relocation of Amtrak service to this former hub of rail service in the Southeast.

4.6.12 Future Analysis and Operations Considerations

Subsequently, more detailed analysis of the streetcar option will require consideration of other roadway environment features, including but not limited to right-of-way requirements, as well as, impact on existing travel lanes and pedestrian access.

This Skyway Technology Assessment and prior streetcar studies have been preliminary in the analysis of the potential streetcar technologies and **additional analysis will need to be performed** to comply with the NEPA processes and documentation necessary to meet future funding requirements. The following is a general list of considerations for future subsequent analyses and is not considered to be inclusive of all areas of analyses for future studies.

4.6.13 Roadway Environment and Conditions

4.6.13.1 Pavement Type and Condition

Many areas of the Downtown Jacksonville street system will require analysis of pavement conditions to consider the structural needs for track and vehicle loads

4.6.13.2 Right-of-Way Requirements

Additional right-of-way may be required for multiple needs, such as

- Lane expansion
- Station/Stop area requirements
- Pedestrian access modifications

- Implementation of streetcar power equipment

4.6.13.3 Utilities

Coordination with utility companies will be necessary to define

- Age and location of utilities
- Overhead or Underground Impacts
- Planned utility improvements by partner agencies

4.6.13.4 Drainage

Roadway modifications or additional construction will need to consider impacts on drainage throughout the Downtown. Specifically,

- Locations of drainage structures
- Drainage flow patterns and issues (flooding areas, etc.)

4.6.13.5 Signalized Intersections

The streetcar alignment will interface will other transit modes as well as vehicular traffic. Along the conceptual streetcar alignment there are 39 signalized intersections which are listed in the following table. Consideration will need to be given to the existing one-way versus two-way operations, as well as, for the implementation of the transit signal priority (TSP). It is assumed that TSP will be incorporated along the streetcar alignment consistent with the implementation of TSP for the BRT and other high frequency transit corridors. Evaluation of the streetcar operations in a future studies will determine the implementation strategy at the intersections.

4.6.13.6 Pavement Markings and Signage

Consideration will be given to pavement markings to clearly delineate the streetcar alignment and station areas in order to minimize vehicular, pedestrian and bicycle conflicts. This may include some unique pavement marking strategies to be determined in subsequent analyses.

Land Use/Accessibility
Additional assessment to determine accessibility to adjacent properties and compatibility with adjacent land use, including multimodal accessibility, will be conducted in subsequent studies.

Development Potential
Current studies of streetcar projects have identified increasing development potential opportunities along streetcar investments. JTA's interest in expanding its portfolio of transit oriented development initiatives would be subject for discussion in subsequent streetcar analyses. Coordination with the City of Jacksonville and Downtown Investment Authority will be necessary to comply with current and planned land development and mobility policies.

4.7 STREETCAR OPERATIONS REQUIREMENTS

Stations/Stops/Platforms

- Platform/Station Locations – at minimum stations would be located at the existing Skyway station locations.
- Assess how many additional stations would be added along the route.
- Assess how much of the existing Skyway station areas may be utilized for supporting customer amenities.
- Existing Skyway Station demolition requirements
- Platform/Station and Customer Amenities
  - Lighting
  - Street Furniture
  - Fare Payment Kiosks
  - Arrival Information

Streetcar Access

- Pedestrian Accommodations
- ADA Requirements at station areas as well as along the streetcar alignment

Power Supply/Propulsion System

- The streetcar system may be powered using an overhead contact system (OCS) that is fed by traction power substations located typically a little bit over a half a mile apart for Direct Current Systems. It is noted that the number and location of substations will depend upon headway, speed, grade, vehicle auxiliaries etc.
- OCS poles will be located along the guideway at an interval of 80-90 feet. The poles have typically cantilever arms to support the contact wire at a minimum of 18 feet above the roadway.
- Alternately, the streetcar system traction power may be based on a middle of the guideway embedded power rail. The power rail will be energized only underneath a vehicle.
- The decision on whether to use OCS or embedded power rail is site specific and typically involves the consultation of the community.

Operations and Maintenance Facilities

- A dedicated Operations and Maintenance Facility is required. The JTA may consider the feasibility of modifying the existing Skyway Monorail maintenance facility to accommodate a streetcar system or finding a suitable strategic location that will be selected with due consideration of future streetcar extensions.

Traffic Signals

- Streetcars will operate on dedicated right-of-way, but will require sharing traffic intersections with vehicular and other bus traffic. Streetcars are typically given priority at roadway intersections; this priority involves additional equipment that interface the streetcar wayside train control with traffic signal controls. This interface allows the implementation of "traffic signal pre-emption" or "transit signal priority (TSP)" (see section 4.6.13.5) that activates the red signal at a given distance from the intersection as the streetcar is approaching. The impact of traffic signal pre-emption on road traffic should be considered in a subsequent study.

Special Trackwork

- Special trackwork will be required at all end stations and at the track junction between the two routes to allow streetcars to change track, merge or diverge.

Streetscaping

- Streetscaping will be required to clearly separate the streetcar lanes from vehicular traffic. This will require close coordination between the JTA and the City of Jacksonville.

Coordination with Agencies/Stakeholders

The City of Jacksonville has multiple agencies that coordinate Downtown transportation and development activities, including:

- City of Jacksonville
- Downtown Investment Authority
- Downtown Development Authority

4.8 RETAINED OPTIONS COMPARISON

This section includes a "Pros-Cons" comparison between the retained options. Option 3 has been split into three distinct options as described below.

JTA RETAINED OPTIONS	1. Overhaul vehicle and run for 10 to 15 years and develop replacement system in meantime	2. Replace vehicle "in-kind" Extensions using elevated structure	2b. Replace vehicle "in-kind" using existing infrastructure Extension with alternative mode – Streetcar or BRT	3A. Replace existing System with street-car "dedicated-lanes", at-grade; River Crossing uses existing Skyway alignment	3B. Replace existing System with street-car "dedicated-lanes", at-grade; River Crossing uses outside travel lane	3C. Replace existing System with street-car "dedicated-lanes", at-grade; River Crossing uses expansion of bridge, new structure for streetcar
Pros	• Second Lowest relative Cost of the options • Allows use of existing infrastructure (Guideway/Stations/ Infrastructure) • No Learning curve • No FTA obligation/payback • Improved System Availability • Allows significant time for development of future transportation plan	• 25 years vehicle life • Improved System Availability • Possibility of Extensions using similar technology • Potential increased attractiveness of the Skyway using transit-oriented development • Extension could provide service to traffic generators	• 25-30 years vehicle life • Improved System Availability • Integrates Skyway with planned BRT transportation modes • Greater flexibility integrating with future transportation plan	• 30 -year-service life • Downtown renewal • Easier expandability (to stadium) • Better insertion into the urban fabric. • Greater flexibility integrating with future transportation plan • Increased opportunities to enhance ridership	• 30 -year-service life • Downtown renewal • Easier expandability (to stadium) • Better insertion into the urban fabric. • Greater flexibility integrating with future transportation plan • Increased opportunities to enhance ridership • Uses existing space of Skyway on Acosta Bridge for Streetcar	• 30 -year-service life • Downtown renewal • Easier expandability (to stadium) • Better insertion into the urban fabric. • Greater flexibility integrating with future transportation plan • Increased opportunities to enhance ridership • Limited impact to existing traffic flow along Acosta Bridge
Cons	• Propulsion Replacement uncertainty • Infrastructure at midpoint of useful design life • Requires infrastructure capital investment • Existing vehicle is unique vehicle (obsolescence issue) • Limited fleet -> Limited capacity of extension • Minor Passenger Service Interruption	• Higher Relative Cost (than other options) • Unique, custom made, vehicle/long term support • Staff Learning Curve o Maintenance o Inventory, parts • Limited procurement competition (sole source), hence higher cost- may not be feasible • Infrastructure at midpoint of useful design life • Requires infrastructure capital investment • System Operation to be considered (Y-junction) • FTA obligation/payback for vehicles? • Major Passenger Service Interruption • Limited flexibility with integration with future transportation plan • Limited ability to increase system capacity	• BRT costs already considered • Unique, custom made, vehicle/long term support • Staff Learning Curve o Maintenance o Inventory, parts • Limited procurement competition (sole source), hence higher cost- may not be feasible • Infrastructure at midpoint of useful design life • Requires infrastructure capital investment • FTA obligation/payback for vehicles • Major Passenger Service Interruption • Requires transfer from Skyway to alternate mode for extension. • Operation/ Maintenance of two different systems • Potential adverse impacts to roadway traffic and capacity for the extension	• Aesthetics (catenary option) • Underground impacts (underground power option) • High operating costs (drivers) • Adverse impact to road traffic and capacity • FTA payback (highest) • Capital Cost (highest of 3 options) • Duplication with BRT Southeast First Coast Flyer • Need for additional real estate (yard, substations, equipment rooms, central) • Disposition of existing guideway infrastructure, stations and right of way • Requires construction of flyover ramp to access center of the Acosta Bridge • Complete training of the workforce • Maintenance learning curve (rail system) • Lowest level of service (8-12 mph commercial speed) • Extensive planning and coordination with stakeholders including FTA, COJ, FDOT, TPO etc.	• Aesthetics (catenary option) • Underground impacts (underground power option) • High operating costs (drivers) • Adverse impact to road traffic and capacity • FTA payback (highest) • Capital Cost (highest of 3 options) • Duplication with BRT Southeast First Coast Flyer • Need for additional real estate (yard, substations, equipment rooms, central) • Disposition of existing guideway infrastructure, stations and right of way • Reduces number of travel lanes on the bridge crossing • Modification to Acosta Bridge deck for embedded rail/platform • Modification to bridge approach/new access ramps to Acosta Bridge • Complete training of the workforce • Maintenance learning curve (rail system) • Lowest level of service (8-12 mph commercial speed) • Extensive planning and coordination with stakeholders including FTA, COJ, FDOT, TPO etc.	• Aesthetics (catenary option) • Underground impacts (underground power option) • High operating costs (drivers) • Adverse impact to road traffic and capacity • FTA payback (highest) • Capital Cost (highest, includes bridge expansion) • Higher impact to adjoining properties at each bridge approach and to adjacent railroad bridge • Duplication with BRT Southeast First Coast Flyer • Need for additional real estate (yard, substations, equipment rooms, central) • Disposition of existing guideway infrastructure, stations and right of way • Complete training of the workforce • Maintenance learning curve (rail system) • Lowest level of service (8-12 mph commercial speed) • Extensive planning and coordination with stakeholders including FTA, COJ, FDOT, TPO etc.
Recomm--endation	• Pursue the process initiated with the Request for Industry Feedback to ascertain with greater certainty the feasibility of the option. • Engage in detailed discussions with SDI to. Consider not proceeding without having firm assurance and guarantee that a replacement propulsion system has been identified, or that the propulsion system can be overhauled. Based on Bombardier's response to the RFIF, investigate whether bogie parts could be manufactured, if required.	• Given the lack of interest noted as part of the RFIF, this options does not appear viable and it is recommended that it be dropped from further consideration.	• Given the lack of interest noted as part of the RFIF, this options does not appear viable and it is recommended that it be dropped from further consideration.	• A business case needs to be elaborated to justify the migration from the Skyway to this technology. • The existing guideway structure is unlikely to support a heavier streetcar system. • The option is viable for further investigation • Any modification to the Acosta Bridge including the existing skyway support must be coordinated with FDOT and City of Jacksonville due to both operational and structural impacts.	• A business case needs to be elaborated to justify the migration from the Skyway to this technology. • The option is viable for further investigation • Any modification to the Acosta Bridge including the existing skyway support must be coordinated with FDOT and City of Jacksonville due to both operational and structural impacts.	• A business case needs to be elaborated to justify the migration from the Skyway to this technology. • The option is viable for further investigation • Any modification to the Acosta Bridge including the existing skyway support must be coordinated with FDOT and City of Jacksonville due to both operational and structural impacts.

Table 4-12: Retained Options Comparison

4.9 OPERATIONS AND MIANTENANCE (O&M) CONSIDERATIONS

Training, staffing (drivers), operating costs higher due to drivers, control center, depot.

4.9.1 Service Operations

The hours of operation and frequency of service should be established for the street car system taking into account ridership characteristics (number of riders per hour of day, per day of the week etc.).

Hours of operation should be coordinated with those of other transportation modes to form an integrated transportation network. The frequency of service, arguably the most important service factor in maximizing ridership, should be high enough to increase the attractiveness of the streetcar. Examples of intervals are the recently opened Tucson Sun-Link system with a variable frequency per time of day and day of the week of: 10, 15, 20 and 30 minutes.

4.9.2 Line Operation

The Streetcar system may operate in a variety of modes, either using one line, or two lines, mirroring the Skyway operation. In case of an operation with two lines, the merging of the lines (King's avenue to Rosa Park stations and Convention Center to Rosa parks stations) should be considered in the elaboration of the time table.

4.9.3 Vehicle Characteristics

A general assumption is that given that the street-car will operate using a dedicated lane and will use traffic pre-emption at road intersections, its commercial speed will be higher than other street cars in the United States where the speed ranges between 8-12 mph. Such speed will however be lower than the existing Skyway Monorail that is driverless and operates on a fully dedicated right of way.
The number of vehicles required for a streetcar system is driven by the frequency of service and spare vehicle requirements. Streetcar vehicle layover requirements are typically similar to those required for bus service, which is 15 to 20 percent of the total travel time.

4.9.4 Maintenance Requirements

Streetcar systems require a storage and maintenance facility for servicing and storing the vehicle fleet and managing system operations. The storage and maintenance facility should be located within close proximity to the streetcar route and should include all special tools and equipment.

Maintenance of the running rail, catenary/embedded power supply will introduce constraints that the JTA is not familiar with and needs to understand. Rail grinding, pantograph and switch machine maintenance in the middle of city streets introduces additional complexities that the JTA should prepare for.

4.9.5 Operations and Maintenance Facility

The Operations and Maintenance Facility serves for both Operations and Maintenance functions and allows streetcar storage when not in operation.

4.9.5.1 Operations

The following general functions will be performed:

- Streetcar assignment,
- Control center for real-time monitoring, passenger support and response to incidents/accidents.

4.9.5.2 Maintenance

The following general functions will be performed:

- Vehicle inspection
- Vehicle maintenance (routine, monthly, annual etc.)
- Cleaning,
- Administration,
- Training

4.9.6 Trackwork

The Figure below illustrates typical trackwork for a Streetcar system.

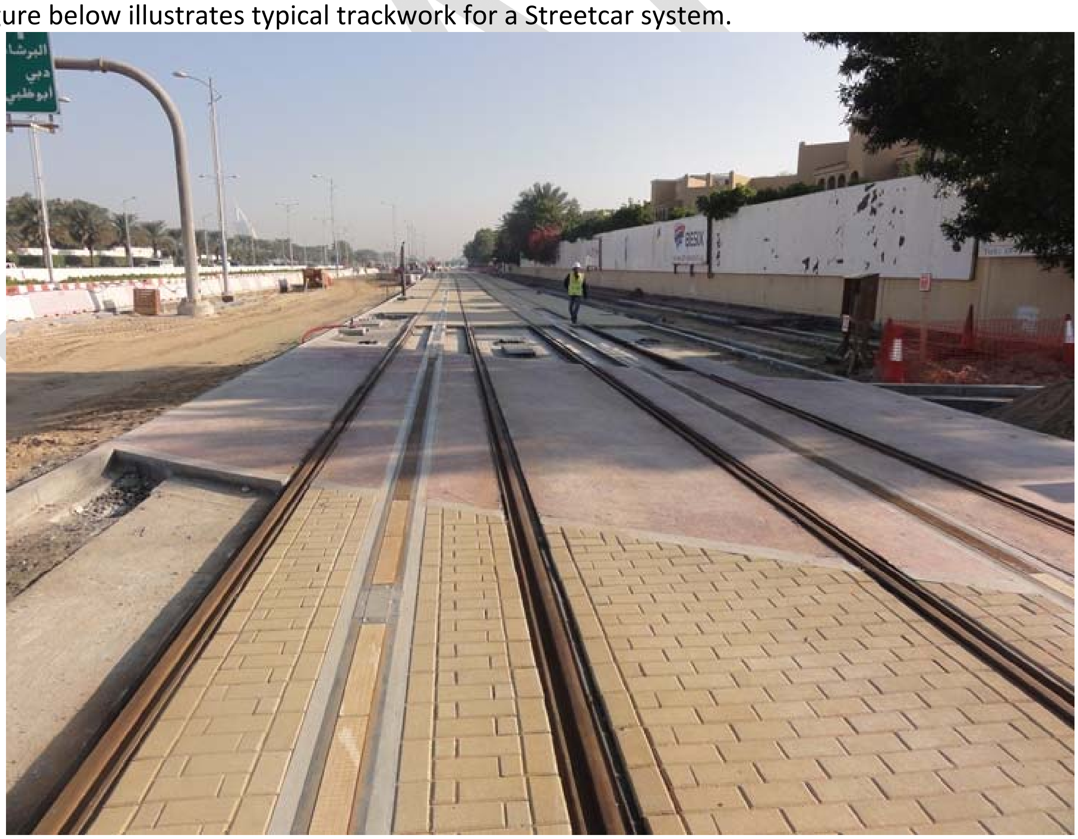


Figure 4-25: Typical Trackwork for a Streetcar system (Source APTA- Light Rail & Streetcar Systems, How they differ; How they Overlap)

4.9.6.1 Catenary or Embedded Power Supply

The figures below illustrate two distinct embedded power rail implementations, and an overhead catenary implementation.

Figure 4-26: Embedded Power Rail (Stream by Ansaldo-Breda)

Figure 4-27: Embedded Power Rail (Citadis, by Alstom)

Figure 4-28: Overhead catenary (Portland Street Car- Credit Steve Morgan)

Figure 4-29: On-Board Streetcar Ticket vending machine; Seattle WA (Source APTA)

Figure 4-30: Simple Ticket vending Machine at Streetcar Stop; Portland, OR (Source APTA)

4.9.6.2 Fare Collection

Streetcar maintenance bears a lot of similarity to that of a rail system, but also includes additional subsystems such as catenary, embedded power supply, batteries, or perhaps super-capacitors to consider. Such maintenance differs from that of a Monorail, or a bus. The JTA will be required to train staff on street car operation and maintenance.

4.9.7 Interaction with road traffic

Given that the street car system will operate in dedicated lanes, the likelihood of accidents with road vehicles or pedestrians will be limited to road intersections. However an information campaign will be necessary to educate the public on the new streetcar system and how to interact with it.

4.10 COST ESTIMATE

4.10.1 General

A detailed cost estimate is beyond the scope of this conceptual study. In the section below, we will present the cost per mile for recent streetcar systems and then list some of the specific considerations of the Jacksonville System.

4.10.2 Literature Review

Review of the literature reveals that cost per Track mile for under construction or recently completed projects varies between $20 Million and $41 Million. These recent projects include between 4 and 7 streetcar vehicles, at an average cost of $4.1 million. These costs per track mile are indicative only as project local conditions such as total track length may vary greatly, and a detailed cost estimate for the Jacksonville streetcar could be developed if required.

Cost estimates are often revised upwards with time and as new or unexpected circumstances are encountered. Some of the preliminary uncertainties for the Jacksonville streetcar are: utility relocations, installation of track bed and embedment on the Acosta Bridge, right-of way acquisition, real estate acquisition (maintenance and storage facility, substations etc.)

4.10.3 Site Specific Physical Constraints

The Jacksonville streetcar alignment considered by the JTA includes the following elements:

- At Grade Street Level System
- River Crossing
- Ramps to connect at grade system to the river crossing.

The Lea+Elliott Team have evaluated three options for the river crossing and ramp connections (see Section 6.6.10):

- 3A Crossing at the same location as the existing skyway at center of the Acosta Bridge
- 3B Crossing on the outside travel lane on the existing Acosta Bridge
- 3C Crossing on a new structure.

Rough cost estimates for the construction of each option are listed below:

Option	Estimate for River Crossing and Ramp ($M)
3A	21-27
3B	18-24
3C	80-115

These estimates should be added to the per mile costs for the at grade system. These estimates are conceptual and only presented to give an idea of the order of magnitude for each option. It is therefore recommended that a more detailed estimate be developed as a part of a subsequent project development.

4.11 ROM CAPITAL COST ESTIMATE SUMMARY

The ROM Cost estimate summary, based on information provided in sections 4.1.2.1, 4.1.3.1, 4.1.3.2, 4.1.3.3, 4.2.2 and 4.10.2 are summarized below. Please refer to those sections and to the complete report for discussions, assumptions and limitations associated with each ROM capital cost estimate.

Skyway Technology Assessment
Estimated Capital Cost Summary
$ Millions

Option	**1 - Overhaul**		**2 Replacement Vehicle**		**3 Streetcar**					
					3A		3B		3C	
	Low	High	Low	High	Low	High	Low	High	Low	High
System [1]	$ 51.9	$ 62.2	$ 80.9	$ 135.7	$ 108.0	$ 221.4	$ 108.0	$ 221.4	$ 108.0	$ 221.4
Infrastructure [2]	$ 28.9	$ 34.8	$ 28.9	$ 34.8	$ 20.0	$ 25.0	$ 20.0	$ 25.0	$ 20.0	$ 25.0
River Crossing	NA	NA	NA	NA	$ 21.0	$ 27.0	$ 18.0	$ 24.0	$ 80.0	$ 115.0
Total Capital Estimate	**$ 80.8**	**$ 97.0**	**$ 109.8**	**$ 170.5**	**$ 149.0**	**$ 273.4**	**$ 146.0**	**$ 270.4**	**$ 208.0**	**$ 361.4**

[1] System Street Car estimate assumes 5.4 mi at $20-$41M per mile and includes system and infrastructure
[2] Infrastructure for 1 and 2 includes Near and Mid Term Recommendations. Infrastructure Cost for Street Car includes Demo of existing only - infrastructure included in System Costs
Please see detail in report for estimate discussion and details.

Table 4-13: ROM Capital Cost Estimate Summary

5.0 RECOMMENDATIONS, POLICY CONSIDERATIONS AND NEXT STEPS

The JTA has engaged in a planning effort and has examined a variety of options. This study is a first step in this planning process that should include involvement of the City of Jacksonville, the citizen community and the various stakeholders.

In order to support the JTA planning effort, the Lea+Elliott Team developed a list of recommendations for the JTA's consideration.

1. **Pursue the process** initiated with the Request for Industry Feedback to ascertain with greater certainty the feasibility of RFIF Options 1 and 3 (hold detailed discussions with manufacturers and obtain a firm commitment prior to selecting an approach to pursue.)
    a. On the overhaul option (Option 1):
        i. Consider not proceeding without having **firm assurance and guarantee** that a replacement propulsion system has been identified, or that the propulsion system can be overhauled. Based on Bombardier's response to the RFIF, investigate whether bogie parts could be manufactured, if required.
        ii. Consider requesting that **Bombardier provide the design details of the Main Propulsion Controller Board** (<u>Part #3MUP0000001-0016 (DMC-120</u>) considering that it will no longer be supported by Bombardier.
    b. On the replacement with a new vehicle "in-kind" (Option 2):
        i. Given the lack of interest noted as part of the RFIF, this options does not appear viable and it **is recommended that it be dropped from further consideration**.
    c. On the replacement with a new vehicle with no net weight increase on the existing infrastructure (RFIF Option 3):
        i. **Engage discussions with SDI, Bombardier and Skyweb express.** For SDI, the JTA should ensure that the original technical project requirements are understood and can be met.
        ii. For Bombardier, **investigate whether the existing structure is adequate to support the loads of the heavier VAL 256**.
        iii. The Skyweb express proposed solution i.e. **PRT requires a detailed planning effort, risk assessment and development of a business case**. The risk assessment is necessary since there is, at this time, no PRT system that would match the complexity and scale of the system proposed by Skyweb Express.
    d. On Streetcar:
        i. A **business case** needs to be elaborated to justify the migration from the Skyway to this technology.
        ii. The existing guideway structure is unlikely to support a heavier streetcar system.
        iii. Three Options were considered:
            1. Option 3A: Street Car Crossing at same location of existing guideway:
            2. Option 3B: Street Car Crossing on Acosta Bridge
            3. **Option 3C:** New Structure on a new alignment
        iv. The assessment of the options listed above is presented to provide potential concepts to consider during a more detailed streetcar study. **Options 3A, B and**

C are viable for further investigation It is also important to note that any modifications to the Acosta Bridge including the existing skyway support must be coordinated with **FDOT and City of Jacksonville** due to both operational and structural impacts.

2. Modifying the existing guideway to accommodate an **alternate** vehicle may be viable. As part of subsequent project development **it is recommended that an in-depth structural analysis be performed for all spans. Each structure span and type and vehicle type under consideration will require its own analysis.**
3. Develop a **business case** for all options under consideration. The business case should include ridership, fare structure, capital and O&M costs.
4. As part of any business plan, determine the required **FTA payback amount** if the vehicles or infrastructure will not be used for the design life agreed upon with the FTA.
5. Implement the **recommendations** listed in the Operating System **condition assessment** report and the Infrastructure **condition assessment** report.
6. Determine the course of action **short term** for the Skyway; i.e.: the JTA should consider initiating repairs that could have an impact on safety (such as Guideway Intrusion System), or availability of the system (such as loop cable, water accumulation, conduits and cables affected by water accumulation etc.).
7. The JTA should consider the implementation with other stakeholders of a **transportation plan** and consolidate the transportation systems in operation today (bus..) with those under planning or design (Street Car, BRT, others)
8. **Conduct a forum** to share results of the Skyway Technology Assessment with key stakeholders to initiate a dialogue regarding:
    - long term transportation planning;
    - the essential connection between transportation and land use;
    - secure advocates; and
    - possible funding partners and programs.

   The forum should include representatives of:
    - DIA
    - City Council
    - Shipyards Development
    - Downtown Business Leaders
    - Urban Design specialists
    - FDOT Urban Office
    - North Florida TPO Board
    - JTA Board of Directors
    - JTA LRPSD staff

9. Advance collaborative efforts for the redevelopment of **Lavilla District**. Streetcar projects typically promote economic development adjacent to the rail line.

10. Develop **Implementation Plan** for selected alternative considering:

    - Planning and Design Effort

- Schedule
- Estimated costs
- Funding Availability
- Stakeholder Coordination
- FTA / FDOT/NEPA Requirements
- Public Involvement

APPENDIX 1: CONDITION ASSESSMENT SKYWAY OPERATING SYSTEM

The Operating System condition assessment was performed between October 8 and October 10, 2014. Prior to the start of the condition assessment, the JTA conducted a safety briefing for the Lea+Elliott Team members. The JTA staff provided valuable documentation, information and details. The following includes a brief summary of the findings (see Condition Assessment Operating System Draft Report dated October 2014 for complete details).

Vehicles

Of the ten trains, only six are currently being used in passenger service. The remaining four trains have experienced Permissive Movement Authority (PMA) signal loss failures that impede their use. The Lea+Elliott Team performed an inspection of Trains 105 and 109 that were that were made available by the JTA in the maintenance shop to assess their general condition and to get a general feel as to the conditions of the fleet. There were three other trains that were parked outside the maintenance shop. Those trains were Trains 104, 106, and 107. Through interviews with the JTA staff, it was noted that trains 104 and 107 have been out of service for 2 to 3 years and have since been used as a source for spare parts. Train 106 has been out of service for about one year and was also experiencing PMA signal loss failures.

The signal and power cables, potential contributors of electromagnetic interference, on two (2) trains were inspected and visually found to be in good condition. There is no indication of dry rotting or damage of the cable insulation. There was no indication of cable insulation discoloration which would indicate that the cable was exposed to high current. Overall the under-car signal and power cables appear to be in good condition.

It was observed that a 480 VAC cable is routed in close proximity, with some parallel run, to the 36 KHz PMA signal cable. The cables are installed about 18 inches apart. This installation is typical on all the trains, and cables are routed under the train next to the collector tree assembly. This could also be a potential source of electromagnetic interference, where propulsion cables would induce interfering signals in the PMA cable.

The management and maintenance of the on-board cables in the Propulsion Control Unit (PCU) cabinet was observed to be lacking and requires improvement.

The undercarriage, bogie structure, and overall general condition of the exterior body panels of Train 109 were visually inspected. Special attention was paid to the undercarriage and bogie structures since the exterior of the train was covered with a train wrap and it was not easy to inspect the condition of the fiberglass body panels. The undercarriage and bogie structure appeared to be in good condition. **There were no visible structural cracks found, however there were a few areas that showed some signs of corrosion and these areas would need to be grinded to bare metal to determine the extent of the corrosion and then recoated and/or repaired if required.**

The train propulsion system was supplied by Bombardier Transportation as part of the UM III Monorail system delivery in 1997. The motor/ gear box was manufactured by Kaman Electromagnetics Corporation, and the PCU was manufactured by a Bombardier subsidiary located in Germany.
The motor/gear is a special unit which is not commercially available on the market. It appears that the unit was custom made for the JTA Skyway application. Even though the manufacturer is not supporting the product line, JTA staff indicated that units are repaired / rebuilt by a local vendor as necessary.

The Propulsion Control Unit which is supplied by a Bombardier subsidiary located in Germany is also affected by obsolescence and a lack of spares. The JTA staff indicated that the manufacturer has informed them that the Main Propulsion Controller Board (Part #3MUP0000001-0016 (DMC-120) will no longer be available. We understand that the JTA is in the process of acquiring the last twenty five (25) spare boards that are available. In the absence of accurate data, it is difficult to determine how long these spares will support the existing fleet of 10 trains.

The JTA informed the Lea+Elliott Team that they had requested Asea Brown Bovery (ABB), a major propulsion supplier, to review the Skyway train propulsion system and provide a proposal to either replace it completely, or partially. Based on that information, the Lea+Elliott Team held several discussions with ABB. ABB confirmed that they were looking at the two options, but also indicated that due to the unique nature of the Permanent Magnet DC Motor, and its interface with the propulsion controller, they were still investigating the issue. In addition, ABB generated questions to the JTA about the existing propulsion converter dimensions as compared to the one that they would propose as a replacement. There would be a possibility that the replacement propulsion converter would also include/integrate the Auxiliary converter. **This needs to be investigated further by the JTA.**

Permissive Movement Authority (PMA)

The JTA indicated that PMA issues started about five years ago. There is evidence however, that the System experienced PMA issues during testing and commissioning, but those issues were apparently resolved at that time and started to occur again in around the year 2009 timeframe. Several attempts have been made to resolve the PMA problem, the latest of which consisted of an investigation performed by Thales on July 26th-28th 2014. The investigation consisted of assessing train 105 PMA alarms, and performs a comparison with train 102, a train known to operate without PMA failures. The test report indicates that Thales was able to verify that the PMA alarms are directly related to a high level of in band noise generated from the traction motors during dynamic braking situations. This high level noise can cause data corruption in the 36 KHz frequency band that the trains use to receive PMA messages from the wayside equipment via the inductive loop cables. Thales was able to detect a higher level of noise on train 105 when compared to train 102. This phenomenon was exacerbated when the trains are moving downhill and using dynamic brakes.

PMA failures can be caused by one, or by several contributing factors. A single failure could be a break in the cable or a loose connection; in which case the problem will always occur. If the PMA signal is not generated at the specified level; if splicing is not performed correctly; or there are too many splices in the cables that cause a high resistance; and if the cable is drooping slightly outside the ideal range of the 36 KHz antenna; the signal will be attenuated before it gets to the VOBC. One or several of these causes, combined with a high level of in-band noise generated by the propulsion system can also lead to PMA failures.

To address the PMA issue, the following recommendations were made:
On-board Equipment

- It was observed that a 480 VAC cable is routed adjacent to a 36 KHz antenna cable which can create Electromagnetic Interference (EMI**). JTA should consider re-routing the 36 KHz antenna cable to provide more separation between the cables and installing EMI shielding on the 36 KHz antenna cable.**

- The 36 KHz antenna cable that runs from the antenna to the VOBC contains several connections between the antenna and the VOBC. JTA should consider installing an antenna cable that goes directly from the antenna to the VOBC. Note: the JTA indicated that they were already working on a similar idea and that they were about to procure a new antenna cable. **The Lea+Elliott Team recommended that Thales be asked to confirm the cable type.**

Wayside

- The IDTS loops were inspected during the guideway inspection and it was observed that there were multiple spices on some cables. These splices will increase the cable resistance resulting in increased signal loss. **It is recommended that Loop resistance measurement be taken at the WCU CTF and confirm that it is within the manufacturer, Thales, specification**. **JTA should also request Thales to provide the procedure on how to splice the IDTS cable.**
- There was no documentation to show that regular preventative maintenance was performed on the WCU. These PM include measuring output from the PMA generator. **JTA should perform the manufacturer recommended PM and ensure that the Hybrid Module, which generate the PMA signal, is outputting the proper signal.**

Some sagging IDTS cables were observed during the Guideway inspection. **JTA should perform the appropriate corrective maintenance to adjust the cable so they are tight and remain within the envelope of the train mounted antenna.**

ATC Overhaul

A teleconference was held with Thales on 10/31/2014 to discuss Thales recommendations for an overhaul. Based on such discussion, the following, general methodology should be adopted:

- Reliability Analysis to identify the top 10 issues (parts that fail frequently, or that fail more frequently than expected) and replacement of parts that are approaching their service life (relay base parts with mechanical component)
- Obsolescence analysis to identify and replace parts that are obsolete or will be obsolete in the near future.

Once the above activities are completed, the 15-year mid-life overhaul scope will be defined with greater certainty.

SCADA

Even though the SCADA servers were replaced a few years ago, many of the overall SCADA subsystem components have become obsolete, and are no longer supported or reproduced by the manufacturer (Siemens). These obsolete components have been increasingly more difficult to obtain to keep the SCADA subsystem up and running. The Lea+Elliott Team recommend that in the near future, the SCADA subsystem be upgraded utilizing currently available state of the art equipment to eliminate compatibility issues and where spare parts will be supported and manufactured for the foreseeable future.

Transdyn Controls, the original SCADA system provider, has submitted a proposal to upgrade the system in August 2013.

<u>Power Distribution System</u>
Except for outages due to the loss of primary power provided by the Jacksonville Electric Authority (JEA), the JTA did not identify any major issues with the Skyway Power Distribution System (PDS) other than tripping of circuit 52-37.

The JTA maintenance staff has done some extensive trouble shooting of the circuit 52-37 failures. A local electrical contractor recently performed some testing; based on the test results and test report; it appears there was some confusion as they did not reach a specific conclusion. After inspection and discussions with the JTA staff, the Lea+Elliott Team believe that it is likely that there is a ground fault in one or more of the cables/conductors that run from the San Marco substation to DuPont station. **These cables should be "megger tested" to test the cable insulation resistance line to line and line to ground in an effort to identify the faulty cable(s).** Any faulty cables should be replaced.

<u>Guideway</u>
Guideway inspection of various part of the system was performed during the two-day investigation. The visual inspection was performed by taking a train on to the system and stopping at various locations. The inspection Team departed the train and walked the guideway in the areas that were identified to be inspected. The inspection was limited to the equipment that was visible.

The JTA staff indicated to the Lea+Elliott Team that the Ground and Signal rail support brackets have deteriorated over time and have been breaking frequently in recent years. The JTA has requested the ground and signal rail provider to identify a different type of support bracket that would not deteriorate over time like the existing ones have. Unfortunately, there was no other type of support bracket that they could recommend. **A possible option is to simply replace all the brackets as they have deteriorated over the past 17+ years of service. The JTA could replace the support brackets systematically over the course of several months possibly replacing sections at a time, on weekends when the system is not in operation.** Once all the brackets are replaced they should last at least another 10-15 years before they start showing signs of deterioration/trouble again.

Water was seen accumulated in several areas along the guideway. After a closer look, it appears that this ponding condition has been present for many years and has started to induce corrosion of the Skyway wayside equipment, conduits, cable trays, etc. If this condition is not quickly addressed and corrected, it could eventually result in failure of wayside equipment and system downtime. **It is recommended that the JTA have the drainage system evaluated and repaired and possibly enhanced to allow for proper drainage of rain water off the guideway. Also a thorough system wide inspection should be performed and all corroded and damaged system equipment, conduit, cable trays, etc. should be repaired as soon as possible to avoid a potentially significant downtime event from occurring**.

<u>Training</u>
As mandated by the FDOT's Sate Safety Oversight (SSO) manual, a training and certification program must be established by the transit agency. JTA has stated that JTA's training and certification program is currently under revision and that they are working with a consultant in revising the new training program. **The Lea+Elliott Team recommends that JTA continues with the revision to the training and certification program and recommends that this program also include a re-certification requirement and a periodic efficiency and safety test/exercises that can help maintain the staff's system safety and operational readiness. In addition to the safety tests/exercises, the Training and Certification**

program should also test the maintenance and central control operator's staff knowledge of the system and its major subsystems.

Spare Parts

Based on The Lea+Elliott Team's interviews with the JTA, a series of issues with spare parts have been identified:

- Lead time and,
- Price: the JTA mentioned the monorail car glass windshield is very expensive if purchased through Bombardier. The JTA is looking for an alternate source of supply using a local vendor. This should be encouraged and expanded whenever possible. **The JTA should also consider purchasing parts from the OEM and not go through Bombardier and paying premium prices for equipment that can be purchased directly from the Original Equipment Manufacturer (OEM).**

The JTA indicated that the design-build contract does not include a trust agreement clause that could be invoked in case the original part is no longer available, or if the prices of spares become prohibitive. The Lea+Elliott Team indicated that their procurement documents include a protection for the owner where the Contractor is required to guarantee availability of spares for 20 years, at a reasonable price. Documents deposited in a trust account can also be accessed by the owner in some cases (non-availability of spares, contractor out-of-business etc...) to allow the supply chain to proceed uninterrupted. **It is recommended that such clause be included in any future rehabilitation contract**.

Maintenance Agreements

The JTA indicated that there are two operating system maintenance agreements in place; one with Thales and the other with Transdyn. The agreement with Thales includes an annual visit by a Thales Field Service Engineer to the Jacksonville site for a 3-day onsite ATC System assessment or operation and maintenance training, , as well as four hours a month of remote maintenance support.

The Lea+Elliott Team recommend that more elaborate maintenance agreements be established with some key suppliers such as Thales, ABB (if ABB will perform the overhaul of the propulsion system), and Powell, etc.

The Lea+Elliott Team understands that starting August 1, 2012, the Preventive maintenance Program has been revised to be mileage-based vs. time based. In order to make sure that the PM program is comprehensive, **the Lea+Elliott Team recommends that the JTA perform an internal maintenance audit to determine whether all maintenance activities specified by Bombardier are performed.**

Safety

The JTA indicated that they participate in the State Safety Oversight program and that TRA has been providing safety and security audits. It was noted to the JTA that safety related maintenance activities need to be performed at regular intervals to maintain the safety of the System. It is not clear whether these activities are performed as specified in the maintenance plans provided by the DBOM Contractor.
As an example, the JTA was asked whether vital relays have undergone calibration checks as per the recommendations of the OEM manufacturer (it is indicated, in the relevant maintenance manual, that vital relays should undergo measurements, checks and visual inspections every two to four years). The

JTA indicated that such verifications were not performed. **The Lea+Elliott Team recommendation is for the JTA to compile all required maintenance activities identified in the O&M manuals and ensure that they are performed as per the recommendations of Bombardier, or the OEM manufacturer**. Finally, it does not appear that the JTA Safety Department has a person in charge of Skyway Monorail Safety who would verify, among other safety responsibilities, that all safety maintenance activities are performed. **The JTA should consider addressing the issue of dedicated Skyway Monorail safety supervision.**

Documentation

It was noted that the Skyway project documentation was not adequately inventoried and no listing of all available documentation, including document number, title and date was available. **It is recommended that the JTA undertakes the effort to perform a complete inventory of the Skyway project documentation.**

APPENDIX 2: CONDITION ASSESSMENT INFRASTRUCTURE (INCLUDING LOAD RATING OF A TYPICAL SPAN)

The infrastructure condition assessment was performed between September 30th and October 11th, 2014. Prior to the start of the condition assessment, the JTA conducted a safety briefing for the Lea+Elliott Team members. The JTA staff provided valuable documentation, information and details.

The Infrastructure condition assessment reports include a detailed description of the findings and recommendations from the site inspection. G.M. Hill Engineering, Inc. prepared a report for the eight skyway stations, and FIT Engineering; LLC prepared a report for the guideway infrastructure.

This summary gives a brief overview of the findings and recommendations for various structural and non-structural items of the existing infrastructure. Near, mid, and long term recommendations are summarized for each aspect of the skyway system. Near term is considered from 0 to 5 years from today, mid-term is 5 to 15 years, and long term recommendations are those which are thought of as being more than 15 years in the future. It should be noted that short term and mid-term recommendations may be dependent on the long term alternatives chosen for the skyway system. Please refer to the Infrastructure Condition Assessment reports for complete details.

SKYWAY GUIDEWAY – GENERAL DESCRIPTION

The guideway was built in five sections beginning in the mid 1980's. Most of the guideway is built on its own infrastructure and within its own right-of-way, but the segment crossing the St. Johns River is supported by the Acosta Bridge and is barrier separated from the vehicular traffic. The guideway is split into a left guideway and a right guideway, for separate, two-directional traffic. "Crossover" segments connect the two sides at strategic locations so that, for example, when a skyway vehicle comes in to a terminal station, it can cross over to the other side to make its way back in the opposite direction.

For much of the system, the two guideways run parallel and are within a few feet from each other. The guideways split apart to flank the stations and then merge back to parallel at locations between the stations. In the areas in which the guideways are close together, they share a substructure unit, typically a hammerhead or "T" shaped pier. Where they are separated, the left and right guideways have individual piers.

The material for all of the substructure units is concrete; typically conventionally reinforced, although there are pier caps on the north side of the river that are post tensioned. In several locations, there are steel cross beams or cross heads, but because they sit above the bearings, they are considered part of the superstructure, not the substructure. The superstructure is framed with two types of beams – concrete tee beams for the shorter spans and steel box girders for the longer spans and most of the curved spans.

SKYWAY GUIDEWAY – FINDINGS AND RECOMMENDATIONS

Drainage System
There are clogged, broken, and missing drain caps at deck level throughout the system. Many of the drain pipes are clogged with dirt and debris. There are multiple locations along the system in which water is ponding on the deck surface due to a variety of issues. It is imperative that maintenance and repairs be done to fix these drainage issues. Refer to the Infrastructure Condition Assessment report for a list of maintenance procedures that should be followed.

Encroachment and Vegetation growth

There are trees encroaching on the Skyway beams at various places. Specific locations cited in the most recent routine inspection report include Span 30 (Bay Street near Broad), Spans 66, 67, 68, 70, 72, 74, 75, 77, 79 (along Hogan Street), and Spans 199 and 200 (at Kings Avenue Station). There is vegetation growing around and on the columns at the O&M Pier 403, and Pier 408 Left.

The growth on Pier 408L should be removed. Trees in contact with the guideway beams or overhanging the sidewalls should be trimmed back. An annual plan to periodically trim trees that are encroaching on the system should be added to the maintenance procedures.

Emergency Walkway

Galvanized emergency walkways are present everywhere throughout the system except at the stations, where passengers can exit directly onto the station platforms.

Overall, the emergency walkway is in good condition. The only structural defect noted in the South Segment is that the grating cover plates are not wide enough over the expansion joints at Acosta Bridge Piers R1 and R6 to fully cover the gap produced by the bridge deck contraction, especially in the winter time. The few minor structural defects noted in the North Segment include missing connectors, loose/missing expansion cover plates, and nuts not fully engaged. There is light to moderate surface corrosion on the emergency walkway grating, grating clips, clip bolts, railings, and support brackets and bolts at various locations throughout the system. Refer to the Infrastructure Condition Assessment report for a list of maintenance procedures that should be followed.

Expansion Joints

The main issue associated with the typical expansion joints are more a function of design as opposed to normal wear and tear. Because the design of the system results in the joint for the guidebeam elements not to line up with the joints for the deck, the guidebeam elements are forced to slide back and forth with the deck expansion and contraction. This design doesn't have the best practical results as there is a lot of concrete mass expected to move back and forth which often results in cracking and spalling of the moving components.

Another issue with the expansion joints occurs when the two beams are not collinear. This presents both longitudinal and lateral movement and the joint must be designed for both. A way to fix this issue includes taking field measurements at full expansion and contraction. Once this data is obtained, an engineered solution detailing these joints should be done to ensure proper movement in all directions are accounted for.

Refer to the Infrastructure Condition Assessment report for a complete list of maintenance procedures.

Deck Elements

Two types of "decks" exist along the guideway system and these "decks" are functions of the superstructure type. In the spans composed of double tee concrete beams, the deck is simply the top flange of the beams. When the spans that are composed of steel boxes, the deck resembles a typical bridge deck – 8" cast-in-place, traditionally reinforced concrete deck.

There is dirt and debris build-up on top of the deck surface throughout the system. The undersides of the deck overhang slab extensions (at the switch beams) have transverse hairline cracks with efflorescence. The conduit support boxes that run along the sidewalls have a minor amount of corrosion at random locations.

Concrete spalling is prevalent throughout the deck area. Most of the spalling on the north section is along the old second pour and the running surfaces.

Refer to the full Condition Assessment report for a complete list of maintenance procedures.

Sidewalls
The barriers along the outsides of the typical sections are referred to as "sidewalls". The sidewalls were cast in place and made integral with the deck. Reinforcement for the sidewalls was cast within the tee beam flanges or within the deck above the steel boxes. See Appendix A - Figure 9 for typical details.

Two prominent deficiencies associated with the sidewalls are typical reinforced concrete defects: cracking and spalling. In the latest routine inspection report, there are comments regarding spalls at 67 locations along the South Segment guideway, 28 of which have exposed reinforcement.

Guidebeam
The guidebeam is essentially a hollow concrete box that sits upon a longitudinal pedestal and runs along the top of the deck surface. It is the riding surface of the skyway vehicle.

The most prominent deficiency associated with the guidebeam is nearly ever-present longitudinal cracking along the centerline of the guidebeam. The widths of these cracks vary, from hardly visible hairline cracks to 1/32" wide. Refer to the full report for a list of maintenance procedures that should be followed.

Concrete Tee Beams
Nearly 70% of the guideway is framed with pre-stressed concrete tee beams. The beams are typically grouped in three or four span units made continuous over the piers by post tensioning tendons that run through the beam top flanges and through the pier cap.

The primary issue of concern with the tee beams is the diagonal and radial cracking of the stems at the dapped ends. Refer to the full report for a list of maintenance procedures that should be followed, as well as a more detailed review of these cracks, FRP Strengthening that has been done, and crack injection repair work that has been completed.

Steel Box Girders and Cross Beams
86 of the 322 guideway spans are framed with steel box girders; representing about 26% of the superstructure. The steel boxes are used at most curved sections and at the long span tangent sections of the guideway.

Many of the steel box access hatches have hasp latches and most, if not all, are not locked. The starter line hatches are secured with bolts, but there are no nuts on the ends.

A review of the most recent routine inspection report indicates that overall, the steel beams are in good condition. There are no significant structural deficiencies and there are no signs of structural distress. It is apparent, however, that the coating system is reaching, if not past the end of its service life. According to the FHWA Steel Bridge Design Handbook Vol. 19, 3-coat, zinc-rich primer paint systems data suggest performance of 25 years in less aggressive, non-marine environments. With the system being built between the late 80's and late 90's, the current coating system is between 25 to 30 years old. The exterior surface coating is breaking down, as evidence by its chalky nature, but fortunately, only a small percentage of the total surface area has succumbed to the corrosion process. Refer to the Infrastructure Condition Assessment report for a list of maintenance procedures that should be followed.

Piers

Pier styles, sizes and shapes vary along the guideway and depend on a number of factors such as station vicinity, surrounding infrastructure and roadway constraints, superstructure type, and required beam continuity.

The piers, for the most part, are in good condition. Hairline cracking is prevalent throughout, on both the pier caps and the pier columns. Please refer to the full report for a detailed discussion on crack locations and types of cracks at the Piers.

Bents and Walls

On the north side of the river, after the guideway crosses the Acosta Bridge, it makes a right turn and goes beneath FDOT Ramps K and G. In this area, for approximately 332 feet, the guideway deck is pile supported with walls along the outer sides and transverse end bents at each end of the span.

In general, the walls surrounding the pile supported slab span are in good condition. Minor structural defects exist such as cracking along cold joints, map cracking of the end bent cheek walls, and spalling up to 8"x6"x1" on the rustications of the wall faces. There is no exposed steel or rust staining to indicate rebar corrosion. The transverse wall faces are stained from runoff through the expansion joints.

SKYWAY STATIONS – FINDINGS AND RECOMMENDATIONS

The eight skyway stations are:

1. Terminal (Convention Center) Station
2. Jefferson Station
3. FSCJ (Rosa Parks) Station
4. Hemming Plaza Station
5. Central Station
6. Kings Avenue (Dupont) Station
7. Riverplace (Flagler) Station
8. San Marco Station

Extensive rust and corrosion at metal surfaces was observed at multiple locations. At some rail posts, the corrosion is extensive and posts either need to be replaced or will need to be replaced in the near future. Rust was noted at concrete spalls with and without exposed rebar.

Surfaces, primarily metal, in need of painting were observed at multiple locations at the stations. Many of the metal surfaces also require removal of minor rust or corrosion prior to painting. Expansion joint material was observed to be damaged, deteriorated, or missing at the stations. This will require regular and ongoing maintenance.

Concrete spalls were observed at multiple locations. Spalls at stair nosings are evident and new spalls may develop near existing spalls or at new locations.

Cracking at concrete surfaces was observed at multiple locations. Cracks at rail posts at stairs are common and contributing to additional damage. These cracks are also contributing to moisture damage and corrosion to the reinforcing steel. These cracks will require regular and ongoing maintenance.

Water intrusion was observed at multiple locations. This water damage causes structural and cosmetic damage, rust/corrosion, mold, and mildew. Every effort should be made to limit water damage and remove the standing water that occurs. Many drains are clogged and improperly installed. Standing water also poses a safety and fall hazard.

Near Term Recommendations

For short term structural serviceability, it has been determined that the current stations are adequate to handle the original design loadings. It should be noted that minor serviceability and structural issues discussed above, and in more detail in the report, can turn into mid or long term issues if they are not handled correctly and in a timely manner. Refer to the report for a detailed description of maintenance procedure that should be carried out to protect the mid and long term sustainability of the stations.

Mid Term Recommendations

For mid-term structural serviceability, the maintenance and repairs must continue to be monitored and completed in order to maintain the structure as it is today. More routine maintenance for concrete repairs will be necessary. It has been determined that, if no plans to modify the existing station or to change the current train loadings are put in place, the current station will be adequate to handle the original design loads. If plans to modify the existing station or to change the train loading are put in place, then a detailed and comprehensive structural analysis must be conducted to properly evaluate each station for any expansion or renovation that may be necessary.

Long Term Recommendations

For long term structural serviceability, it is likely that plans to modify the existing station or to change the train loads will occur. A detailed and comprehensive structural analysis must be conducted to properly evaluate each station for any expansion or renovation that may be necessary.

CONCLUSIONS & RECOMMENDATIONS

Guideway Infrastructure

Based on our preliminary findings we recommend that JTA consider the following improvements for the Guideway Infrastructure:

Near Term (0-5 years):

- Perform repairs from recent inspection report
- Drainage Repairs and Maintenance
- Vegetation Trimming
- Cleaning and Repairing Spalls in Deck & Piers
- Expansion Joint Repair
- Steel Beam Spot Painting

- Steel Beam Maintenance Access Locks

Mid-Term (5-15 years):

- Engineered drainage solution
- Vegetation Trimming
- Galvanic coating to the walkway
- Engineered solution to expansion joint problems
- Comprehensive coating system for Steel Beams and other steel components

We also recommend that the JTA also perform the following in the mid-term particularly if there are any changes to the condition of the structure and/or types of vehicles. It should be expected that as the condition deteriorates there will be a corresponding reduction in load carrying capacity of the structure.

- Comprehensive load rating analysis of entire guideway infrastructure
- Map and Monitor Cracks in concrete substructure and superstructure as part of regular inspections

Long Term (15 years +)
Recommendations for the long term will be dependent on the selected alternative. If Mid-Term recommendations are implemented this will help extend the service life and minimize long term rehabilitation costs. It is to be expected that rehabilitation costs and the duration of service interruptions will increase as the infrastructure approaches its useful life, and deterioration accelerates.

Please see sections 4.1.3.1 and 4.1.3.2 for estimates for the near and mid-term recommendations for guideway infrastructure.

Skyway Stations
Based on our preliminary findings we recommend that JTA consider the following improvements for the Skyway Stations:

Near Term (0-5 years):

- Cleaning and Repairing Spalls in Concrete
- Drainage Repairs and Waterproofing
- Fire Alarm and Security System

We also recommend that the JTA continue to perform regular inspections in the near term to monitor the condition of all station elements including concrete cracking and expansion joints.

Mid Term (5-15 years):

- Repair/Replace Corroded Elements
- Painting of Metal Elements
- Replace Failed Expansion Joints

- Maintenance to Concrete Spalls
- Drainage Repairs and Waterproofing

We also recommend that the JTA continue to perform regular inspections in the mid-term and throughout the systems remaining life to monitor the condition of all station elements.

Please see sections 4.1.3.1 and 4.1.3.2 for estimates for the near and mid-term recommendations for the skyway stations.