Greater Orlando Aviation Authority
Orlando International Airport
Automated People Mover

Assessment of Various APM Technologies' Viability for Airsides 2 and 4 Replacement Project

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1. EXECUTIVE SUMMARY

The Orlando International Airport utilizes four independent Automated People Mover (APM) systems (A1, A2, B3 & B4) connecting the main Terminal building to each of the remote Airside buildings (namely Airsides 1, 2, 3 and 4 respectively). Rubber-tired APM vehicles transport passengers between Terminals on elevated guideways. This report focusses on the Airside 2 & 4 (A2 & B4) APM systems which GOAA is currently considering plans for upgrade/replacement.

Each A2 and B4 System is a dual shuttle "must-ride" system of approximately 2,000 ft. guideway connecting between two stations at each end. Each system is served by two trains consisting of three cars. The system round trip time is about 3.5 - 4 minutes and the headway is about 1.8 – 2.0 minutes. This results in a capacity of about 6,600 – 7,000 passengers per hour per direction (pphpd) for the existing system. The Airside B4 APM operation includes an International Mode (IM) of operation due to the need to carry international passengers separate from the domestic passengers. Based on field observations, when the APM is in IM, the roundtrip times are significantly increased due to the need for manual operation and screening of each train once international passengers have disembarked. The increased trip time reduces the capacity to approximately 3,900 passengers per hour per direction (a drop of about 40%) for the system.

Due to the must-ride nature of these systems, the replacement program must have minimal operational impact on the APM service and the passenger experience, and would ideally be scheduled during off-peak seasons based on the historical traffic demands of the airport.

The purpose of this document is to establish the technologies that are the most appropriate candidates for this project. The report also reviews the advantages and disadvantages of various candidate technologies, and also includes the potential for refurbishing the existing system. The evaluation and conclusion is intended to highlight and provide clear definition of the extent of modifications and rework that will be required for adopting some of the candidate technologies, and evaluate the extent of the airport's operations and passenger movement that may be adversely affected by the required work for fit out.

The report analyzes the types of technologies available in the market and reviews their site specific fit for the project. The analysis is based on the impacts on system capacity, vehicle compatibility (which drives the extent of facilities re-work required), track and station layout compatibility and/or impacts. The constraints related to existing maintenance space, transition of maintenance from existing to future systems in a phased manner and the terms and conditions of the O&M contracts was also considered. The impact of any such decision on the growth and operational capability of the airport was key consideration in the evaluation.

2. INTRODUCTION

The Orlando International Airport utilizes four independent Automated People Mover (APM) systems (A1, A2, B3 & B4) connecting the main Terminal building to each of the remote Airside buildings (namely Airsides 1, 2, 3 and 4 respectively). Rubber-tired APM vehicles transport passengers between Terminals on elevated guideways. This report focusses on the Airside 2 & 4 (A2 & B4) APM systems which GOAA is currently considering plans for upgrade/replacement. Each A2 and B4 System is a dual shuttle system of approximately 2,000 ft. guideway connecting between two stations at each end. Each system is served by two trains consisting of three cars. The A2 & B4 APM System technology is a modified CX-100 by Bombardier Transportation. The system round trip time is about 3.5 - 4 minutes and the headway is about 1.8 – 2.0 minutes. This results in a capacity of about 6,600 – 7,000 passengers per hour per direction (pphpd) for the existing system.

The Automated People Mover (APM) systems serving Airsides A2 & B4 in the North Terminal are considered as a "must-ride" system. That is, they are the primary mode of transportation to shuttle ticketed passengers to and from the main Terminal and the Airsides 2 and 4. Each APM system is configured as dual lane shuttle which provides redundancy such that in case of a shutdown of one lane of the dual lane shuttle (due to failure, maintenance or rehabilitation); at least one "single-must-ride" train will be available. Each APM system operates approximately 16-20 hours per day with an average round-trip period of about three to four minutes. The maintenance hours for each train of A2 or B4 are staggered such that there is always one train available 24 hours of the day.

The Airside B4 APM operation is unique in that it includes an International Mode (IM) of operation due to the need to carry international passengers separate from the domestic passengers. When the system is operating in IM Mode, all trains must go through a manual security sweep process once the international passengers have departed the train, prior to any domestic passengers boarding. Since this process is not under automated train control operations; and is instead manually turned on and off by the actual airport security personnel, the trains typically take longer to complete a round trip. These longer round trip times reduce the overall capacity of the system. Based on field observations, when the APM is in IM, the roundtrip times are significantly increased due to the need for manual operation and screening of each train once international passengers have disembarked. The increased trip time reduces the capacity to approximately 3,900 passengers per hour per direction (a drop of about 40%) for the system. Once there are no longer any International Passengers on the trains, the system returns to normal operations.

Due to the must-ride nature of these systems, the replacement program must have minimal operational impact on the APM service and overall passenger experience, and would ideally be scheduled during off-peak seasons based on the historical traffic demands of the airport. These options will be coordinated with the Authority and airport operations and will be a consideration in the development of the procurement option for the project.

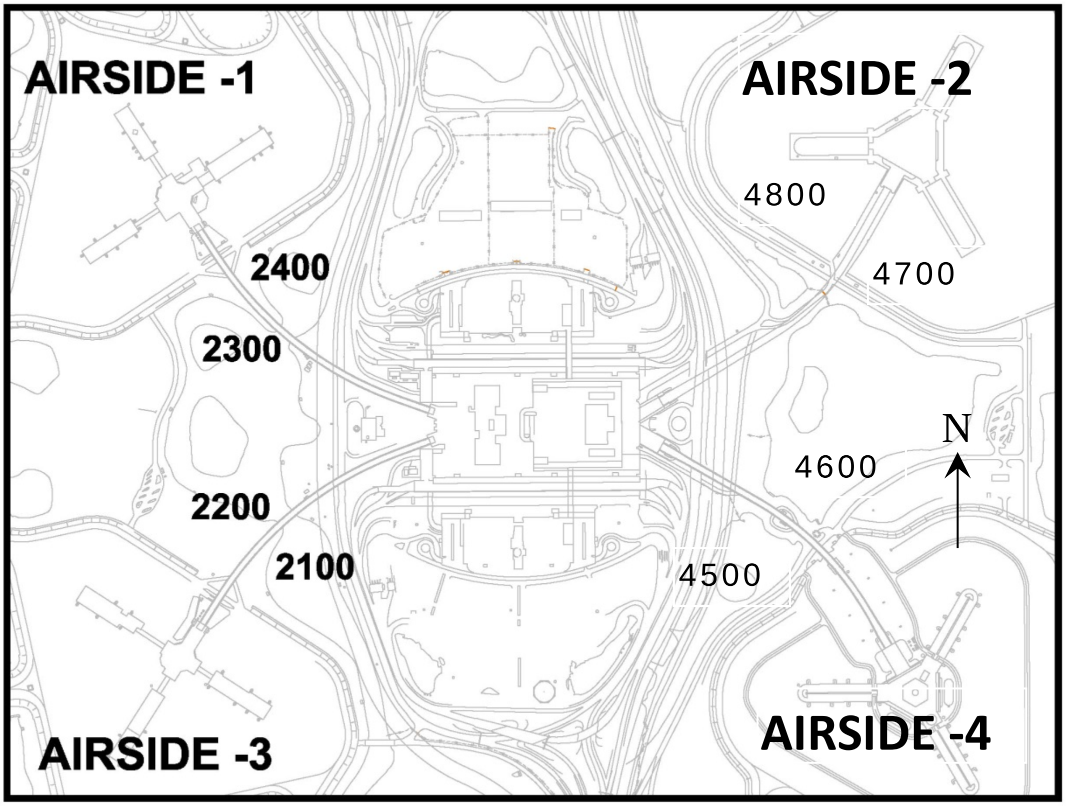


Figure 2-1: OIA - General Layout (Airsides and Guideway Designations)

3. PURPOSE

The Greater Orlando Aviation Authority is currently undertaking an evaluation of Procurement Options to prepare for the replacement project for the existing Airsides A2/B4 APM systems. The purpose of this document is to evaluate the technologies that are the most appropriate candidates for this project.

There are several manufacturers of APM technologies that can be considered as candidates for the A2/B4 APM System replacement in Orlando International Airport. APM systems are based on proprietary designs provided by suppliers/ manufacturers active in the market place. Among these suppliers, there is considerable variance in approach to design and implementation of their basic system elements into existing fixed facilities elements.

The report reviews the advantages and disadvantages of various candidate technologies, and also includes the potential for refurbishing the existing system. The evaluation is intended to highlight and provide clear definition of the extent of modifications and rework that will be required for adopting some of the candidate technologies and evaluate the extent of the airport's operations and passenger movement that may be adversely affected by the required work for fit out.

4. TECHNOLOGY ASSESSMENT & LIST OF APM TECHNOLOGIES

The APM technologies are specialized and there are only a few known suppliers in the market place. Some suppliers have multiple classes of technologies and they typically propose a technology for a project based on its cost competitiveness and best fit to the requirements in response to a solicitation. The range of such technologies includes:

- Personal Rapid Transit (PRT)
- Monorails
- Cable-propelled APMs
- Self-propelled Rubber-Tired APMs
- Large Steel Wheel-Rail ALRTs or APMs

All of the above technologies operate in a fully automated, driverless mode. The site-specific application of the technology is based on proprietary "off-the-shelf" equipment designs that are customized to satisfy site-specific constraints. For technology assessment purposes, the recommended screening criteria considered include:

- Safety & Reliability
- Technical maturity
- Ability to meet ridership demands
- Ability to meet and fit into existing fixed facilities, spaces and requirements (minimize major modifications, if modifications are required)
- Ability to meet operational requirements
- Opportunities for competitive procurement

4.1 New Technology Implementation vs Refurbishment

Prior to implementation of a new Technology or System, it is also important to consider the possibility of refurbishing the existing system and the benefits or possibly disadvantages that may offer to GOAA. A new system may provide a Design Life of about 25 years for the vehicles and up to 30-years for other subsystems. A refurbished system may provide an additional 15 years of extended service life to a system/subsystem that has already been in operation for at least 20-30 years.

For refurbishment of the existing system, the following items, at a minimum, will need to be upgraded and modified: the vehicles, the Automated Train Control (the operating system and the vehicle system), the Communications, Central Control/ATS upgrade/interface and inspection of the Power Distribution System and emergency generator, the Guideway structure, and the Running Surfaces. Consideration must also be given to the amount of time it will take to perform the refurbishment and the impact to the existing operations. This is further discussed in Section 5.5 of this report.

4.2 Personal Rapid Transit

Personal Rapid Transit (PRT) is a transit technology characterized by small (4-6 passengers) vehicles, operating over a dispersed network, and designed to provide nonstop, origin-to-destination service to individuals or small groups of passengers. Currently there are three PRT suppliers world-wide that have systems in passenger service or on test tracks: ULTra (U.K.), 2GetThere (Netherlands), and Vectus (Korea). ULTra has a three-station operating system between a parking lot and Terminal 5 at the London Heathrow International Airport (LHR). 2GetThere has a two station system operating at Masdar City in Abu Dhabi. Vectus has a test track in Sweden and is building a two-station system at an amusement park in Suncheon Bay, South Korea. All of these are "starter" systems and do not represent a dispersed network application with on-demand origin/destination and direct routing i.e., the representative project application for a PRT.

The ULTra system operating at LHR, described below, represents the most extensive active application of a PRT technology. Further, it operates in an airport landside environment. Details of this application are:

- 2.4 miles of single lane guideway (end to end about 1.2 miles). (See Figure 2.1)
- 3 stations
- 21 vehicles in fleet
- Vehicle capacity: 4 (all seated) or 2 seated and one wheelchair (See Figure 2.2)
- Line capacity: approximately 1125 pphpd
- Connects the terminal and the parking lot stations

LHR Station and Vehicle Pictures

Viability of PRT for A2-B4 Replacement project:

PRT systems are not compatible for this project application due to station modification requirements and the lack of ability to meet line capacity. Since the carrying capacity per vehicle is a maximum of 4 passengers, the system will have extreme difficulties in meeting the operational capacity of the passenger demand. Due to the significantly smaller size of the vehicle, as compared to the present technology, modifications to the stations will be required. This may include changes to the platform barrier, the station doors, the structural system, etc.; this results in significant operational impacts and therefore the technology is not under consideration.

4.3 Monorails

Monorails that have been applied in airport environments are typically in the small/medium category. These are characterized by trains with connected vehicles, usually operating at speeds of 20 to 30 mph, designed to carry a moderate number of passengers within a geographically compact area.

Newark Airport (EWR) Monorail Vehicle

There are two types of large monorail systems: straddle-beam (guidebeam below the vehicle) and suspended (guidebeam above the vehicle). Large straddle-beam monorail systems have been built overseas by: 1) Hitachi in Japan and Dubai (Palm monorail) in urban applications and one airport access (Tokyo Haneda) application; and 2) a Malaysian company (Scomi Rail) in an urban application in Kuala Lumpur (KL line). Other urban applications of monorails are in Las Vegas, Riyadh, Saudi Arabia, and Sao Paulo, Brazil. Additionally, there are some applications of monorails that are suspended from the support beams.

Las Vegas Monorail Four-car Vehicle

Viability of Monorails for A2-B4 replacement project:

Monorail systems **are not compatible** for this project application due to the need for a specific guidance system structure and configuration when compared to the existing condition of the guideway. The operating systems and vehicles cannot be superimposed onto the existing guideway structure and will require a new and/or completely modified guideway for the technology to operate. As these are "must ride" systems; the significant operational impacts resulting from the construction of new/modified guideways system, stations, etc. make this not a feasible replacement technology option. Further, the suspended monorails cannot meet the NFPA 130 requirements for emergency evacuation, which is a requirement and therefore are not compatible.

4.4 Cable-Propelled APMs

This type of technology consists of vehicles that use cable propulsion and various types of suspension systems (rubber tire, air levitated or steel-wheel/steel-rail). Trains can be up to five cars long. Suppliers' claim that longer trains are possible but these have not been implemented – primarily impacts are to the drive cable and drive machinery which must now "pull" the higher weights associated with the longer train. The number of cars per train is fixed; a train has permanently coupled individual cars and grips to the cable at fixed points. Typically, cable systems are operated in a shuttle mode. Typical configurations are single and dual-lane shuttles and bypass shuttles. This technology is best suited for two or three station shuttle applications of 1.0 to 1.5 miles; should a longer route be required, then additional equipment/cables/drives/transfer points will be required.

Otis Transit Systems (subsequently Poma-Otis, and now Leitner-Poma) installed air levitated, cable systems at Cincinnati, Narita (Tokyo), Minneapolis/St Paul, Detroit, Zurich and Cairo

International Airports. Leitner-Poma was selected to replace the existing MIA Concourse E APM of dual shuttle system connecting landside terminal to airside satellite station. The Tampa Harbour Island APM, was an Otis air-levitated system. Doppelmayr Cable Company (DCC) has cable-propelled systems installed at Mexico City, Birmingham (UK) International Airports and recently completed systems within the terminal building at the new Hamad International Airport (Doha, Qatar) and a 3 mile airport access system connecting the Oakland International Airport and the BART rail system. Data for example systems at airports are given below:

BART Oakland Airport Connector: System's salient features are:

- 3.2 mile, pinched-loop
- Drive rooms are at the maintenance facility at system mid-point where trains change cables
- 2 stations
- Four, 3-car trains
- Initially 1,400 pphpd, expandable to 1,900 pphpd by adding a car to each train (a major, permanent undertaking)
- 4.6 minute headway

BART OAK Cable APM 3-Car Train

MIA Concourse E APM Replacement: The System is in installation and testing phase at the time of the report. System's salient features are:

- 1,230 ft. Dual Lane shuttle system
- Drive rooms are at ground at system mid-point
- 2 stations
- Two, 3-car trains
- 2,814 pphpd,
- 1.6 minute headway

MIA Concourse E Leitner Poma

Viability of Cable system for A2-B4 replacement project:

Cable propelled systems **are technically viable** for this project application. This technology's potential application is further analyzed in Section 5 of the Report.

The longer version of the cable technology that have been implemented recently in BART and earlier in Minneapolis, Detroit and Zurich do not easily fit into the existing infrastructure for A2 -B4, and would need either modifications in the stations and station platform doors or would require vehicle modification, as has been completed by Leitner Poma in the MIA Concourse E cars.

Cable propelled system will face certain challenges related to space requirements for its pulley based propulsion equipment in the two existing satellite stations and at the Maintenance Facility (MF) under the station. The cable propelled system also needs additional room along the guideway to house the drive bullwheel systems.

4.5 Self-Propelled Rubber-Tired APMs

Large rubber-tired APM systems are in widespread use at airports around the world and in some urban areas. These systems feature one-car to six-car trains operating in a shuttle or pinched loop configuration. Train speeds of up to 50 mph can be achieved. Airside system car capacity is about 70 to 80 passengers per car passengers who travel with only their carry-on baggage.

Currently available self-propelled rubber-tire APM systems are:

- Bombardier: Innovia 100 (previously CX-100) and Innovia 200/300
- Mitsubishi Heavy Industries (MHI): Crystal Mover and "Japanese Standard"
- Siemens-Matra VAL258 and AirVAL
- IHI/Niigata: I-Max and "Japanese Standard"
- Woojin Industrial Systems: Rubber tyred light rail vehicle

Airports where this technology is operating and the suppliers of the systems include:

United States

- Atlanta (ATL): Bombardier for Airside system, and MHI for landside/ConRAC system
- Chicago (ORD): Siemens-Matra
- Dallas/Ft. Worth (DFW): Bombardier
- Denver (DEN): Bombardier
- Houston (IAH): Bombardier
- Las Vegas (LAS): Bombardier
- Miami (MIA): Bombardier (Concourse E - a two station, dual lane shuttle system currently being replaced with a Leitner-Poma system), and MHI (North Terminal airside and MIA Mover landside CTA to parking/ConRAC/transit)
- Orlando (MCO): Bombardier; MHI recently selected for vehicle replacement Airside 1, Airside 3 and installation of new North-South terminal APM
- Phoenix (PHX): Bombardier landside to parking/transit with future extension to ConRAC)
- Sacramento (SMF): Bombardier
- San Francisco (SFO): Bombardier (landside CTA to transit/ConRAC
- Seattle/Tacoma (SEA): Bombardier
- Tampa (TPA): Bombardier airside systems, MHI recently selected to provide landside system CTA to parking/ConRAC

- Washington-Dulles (IAD): MHI

Europe

- Frankfurt (FRF): Bombardier
- London – Heathrow (LHR): Bombardier
- Madrid (MAD): Bombardier
- Munich (MUC): Bombardier (under construction)
- Paris – de Gaulle (CDG): Siemens-Matra
- Paris – Orly (ORY): Siemens-Matra
- Rome (FCO): Bombardier

Asia

- Beijing (PEI): Bombardier
- Hong Kong (HKG): IHI/Niigata and MHI
- Kuala Lumpur (KUL): Bombardier
- Osaka (KIX): IHI/Niigata
- Seoul – Incheon (ICN): MHI
- Singapore (SIN): MHI
- Taipei (TPE): IHI/Niigata

Middle East

- Dubai (DXB): MHI (operational) and Bombardier (under construction)
- Jeddah (JED): Bombardier (under construction)

Self Propelled technology examples are listed below:

Bombardier Transportation's Dallas/Ft. Worth SkyLink is an example of the Innovia 200/300 that connects all terminals on the airside. System's salient features are:

- 4.9 mile, double loop elevated guideway
- 10 stations
- 5,000 pphpd
- 2 minute headways
- Transfer among all terminals
- 64 vehicles

Dallas / Ft. Worth Innovia 200 Vehicles

Mitsubishi Heavy Industries' (MHIA) Atlanta CONRAC System is a recent example of the MHI Crystal Mover applied to the landside of an airport. System's salient features are listed below:

- 1.4 mile elevated guideway
- Pinched-loop operation
- 3 stations
- 2,700 pphpd
- 2.3 minute headways
- 12 vehicles
- Connects the landside terminal with a convention center complex and a consolidated rental car facility

Atlanta CONRAC MHI Crystal Mover Vehicles

MIA Mover at Miami International Airport is another recent MHI Crystal Mover system.

- 1.25 mile system.
- 2 stations, with planned future third station to be located in between the end of line stations

- 2800 pphpd
- 4 minute headways
- Pinched-loop operation
- 12 cars
- Connects the landside terminals with the Miami Intermodal Center (MIC), a consolidated rental car facility / multi-modal center

Miami International Airport (MIA Mover) MHI Crystal Mover Vehicles

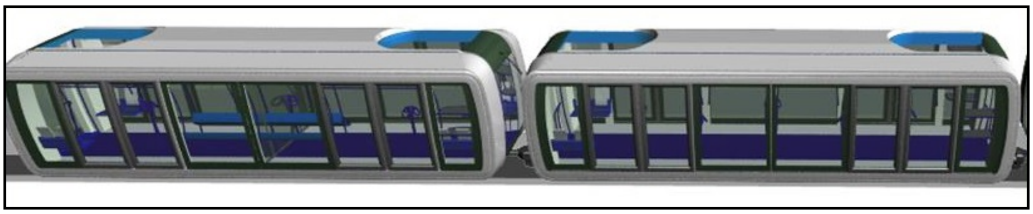
Siemens-Matra built the Chicago-O'Hare APM with VAL 256. System's salient features are:

- 2.7 mile elevated dual-lane guideway
- 5 stations
- 2,600 pphpd
- 4 minute headways
- Connects Terminals 1, 2, 3, and 5 and a large remote parking lot
- Opened: 1993

ORD Siemens-Matra VAL 258 Vehicles

Siemens-Matra VAL 208 vehicles operate at Charles de Gaulle (CDG) and Orly (ORY) International Airports in France. They are slightly narrower, but a newer model then the ORD VAL206. Siemens also has a new product, the AirVAL, but has yet to implement any projects with it, so following figure is an artist's rendering.

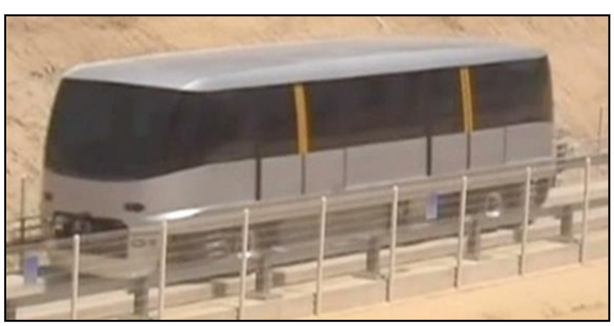
Siemens-Matra VAL 208 Vehicle at CDG



Siemens AirVAL Vehicle

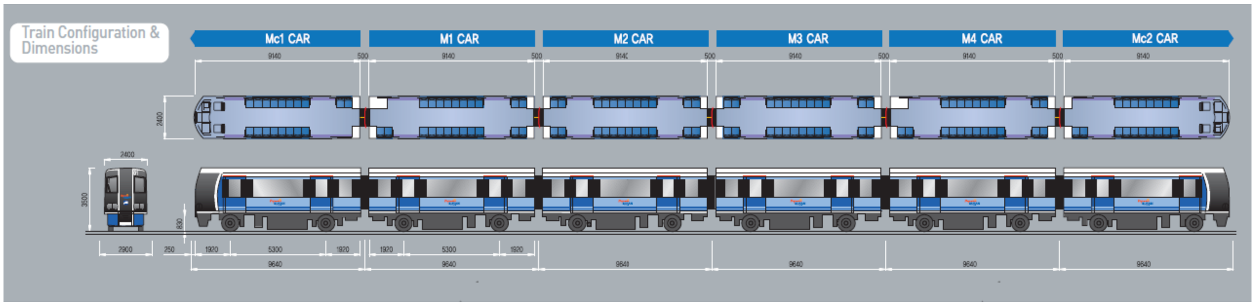
<u>IHI/Niigata</u> provided vehicles and other system elements to the Hong Kong International Airport (HKG) and is currently adding more vehicles. Following figure shows the typical "Japanese Standard" APM vehicle provided by IHI/Niigata; four car vehicle in this case. IHI/Niigata has developed a new, larger vehicle, the "I-Max", and tested it extensively on a test track in Korea as shown in the figure. This vehicle has yet to be implemented on a project.

IHI/Niigata "Japanese Standard" Vehicle at HKG



IHI/Niigata "I-Max" Vehicle on the Test Track

Woojin Industrial Systems provided Busan metro line No. 4 (South Korea). It started revenue service in 2011. These cars are slightly narrower (7' 10.5") and shorter (30') comparing to other self-propelled technologies.



Woojin Vehicle Dimensions

Woojin vehicle at Busan Line No.4

Viability of Self-propelled APM system for A2-B4 replacement project:

The self-propelled APM operating systems **are compatible** and will be a strong candidate due to its suitability to the project context and keen interest shown by many manufacturers in USA. This technology's potential application is further analyzed in Section 5 of the Report.

In addition to Bombardier, the current System Supplier, MHI is anticipated to compete with its center guidance car that is being used in Orlando airport's A1/B3 System replacement project. Given the recent Orlando International Airport APM project history, it is likely that at least Bombardier (existing system technology) and MHI would compete for this project. Recently Siemens, IHI and Woojin have also shown interest in US projects.

4.6 Automated Light Rail Transit System (ALRT)

Light rail transit systems are in operation in many urban areas throughout North America, Middle East, Asia, and Europe. Light rail vehicles are considerably larger than APM vehicles, and many are articulated, so as to allow the vehicle to facilitate short-radius turns. Most often, light rail transit vehicles operate on steel wheels, running on conventional steel rails, though some rubber-tyre ALRT vehicles are available. A vast majority of the ALRTs are steel wheel–steel rail "ALRT (SW-SR)"; however, some ALRTs systems run on rubber tired wheels "ALRT (RT)". Typically the systems have longer car lengths and results in larger guideway sweep radius, different demands at the stations and have substantially different characteristics when they are steel wheel systems.

However in case of shorter length and rubber tired ALRT vehicles that will be required to fit in the existing stations they become very similar to the self-propelled APM systems (which are considered above).

Viability of ALRT system for A2-B4 replacement project:

Steel wheel-steel rail APM technology has been successfully applied to larger systems such as the JFK Air Train (over 10 miles long with 8 stations) and large Rubber tired LRTs have been applied in urban applications such as Metro Paris.

Without significant guideway and station modifications, steel wheel–steel rail and longer vehicle rubber-tire ALRT systems **are not compatible** and will not fit in the context of the short system length and the existing guideway structure, stations and fixed facilities. The A2 B4 system is just too small (length and turning radius) of a configuration to allow cost effective implementation of these bigger technologies.

5. SITE/PROJECT SPECIFIC ASSESSMENT

This section provides a detailed review of the potential technologies that are compatible with the existing infrastructure and guideway, and provides a better understanding of the requirements or alterations that will be necessary for the application of the technology for the project. The various sections will provide comparisons and analysis of the technologies, which will then be summarized and qualitatively evaluated after the discussion.

Candidate Technologies

There are three or four active self-propelled technologies who may be interested in the project. In addition to that, there are at least two cable propelled technologies that are active in the US market. Possible technologies include:

Self Propelled Technology:

- Technology A (Innovia by Bombardier); the contemporary evolution of the existing A2 – B4 system.
- Technology B (Crystal Mover by MHI); the technology that is being adopted for Airside 1 and 3. This is a version of MHI's Crystal Mover that uses a center guidance system.
- Similar other Self Propelled technologies such as Siemens, IHI and Woojin have recently shown keen interest.

Cable Propelled Technology:

- Technology C (Mini Metro by Leitner Poma); the technology that is being implemented in MIA as a replacement project.
- Doppelmayr is a Cable Propelled system that had proposed for Miami project and is active in US market and is an option; their specifications are similar to that of Technology C and have been considered together.

These Technologies will be reviewed in the following section for their specific technological features and applications, as they relate to implementation for Airsides 2 and 4. Though there are various redesigns of vehicle body that can be visualized, it is prudent to state that the market driven technology modifications that have been proposed in prior projects, or those already implemented and operational, provide the best potential solution. Though there are other vehicle designs, these specific vehicles do not readily fit into the existing stations of Airsides 2 and 4 and would require substantial station modifications. Major station modifications will create operational disruptions which may not be suitable for the replacement project.

5.1 System Capacity

The current (2016) demands for the system were analyzed based on the flight schedule obtained from the Airport and the Airport's Master Plan team. As can be extracted from the data, and depicted in the figures below, and because the Airside 2 & 4 APMs are "must ride" systems a dual lane system is required to provide the required capacity with a reasonable level of reliability. However, the impact of a 3-car, single lane system to support the demands was also reviewed. The need for a single shuttle system to be able to support the demands is critical; specifically due to the expected operation during the construction/replacement. It is anticipated that during the replacement of the system, one lane will be undergoing improvements at a time, thus allowing Airsides 2 and 4 to remain operational; utilizing the other lane to carry passengers on the "must ride" system. Presently, based on field observations, when the train is supporting the International Mode (IM) operation for Airside 4

(B4), the capacity is reduced significantly (approximately 40% reduction). The system capacity, while in IM operation, is very similar to a single lane system and must be further analyzed for adequacy today, including alternatives for efficiency and operational growth.

To better evaluate the system capacity, the flight schedules were reviewed and the passenger demand was then "metered" to present a more representative demand at the APM Platform. The domestic demand was metered based on the average deboarding rates for various size aircraft; and the international demand was based on the average FIS passenger processing rates. The effect of this evaluation was to spread out the arrival of passengers at the platform over the time period. Based on the provided flight schedule, no adjustments required on Airside 2 (A2), as all the flights are domestic and the aircraft capacities were such that the planes could be deboarded in the 9 minute timeframe that was used as a unit block for the demand/ capacity analysis. Airside 4 (B4) did require metering to adjust for the larger aircraft sizes and the international flights. Figure 5-1 shows the effect of the metering on the flight schedule.

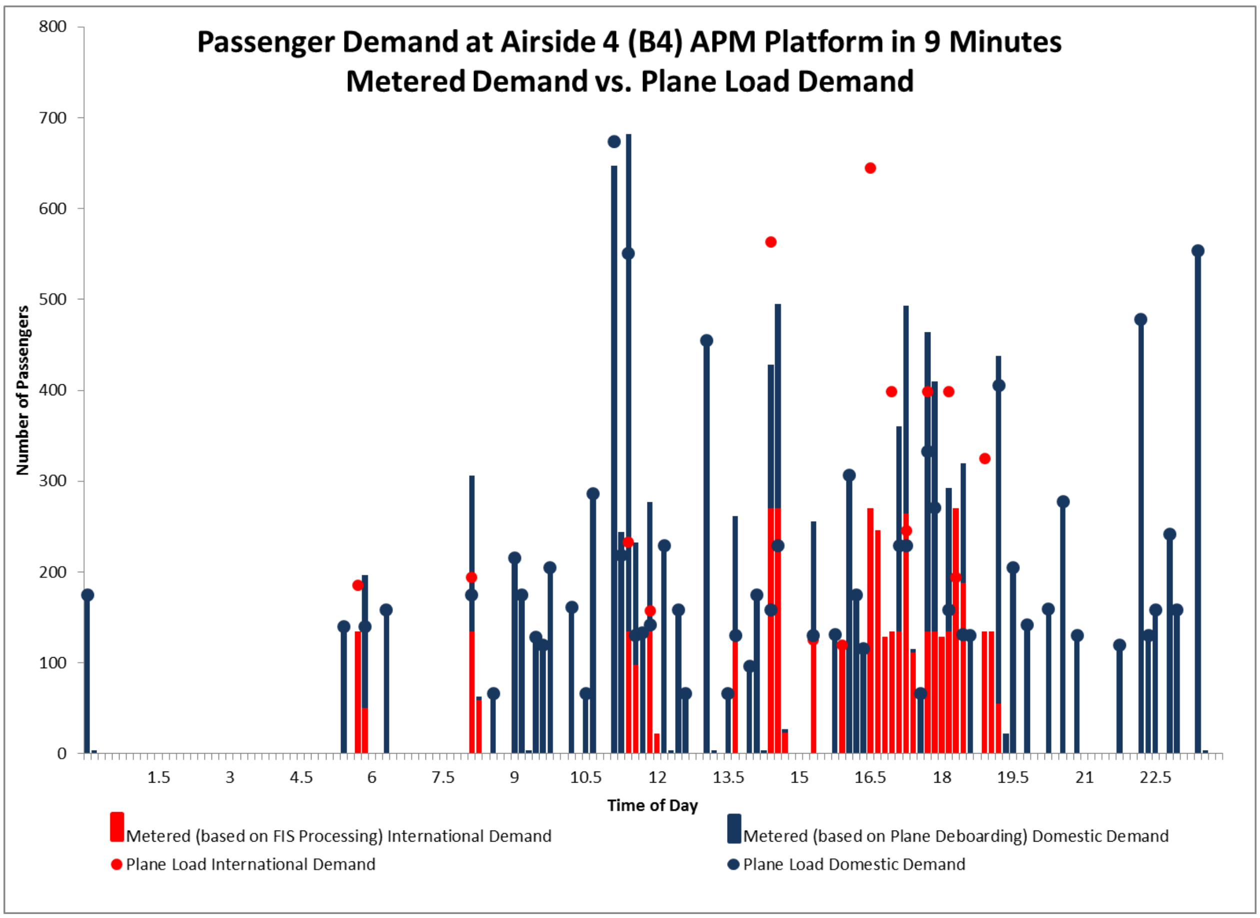


Figure 5-1: Passenger Demand at Airside 4 (B4) Metered Demand vs. Flight Arrival Demand

Using the metered domestic and international demands, the data was then compared against the fleet capacities at the platforms. For the Self-Propelled, Dual Lane system this capacity is approximately 960 passengers, per 9 minute intervals and for Self-Propelled, Single Lane system this is approximately 480 passengers, per 9 minute intervals; refer to Figure 5-2 for Airside 2 (A2) and Figure 5-3 for Airside 4 (B4). These figures also incorporate reduced capacities used for the Cable-Propelled technologies (Dual Lane capacity is approximately 691 and Single Lane capacity is approximately 346 passengers per 9 minute intervals) and the Airside 4 figure includes the additional adjustments made for the international arrivals and security procedures.

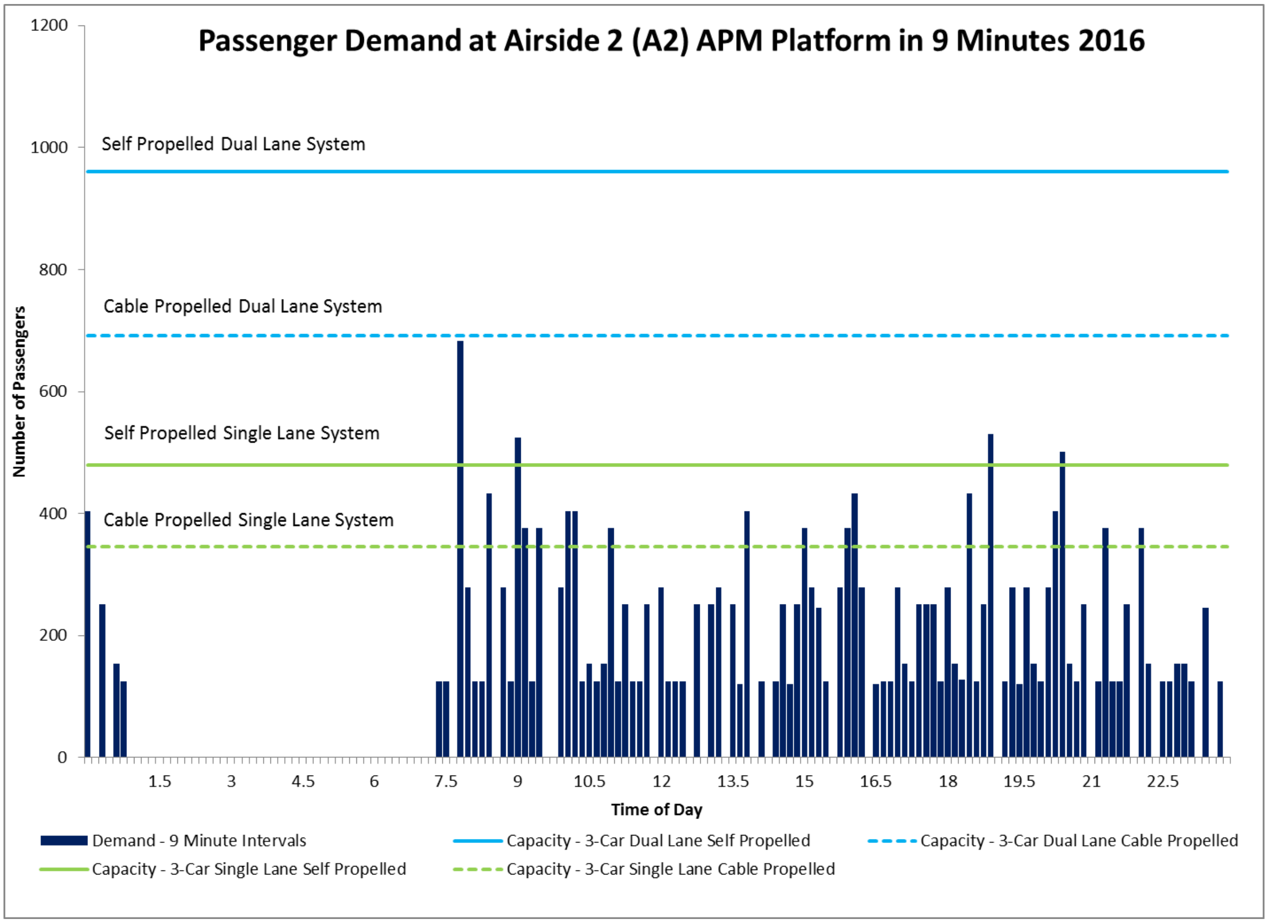


Figure 5-2: Domestic Passenger Demand at Airside 2 (A2)

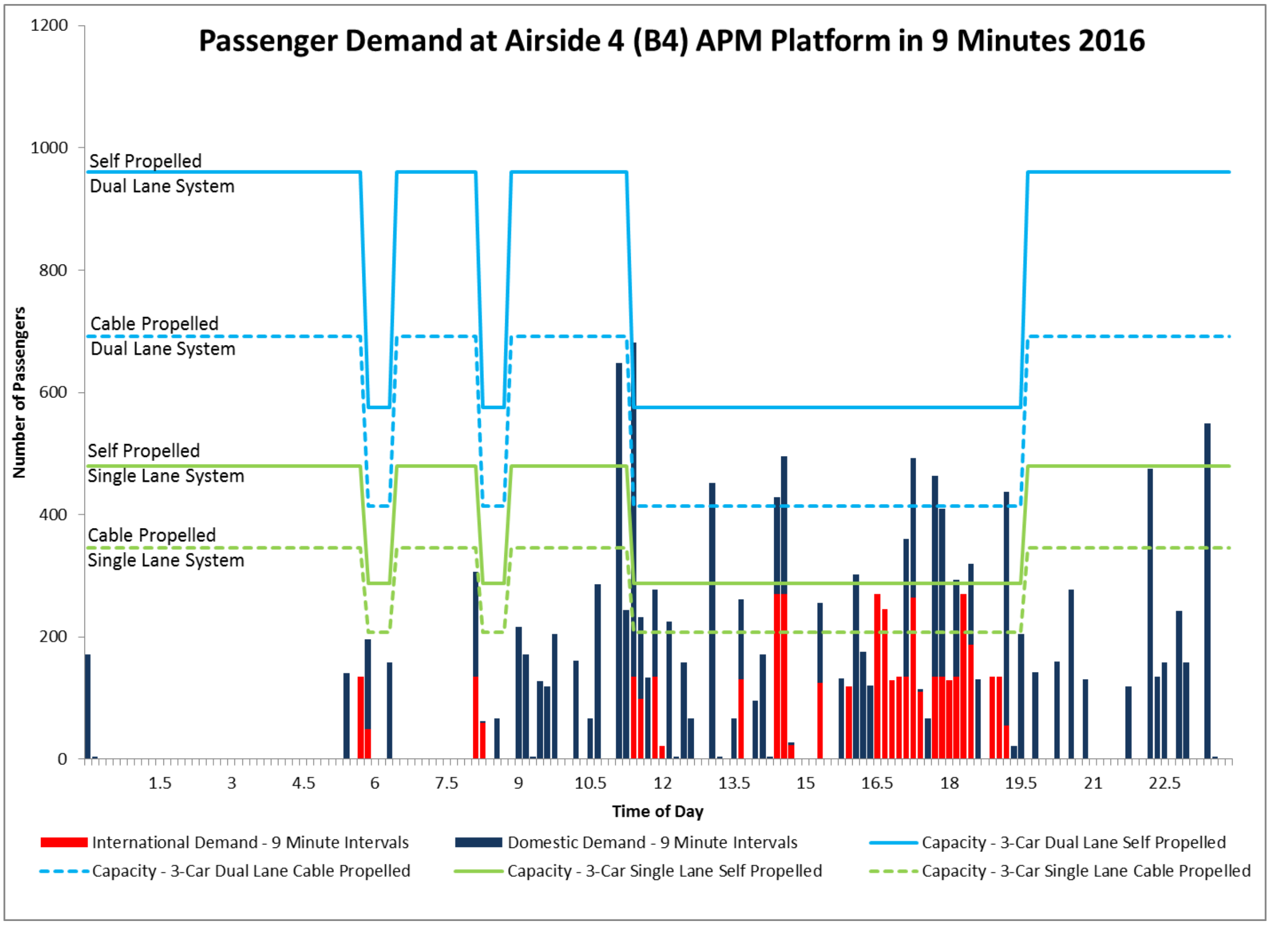


Figure 5-3: Domestic and International Passenger Demand at Airside 4 (B4)

Due to the vehicle (car) size differential between the technologies, the cable propelled vehicle in operation at MIA has a carrying capacity of about 72% of that of the self- propelled technologies (approximately 80 passengers per self-propelled car vs. 58 passengers per cable propelled car). Though the carrying capacities for both the Self Propelled system and Cable Propelled system for the normal operations of Dual Lane shuttle are adequate for today's demand, the capacity of the Cable Propelled technology is about 25- 28% lower than that of the self-propelled technology. Therefore, the Cable Propelled system will have greater challenges to address in meeting the airport's growing demand, and for the international passenger demands, than that of the Self Propelled system, especially when the system is undergoing the technology replacement and will be operating as a single-lane during implementation.

Additional analysis was performed to evaluate the number of passengers that may possibly be remaining on the platform, when the system is operating at maximum capacity.

Table 5-1 and Table 5-2 summarize the results for the metered system demand at 9 minute intervals. For the A2 system with dual lanes, and domestic travelers only, both the cable propelled and the self-propelled systems handle the passenger capacity during all times of the day, with no passengers left on the platform. However, when the system operates as a single lane, there are several occasions when passengers must wait for another train. For the self-propelled vehicles, this occurs only a few times, and the passengers clear the platform within 10 minutes (next train cycle). The cable-propelled system however, struggles multiple times throughout the day and will take upwards of 20-25 minutes (3-4 round trips) to clear the platforms.

For the Airside 4 (B4) platform, more concerns surface when studying the passengers remaining on the platform. Since this terminal handles the international passengers, and the IM mode requires that security personnel sweep the trains between international and domestic passengers, the round-trip times and capacities are much reduced when compared to regular operations. The dual lane, self-propelled shuttle has only one instance where passengers are remaining. This instance clears itself within one train cycle (under 10 minutes). For the cable-propelled, dual lane shuttle operating in the IM mode, there are at least 6 times throughout the day that passengers will be waiting due to train capacities. Half of these will clear within 10 minutes, but the others will take 2-3 cycles to move all the passengers.

When the single lane shuttles are studied there are multiple instances for both trains that take more than 20-30 minutes to clear; with the cable system taking upwards of 2 hours in the worst case scenario. Refer to Table 5-1 and Table 5-2 for complete details.

Passengers Remaining on Airside 2 (A2) Platform

Time of Day	Total Metered Pax Arriving	Passengers Remaining on the Platform				Time of Day	Total Metered Pax Arriving	Passengers Remaining on the Platform			
		Cable Propelled Single Lane	Self Propelled Single Lane	Cable Propelled Dual Lane	Self Propelled Dual Lane			Cable Propelled Single Lane	Self Propelled Single Lane	Cable Propelled Dual Lane	Self Propelled Dual Lane
7:30	125	0	0	0	0	14:24	0	0	0	0	0
7:39	125	0	0	0	0	14:33	125	0	0	0	0
7:48	0	0	0	0	0	14:42	251	0	0	0	0
7:57	683	337	203	0	0	14:51	120	0	0	0	0
8:06	279	270	2	0	0	15:00	251	0	0	0	0
8:15	125	49	0	0	0	15:09	376	30	0	0	0
8:24	125	0	0	0	0	15:18	279	0	0	0	0
8:33	432	86	0	0	0	15:27	246	0	0	0	0
8:42	0	0	0	0	0	15:36	125	0	0	0	0
8:51	279	0	0	0	0	15:45	0	0	0	0	0
9:00	125	0	0	0	0	15:54	279	0	0	0	0
9:09	524	178	44	0	0	16:03	376	30	0	0	0
9:18	376	209	0	0	0	16:12	432	117	0	0	0
9:27	125	0	0	0	0	16:21	279	49	0	0	0
9:36	376	30	0	0	0	16:30	0	0	0	0	0
9:45	0	0	0	0	0	16:39	120	0	0	0	0
9:54	0	0	0	0	0	16:48	125	0	0	0	0
10:03	279	0	0	0	0	16:57	125	0	0	0	0
10:12	404	58	0	0	0	17:06	279	0	0	0	0
10:21	404	117	0	0	0	17:15	153	0	0	0	0
10:30	125	0	0	0	0	17:24	125	0	0	0	0
10:39	153	0	0	0	0	17:33	251	0	0	0	0
10:48	125	0	0	0	0	17:42	251	0	0	0	0
10:57	153	0	0	0	0	17:51	251	0	0	0	0
11:06	376	30	0	0	0	18:00	125	0	0	0	0
11:15	125	0	0	0	0	18:09	279	0	0	0	0
11:24	251	0	0	0	0	18:18	153	0	0	0	0
11:33	125	0	0	0	0	18:27	128	0	0	0	0
11:42	125	0	0	0	0	18:36	432	86	0	0	0
11:51	251	0	0	0	0	18:45	125	0	0	0	0
12:00	0	0	0	0	0	18:54	251	0	0	0	0
12:09	279	0	0	0	0	19:03	530	184	50	0	0
12:18	125	0	0	0	0	19:12	0	0	0	0	0
12:27	125	0	0	0	0	19:21	125	0	0	0	0
12:36	125	0	0	0	0	19:30	279	0	0	0	0
12:45	0	0	0	0	0	19:39	120	0	0	0	0
12:54	251	0	0	0	0	19:48	279	0	0	0	0
13:03	0	0	0	0	0	19:57	153	0	0	0	0
13:12	251	0	0	0	0	20:06	125	0	0	0	0
13:21	279	0	0	0	0	20:15	279	0	0	0	0
13:30	0	0	0	0	0	20:24	404	58	0	0	0
13:39	251	0	0	0	0	20:33	502	214	22	0	0
13:48	120	0	0	0	0	20:42	153	21	0	0	0
13:57	404	58	0	0	0	20:51	125	0	0	0	0
14:06	0	0	0	0	0	21:00	251	0	0	0	0
14:15	125	0	0	0	0	21:09	0	0	0	0	0
Regular Operations Capacity (pax/9 min)		346	480	691	960	Regular Operations Capacity (pax/9 min)		346	480	691	960

Table 5-1: Passengers Remaining on Airside 2 (A2) Platform

Passengers Remaining on Airside 4 (B2) Platform

Time of Day	Total Metered Pax Arriving	Passengers Remaining on Platform				Time of Day	Total Metered Pax Arriving	Passengers Remaining on Platform			
		Cable Propelled Single Lane	Self Propelled Single Lane	Cable Propelled Dual Lane	Self Propelled Dual Lane			Cable Propelled Single Lane	Self Propelled Single Lane	Cable Propelled Dual Lane	Self Propelled Dual Lane
11:15	647	301	167	0	0	15:45	0	0	0	0	0
11:24	244	200	0	0	0	15:54	132	0	0	0	0
11:33	682	675	394	267	106	16:03	119	0	0	0	0
11:42	233	700	339	85	0	16:12	303	96	15	0	0
11:51	133	627	184	0	0	16:21	175	64	0	0	0
12:00	277	697	173	0	0	16:30	120	0	0	0	0
12:09	22	512	0	0	0	16:39	270	63	0	0	0
12:18	225	530	0	0	0	16:48	246	102	0	0	0
12:27	4	327	0	0	0	16:57	129	24	0	0	0
12:36	158	277	0	0	0	17:06	135	0	0	0	0
12:45	67	137	0	0	0	17:15	360	153	72	0	0
12:54	0	0	0	0	0	17:24	493	439	277	78	0
13:03	0	0	0	0	0	17:33	115	347	104	0	0
13:12	451	244	163	36	0	17:42	67	207	0	0	0
13:21	4	41	0	0	0	17:51	464	464	176	49	0
13:30	0	0	0	0	0	18:00	410	667	298	44	0
13:39	67	0	0	0	0	18:09	129	589	139	0	0
13:48	261	54	0	0	0	18:18	293	674	144	0	0
13:57	0	0	0	0	0	18:27	270	737	126	0	0
14:06	96	0	0	0	0	18:36	320	850	157	0	0
14:15	171	0	0	0	0	18:45	131	774	0	0	0
14:24	4	0	0	0	0	18:54	0	567	0	0	0
14:33	428	221	140	13	0	19:03	135	495	0	0	0
14:42	495	509	347	93	0	19:12	135	423	0	0	0
14:51	27	329	86	0	0	19:21	438	653	150	23	0
15:00	0	122	0	0	0	19:30	22	468	0	0	0
15:09	0	0	0	0	0	19:39	205	467	0	0	0
15:18	0	0	0	0	0	19:48	0	121	0	0	0
15:27	256	49	0	0	0	19:57	142	0	0	0	0
15:36	0	0	0	0	0						
Regular Operation Capacity (pax/9 min):		346	480	691	960	Regular Operation Capacity (pax/9 min):		346	480	691	960
International Mode Capacity (pax/9 min):		207*	288*	415*	576*	International Mode Capacity (pax/9 min):		207*	288*	415*	576*

* International Mode from 11:33 through 19:39

Table 5-2: Passengers Remaining on Airside 4 (B4) Platform

5.2 <u>Vehicle Compatibility</u>

For all technologies, the vehicle was analyzed for compatibility with the existing infrastructure; this includes the guideway, platforms, station doors, emergency walkways, etc.

5.2.1 Car Dimensional Interface

In order to gain a better understanding of the various technology candidates' vehicle structure, a comparison of the representative technologies was created. This is necessary to analyze and plan to work within the existing station limits. Throughout the document, this analysis will be referred to with regard to a variety of structural and alignment comparisons.

The Stations and the framing of the Station Platform Doors are an existing condition and it is incumbent on the proposer to match the existing door configuration. Any alterations, if needed, must be accomplished on the vehicles rather than major changes to the Station platform barrier/structural system. Modifications to the Station platform barrier/structural system would be highly disruptive to the operations, would likely increase the overall construction timeframe, and would have a significant negative impact on the passenger experience.

The following figure summarizes how the potential technologies compare to door spacing and alignment of the existing conditions as well as possible modifications:

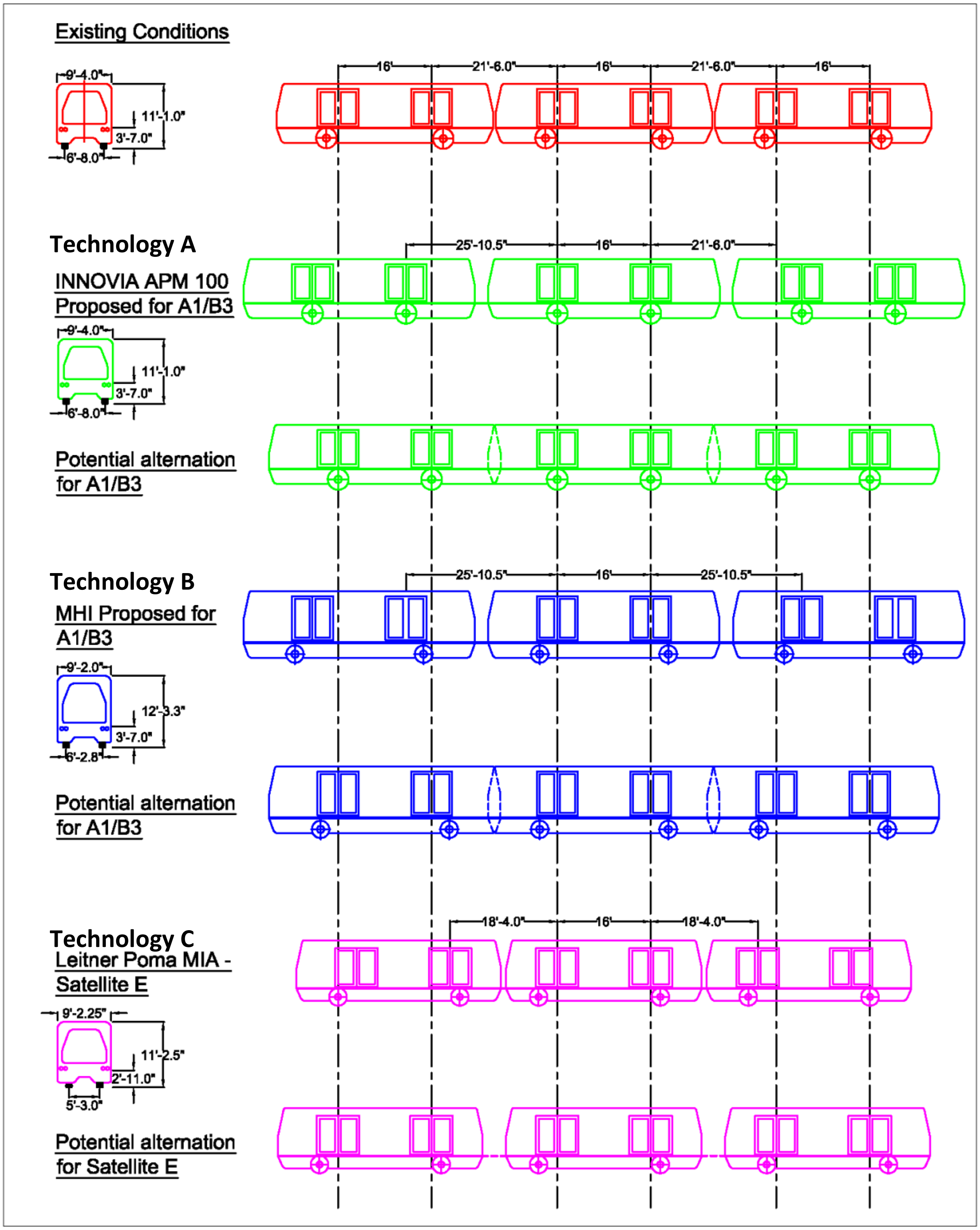


Figure 5-4: Various Technology Comparisons for Vehicle Configurations

5.2.2 Longitudinal Layout and Door Interface

When analyzing the Station layout and Station Platform Screen Doors (PSD) interface; vehicle dimensions and the dynamic envelope are key factors that must be considered by the potential technologies to accommodate to the existing conditions.

Regarding PSD, the different dimensions to consider include, but are not limited to: dimension from center line to center line of two adjacent doors within the same car, and the dimension from center line to center line of two adjacent doors when each door is located in one of two coupled cars.

It appears that in all the evaluated Technologies, the cars or coupling system will need some modifications in order to accommodate the existing PSD conditions of door to door dimension of two following cars in the train.

All of the possible technologies evaluated match the door position of each vehicle for the actual door location; where possible modifications are required will be with the actual overall lengths of the vehicles and the coupling between cars. Technologies A and B will need to modify the car nose structure to accommodate the existing PSD conditions (the door positons are longer than the existing door locations) while Technology C would need to modify the coupler connection by elongating it (the door positions are shorter than the existing door locations). Therefore, all technologies are considered equal for this criterion.

5.2.3 Vehicle Section and Wheelbase Interface

Vehicle sectional dimensions are analyzed for the candidate technologies to determine if the vehicle dynamic envelope will accommodate the existing fixed facilities for the guideway and the Stations. Vehicle clearance in Stations is critical and depends on the vehicle dynamic envelope, width and height.

Candidate Technology A has same width (9'-4") as the existing system, both Technology B and Technology C are slightly tighter at (9'-2") and (9'-2.25"), respectively. Candidate Technology A has same height (11'-1") as the existing system, Technology B is approx. one foot higher (12'-3.3") and Technology C is only slightly higher than the existing system (11' – 2.5"). All technologies are considered equal for the criterion of vehicle dynamic envelope.

5.3 Compatibility with Existing Layouts and Facilities

One of the important factors in implementing the new APM systems is the ability of the technology to work within the constraints of the existing layouts and facilities. This allows for minimum disruptions to an already operating system and associated facilities. The following discusses the various aspects of the existing system and the impacts or benefits of the various possible technologies.

5.3.1 Guideway Interface

Wheelbase:

One of the key factors to consider is how effectively the candidate technology's wheelbase fits into the guideway existing conditions. After analyzing the wheel gauge dimension it was found that Technology A has the same dimension (6'-8") as the existing system, Technology B has slightly tighter wheel gauge (6'-2.8") and Technology C has an even tighter wheel gauge (5'-3"). Technologies with a tighter wheel gauge would require the running surface to be shifted from the existing alignment and would apply extra stresses on the existing running surface support beam, due to the eccentricity of the load applied on the running surface relative to its supporting beam. This means that the vehicles would be riding along and loading the flange of the beam rather than at the web. This will require additional modifications to the system to address eccentricity (i.e. additional plates, reinforcement, etc.) Refer to Figure 5-5 for a better understanding of the running surface alignment. Since Technology A has an exact alignment to the guideway running pad, the technology is very compatible. Similarly, Technology B lines up relatively closely to the guideway running pad, requiring minimal enhancements and is in general structurally compatible, thus receiving a "Neutral" evaluation. With a centerline differential of (± 8"), Technology C will require structural adjustments to the guideway running surface and possibly the structural supports. These structural enhancements and adjustments will have an adverse impact to the overall construction timeline and will potentially create longer operational impacts while the lanes are undergoing the improvements. This will be a requirement of the Technology Contractor to analyze, design and implement; and considering that these modifications are possible and will most likely be needed, Technology C is not as compatible as the other technologies for this criterion.

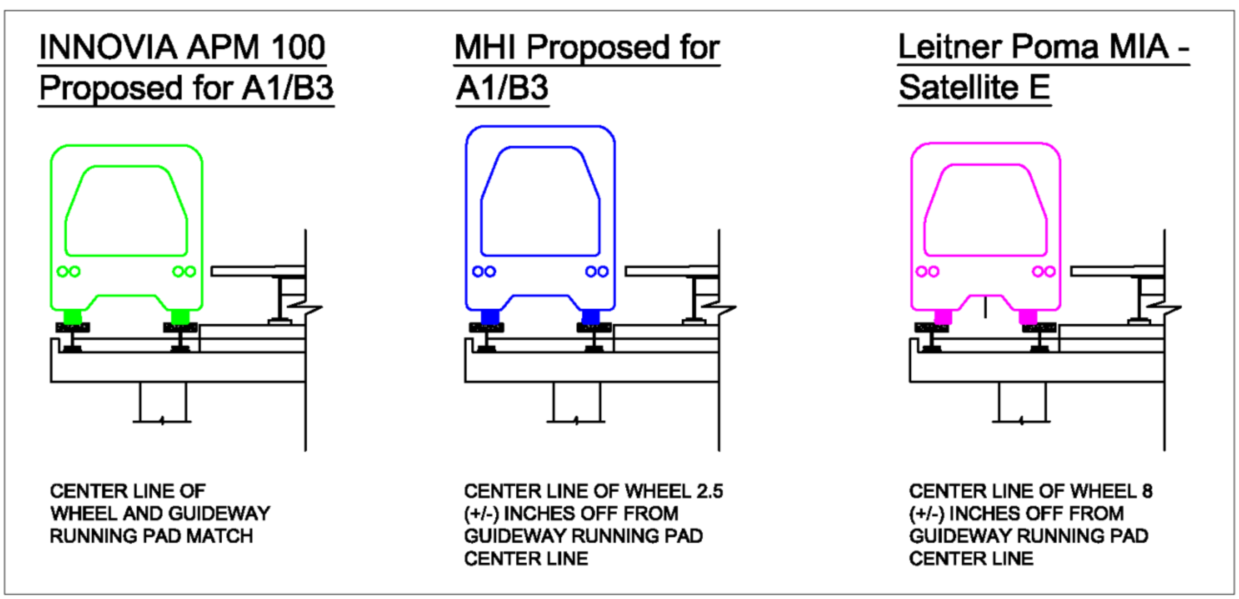


Figure 5-5: Running Surface Center Line of the Wheels

Emergency Walkway:

Another important criterion for analysis is the ability of the Candidate Technology to accommodate the existing emergency walkway located on the guideway. This was done by comparing to the existing vehicle floor height from the existing running surface (3'-7"). It was found that Technologies A and B have the same floor height (3'-7") as the present technology and will perfectly accommodate the existing emergency walkway. These Technologies receive a "Good" rating for the emergency walkway.

Technology C has a floor height of (2'-11") from running surface, which is shallower than the existing technology. In looking at the Technology C installation in Miami Concourse E, the connection of the running beams to the existing system raises the overall system and makes the floor of the train up to 24 inches higher than the emergency walkway. See Figure 5-6 below.

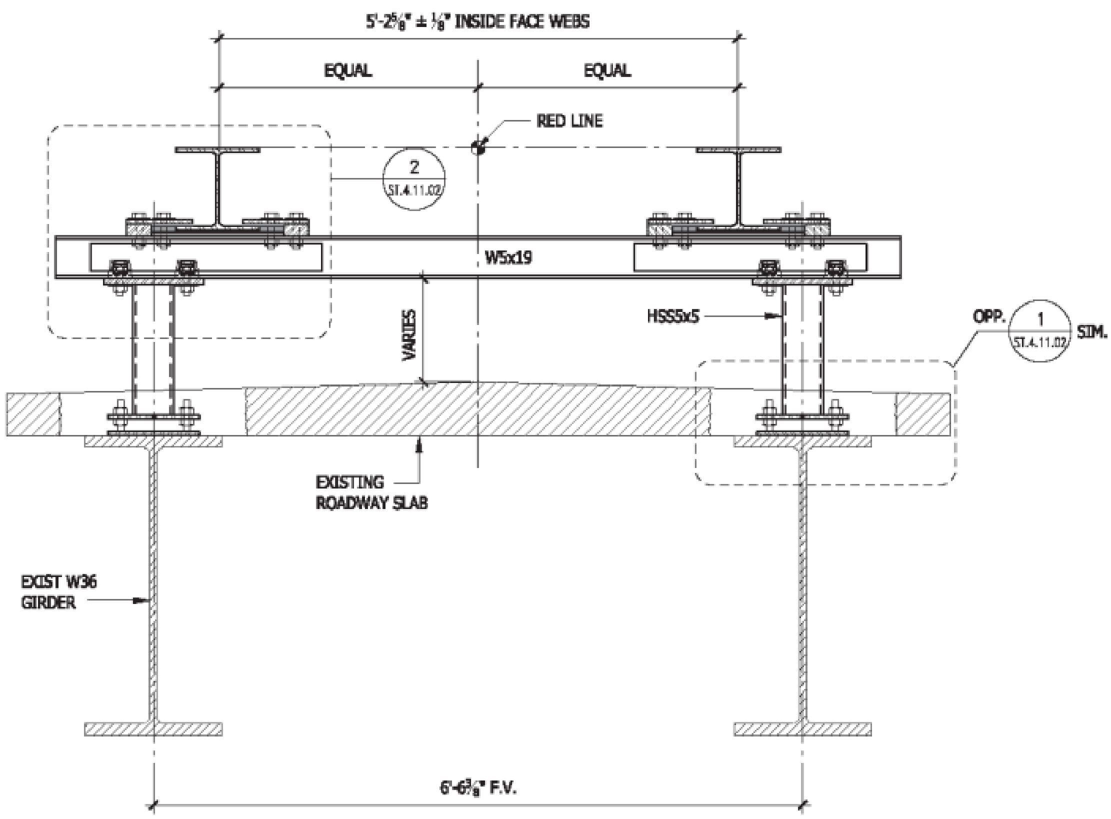


Figure 5-6: Technology C Installation in Miami Concourse E

Because of the passenger demographics at the Orlando International Airport, complexity of the evacuation and the overall passenger experience, one of the few "must-have" requirements is a car floor level emergency egress walkway; the walkway must meet the floor level of the car. In the case of Technology C, this condition is not met. It may be achievable for the technology to lower the Level, but the feasibility of matching the existing walkway elevation is not clear.

5.3.2 Station Evaluation

The next area that must be considered in the evaluation of the various technologies is how the systems will interact / match with the existing platforms and stations, including discussions on the layout fit and feasibility of installation and equipment installation. There are three areas that will be addressed, the Landside Station, the Airside Station, and the overall impacts to the Area Layout.

5.3.2.1 LANDSIDE STATION

For the Landside Station Layout, all the proposed Technologies appear to have minimal impacts and are similar in implementation. As discussed in Section 5.2 each car has a door spacing of 16' between and will align with the existing Station Doors. All the Technologies will require some modifications to the cars and the coupling systems to meet all the door spacing requirements. At this time, there is nothing to suggest that modifications to the cars and /or couplings should be a challenge to any of the Technologies.

Some concerns may be raised regarding the vehicle's dynamic envelope and the alignment to the platform (some of the technologies are taller than the existing cars and some are more narrow), but in looking at the Technology upgrade presently under Contract for Stations A1 & B3, it appears that there are no issues with the clearance heights and platform alignments. This will, again, be something that the specific Technology Candidates must review, analyze and design for. At this time however, no issues are present for the Landside Stations and all Technologies are given a "Good" rating.

The Cable Propelled Technology requires placement of a Tension Bull Wheel in the Station area. Based on the installation at MIA, this is accomplished by placing the Tension Bull Wheel in the maintenance space. The placement of this equipment has no direct impact on the station. The impact of the Tension Bull Wheel on the maintenance floor is described separately in Section 5.3.3.

5.3.2.2 AIRSIDE STATION

Similar to the discussion above for the Landside Station, all the technologies are comparable and compatible on the Airside Station with regard to the General Configuration and the Platform Station Doors; thus all technologies are essentially equal on this factor.

The Technologies do differ however in the discussion of required Additional Equipment necessary to operate the system. With Technologies A and B, they function with the similar operating system as the existing system and require no additional major equipment within the station area and below to work. This factor renders Technologies A and B more feasible and compatible for use, as there is no additional equipment required.

For Technology C, the Cable Propelled System, additional major equipment is required to operate the propulsion technology. Cable System Technologies require the implementation of return and tension equipment (bull wheels) necessary for the vehicle propulsion system. In the case of the Airside Stations a Return Bull Wheel will be needed in Airside 2 and 4. This Return Bull Wheel will require cutting of the slab at the Station Level, as well as assigning space for a room at the Level directly below. The Return Bull Wheel hatch at the Station Level is approximately 24 ft. x 3.5 ft. per lane. Each Return Bull Wheel requires a room directly below the station of approximately 25 ft. x 20 ft. (300" x 240") in size to accommodate the equipment. Figure 5-7 shows an example of a return wheel installed at MIA Concourse E:

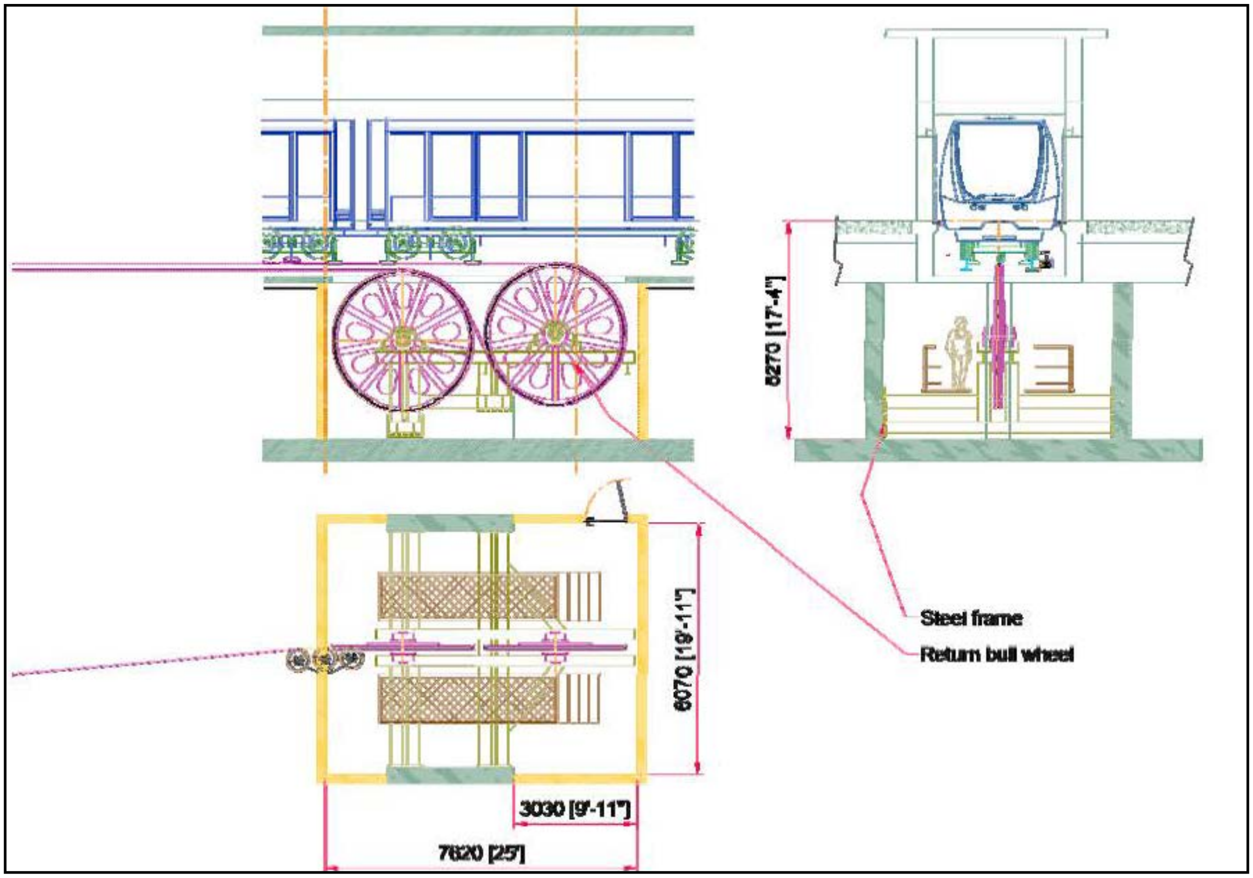


Figure 5-7: Return Bull Wheel from MIA Concourse E

The following figures show the potential location of the Return Bull Wheel for both Airside 2 and Airside 4 at the Station Level and the Level directly below:

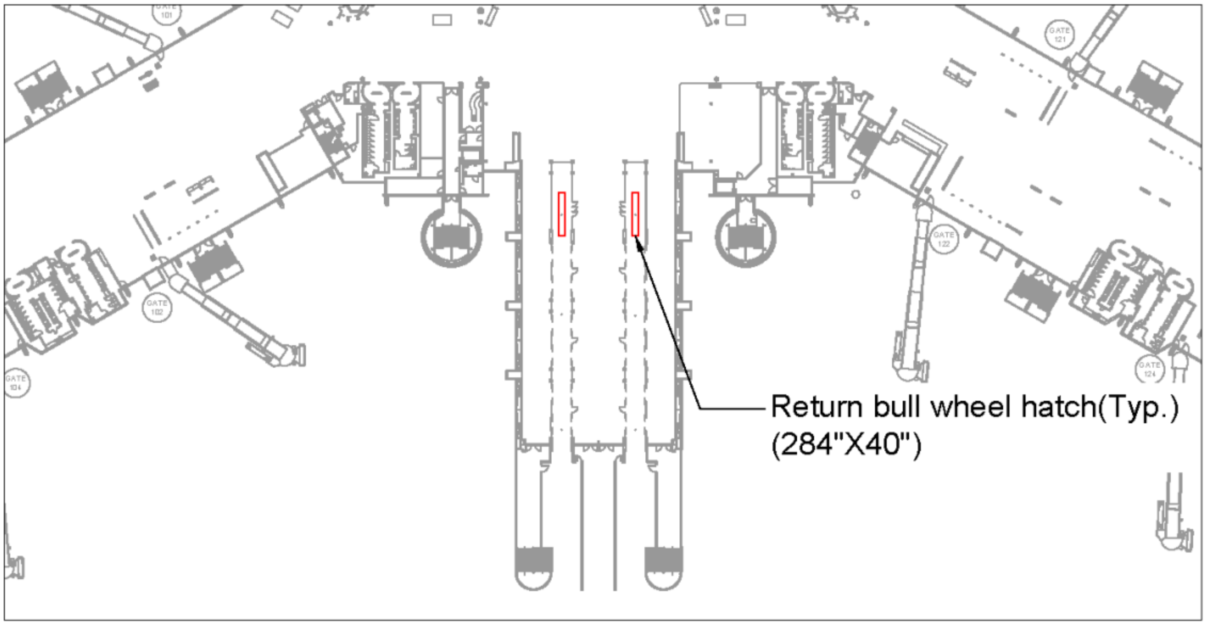


Figure 5-8: Airside 2, Level 2 (Station)

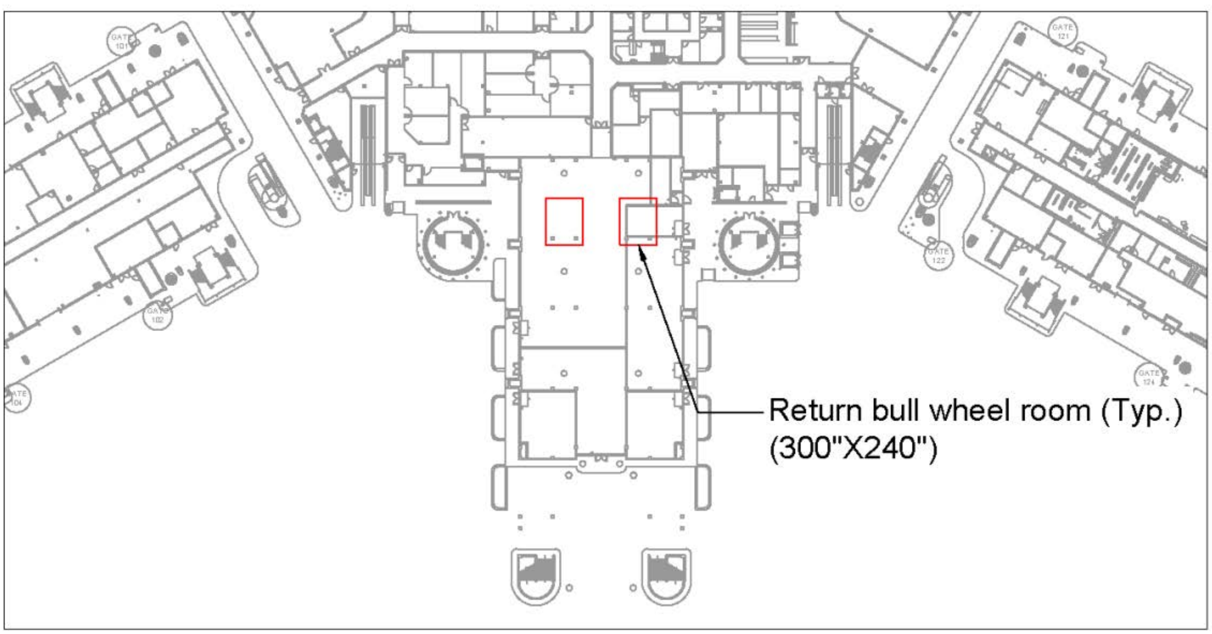


Figure 5-9: Airside 2, Level 1 (Under the Station)

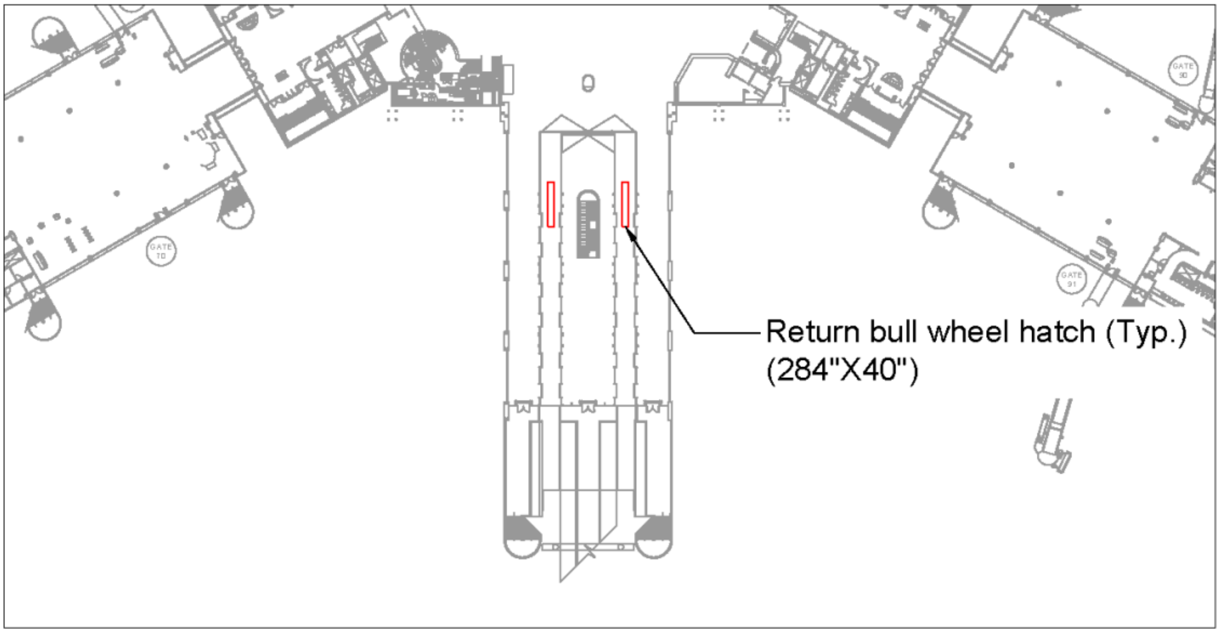


Figure 5-10: Airside 4, Level 2 (Station)

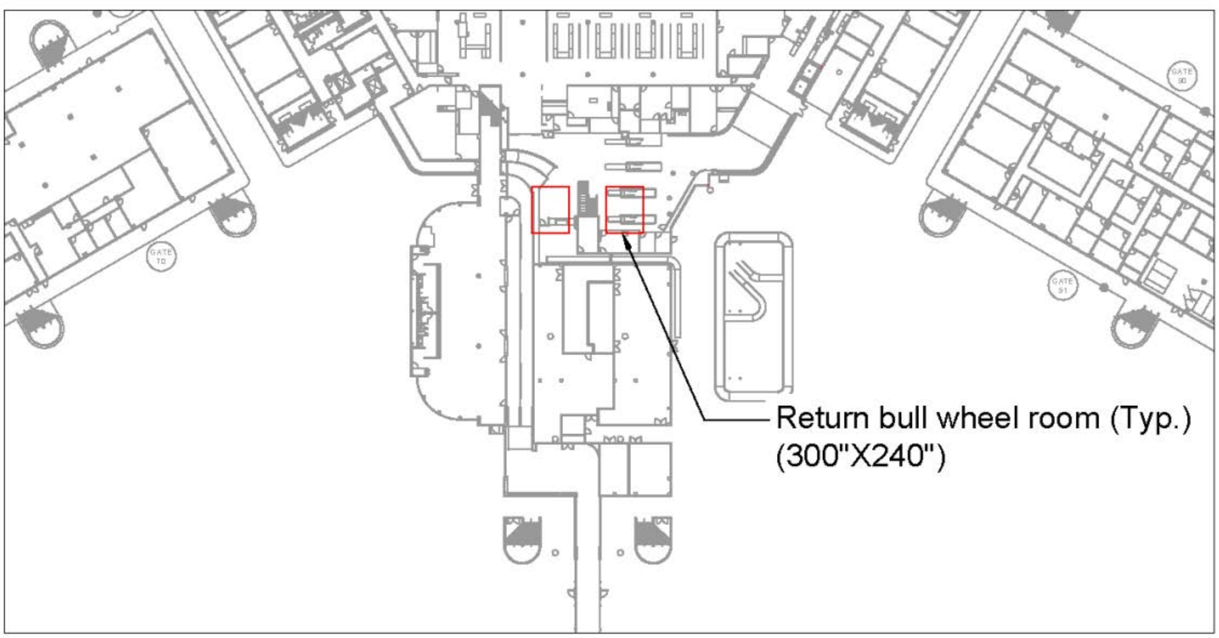


Figure 5-11: Airside 4, Level 1 (Under the Station)

Based on analysis of the cable system installed and in operation at MIA, the location of the Return Bull Wheel for Airside 4 would impact the existing Federal Inspection Station (FIS) facilities on Level 1, which is not acceptable. If this Technology was to move forward, it would require further investigation and mitigation from the candidate Technology Contractor. Because of this impact and the significant space requirements and structural modifications that would be required at the existing station layouts, Technology C is not feasible compared to Technology A and B for additional Equipment.

5.3.2.3 AREA LAYOUT

Since Technologies A and B are both Self Propelled Systems, which are comparable to the existing system; their installation on the guideway is at the level of the running surface and will not impact the area under the bridge after construction. There are no adverse impacts to the existing area layout by either of these Technologies.

As part of the Cable Propelled System, in addition to the Return Bull Wheels required at the Airside Station and the Maintenance Facility, two Deviation Bull Wheels (and associated infrastructure) are required on the guideway. These Deviation Bull Wheels are approximately 11 -12 ft. in diameter (depending on the diameter of the rope) and also require the installation of line sheaves under the train path. The deviation wheels must be close to the track and installed along the longitudinal axis of the track. Some applications have set the wheels directly under the track longitudinal axis (primarily for new applications) whereas others have set them adjacent to the track (MIA Concourse E application). Deviation wheel under the track would require a deep below-ground room to accommodate the wheel which was considered not feasible by one supplier during A1-B3, due to the complexity and cost of below water table construction in Florida.

Alternately, it is anticipated that the cable propelled system contractor will most likely propose deviation wheels adjacent to the track that will be similar to MIA. This greatly impacts the aesthetics of the guideway and would require a designated space along the guideway. Figure 5-12 shows a set of Deviation Bull Wheels installed at MIA Concourse E.

Figure 5-12: Deviation Bull Wheel Installed at MIA Concourse E

In addition to the Deviation Bull Wheels, Technology C will also require a designated area at the Ground Level somewhere along the guideway for installation of the main motor and drive wheel equipment (Gear room). Figure 5-13 shows the Gear Room for MIA Concourse E.

Figure 5-13: Gear Room at MIA Concourse E

For Airside 2 and 4 Systems, the tug roads run under the bridge. Therefore, the Gear Room could be placed individually for each lane. For that reason it is anticipated that there will be a pair of Gear Rooms for each leg. Potential locations for the required Gear Rooms (one for each lane) could either be at the Landside or Airside space. The Gear Rooms' potential locations, along with the right of way of the future AAF and LRT lines are shown in Figure 5-14. Because of the modifications required to the existing guideway, the additional dedicated space requirements, and the overall impact to the aesthetics; Technology C is not feasible compared to Technologies A and B.

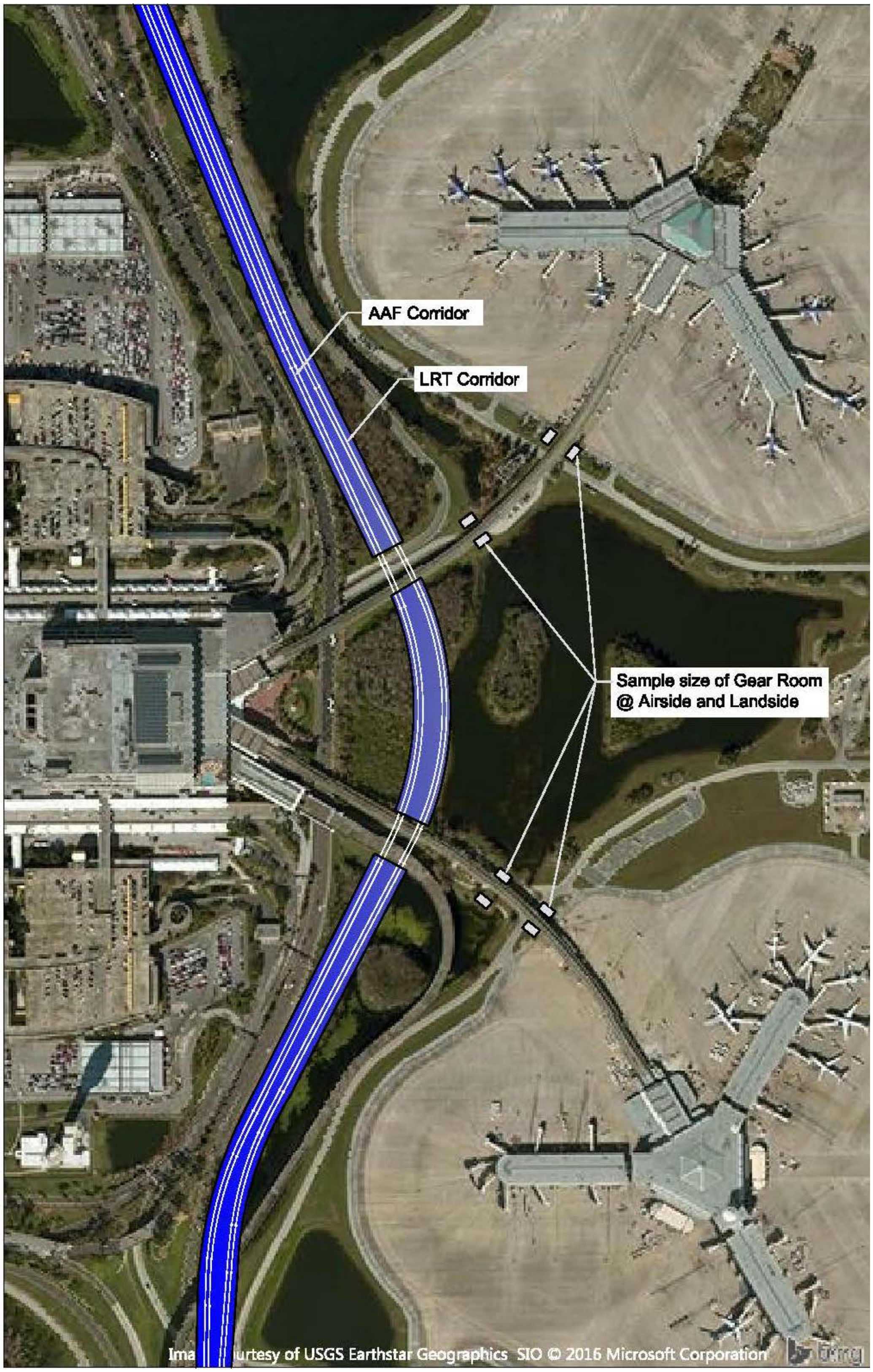


Figure 5-14: Potential Location of Gear Room for Cable Technology

5.3.3 Maintenance Facility Interface & O&M Contract

The existing Maintenance Facility (MF) for A2/B4 System is located on Level Two under the Landside Terminal Stations; refer to Figure 5-15 for details on space layout. The existing MF, or portion of the existing MF, will be provided to the selected Technology Contractor on an as-is basis. All modifications are the responsibility of the selected Contractor. The selected Technology Contractor shall be responsible to analyze, plan, design and implement (cutover) the necessary work in accordance with the system must-ride nature, emphasizing on coordination with the existing system's O&M Contractor within the MF dimensions and space limits.

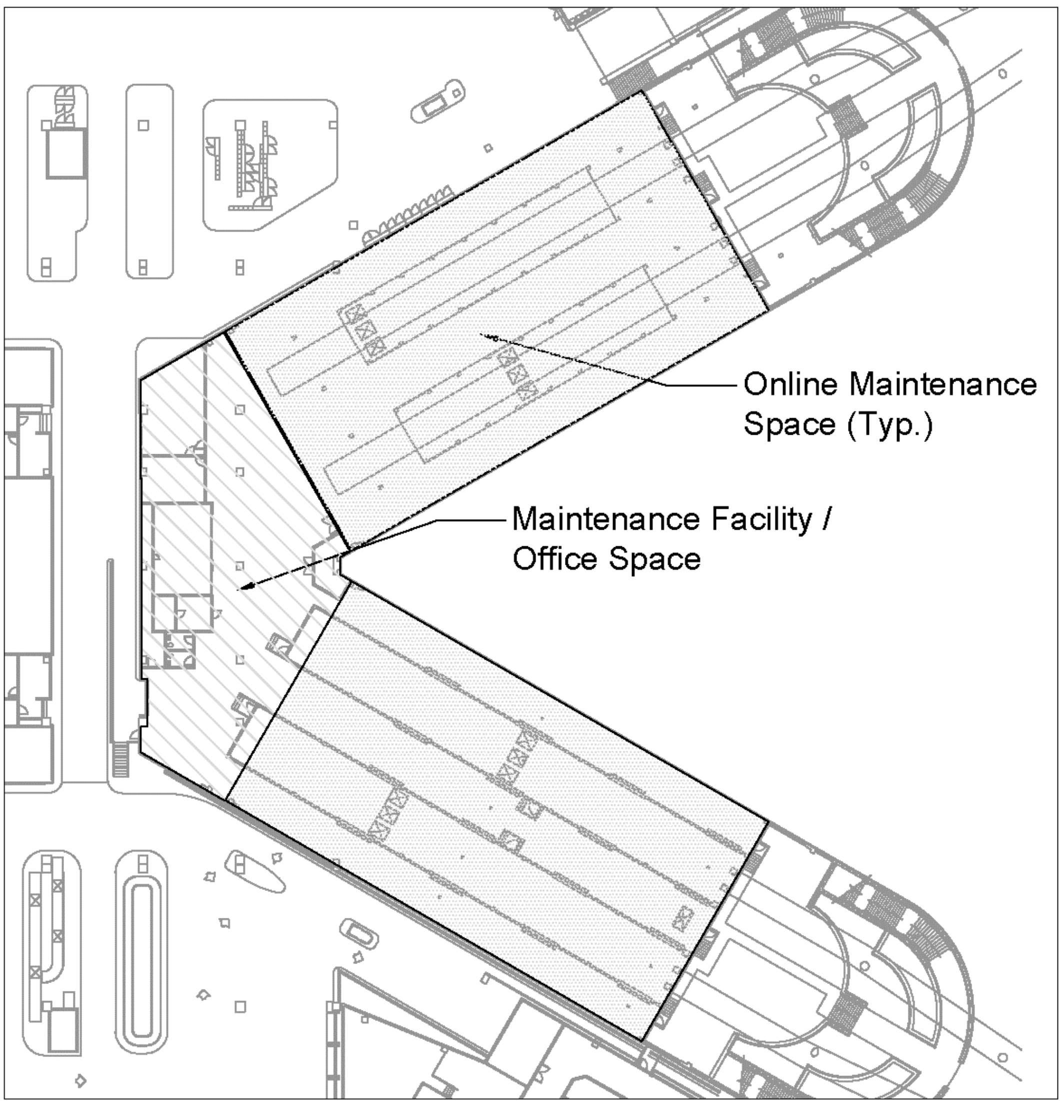


Figure 5-15: Maintenance Facility Layout

5.3.3.1 IMPACT OF NEW INSTALLATION

The Self Propelled Technologies would have the same MF requirements as existing system for equipment rooms, CCR, administrative rooms, shop and storage rooms; they would just require technology upgrades to match the new systems. The Cable Propelled Technology would however, require additional space within the existing MF and under the two Satellite Airside Stations to install the required return and tension equipment (bull wheels) necessary for the vehicle propulsion.

The tension wheel has to be installed at the MF approaching the end of the guideway in each lane. A designated space under the running plinth will be needed to accommodate the wheel and support structure. Due to the limited space under the MF though, there is a possibility of placing the wheel in an angle; this installation may require carving out space from the maintenance floor. Figure 5-16 shows and example of an incline tension wheel installed at MIA Concourse E:

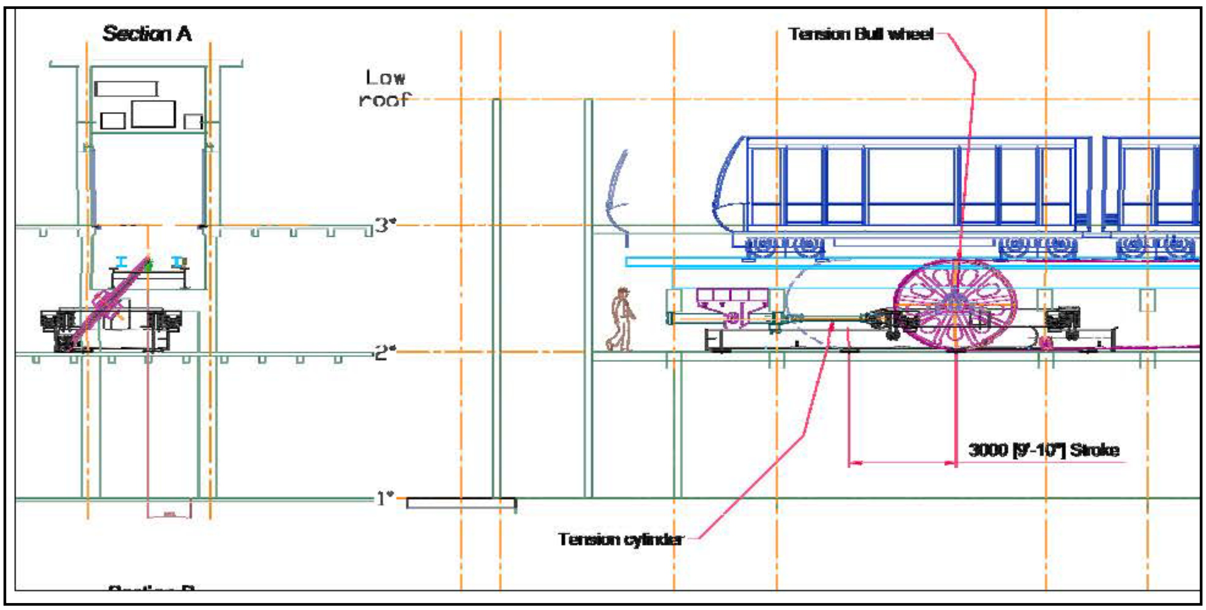


Figure 5-16: Tension Wheel from MIA Concourse E

Figure 5-17 shows the potential location of the tension wheel at the MF:

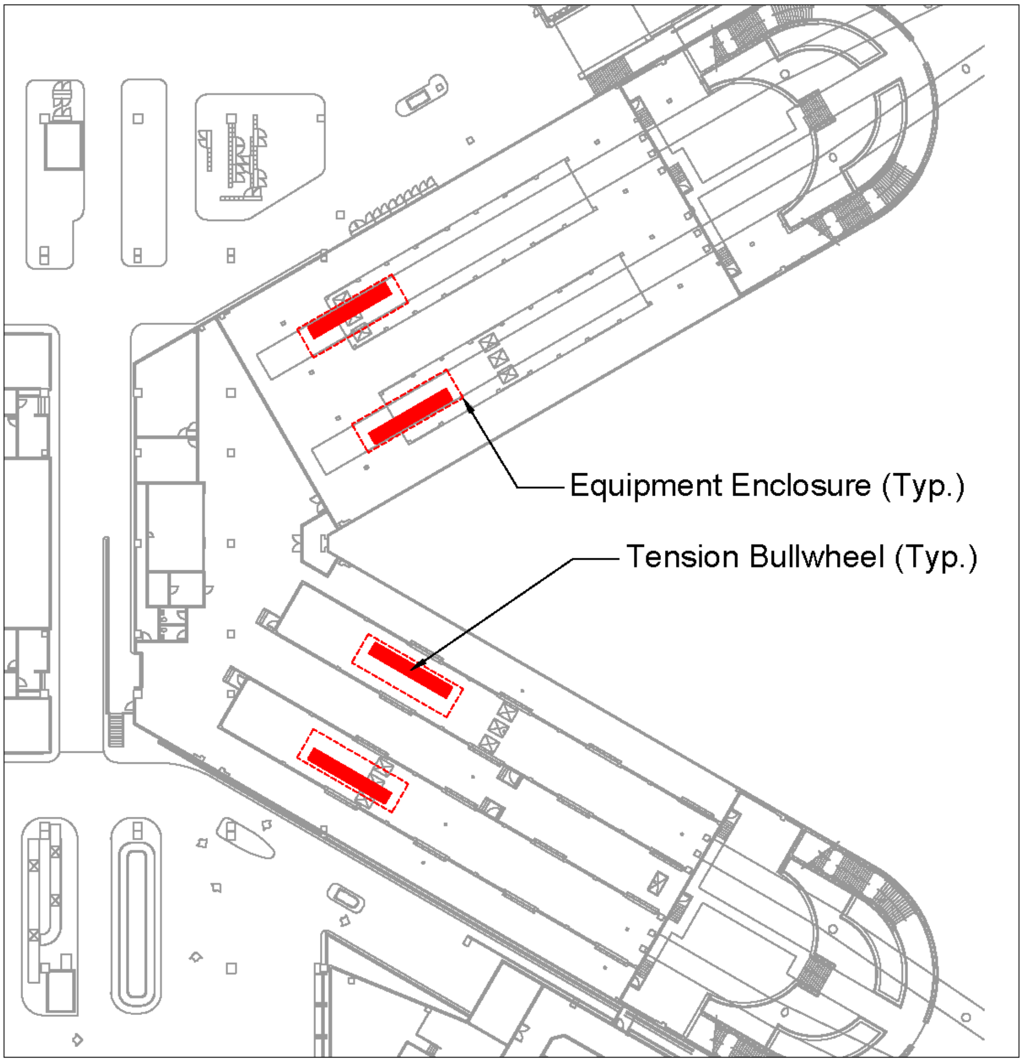


Figure 5-17: Maintenance Facility Tension Wheel

Because of the significant additional space requirements (above and below) for Technology C, it is not feasible compared to Technologies A and B, as they match the present configurations without the need for additional installations to operate in an already constrained environment.

5.3.3.2 IMPACT OF PHASED COMMISSIONING

Due to the sequencing of the construction (one leg, one lane at a time) and implementation of the new technology, there will be a period of overlap between the existing O&M Contractor and the new Contractor in the MF. Presently, the space is extremely limited. As one lane/leg of the replaced system comes on-line for operation, the new O&M Contractor will need space inside the MF for their controls/equipment, spare-parts, personnel, etc. This will be an extremely challenging environment for all Contractors to maintain their systems and operations. Since Technology A is comparable to the existing system (same Contractor) they are considered compatible; Technology A will still require additional space for new parts, equipment, etc. but the team may have some overlap that could reduce personnel duplications. Technologies B and C will require much more in terms of space requirements, parts, personnel etc. and thus are considered less compatible in this regard for use at GOAA.

5.3.3.3 O&M CONTRACT AND SYSTEM REPLACEMENT TIMELINE

One of the unique challenges facing GOAA with the system replacement is the timeframe for each of the legs that require replacement. Presently, A2 is ready for consideration and replacement in 2019, but the B4 leg will still have an approximately 6 to 7 years of design life left before replacement is required. This makes the O&M aspect of the systems challenging. In the case of Technology A, the new Contractor and the existing would be the same; so there will be no impacts to either of the technologies sharing space for an extended period of time. For Technologies B and C, there will be a long-term overlap between the existing and new Contractors. This presents significant challenges, especially for a cable- propelled technology, that will be reviewed and evaluated in the procurement strategy report separately.

5.3.4 Flexibility of Airport's Future Expansion and Growth

An important consideration for GOAA will always be that of future growth and expansion of the airport; this applies for both the airport facilities and the selected Technology in meeting the future demands of the system.

5.3.4.1 GROUND LEVEL IMPROVEMENT

In looking at the Candidate Technologies, Technologies A and B appear to have minimal impacts on the existing fixed facilities and will not require additional space from the airport in order to operate their technologies, thus they have been given a "Good" rating. Technology C, however, requires additional space to operate the cabling system. This will require additional space on the Ground Level along the guideway and impact some existing operations (FIS) at the Station, thus constraining any future use and growth for the airport. Because of this, Technology C is not feasible in this regard for use at GOAA.

5.3.4.2 POTENTIAL FOR EXPANSION OF B4 INTERNATIONAL MODE

Based on the evolving business plan of the airport and the potential need for more flexibility and dedicated service for the international passengers, GOAA is evaluating the option where one lane of the B4 APM Leg could be used exclusively for international passengers. This will provide the airport about 3,300 pphpd capacity for the IM and domestic mode. This would potentially lead to a normal operation condition where the domestic demand would have to be supported by a single train. As previously shown in Section 5.1, the capacity demands for a single lane for Technologies A and B meet the capacity demands for most peaks throughout the day, but Technology C struggles to meet the demands at multiple times throughout the day. Because of this Technologies A and B have been given "Neutral" ratings and Technology C is considered less compatible.

5.4 Alternative Evaluation Matrix

Table 5-3 provides a qualitative summary of the outcome of the analysis from Section 5. Any airport operation related major concerns that are not acceptable by the airport have been marked as such.

Table 5-3 Alternative Evaluation Matrix

	Self Propelled (S.P.)			Cable Propelled	Remarks
	Tech. A	Tech. B.	Other S.P.	Tech. C	
Capacity					
Car Capacity	Good	Good	Good	Neutral	
Normal Ops.	Good	Good	Good	Neutral	
Adequacy of Single Lane	Neutral	Neutral	Neutral	Reduced	During Construction & IM Plan
Vehicle Size	Neutral	Neutral	Neutral	Neutral	Car nose modifications req. for door interface.
Guideway Structure Needs / Compatibility					
Wheel Base	Good	Neutral	Neutral	Inferior	
Gen. Str. Compatibility	Good	Good	Good	Neutral	
Aesthetics	Good	Good	Good	Intrusive	
Walkway Elevation	Good	Good	Good	Less Compatible **(not. Accept.)**	**Not Acceptable,** If Emergency Walkway not at car floor level.
Landside Station:					
General Config.	Good	Good	Good	Good	
Added Equip.	Good	Good	Good	Good	
Station Doors	Good	Good	Good	Good	
Airside Station:					
General Config.	Good	Good	Good	Good	
Added Equip.	Good	Good	Good	Significant **(not. Accept.)**	**Not Acceptable,** Return Wheel impacts B4 FIS
Station Doors	Good	Good	Good	Good	
Maintenance Space					
Impact of New Installation	Good	Good	Good	Significant	Space Constraint. Return Wheel in MF
Impact of Phased Commissioning.	Neutral	Less Compatible	Less Compatible	Less Compatible	
O&M Contract & System Repl. Timeline	Good	Neutral	Neutral	Neutral	
Flexibility for Growth of Airport Ops.					
Gr. Level Improvement	Good	Good	Good	Significant	
Suitability for Expansion of B4 IM	Neutral	Neutral	Neutral	Reduced	
Total (rated)	**Acceptable**	**Acceptable**	**Acceptable**	** Includes **Two Not Acceptable**	**: Need input/ confirmation from GOAA

5.5 New vs. Refurbished System

The previously discussed Alternative Matrix provides an evaluation on the implementation of a New APM Technology; it does not address the possibility of refurbishing the existing system. A refurbished system should provide GOAA with a Design Life of approximately 15 Years at a reduced cost over what the implementation of a completely new system will be. Should the airport have financial constraints GOAA will want to pursue the best value in terms of cost, quality and sustainability and this solution could offer a possible, albeit temporary, solution. Refurbishing the existing system will require, at a minimum, upgrades to the following subsystems/components: vehicles, Automatic Train Controls (system and vehicles), communications and upgrade/interface with new Central Control. There could be benefits of upgrading the power distribution system and generators, guideways and running surfaces too though they may not be immediately necessary.

The cost of refurbished systems varies substantially based on the number of subsystems that have to be changed. Additionally it also becomes a project to project commercial decision by the host supplier and any new potential competitor. However a level of cost comparison has been undertaken in Section 5.5.1 for a better understanding of the comparable value attached to the technical pros and cons described in this Section.

The primary advantage to the implementation of a refurbished system would be that the existing infrastructure will support the technology without enhancements (other than those required to refurbish the system). There will be no issues with compatibility at the stations and platform doors; the guideway is generally structurally sound to support the system; and from an O&M standpoint, there will be a minimal disruption to the Maintenance Facility.

However, there are a several concerns and open issues that would require investigation and guarantees from the present Supplier before making any commitments to the refurbishment option. This report identifies potential concerns for discussion and consideration:

- Has the existing Supplier or other potential competitor demonstrated that a refurbished system is a viable option / solution for the anticipated duration of minimum 15 years?
- Will the Supplier be able to maintain/provide support of the system for the additional design life (parts, labor, etc.)? Or will some components become obsolete? Will the Supplier provide guarantees to maintain the refurbished system for a specific period of time?
- How long will the refurbishment of the existing vehicles take and how long will the system be out of service and down to a single track as each train set is removed and refurbished? When Airsides 1 & 3 were refurbished back in 1997-1999 timeframe GOAA was able to purchase new Airside 2 cars in advance and utilize these cars to replace each train set as they were removed for refurbishment essentially minimizing the dual lane

shuttle downtime during the refurbishment process. This would not be the case for the Airside 2 and 4 refurbishment option.

- Will the overall annual maintenance costs be higher than those of a new system; and if so, at what cost?
- Will increased maintenance mean more vehicles are "out of service" more often and will the existing fleet be able to absorb the increased down-times?
- Will all the operating system, train control and communication and central control upgrade systems be able to be replaced/upgraded, with minimal impacts to the existing infrastructure?
- How long will the warranties be for?
- What will the increased costs be to implement the new system 10-15 years from now, what is the return on investment in today's dollars?

5.5.1 Cost Comparison New vs. Refurbished

In some cases, the decision to use a new or refurbished system is driven by the evaluation of the technical pros and cons or based on financial constraints. However, the following Section has been provided to facilitate the Authority's' decision making process.

This Section provides an estimated equivalent value of the options available to the project in today's dollars, if the Authority decides to evaluate the value of refurbishment against that of the new system. See Table 5-4.

The analysis is done based on normalizing the cost (using life cycle cost) of the new vs. refurbished options at a 15 year mark after implementation. This includes the initial capital costs, the cost to upgrade or replace the subsystems, as appropriate for each option, Annual O&M costs, and residual costs of the vehicles and other systems at the end of the 15 year period. The following table summarizes the cost comparison.

A2 B4 System Cost Comparison 15 Year Normalized New System vs Refurbished System						
Description	**New System Cost in Million $ (NO Run. Plinth)** *{Cost Basis 1,2}*		**New System Cost in Million $ (w/ Run. Plinth)** *{Cost Basis 1,2}*		**Refurbished System Cost in Million $** *(Cost Basis 1,2&3)*	
		$ in Million		$ in Million		$ in Million
Capital Cost						
Vehicle (6 Cars)	6 x $2.5 x 1.25	$ 18.8	6 x $2.5 x 1.25	$ 18.8	6 x $1.8 x 1.25	$ 13.5
ATC Wayside	$1.5 x 1.25	$ 1.9	$1.5 x 1.25	$ 1.9	$1.5 x 1.25	$ 1.9
Vehicle ATC	$1.0 x 1.25	$ 1.3	$1.0 x 1.25	$ 1.3	$1.0 x 1.25	$ 1.3
Communications	$1.3 x 1.25	$ 1.6	$1.3 x 1.25	$ 1.6	$1.3 x 1.25	$ 1.6
Station Work	$0.6 x 1.25	$ 0.8	$0.6 x 1.25	$ 0.8	$0.3 x 1.25	$ 0.4
MSF Equip/ Tool and Work	$1.1 x 1.25	$ 1.4	$1.1 x 1.25	$ 1.4	$0.6 x 1.25	$ 0.8
Guideway/ Rehabilitation	$2.0 x 1.25	$ 2.5	$4.1 x 1.25	$ 5.2	$1.5 x 1.25	$ 1.9
Power *{4}*	$1.0 x 1.25	$ 1.3	$1.0 x 1.25	$ 1.3	$1.0 x 1.25	$ 1.3
Subtotal Capital Cost:		**$ 29.6M**		**$ 32.3M**		**$ 22.7M**
15 Year O&M Cost	$1.7 x 15yr	$ 25.5M	$1.7 x 15yr	$ 25.5M	$2 x 15yr	$ 30.0M
Subtotal O&M Cost:		**$ 25.5M**		**$ 25.5M**		**$ 30.0M**
Total : 15 Year Normalized Cost		**$ 55.1M**		**$ 57.5M**		**$ 52.5M**
Other Factors (Costs, Benefits and/or Risks)						
Cost for 4 **additional** months x 2 lanes of standby (10) Buses *{5}*		None		None	$100/hr/bus *4 mo*2 ln. 8-20 hr/day	1.9M – 4.8M
Vehicle Residual Value after 15 years (approx. 25% of vehicle cost) *{6}*		**$ 4.7M**		**$ 4.7M**		**$ 0 M**

Notes:

1. *The Cost Basis is based on A1/B3 Bid from 2013 for the selected Contractor.*
2. *A 25% cost has been added for PM, Design coordination and management per Note 1 data.*
3. *The vehicle refurbishment cost is based on cost for refurbishment of A1/B3 cars.*
4. *No substations are required.*
5. *Existing trains will have to be pulled out and sent to Factory for refurbishment, resulting in an additional 4 months of single tracking with potential need for bus standby.*
6. *Cost basis:10 year remaining out of 25 year vehicle design life, discounted for opportunity cost and lack of market demand.*

Table 5-4: Cost Comparison of New vs. Refurbished

Should GOAA entertain the option of replacing the B4 system subsequent to the completion of the A2 system, there will be a residual value associated with the vehicles that should be addressed. The following summarizes the potential residual value associated with the vehicles (starting cost is $2M per car):

1) Based on the Suppliers' defined replacement at 1,000,000 miles of use:
   a) Per GOAA, there are 6.5 years remaining for service
   b) Annual mileage = 80,000 miles/year
   c) Total Years for Car = 12.5 years
   d) $Residual\,Value = \left(\frac{6.5\,years}{12.5\,years}\right) \times \frac{\$2M}{car} \times 6\,cars = \$6.24M$
2) However, based on the general replacement cycle used by GOAA, the cars' life has been approximately 1,400,000 miles. For this scenario, the residual value is:
   a) Per GOAA, there are 6.5 years remaining for service
   b) Annual mileage = 80,000 miles/year
   c) Total Years for Car = 17.5 years
   d) $Residual\,Value = \left(\frac{6.5\,years}{17.5\,years}\right) \times \frac{\$2M}{car} \times 6\,cars = \$4.46M$

6. PREFERRED ALTERNATIVE

The summary of results was presented to GOAA staff. Based on their anticipated future growth and review of day-to-day operational needs GOAA has indicated that there are several constraints which are important to the airport.

First, the new technology must be able to fit within the existing infrastructure without significant impacts to the platforms, station doors, guideways, etc. Next, the technology must be able to maintain the current and forecasted capacities for passenger growth, including the ability to support operations in a single-train mode during implementation of the new technology and International Mode (based on field observations of this manual operating process). The technology must be ADA compliant and maintain an emergency egress path in alignment with the train car floor level.

Based on these requirements and evaluation, L+E recommends the Self-Propelled Technologies as the preferred alternative. The Self-Propelled Technologies were found to have a better ability to match the existing guideway structures and running surfaces; were able to meet the required passenger demand capacities, including the single lane; had less impact on the existing facilities and aesthetics, were more likely to have minimal impacts to the airport operations thus reducing the potential for a degraded passenger experience.

The second important option that was reviewed was whether or not to refurbish the existing Self-Propelled system or go forward with a newer technology. Due to the significant unknowns with the possibility of refurbishment (limited design life, warranties, parts availability, maintenance costs, etc.) and the possibility for significant downtimes due to the vehicles being removed from service to undergo refurbishment, this option was considered very disruptive (with a net 5 – 10% cost benefit) to an operational airport and thus was not acceptable.

It is recommended to proceed with a new technology procurement that will provide a longer design life, state of the art automated control systems and computer centers, and has the ability to maintain the present capacities and handle the future growth.