Condition Assessment for
Orlando International Airport
Airside 2 and 4 APM Systems

GOAA Project BP-477

Prepared by:

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INTRODUCTION

The Orlando International Airport serves over 40 airlines that provide transportation to approximately 48 million annual passengers. As part of its operations, the Airport utilizes APM systems to transport passengers and employees twenty-four (24) hours per day, seven (7) days per week between the landside and airside terminals, and the North and South Terminals.

Each of the Airside APM systems consists of two lanes, each connecting the North Terminal landside terminal to the respective Airside 2 and Airside 4 satellite buildings/gates. An illustration of the Airside lanes is included below. Two trains, each 3-cars long, operate in a dual lane shuttle mode carrying passengers to their destination. The existing Airside 2 APM System was placed into service in 2000. The Airside 4 APM System was first placed into service in 1989 but the cars were replaced in 2008. The Airside 2 trains have been in operation for approximately 18 years and have reached over 2.9 million service miles between the two trains. The Airside 4 APM system has been in service for nearly 27 years, and the newer trains have currently reached 1.2 million miles between the two trains.
1 EXECUTIVE SUMMARY

The Greater Orlando Aviation Authority (GOAA) is currently undertaking a project at the Orlando International Airport (OIA) to review options to extend the service life of the existing APM trains serving the Airside 2 and 4 for at least another 6 years. Lea+Elliott has been tasked with performing a condition assessment of the Airside 2 & 4 APM Systems and providing recommendations to GOAA to achieve this goal. The scope of work includes the Airside 2 and 4 APM system trains, train control, running surface, power distribution, central control equipment and other operating system elements as needed.

The results of the assessment included in this report are provided based on a review of relevant documents received from GOAA and Bombardier (Airside 2 & 4 OEM and maintainer), and on-site observations and evaluation of the APM operating system elements including vehicles, train control, communications, and power distribution system, as well as the fixed facilities including the existing stations, equipment rooms and guideway structures.

This report focuses on the Near-Term (1-6 years) objectives and will identify recommendations to improve the Airsides 2 and 4 operational reliability with the goal of extending the service life of the Airside 2 APM for an additional six years to align with the expected remaining service life of the Airside 4 vehicles projected to be in the 2024 timeframe.
2 VEHICLE

2.1 Vehicle Visual Inspection and Observations

The A2/B4 Airside APM systems fleet consists of four three-car trains, one on each guideway lane for a total of twelve vehicles for both systems. In this report a three-car train will be defined as a vehicle. Vehicles for Airside B4 system were commissioned in 2008. The vehicles for A2 system were commissioned in 2000.

During site visits conducted on June 13th and 14th, 2018, Bombardier Transportation (BT) allowed Lea+Elliott access to perform visual inspections on the vehicles for both Airsides A2 and B4. Vehicle (14/15/16) of Airside B4 was inspected on June 13th, with Vehicle (23/24/25) of Airside A2 inspected the following night on June 14th. The visual inspection consisted of the vehicle undercarriage, interior, exterior and door assemblies. During the undercarriage inspection, close attention was paid to areas around the bogie, axle assembly, drive motors, pneumatic and HVAC systems.

### Airside 2 Vehicle Fleet Mileage (as of 07/08/2018)

<table>
<thead>
<tr>
<th>Lane</th>
<th>Mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4700</td>
<td>1,368,854</td>
</tr>
<tr>
<td>4800</td>
<td>1,539,029</td>
</tr>
</tbody>
</table>

Table 2-1: Airside 2 Vehicle Fleet Mileage

### Airside 4 Vehicle Fleet Mileage (as of 07/08/2018)

<table>
<thead>
<tr>
<th>Lane</th>
<th>Mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4500</td>
<td>577,774</td>
</tr>
<tr>
<td>4600</td>
<td>591,257</td>
</tr>
</tbody>
</table>

Table 2-2: Airside 4 Vehicle Mileage

During the Airside B4 inspection of Vehicle (14/15/16) Lane 4500 on June 13th, the following observations were made:

- The undercarriage appeared to be in generally good condition and there were no noticeable signs of corrosion or cracks on any of the structural members.
Corrosion was noted on the leveling valves and braking resistor brackets. This is not considered to be an immediately critical issue; however, considering environmental conditions prevalent in the Orlando area such as heavy rain, high humidity, etc., these items may corrode more quickly than normal and fail in the future, requiring replacement or repair. The leveling valves and braking resistor brackets should be monitored through regular inspection and replaced as necessary. This monitoring/inspection regime should be included as part of BT’s regular preventive maintenance (PM) for vehicle visual inspections. See Figure 2-1 and 2-2 below showing the key areas where corrosion was observed.

- Wired bundles for the train line cables are attached to the draw bars between cars utilizing tie wraps (see Figure 2-3 below). Although this is not an immediate issue, over time the tie wraps will wear due to vibration and age causing the cable to sag, potentially causing a fault. BT should consider the use of a permanent bracket to be used to attach the train line cable to the draw bar, such as the one in Figure 2-4 below.
During the inspection it was noted that car #16 had a pneumatic rotary compressor as opposed to the reciprocating type. Through interviews with the maintenance staff it was discovered that this compressor is no longer functional, and it is necessary to train line air from the other cars. **L+E recommends that this compressor be replaced as soon as possible to eliminate a possible failure which will cause a downtime event.** (Note: GOAA Maintenance has indicated that repair or replacement is included as part of BT’s Maintenance Agreement with GOAA.) See Figure 2-5 below.
The vehicle interior and exterior were also visually inspected, and it was noted that there were no noticeable signs of any damage to the exterior. The overall condition of the vehicle interior was also inspected. The flooring was in good condition; there are no signs of damage and all three cars had a solid floor. The interior paneling was also in good condition.

The following night on June 14th, a similar inspection was conducted on the Airside A2 vehicle (23/24/25) Lane 4700. This vehicle was commissioned into service in 2000. During the inspection, close attention was paid to areas around the bogie ring structure, though it was noted that the inspected areas appear to be in good condition for all three cars. L+E noted the following general observations:

- Leaky differentials; this vehicle is equipped with obsolete differentials, which are no longer available from the manufacturer. Note that the Airside 4 newer vehicles have newer style differentials which are not obsolete. The leaky differential does not affect operation or reliability, it does however require greater maintenance attention. Due to the high mileage of the vehicle and differential obsolescence issues, a campaign to rebuild these units should be considered to avoid possible failures in the future – see Figure 2-6 below. BT has some spare differentials which could be used to replace the ones on the existing Airside 2 fleet. BT maintenance explained that they typically wait until they hear loud noises coming from the differentials or metal shavings in the oil before they replace them. Running these units until signs of failure become evident is not a recommended practice, especially due to the high mileage already on these units. A refurbished differential will easily last the remainder of the expected service life of the trains before they are replaced in approximately 6 years.

Figure 2-5: Rotary Compressor, Car #16
HVAC units appear to have had some minor leaks which have caused oil buildup on some of the components; to confirm this is the case these areas of oil buildup should be cleaned and regularly inspected to ensure that there is no further leakage. See Figure 2-7 below. If leakage is confirmed these HVAC units should be repaired immediately.

All cars include two HVAC units that utilize R-22 refrigerant. It is well-known in the industry that the U.S. Environmental Protection Agency (EPA) has mandated, in accordance with Title VI of the Clean AIR ACT and the Montreal Protocol, the phasing out R-22 refrigerant which will no longer be manufactured after 2020. GOAA will need to plan for a near-future retrofit or replacement of all vehicle HVAC units for the entire fleet.
An inspection of the vehicle interior and exterior was also conducted. There were no notable signs of any major damage to the exterior or interior. The flooring and the interior paneling are in acceptable condition.

In addition to the above visual inspections and stated observations, L+E interviewed members of the maintenance staff who were knowledgeable about the vehicle specifications and maintenance work. During these interviews the following was noted:

- Parts to rebuild (valves, oil pumps and air pump) the pneumatic reciprocating compressors are becoming difficult to obtain and exhibit frequent failures. **L+E recommends replacing these older compressors with rotor type compressors which are more reliable.**
- Vehicle HVAC units currently utilize R-22 refrigerant. **L+E recommends that these packaged HVAC units be replaced with new EPA approved refrigerant.**
- Differentials for the older vehicle fleet on the A2 Airside are obsolete. **L+E recommends that these differentials be refurbished to avoid potential long period downtime.**
- Door switches (cam switches) experience a high failure rate. **L+E recommends that BT contact the door supplier with regard to obtaining recommendations for a more reliable replacement.**
- Mechanical filters for speed code RX boards are difficult to obtain due to obsolescence. BT stated that they have a significant quantity of spares due to the decommissioned Airside 1 & 3 vehicles. **L+E recommends that BT monitor the inventory of these spare parts and if they fall below 10% BT engineering should develop an alternative design replacement.**

Additionally, the exterior paint on the vehicles is significantly discolored/deteriorated. **L+E recommends that new vehicle exterior wraps be procured (note: this recommendation is optional for improvement of vehicle aesthetic quality and does not extend the service life of the system).**

### 2.2 Bogie

During the undercarriage inspection close attention was paid to the bogies and pivot bearings. The following components were inspected, air springs (bags), leaf springs, brake chambers, sway bar bushings, radius rods, the guidance structure including spindles and guidewheels were also inspected. All these components appear to be in generally good condition and are well maintained.

### 2.3 Collector Shoes

All collector shoes and assemblies were inspected for proper alignment and wear. No abnormalities were found.

### 2.4 Brackets

Brackets for the train line jumper cables were missing, the cables are tie wrapped to the draw bars. These brackets should be replaced. See Figures 2-3 and 2-4 above for reference.

### 2.5 Spare Parts / Obsolescence of Components

Obsolescence of spares parts is a key issue to consider in maintaining the vehicle fleet operational. As previously mentioned in this report, some of the vehicle parts (differentials, mechanical filters for printed
circuit boards and pneumatic reciprocating compressor parts) are no longer manufactured by the OEM and are difficult to obtain. Bombardier maintenance staff has stated that they currently have adequate spares for the near future; they indicated that numerous APM parts were salvaged from decommissioned vehicles from other airsides within the Airport (A1/B3). Lea+Elliott has reviewed the spare parts inventory and found it is adequate to properly maintain the system, however the salvaged parts from A1/B3 have not been included in the inventory parts list. **L+E recommends that BT perform a comprehensive inventory of spare parts salvaged as part of the A1/B3 rehabilitation effort and incorporate this information within their MMIS inventory.**

**L+E also recommends the overhaul of the obsolete differentials. The replacement of the pneumatic compressors should also be considered.** Note that the current compressors are the older reciprocating models, other sites with similar CX 100 vehicles have upgraded to rotatory compressor assemblies (HYDROVANE P/N# V04T-CT1015-NSP2006).

### 3 POWER DISTRIBUTION SYSTEM

#### 3.1 Power Distribution System Visual Inspection and Observations

The Power Distribution System (PDS) for Airside 2 and Airside 4 is designed to provide redundancy such that a single point failure in the PDS will not result in a system shutdown. GOAA maintains the PDS. For each airside, two 12.47 kV feeds enter at each of the APM power distribution locations where they are connected to the APM traction power transformers through two disconnect switches. The disconnect switches, metering, and traction power transformers are all provided by Orlando Utilities Commission (OUC). The two 12.47 KV feeds are stepped down to 600 volts, 3-phase power through redundant traction power transformers on each Airside APM system. The PDS configuration is set up such that one transformer powers one lane and the other transformer powers the opposite lane. If one of the two 600V feeds is lost, the tie breaker between the two 600V feeds is utilized to continue providing traction power to the failed lane, thereby maintaining operation of both lanes. The secondary (600V) breakers are equipped with digital trip protection units. This condition assessment shall focus on the PDS substation equipment and generator units for Airsides 2 and 4.

**Airside 2**

Airside 2 PDS equipment (shown in Figure 3-1 below) is located directly underneath the 4700 and 4800 APM guideways and provides 600VAC power to the APM guideways. Airside 2 PDS equipment consists of the PDS Substation (including switchgear and monitoring equipment), generator unit, blue light station (BLS), and Orlando Utilities Commission (OUC) equipment.
The Airside 2 PDS substation is a stand-alone, outdoor rated enclosure as shown in Figure 3-2 below. This PDS Substation houses the breakers, monitoring equipment (i.e. North/4800, South/4700, Generator Ground Resistor Alarm Relays, Voltage and Power meters, Generator multimeter, etc.) and ventilation air-filters. GOAA indicated that the switchgear is in good operating condition and is being maintained on a regular basis. GOAA further indicated that there are no major faults or reoccurring issues with these breakers.

The Airside 2 switchgear is manufactured by Cutler-Hammer and are 600 V-rated, 3-phase, 30kA short circuit current, with a 2.2 kV insulation level. The Airside 2 switchgear layout is as shown in Figure 3-3 below. The Airside 2 switchgear consists of the following breakers:

- 4700 Transformer South Main Breaker “A2SB”
- 4700 Generator South Breaker “A2SE”
- 4800 Transformer North Main Breaker “A2NB”
- 4800 Generator North Breaker “A2NE”
- Tie Breaker “A2TB”

A representative picture of the above breakers is provided in Figure 3-4 below, which shows the actual enclosure for the 4800 Transformer North Main Breaker “A2NB”.

![Figure 3-3: Airside 2 Switchgear Layout](image1)

Figure 3-3: Airside 2 Switchgear Layout

![Figure 3-4: 4800 Transformer North Main Breaker “A2NB”](image2)

Figure 3-4: 4800 Transformer North Main Breaker “A2NB”

Monitoring devices are also provided for this switchgear and is installed in the switchgear cabinets. GOAA’s maintenance personnel indicated that although there are no known issues with the current monitoring equipment and this equipment is inspected in accordance with the preventive maintenance plan, the Eaton IQ Analyzer and Power Xpert are obsolete, no longer supported by Eaton, and there are no spares onsite. This PDS equipment is maintained by GOAA Terminal Electricians who have indicated
their desire to see monitoring of PDS equipment routed to their shop; this would help avoid delays in incident response which occur in the time between the Comm Center noticing an issue with the system and notifying GOAA maintenance staff. The Airside 2 switchgear monitoring equipment consists of the following devices:

- GE Voltage Relay (64 Relay) - (North Ground Resistor Alarm Relay)
- GE Voltage Relay (64 Relay) - (South Ground Resistor Alarm Relay)
- GE Voltage Relay (64 Relay) - (Generator Ground Resistor Alarm Relay)
- Eaton Power Xpert - (North Metering Incoming Volts)
- Eaton Power Xpert - (South Metering Incoming Volts)
- Electroswitch Voltmeter – (Control Power)
- Eaton IQ Analyzer - (Generator Meter)

Representative pictures of the above monitoring devices are provided in Figures 3-5, 3-6 and 3-7 below.

Figure 3-5: Ground Resistor Alarm Relays
Because the PDS Substation is an outdoor, non-airconditioned unit, ventilation must be provided. This PDS substation has natural ventilation with filters over the louvers to control the penetration of dirt/dust. Figure 3-8 below shows the air-filters provided for the PDS substation enclosure. GOAA maintenance indicated that these filters are changed regularly in accordance with the preventive maintenance schedule.
Airside 2 also contains additional protection outside of the substation in the form of a Blue Light Station (BLS). The BLS serves as an emergency shut-off which opens the breaker and removes power from the guideway. This BLS and the associated two-way emergency audio communication device allowing communications to the Comm Center are located on the outside of the substation as shown in Figure 3-9 below and is installed in accordance with ASCE 21-05 and NFPA 130.

Based on visual inspections of the Airside 2 PDS Substation equipment and information provided by GOAA Maintenance, the following actions are recommended:

- Currently the communication from the switchgear trip units to the gateway is not functional. The gateway is a device internal to the PDS switchboard that acquires and consolidates data from PDS devices and allows remote access to this information. This gateway is not functioning and is
preventing remote monitoring of this switchgear by GOAA. **L+E recommends the immediate repair of this communication link.**

- Access and operational clearance of the existing PDS substation design does not meet the current requirements of the National Electrical Code (NEC), Section 110-26 and NFPA 70E as it relates to workspace clearances and Arc Flash, respectively. Refer to Figure 3-10, which shows the Arc Flash warning signs installed on the existing Airside 2 switchgear as a mitigation for existing access and operations. **L+E recommends that remote breaker capability/operation be installed outside of the existing substation.** Figure 3-11 below shows the remote breaker unit installed on the outside of the Airside 4 PDS substation to comply with the Arc Flash requirements and allow safe, local operation of the PDS breakers. **Note that GOAA informed that this work is planned as part of project E-192.**

![Figure 3-10: Switchgear Arc Flash Labels](image1)

![Figure 3-11: Remote Breaker Control Cabinet on AS4](image2)
• Currently the ability to monitor the status of the Airside 2 PDS Substation at the Terminal Electric Shop via the Power Xpert Monitoring System is not available. Airside 2 PDS Substation status notification is currently provided to GOAA Maintenance personnel either by Comm Center or BT. GOAA Maintenance stated that the Eaton Meters (i.e. Eaton Power Xpert, Eaton IQ Analyzer, and the Building Interface Module (BIM)) are all obsolete and no longer supported by Eaton. The Eaton Power Xpert and IQ Analyzer shown in Figures 3-6 and 3-7, respectively, are no longer manufactured and replacements parts are not available. These devices are currently used to collect PDS data and display the information at Comm Center; however, as previously indicated, this information is not being transmitted to the Terminal Electric Shop. Eaton is recommending that GOAA install the new Power Xpert Metering System at the PDS Substation to facilitate status monitoring and data logging capability of the PDS System for the Terminal Electric Shop. **L+E recommends replacement of the Eaton Multi-Meter, Eaton IQ Power Meters, and the Building Interface Module (BIM) to allow GOAA Maintenance real-time PDS status capability. Note that GOAA informed that this work is planned as part of project E-192.**

• The Comm Center currently receives the status of and has the ability to control the Airside 2 PDS breakers. GOAA Maintenance indicated that APM copper communication cabling replacement for A2/A4 PDS control at the COMM Center is being upgraded to fiber as part of Project E-192. It is our understanding from GOAA maintenance that additional funding is required to procure the Power Xpert Meters and copper replacement for monitoring and controlling the PDS equipment. **L+E recommends the replacement of copper cabling to fiber and the installation of the Power Xpert Meters. Note that GOAA informed that this work is now planned as part of project E-192 and if additional funding is required it is recommended that GOAA proceed with the entire E-192 scope.**

• Lighting levels within the PDS substation are currently very poor, and it is difficult to see and service the equipment. **L+E recommends increasing the lighting levels inside of the PDS substation (note: this recommendation is optional for improvement of substation visibility and does not extend the service life of the system).**

• The PDS substation door locking system is significantly corroded and cumbersome to lock (refer to Figure 3-12 below). **L+E recommends the replacement of the PDS substation locking device and padlock (note: this recommendation is optional for improvement of substation security and does not extend the service life of the system).**
Airside 4

Airside 4 PDS equipment provides 600 VAC power to the 4500 and 4600 APMs and is located directly under the 4500 and 4600 APM guideways as shown in Figure 3-13 below. Airside 4 PDS equipment consists of the PDS Substation (including switchgear and monitoring equipment), generator unit, and Orlando Utilities Commission (OUC) equipment.

The Airside 4 PDS substation is a stand-alone, outdoor rated enclosure and is shown in Figure 3-14 below. This PDS Substation houses the breakers, monitoring equipment, and ventilation air-filters. GOAA Maintenance indicated that the switchgear is in good operating condition and is being maintained on a regular basis. GOAA Maintenance further indicated that there are no major faults or reoccurring issues with these breakers. GOAA Maintenance did indicate, however, that the enclosure is currently experiencing water leaks at the switchgear door locations.
The Airside 4 PDS Substation contains the Eaton Magnum DS Metal-Enclosed LV Switchboard. The LV Switchboard assembly is 600 V-rated, 3-phase, 66kA short circuit current, with a 2.2 kV insulation level. The Airside 4 switchgear layout is as shown in Figure 3-13 below. The Airside 4 switchgear consists of the following breakers:

- 4500 South Main Breaker “B42SB”
- 4500 Generator South Breaker “B4SE”
- 4600 North Main Breaker “B4NB”
- 4600 Generator North Breaker “B4NE”
- Tie Breaker “TB”

Representative pictures of the above breakers are provided in Figures 3-15 and 3-16 below, which show the actual enclosure for the 4600 Transformer North Main Breaker “B4NB”. 
Monitoring devices are also provided for this switchgear and are installed in the switchgear cabinets. GOAA’s maintenance personnel indicated that there are no known issues with the current monitoring equipment and this equipment is inspected in accordance with the preventive maintenance plan. However, GOAA Maintenance did indicate that the Eaton IQ Analyzers are obsolete, no longer supported by Eaton, and there are no spares onsite. The Airside 4 switchgear monitoring equipment consists of the following devices:

- Eaton IQ Analyzer - (2B Metering)
- Eaton IQ Analyzer - (4B Metering)
- Eaton IQ Analyzer - (Generator Metering)
- Ground Relay - (SB)
- Ground Relay - (NB)
- Ground Relay - (Generator)

Representative pictures of the above monitoring devices are provided in Figure 3-17, 3-18 and 3-19 below.

![Ground Relays Cabinet](image1.png)

**Figure 3-17: Ground Relays Cabinet**

![Eaton IQ Analyzer (PDS)](image2.png)

**Figure 3-18: Eaton IQ Analyzer (PDS)**
Since the PDS Substation is an outdoor, non-airconditioned unit, ventilation must be provided. This PDS substation has natural ventilation with filters over the louvers to control the penetration of dust. Figure 3-20 below shows the air-filters provided for the PDS substation enclosure. GOAA maintenance indicated that these filters are changed regularly in accordance with the preventive maintenance schedule.

Based on visual inspections of the Airside 4 PDS Substation equipment and information provided by GOAA Maintenance, the following actions are recommended:

- Currently the ability to monitor the status of the Airside 4 PDS Substation at the Terminal Electric Shop via the Power Xpert Monitoring System is not available. Airside 4 PDS Substation status notification is currently provided to GOAA Maintenance personnel either by Comm Center or BT. GOAA Maintenance stated that the Eaton Meters (i.e. Eaton IQ Analyzer and the Building Interface Module (BIM)) are all obsolete and no longer supported by Eaton. The Eaton IQ Analyzers shown
in Figures 3-18 and 3-19 are no longer manufactured and replacements parts are not available. This device is currently used to collect PDS data and display the information at Comm Center; however, as previously indicated, this information is not being transmitted to the Terminal Electric Shop. Eaton is recommending that GOAA install the new Power Xpert Metering System at the PDS Substation. This would facilitate status monitoring and data logging capability of the PDS System for the Terminal Electric Shop and obviate the need for GOAA maintenance personnel to wait on Comm Center or BT to provide notification. **L+E recommends replacement of the Eaton IQ Analyzers and the Building Interface Module (BIM) to allow GOAA Maintenance real-time PDS status capability.** Note that GOAA informed that this work is planned as part of project E-192.

- Comm Center currently receives the status of and has the ability to control the Airside 4 PDS breakers. GOAA Maintenance indicated that APM copper communication cabling replacement for A2/A4 PDS control at the COMM Center is being upgraded to fiber as part of Project E-192. It is our understanding from GOAA maintenance that additional funding is required to procure the Power Xpert Meters and copper replacement for monitoring and controlling the PDS equipment. **L+E recommends the replacement of copper cabling to fiber and the installation of the Power Xpert Meters.** Note that GOAA informed that this work is planned as part of project E-192 and if additional funding is required it is recommended that GOAA proceed with the entire E-192 scope.

- Currently a blue light station is not installed at the Airside 4 PDS Substation. **L+E recommends** that a blue light station be installed at the Airside 4 PDS substation to comply with the requirements of NFPA 130. Note that GOAA informed that this work is planned as part of project E-192.

- GOAA Maintenance has indicted that the Airside 4 PDS Substation is currently experiencing water leaks. **L+E recommends conducting a thorough inspection to verify the extent of water intrusion and implementing repairs/mitigation as appropriate in accordance with the manufacturer’s recommendations.**

- Lighting levels within the PDS substation are currently very poor, and it is difficult to see and service the equipment. **L+E recommends increasing the lighting levels inside of the PDS substation (note: this recommendation is optional for improvement of substation visibility and does not extend the service life of the system).**

- The PDS substation door locking system is significantly corroded and cumbersome to lock (refer to Figure 3-21 below). **L+E recommends the replacement of the PDS substation locking device and padlock (note: this recommendation is optional for improvement of substation security and does not extend the service life of the system).**
3.2 Maintenance History / Overhauls

Proper maintenance of the PDS equipment is essential for the efficient operation and longevity of equipment. Interviews with Bombardier’s maintenance manager indicated that maintenance and inspections of the traction power equipment are performed by a contractor engaged directly by GOAA. As such, maintenance history and records for the PDS equipment (e.g. switchgear, cables, generators, etc.) were requested from GOAA. Review of the inspection records (obtained in response to a request for inspection procedures and repair records of the equipment) indicates that breakers are regularly maintained, and that the last maintenance and inspection of the Airside 2 breakers was performed on June 27-29, 2017. Reports also show that the breakers are generally in good condition. Airside 4 maintenance records received from GOAA show that the last maintenance and inspections were performed on July 14, 2017 for breakers B4NE4600, B4NB4600, Tie Breaker, B4SE4500, and B4SB4500. Preventive maintenance records for both Airsides 2 & 4 show that tests on the switchgear, controls, and IR Test Downstream Equipment are performed yearly.

Similarly, the APM generators are maintained by an outside contractor engaged directly by GOAA. Maintenance records obtained for the years 2016 to present show that the generators on both Airsides 2 & 4 are maintained regularly. Maintenance records show that the generators are inspected monthly, quarterly, and annually. Load bank and fuel testing are also performed; however, the frequency for which this task is performed should be confirmed by GOAA. The load bank records provided show that the load bank test for Airsides 2 & 4 generators were performed in 2012.

3.3 Breakers

The LV Switchboard at Airside 2 contain Cutler-Hammer breakers and Airside 4 LV Switchboard contain Eaton breakers. According to GOAA Maintenance, there are no known issues with these breakers and they are performing very reliably. However, in an effort to maintain reliable performance of the breakers and associated monitoring equipment, L+E recommends that GOAA continues to have all switchgear
being thoroughly inspected and overhauled as necessary as prescribed by the equipment manufacturer and any future obsolescence issues be addressed as necessary.

3.4 Generators

Inspection of the Airside 2 and Airside 4 generators was performed on July 12, 2018 with GOAA Maintenance representatives. According to interviews with the GOAA’s Maintenance, review of the maintenance records, and inspection of the Airside 2 and Airside 4 generators, the generators are maintained on a monthly, quarterly, and annual basis.

The Airside 2 generator is a 1750 kW genset and appears to be in good operating condition. This genset is shown in Figure 3-22 below.

![Figure 3-22: Airside 2 Generator](image)

The following are recommendations based on interviews with GOAA Maintenance and inspection of the Airside 2 generator:

- Lighting levels within the Airside 2 generator are currently very poor, and it is difficult to see and service the equipment (refer to Figure 3-23 below). **L+E recommends upgrading the lighting system within the enclosure of the generator to increase the lighting levels (note: this recommendation is optional improvement for generator equipment visibility and does not extend the service life of the system).**
GOAA Maintenance indicated that there are no spares for the generator molded-case breaker shown on Figure 3-24 below in inventory. Based on further discussions with GOAA electrical shop similar molded-case breakers are available but are quite expensive depending on the degree of replacement. An alternative more cost-effective approach is being looked at to purchase a refurbished breaker as a spare. **L+E recommends that GOAA continue to explore options and to purchase a spare breaker.**

Extensive rusting was noted on the generator floor (see Figure 3-25 below). **L+E recommends a thorough inspection and mitigation of surface rust.**
• GOAA Maintenance indicated that the Program Logic Controller (PLC) in the control panel (see Figure 3-26 below) is damaged and not functional. **L+E recommends replacing the damaged Program Logic Controller (PLC) in the control panel and its associated functionality.**

![Figure 3-25: Airside 2 Generator Interior Surface Rusting](image)

The Airside 4 generator is a 1180 kW genset and is shown in Figures 3-27 below. Interviews with GOAA Maintenance and inspection of the Airside 4 generator have revealed that the generator is roughly 28 years old and has a number of reliability and operational issues. This coupled with the number of other issues identified with the generator within this report, leaves GOAA with the option to either replace the generator and fuel tank in its entirety or replace/refurbish the various items identified herein. If replaced, the new generator should be designed and sized similar to the new Airside 1 & 3 generators which provides redundancy, flexibility and enough power to operate both lanes in synchronized double shuttle operation and these new generators can be reutilized for future replacement APM system/applications.

![Figure 3-26: Non-Functional PLC](image)
Below is a list of noted issues to be addressed should GOAA instead prefer to rehabilitate the generator:

- Lighting levels within the Airside 4 generator are currently very poor, and it is difficult to see and service the equipment (refer to Figure 3-28 below). **L+E recommends upgrading the lighting system within the enclosure of the generator to increase the lighting levels. (note: this recommendation is optional improvement for generator equipment visibility and does not extend the service life of the system). If the generator is replaced as an option, then this lighting recommendation is moot.**
• Severe rusting and corrosion around the entire housing (refer to Figures 3-29 and 3-30 below). **L+E recommends a thorough inspection of the generator exterior and interior enclosure and flooring and address all corrosion issues. If the generator is replaced as an option, then this issue is moot.**

![Figure 3-29: Airside 4 Generator Enclosure Rusting](image)

![Figure 3-30: Airside 4 Generator Enclosure Rusting](image)

• The underground fuel tank shown in Figure 3-31 below is approaching the end of its useful life. If it is decided to replace the underground tank, **L+E recommends that a compatible above-ground generator fuel tank be provided. The existing underground fuel tank can be left in place; however, it must be properly addressed. If the generator is replaced as an option, then this issue is moot.**
• GOAA Maintenance indicated that the alternator needs to be inspected and repaired/refurbished as necessary. Refer to Figure 3-32 below. *L+E recommends that the alternator is inspected and repaired as part of the PDS maintenance regime. If the generator is replaced as an option, then this issue is moot.*

![Figure 3-32: Airside 4 Generator Alternator](image)

- Voltage regulator is outdated and needs to be replaced per GOAA Maintenance. *L+E recommends that a voltage regulator be inspected and replaced. If the generator is replaced as an option, then this issue is moot.*

- Access and operational clearance in front of generator switchgear does not meet the current requirements of the National Electrical Code (NEC), Section 110-26 and NFPA 70E as it relates to workspace clearances and Arc Flash, respectively. The generator is an old installation and does not comply with these current codes with respect to working clearances around electrical equipment. Refer to Figure 3-33 below. *L+E recommends the installation of a remote operational outside of the generator enclosure to meet the current codes for safe
operation of the generator breaker. If the generator is replaced as an option, then this issue is moot.

Figure 3-33: Airside 4 Generator Breaker

- The generator electrical panel is functional but outdated and no spares are available. **L+E recommends the replacement of the electrical panel. If the generator is replaced as an option, then this issue is moot.**
- No schematic drawings are available for this unit. **L+E recommends that schematic drawings be developed to allow proper troubleshooting and operation of the generator. If the generator is replaced as an option, then this issue is moot.**
- Ground fault relays are obsolete and spares are not available. **L+E recommends that the existing ground fault relays be replaced with new ground fault relays and adequate spares provided. If the generator is replaced as an option, then this issue is moot.**

Based on the above, L+E provides the following two (2) options for GOAA’s consideration:

1. **Option 1** – Replace the single 1180-kW generator with new above-ground sub-base fuel tank. GOAA should consider a similar design to the new generators on A1/B3 APMs which provides for redundancy, operational flexibility and sufficient power to allow both lanes to operate in synchronized double shuttle. The generator(s) can then be re-used when GOAA is ready to replace Airsides 2 and 4 APMs. The expected life of these new generators is 30 years. The existing underground fuel tank can be left in place; however, must be properly addressed based on environmental regulations. If generator is replaced, many of the above recommendations are moot and need not be implemented, as noted above.

2. **Option 2** – Perform a complete inspection and overhaul of the generator to address all issues as outlined above and the acquisition of adequate spares for all pertinent equipment.
3.5 Spare Parts / Obsolescence of Components

According to GOAA Maintenance, the following equipment are lacking spares or are at/near obsolescence:

- **Airside 2 PDS** – The Eaton monitoring equipment (i.e. IQ Analyzers, Power Xpert, and Gateway) is obsolete. GOAA does not have any spares onsite and this equipment is no longer supported by Eaton. **L+E recommends replacing these meters with the Power Xpert Meters per Eaton’s discussion with GOAA.** Note that GOAA informed that this work is planned as part of project E-192.
- **Airside 2 Generator** – No spare breaker. **L+E recommends procuring a spare breaker which can either be new or refurbished at a lower cost.**
- **Airside 4 Generator** – No spare parts are available for the ground fault relays, which are now obsolete. **If the generator is replaced as an option, then this issue is moot. If not, GOAA should identify a suitable replacement that is readily available.**
- **Airside 4 Generator** – GOAA Maintenance indicated that notification from GOAA Risk Management was received stating that the Airside 4 generator underground tank is at the end of its useful life and must be replaced. **If the generator is replaced as an option, then this issue is moot. If not, GOAA should identify a suitable replacement tank that is compatible with the existing generator.**
- **Airside 4 Generator** – the voltage regulator is obsolete and needs to be replaced. **If the generator is replaced as an option, then this issue is moot. If not, GOAA should identify a suitable replacement voltage regulator that is compatible with the existing generator and have it replaced as part of the GOAA PDS maintenance regime.**

3.6 Grounding

Additionally, L+E recommends the inspection and testing of all existing APM system ground rods, down conductors and lightning protection subsystems to ensure that they do not exceed the 5-ohm resistance when measured in accordance with IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems, IEEE Standard 142-1991. Rods, cables and equipment should be inspected, and any which have been found to be significantly deteriorated should be replaced as necessary and retested to demonstrate they meet the 5-ohm requirement. Grounding and lightning protection should be provided in accordance with the requirements of the NEC and Orlando Airport design guideline specifications, as applicable. (Note: these inspections were not included as part of this assessment but are recommended).
4  STATIONS

4.1  Station Visual Inspection and Observations

A2 and B4 stations, both airside and landside (identified in Figures 4-1 through 4-4 below) are useable as-is. Communications in the way of audio/video and dynamic graphic signs are non-existent. The Owner has provided static signs as shown in Figure 4-5 below. Live and pre-recorded PA announcements are coordinated by GOAA’s communications group. Bombardier provided a Communication Cabinet for the B4 lane; however, the cabinet is not currently in use. This cabinet and/or wiring could be used in the future to enhance station communications, if desired.

Figure 4-1: B4 Landside Station

Figure 4-2: B4 Airside Station
Figure 4-3: A2 Landside Station

Figure 4-4: A2 Airside Station

Figure 4-5: Static Signage
4.2 Doors

The automated, bi-parting Platform Screen Doors (PSD’s) used on B4 (Airside and Landside) were originally installed in 1990. The PSD’s received a major rebuild/ update in 2008. The doors were provided by Stanley Access Technology. Stanley continues to support this door system with replacement parts.

Two concerns were identified related to maintaining the B4 PSD’s for the next 5 to 6 years;

1. The header door track is worn in multiple areas as illustrated in Figure 4-6 below. Bombardier has sufficient spares to replace the header door tracks on an as needed basis. **No additional action recommended at this time.**

2. The door motors are experiencing wear on the motor brushes as illustrated in Figure 4-7 below. The supplier does not offer replacement motor brushes. The motor itself is identified as the Line Replaceable Unit. **It may be prudent to acquire several spare Stanley door motors as Bombardier has indicated that the lead times on these motors are variable up to 1 year.**
The automated, bi-parting Platform Station doors used on A2 (Airside and Landside) were installed and placed into operation in 2000. The PSD’s were provided by Horton Automatics. Horton Automatics support for replacement parts is considered sporadic at this time.

Three concerns were identified related to maintaining the A2 PSD’s for the next 5 to 6 years;

1. The header door track is worn in multiple areas as identified in Figure 4-8 below. Bombardier has stated they believe they have sufficient spares to replace the header door tracks on an as needed basis. **No additional actions are required at this time.**

2. Horton Automatics supply of replacement parts has become sporadic, with Bombardier indicating that various parts have very long lead times (i.e., door motors) upwards of 1 year, and future support is questionable. **L+E recommends that the Owner / BT consider procuring additional spares to reduce the risk of parts shortage in the future.**

3. The frames that support the screen door panels are beginning to fail. To date three door frame/hangars have cracks, one of which failed as illustrated in Figure 4-9 below. The APM maintainer has located local shops that can repair the frame/headers. **L+E recommends continued periodic inspections, with follow-up corrective action as necessary.**

![Figure 4-8: A2 PSD Worn Header Track](image_url)
4.3 Life-Safety Announcement Devices

Station Life Safety Announcements are limited on Airsides 2 and 4 to the audio PA announcements made via the GOAA PA System. GOAA also has the ability to make announcements on the trains. There is an operable on-board radio system that allows 2-way communication between passengers and the GOAA Comms. group. Existing equipment is in good operating condition.

4.4 Spare Parts / Obsolescence of Components

Several items are or will be obsolete and may become unavailable soon. Bombardier has stated that there are sufficient spare parts on site to continue operations until the desired 2024 timeframe, with the exception of the recommended additional spare parts mentioned herein. L+E has requested and received a comprehensive inventory of spare parts from BT, but this information excludes spares salvaged as part of the A1/B3 rehabilitation effort. **L+E recommends that BT perform a comprehensive inventory of spare parts salvaged as part of the A1/B3 rehabilitation effort and incorporate this information within their MMIS inventory.**
5  GUIDEWAY

5.1 Guideway Visual Inspection and Observations

A visual evaluation and inspection of the APM running surface was performed during the evenings of June 13th and 14th; the Guideway and Emergency Walkway sub-structure were not part of the assessment inspection.

The evaluation and inspection produced the following observations:

- Transverse cracking appeared to be frequent on the guideway, especially inside the station tunnels where cracks were found with average spacing between 12” to 24” along the longitudinal axis. Most of the transverse cracks appear to extend the full width of the plinth, however visual inspection of the plinths’ edges revealed that the cracks did not extend the full depth of the plinth, and the width of cracks appear to be between 0.01” to 0.03”. See Figure 5-1 below.

![Figure 5-1: Transverse Cracks along the Plinth Longitudinal Axis](image)

- Map cracking was observed along the running surface with minimal cracks widths of less than 0.01”. It appears that these cracks were developed at the time of the concrete placement of the plinth due to water loss, thermal and shrinkage effects. See Figure 5-2 below.

![Figure 5-2: Map Cracks](image)
• Minor pitting along the guideway with dimensions bigger than ½ inch will need to be repaired. One such observed location is the Guideway lane 4800 airside station. See Figures 5-3 and 5-4 below.

![Figure 5-3: Minor Pitting at Plinth Edge](image)

• Previous repairs were observed along the guideway. The cut-and-patch and the replacement of concrete repairs were in a good condition; however, it was noted that the cracks filling and sealing materials were in poor condition and need to be replaced. See Figures 5-5 and 5-6 below.

![Figure 5-4: Minor Pitting at Plinth Edge](image)
Guide Rail paint abrasion/ scraping and minor rust was observed. See Figures 5-7 and 5-8 below.

Figure 5-5: Previous Repair in Poor Condition

Figure 5-6: Previous Repair in Poor Condition

Figure 5-7: Guide Rail Abrasion
5.2 **Power Rail**

A visual inspection of the guideway power rail was also conducted. The following items of note were observed:

- There is significant rusting at the power rail brackets which serve to clamp the power rail onto the power rail supports, as indicated in Figure 5-9 below. **L+E recommends that these brackets be replaced where the rusting is heavy. Other brackets should be cleaned and treated with a rust inhibitor.**

![Figure 5-8: Guide Rail Abrasion](image)

![Figure 5-9: Corroded Support Brackets](image)
The power rail protective covers are cracking in various areas (see Figure 5-10 below). **L+E recommends that cracked rail covers be replaced.**

![Cracked Power Rail Cover](image)

**Figure 5-10: Cracked Power Rail Cover**

Various expansion joints (for power, ground and signal rail) show significant wear as illustrated in Figure 5-11 below. **L+E recommends that every expansion joint be thoroughly inspected and replaced or rebuilt.**

![Worn Expansion Joints](image)

**Figure 5-11: Worn Expansion Joints**
5.3 **Guideway Visibility / Accessibility**

Additionally, L+E noted the following deficiencies for corrective action:

- Emergency walkway visibility is currently poor. L+E **recommends adding additional emergency walkway guideway cameras similar to the Airside 1 & 3 APM’s configuration to meet TSA compliance requirements.**

- There are currently no Blue Light Stations along the emergency walkway on Airside 4 APM. L+E **recommends adding Blue Light Stations along the emergency walkway to bring B4 Airside up to NFPA-130 compliance.**
6 COMMUNICATIONS, SCADA AND TRAIN CONTROL

6.1 Communications / SCADA Visual Inspection and Observations

SCADA equipment related to the PDS is under the control of the Owner. The Communications and SCADA equipment are in good working order.

6.2 Onboard Communication System

The on-board Communication System is operable and maintained and inspected at regular intervals. Bombardier has indicated they would like to have the base station radio moved from the west end of the airport to the east end – into their M&SF for ease of maintenance / repair. The move is not necessary but would be a benefit to the O&M provider.

6.3 Spare Parts / Obsolescence of Components

Bombardier has stated that there are sufficient spare parts on site to continue operations. Several items (i.e., vehicle carried radios) are or will be obsolete and may become unavailable. L+E has requested and received a comprehensive inventory of spare parts from BT, but this information excludes spares salvaged as part of the A1/B3 rehabilitation effort. L+E recommends that BT perform a comprehensive inventory of spare parts salvaged as part of the A1/B3 rehabilitation effort and incorporate this information within their MMIS inventory.

6.4 Train Control Visual Inspection and Observations

The train control for lane A2 is operable and supported as is. The ATO and related equipment for the B4 lane has been upgraded this year and is fully operable. The Maintenance monitors for A2 and B4 provide real time indications and alarms of System operation, as illustrated in Figure 6-1 below. The GOAA Comm. Center Train Control panel is an older model (see Figure 6-2 below) but remains operable and sufficient for a Shuttle System.

Figure 6-1: A2/B4 MSF System Monitoring
6.5 Wayside Train Control

Wayside train control equipment is in good condition and operable as is.

6.6 Train Control Spare Parts / Obsolescence of Components

Bombardier has stated there are sufficient spare parts on-site to continue operations for the foreseeable future. Several items are or will be obsolete and may become unavailable. Additional spares have been collected from the A1 and B3 systems and are stored in the A2 B4 MSF, as illustrated in Figures 6-3 and 6-4 below. L+E has requested and received a comprehensive inventory of spare parts from BT, but this information excludes spares salvaged as part of the A1/B3 rehabilitation effort. **L+E recommends that BT perform a comprehensive inventory of spare parts salvaged as part of the A1/B3 rehabilitation effort and incorporate this information within their MMIS inventory.**
Bombardier has indicated that they have sufficient spare parts for the foreseeable future (see Figures 6-5 through 6-9 below). Based on the current status of equipment and spare parts, no additional action is recommended at this time with regards to the train control and communications systems. **However,** GOAA may consider relocating the base station radio from the west end of the airport to the east end – into the BT occupied M&SF area for ease of maintenance / repair.
Figure 6-6: Additional Spare Parts – Station Door Parts and Equipment

Figure 6-7: Additional Spare Parts – Equipment Boxes/Power Rail Covers/Expansion Joints/Misc.
Figure 6-8: Additional Spare Parts – Vehicle Termination Boards, ATO Equipment, Car Logic Cradles

Figure 6-9: Additional Spare Parts – Vehicle/ATO Cradles, PC Boards, Comm. Equipment
7 MAINTENANCE FACILITY

7.1 Maintenance Facility Visual Inspection and Observations

The maintenance facilities on both Airside A2 & B4 APM systems are on line facilities, meaning that maintenance, inspection and repairs occur at the APM station on the landside. The vehicle maintenance can only be performed after the system is shutdown. Through inspection of the facilities and interviews with the maintenance staff it was apparent that maintenance personnel have adapted well to performing the necessary maintenance inspections and repairs at these facilities. Various specialty tools that are utilized for working in such close quarters were observed. Based on visual inspections, the maintenance equipment appears to be in good working order.

Based on the inspections and interviews above, no additional action is recommended at this time with regard to the A2/B4 maintenance and storage facility.

8 ESTIMATED REMAINING USEFUL LIFE

8.1 Asset Estimated Remaining Useful Life Criteria

Design Life of the Operating System is specified as 30 years (see ASCE-21-13 Section.1.6). Lea+Elliott notes that typically design life specification is related to a specific subsystem, noting that obsolescence of communications equipment, for example, leads to a shorter design life, typically 15 years. In consideration of this, and of the overall condition of the GOAA Airside 2/4 APM, five rating criteria have been developed to be used in determining the estimated useful life of the APM System equipment, as reflected in Table 8-1.

<table>
<thead>
<tr>
<th>Estimated Remaining Useful Life Rating</th>
<th>Estimated Remaining Useful Life Description</th>
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<tbody>
<tr>
<td>“A” (5)</td>
<td>Greater or equal to 15 years</td>
</tr>
<tr>
<td>“B” (4)</td>
<td>10 to 15 years</td>
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<tr>
<td>“C” (3)</td>
<td>5 to 10 years</td>
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<tr>
<td>“D” (2)</td>
<td>1 to 5 years</td>
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<tr>
<td>“F” (1)</td>
<td>Reaching or past its useful life</td>
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</table>
These criteria essentially provide a 15-year look ahead at the remaining estimated useful life of the GOAA Airside 2/4 APM system equipment assets and have been used in developing the projected remaining useful life estimates of the system assets in the following section. The estimated remaining useful life is based upon future maintenance being performed at the current level with the recommendations observed during the physical condition assessment being incorporated within the timeframe described in Section 9, below. Factors such as the asset’s physical condition, type, age, past utilization, rehabilitation history, obsolescence, original equipment manufacturer (OEM) support, and spare parts availability are considered in the estimated remaining useful life ratings. Therefore, where a subsystem or component may currently be in excellent condition, for example, spare parts may be unobtainable or there may be no OEM support, which may provide for a different rating in as compared to its present observed condition.

### 8.2 Asset Remaining Useful Life

The system equipment assets are organized into a hierarchy of eight (8) subsystems, as discussed. Each of these subsystems is further subdivided into the primary major components. The physical condition rating of each of these major components is provided in Table 8-2. When the rating or term is applied to an overall subsystem, assembly, part, or component, this does not indicate that all sub-elements of the subsystem, assembly, part, or component are in the same condition.

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<thead>
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<th>Estimated Remaining Useful Life</th>
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<td>Rating</td>
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<tr>
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<td>Trains- Vehicle Door System</td>
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<tr>
<td>Trains – Pneumatic System</td>
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<tr>
<td>Trains- HVAC System</td>
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<td>Supervisory Control Interface and Other Termination Cabinets</td>
<td>B</td>
</tr>
<tr>
<td><strong>Central Control Facility Equipment</strong></td>
<td></td>
</tr>
<tr>
<td>ATP</td>
<td>B</td>
</tr>
<tr>
<td>ATO</td>
<td>B</td>
</tr>
<tr>
<td>ATS</td>
<td>B</td>
</tr>
<tr>
<td>Subsystem / Major Component</td>
<td>Estimated Remaining Useful Life</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
<td>Rating</td>
</tr>
<tr>
<td>Human Machine Interface (HMI)</td>
<td>C</td>
</tr>
<tr>
<td>Video Wall</td>
<td>N/A</td>
</tr>
<tr>
<td>MMIS</td>
<td>C</td>
</tr>
</tbody>
</table>
9 RECOMMENDATIONS

This section includes a summary of the L+E Team findings and recommendations. They are categorized by subsystem and criticality, and divided into three groups; critical items which L+E recommends be addressed within the next 12 months (“Immediate”), items which are not critical but must be addressed in order to meet the desired goal of reliable system operation for the next 5-6 years (“Near-Term”), and recommendations which would help improve/facilitate existing conditions, functionality, and/or ease of maintenance of the system but which are not ultimately necessary for the continued reliable operation of the system (“Optional”).

9.1 Vehicles

Immediate

- All cars include two HVAC units that utilize R-22 refrigerant. It is well-known in the industry that the U.S. Environmental Protection Agency (EPA) has mandated, in accordance with Title VI of the Clean AIR ACT and the Montreal Protocol, the phasing out R-22 refrigerant which will no longer be manufactured after 2020. GOAA will need to plan for a near-future retrofit or replacement of all vehicle HVAC units for the entire fleet.

- It is also recommended that BT start a campaign to rebuild the older high mileage vehicle differentials on Airside A2, these units are obsolete. This campaign will prevent any future failures that could cause a lengthy system delay.

Near-Term

- L+E recommends that BT contact the door operator manufacturer to replace the door switches with a more durable or heavier duty switch.

- During interviews with BT’s maintenance staff it was noted that obtaining spare parts for the current pneumatic compressors is becoming difficult due to the age of the equipment. It is recommended that BT seek engineering expertise in obtaining a new type of compressor design for the current operation demand of the APM system.

- Based on available information, the mechanical filters which are used on the speed code RX boards may or have already become obsolete and are no longer manufactured. The lack of these parts can cause a problem in the future. However, it was noted that the maintenance staff has a very high spare ratio (over 30%) on speed code RX modules due to the decommissioning of the A1/B3 system. L+E recommends that if the spare ratio falls below 10 percent the vehicle manufacturer should be contacted to provide an engineering solution.

Optional

- The exterior paint of the vehicles is currently significantly discolored/deteriorated. L+E recommends that new vehicle wraps be procured and installed to improve the aesthetic quality of the vehicles.
9.2 Power Distribution System

Note that several of the items listed below are planned as part of the GOAA Project E-192 and are indicated as such below.

Immediate

- Airside 2 PDS Substation
  - Repair the communication link from switchgear trip units to the gateway.  
    (E-192)
  - Install remote breaker capability/operation outside existing substation to facilitate to meet the access and operational clearances to the breakers per National Electrical Code (NEC), Section 110-26 and NFPA 70E.  
    (E-192)

- Airside 4 PDS Substation
  - Repair the communication link from switchgear trip units to the gateway.  
    (E-192)
  - Install a blue light station at the Airside 4 PDS Substation to comply with the requirements of NFPA 130.  
    (E-192)
  - Install a blue light station at each Airside 4 station platform end at the entrance to the guideway emergency walkway similar to all other airside APMs to comply with the requirements of NFPA 130.
  - Perform water leak inspection and make repairs as necessary repairs to prevent water from intruding into the PDS Substation.

- Airsides 2 and 4 PDS Substations (Common)
  - Institute PDS status monitoring for the Power Xpert Monitoring System located in the Terminal Electric Shop. This can be accomplished once the fiber cable is installed.  
    (E-192)
  - Procure Comm Center Copper to Fiber replacement as part of Project E-192.

- Airside 2 Generator
  - Perform comprehensive rust inspections & mitigation.
  - Recommend replacing molded-case breaker with a draw-out type breaker as there is currently no spare available.
(Note: Recommend full inspection of generator by supplier to identify appropriate spare breaker, PLC unit, and other parts requiring overhaul or replacement.)

- Replace damaged Program Logic Controller (PLC) in the control panel.

- **Airside 4 Generator**
  - **Option** - Replace the single 1180-kW generator with new generator(s) and new above-ground sub-base fuel tanks similar in design to the Airside 1 & 3 generators due to extensive issues as noted in Section 3.4.
  - If generator is not replaced perform all recommended replacements/upgrades or refurbishments associated with the generators herein:
    - Procure spares for ground fault relays, which are now obsolete. Not necessary if the generator is replaced with new.
    - Perform comprehensive rust inspection & mitigation.
    - Replace old underground fuel tank with new above-ground tank.
    - Procure spare breaker.
    - Perform complete inspection of generator to identify equipment requiring overhaul or replacement.

**Near-Term**

- **Airside 2 and 4 PDS Substations (Common)**
  - Inspect and overhaul all breakers. Replace if necessary.
  - Inspect and test all system grounds and associated ground rods, and lightning protection system. Replace and test as necessary.

**Optional**

- **Airside 2 and 4 PDS Substations (Common)**
  - Replace PDS substation door-locking mechanisms.
  - Enhance lighting levels within substations.

- **Airside 2 Generator**
  - Enhance lighting level inside generator enclosure.

- **Airside 4 Generator**
  - Enhance lighting levels within generator enclosure.
  (Note: not required if new generator is purchased.)
9.3 Stations

Immediate

- Continuous periodic inspections of the door panel supports/hangars for cracks, corrective action as necessary.
- No immediate steps necessary to continue operations.

Near-Term

- Procure additional spare door motors consistent with O&M provider recommendations to avoid long lead times.

9.4 Guideway

Immediate

- Cracks that are not extending to a full depth and up to 0.03” wide and cold joint lines between concrete should be filled using High Molecular Weight Methacrylate Sealer (HMWM).
- Cracks that are wider than 0.03” and not extending for a full depth to be opened to 1/8” wide then cleaned by mechanical means (wire brush/water) and sealed using high strength epoxy-based material.
- Minor concrete pits should be repaired using high strength epoxy-based patching mortar.
- A silane sealer should be applied to local repairs or to the entire horizontal concrete running surface after all repairs are completed; prior to application of the Silane, the running surface should be cleaned of all dirt and tire marks by mechanical means such as wire brush or pressure wash (2000-3000 PSI) the entire plinth.
- Perform abrasive blasting of locally rusted spots on the guiderail steel surface and apply inorganic zinc primer coat and an overall top coat of epoxy polyurethane. Repainting of guiderail to be performed according to GOAA-approved paint specifications.

Near-Term

- Install additional emergency walkway guideway cameras to meet TSA compliance.

9.5 Communications, SCADA and Train Control

Immediate

- No immediate steps necessary to continue operations.

Near-Term

No immediate steps necessary to continue operations. However, an increase in materials’ costs for spare parts is expected due to a higher rate of parts replacement, as well as slightly increased costs for parts which are no longer available as part of general supply.
### SUMMARY RECOMMENDATIONS

Below is a summary table of recommendations based on subsystem.

#### Table 10-1: Recommendations by Subsystems

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Criticality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicles</strong></td>
<td></td>
</tr>
<tr>
<td>1 HVAC Units</td>
<td>Immediate</td>
</tr>
<tr>
<td>2 Differentials (Airside 2)</td>
<td>Immediate</td>
</tr>
<tr>
<td>3 Door switches</td>
<td>Near-Term (12-18 months’ timeframe)</td>
</tr>
<tr>
<td>4 Pneumatic compressors</td>
<td>Near-Term (12-18 months’ timeframe)</td>
</tr>
<tr>
<td>5 Vehicle wraps</td>
<td>Optional</td>
</tr>
<tr>
<td><strong>Power Distribution System</strong></td>
<td></td>
</tr>
<tr>
<td>1 Airside 4 PDS – Install Blue Light Stations at Each Airside 4 Platform End / Entrance to Emergency Walkway</td>
<td>Immediate</td>
</tr>
<tr>
<td>2 Airside 4 Substation – Water Intrusion Inspection &amp; Mitigation</td>
<td>Immediate</td>
</tr>
<tr>
<td>3 Airside 2 Generator – Rust Inspection &amp; Mitigation</td>
<td>Immediate</td>
</tr>
<tr>
<td>4 Airside 2 Generator – Drawout Type Breaker and Spare Breaker (Refer to Note 1, below)</td>
<td>Immediate</td>
</tr>
<tr>
<td>5 Airside 2 Generator – Damaged PLC Replacement</td>
<td>Immediate</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Airside 4 Generator Replacement (Whole Unit)</td>
</tr>
<tr>
<td>7</td>
<td>Airside 4 Generator – Ground Fault Relay Spares <em>(Not necessary if new generators are purchased).</em> (Refer to Note 2, below)</td>
</tr>
<tr>
<td>8</td>
<td>Airside 4 Generator – Rust Inspection &amp; Mitigation <em>(Not necessary if new generators are purchased).</em> (Refer to Note 2, below)</td>
</tr>
<tr>
<td>9</td>
<td>Airside 4 Generator – Underground fuel tank replacement with new aboveground fuel tank <em>(Not necessary if new generators are purchased).</em> (Refer to Note 2, below)</td>
</tr>
<tr>
<td>10</td>
<td>Airside 4 Generator – Spare Breaker <em>(Not necessary if new generators are purchased).</em> (Refer to Note 2, below)</td>
</tr>
<tr>
<td>11</td>
<td>Airside 4 Generator – Complete inspection of generator to identify equipment requiring overhaul or replacement <em>(Not necessary if new generators are purchased).</em> (Refer to Note 2, below)</td>
</tr>
<tr>
<td>12</td>
<td>Airside 2 / 4 Substations – Breaker Inspection / Overhaul as Necessary</td>
</tr>
<tr>
<td>13</td>
<td>Airside 2 / 4 Substations – Inspect / Test Grounding &amp; Lightning Protection Systems</td>
</tr>
</tbody>
</table>
### Note:

1. Recommend full inspection of generator by supplier to identify appropriate spare breaker, PLC unit, and other parts requiring overhaul or replacement.
2. Recommend full inspection of generator to identify appropriate spare breaker, above-ground fuel tank, and other parts requiring overhaul or replacement.

#### Stations

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Criticality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Platform Screen Doors Spare Motors</td>
<td>Near-Term</td>
</tr>
</tbody>
</table>

#### Guideway

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Criticality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 HMWM Sealing of Small Cracks</td>
<td>Immediate</td>
</tr>
<tr>
<td>2 Cleaning / Epoxy Sealing of Large Cracks</td>
<td>Immediate</td>
</tr>
<tr>
<td>3 Repair of Concrete Pits w/ Mortar</td>
<td>Immediate</td>
</tr>
<tr>
<td>4 Apply Silane Sealer to Local Repairs</td>
<td>Immediate</td>
</tr>
</tbody>
</table>
### Abrasive Blasting / Guiderail Repainting
- Immediate

### Install Additional Emergency Walkway Cameras
- Near-Term

### Communications, SCADA and Train Control

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Criticality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 General Materials</td>
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</tbody>
</table>

### Power Distribution System (Part of E-192)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Criticality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Airside 2 Substation – Gateway Communication Link to Trip Units</td>
<td>Immediate</td>
</tr>
<tr>
<td>2 Airside 2 Substation – PDS Breaker Remote (External) Operation Capability</td>
<td>Immediate</td>
</tr>
<tr>
<td>3 Airside 4 Substation – Gateway Communication Link to Trip Units</td>
<td>Immediate</td>
</tr>
<tr>
<td>4 Airside 4 Substation – Install Blue Light Station</td>
<td>Immediate</td>
</tr>
<tr>
<td>5 Airside 2 / 4 Substation – Replace Eaton IQ Analyze Meters and BIMs with Eaton PWR XPERT Meter and Monitoring system</td>
<td>Immediate</td>
</tr>
<tr>
<td></td>
<td>Airside 2 / 4 Substation - Replacement of copper communication cabling to fiber at Comm Center. (Refer to Note 3, below)</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>

[Image 71x37 to 215x59]