ACI-HERZOG
Tren Urbano Project

Transit Asset Management Plan
2020

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Document Control List

Revision	Date	Description
0	January/2017	Initial Issuance
1	May/2020	Updates to plan and SOPs in accordance with the March 2018 *TAM Facility Performance Measure Reporting Guidebook* and the April 2017 *TAM Infrastructure Performance Measure Reporting Guidebook*.

List of Attachments

Attachment	Rev. No.	Subject
Appendix 1	1/2020	Asset Performance Targets (2019 NTD Narrative Report)
Appendix 2	0/2018 1/2020	Asset Condition Assessment Procedures: PM-01-02 - NTD Performance Restriction (Slow Zone Calculation) PM-01-03 - NTD Facilities Condition Assessment Calculation
Appendix 3	0/2017	Level of Service and Performance Measures
Appendix 4	1/2020	Project Prioritization List

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1.0 Introduction

1.1 Executive Summary

Tren Urbano is made up of multiple asset classes with unique maintenance requirements and varying lifespans. This Transit Asset Management Plan (TAMP) provides the underlying rationale for long-term management of those assets consistent with evolving federal requirements and industry best practices. The Plan discusses how ACI-Herzog (AHJV) will support the Puerto Rico Integrated Transit Authority (PRITA) and the Puerto Rico Highway and Transportation Authority (PRHTA) to catalogue, assess and replace assets based on a comprehensive life cycle maintenance approach. The plan includes sections on performance measures, decision support tools, investment prioritization, and potential future steps necessary to refine plan elements.

The mission of the Tren Urbano System is to provide safe, reliable and efficient transportation services that meet the needs of our customers. ACI-Herzog is committed to a comprehensive asset management program to ensure that assets are maintained in a state-of-good repair (SGR) to both serve that mission and to preserve the long-term value of infrastructure investments.

This plan is intended to be a living document based on current information and assumptions, and is therefore subject to recurrent revision. Tren Urbano's intent is to update this plan every four years and to use the Plan as an input into Tren Urbano's capital and operating budget process.

1.2 Background

On July 26, 2016, the Federal Transit Administration (FTA) published 49 CFR Parts 625 Transit Asset Management and 630 National Transit Database (Federal Register/Vol. 81, No. 143). The final rule established minimum requirements for transit asset management (TAM) and requires public transportation agencies to a) maintain an inventory of capital assets—including rolling stock, systems, infrastructure and facilities; b) document the condition of those assets; c) identify risks, including safety risks, associated with deferred maintenance; d) prioritize investments; e) establish Stage of Good Repair (SGR) performance measures and targets; and f) report targets and results to the National Transit Database (NTD).

> "Transit Asset Management (TAM) is a business model that uses the condition of assets to guide the optimal prioritization of funding at transit properties in order to keep our transit networks in a State of Good Repair (SGR)"
>
> Federal Transit Administration

As defined in the FTA's Asset Management Guide, the Transit Asset Management Plan (TAMP) incorporates processes, activities and the tools necessary to give an organization the ability to manage the efficient use of its transit assets. The TAMP outlines how people, processes and tools come together to address asset management policy and goals. The implementation of an asset management plan is a part of a dynamic process that has the capability to change and fine-tune to reflect the changes in the organization as well as the influence of external factors, such as changes in federal policies, fiscal and economic conditions, and the impact of force majeure events.

1.3 Purpose

The purpose of this plan is to describe the major elements of asset management and outline how AHJV will support PRITA's and PRHTA's asset management process as Operations and Maintenance (O&M) contractor. In this context, the TAMP describes the framework and processes AHJV intends to employ in the delivery of asset management related services for the Tren Urbano system assets. AHJV will play a primary role in the asset inventory, condition assessment and maintenance elements of the asset management process. Our intent is to serve in a supporting capacity to PRITA and PRHTA for other plan and process elements, since they are primarily driven by policy and financial considerations.

We will also actively participate in and support plan and process updates as required by the FTA and illustrated in Figure 1.

Figure 1. FTA Asset Management Requirements

1.4 Plan Objectives

AHJV is responsible for maintaining Tren Urbano assets in order to deliver reliable, safe and efficient public transportation services. To accomplish this, AHJV employs a skilled and experienced workforce. Our management philosophy is based on a detailed understanding of the assets as integrated systems and as individual elements maintained to reduce the probability of failures and service disruptions, maximize availability and keep the infrastructure in a state-of-good repair.

> State of Good Repair: The condition in which a capital asset is ab le to operate at a full level of performance. This means the asset is 1) able to perform its designed function, 2) does not pose a known unacceptable safety risk, and 3) its lifecycle investments have been met or recovered.
>
> Final Rule: National Transit Asset Management System

This plan was developed using FTA MAP-21/FAST Act documentation, industry standards and best practice recommendations along with the O&M contractor's own project experience. The plan will be revised based on changes to the PRITA and PRHTA asset management strategy; significant and unexpected changes in the asset inventory, condition assessment or investment prioritization and process, and changes in FTA regulations.

Tren Urbano asset management efforts will be implemented in accordance with all local and federal transit laws and regulations, procedures and inspections and licensing/certification requirements.

2.0 Organization Structure and TAM Resources

A functional organizational structure has been designed for the completion of all ACI-Herzog Operations and Maintenance activities including TAM responsibilities. Figure 2 below illustrates the O&M organizational structure.

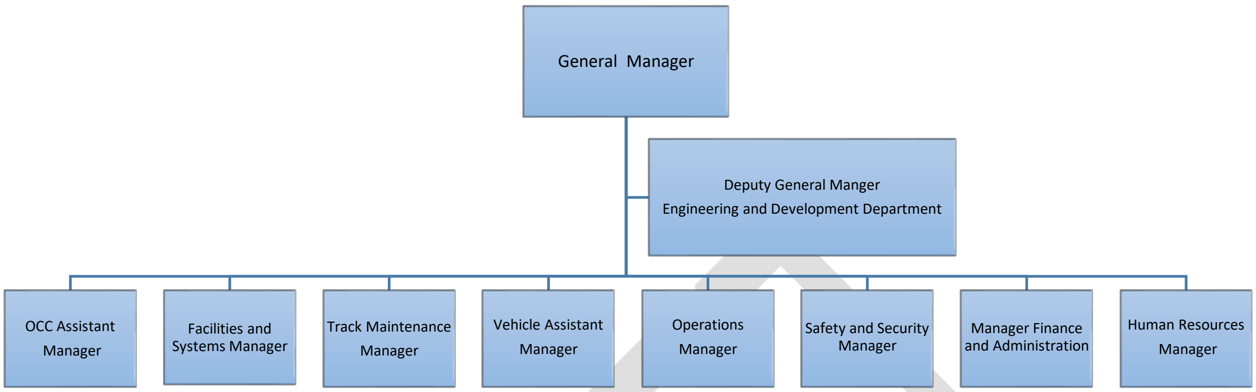

Figure 2. ACI-Herzog Organization Structure

The General Manager has overall authority and responsibility for all aspects of Operations and Maintenance including TAM responsibilities, and serves as the ACI-Herzog's primary contact for the Authority's Accountable Executive. It is the responsibility of the General Manager to ensure that the overall system and operational goals of the Tren Urbano System are being met by the organization, and that the Tren Urbano staff is confident that resources are being deployed in an intelligent, cost-effective manner.

The main organization staffing resources with TAM responsibility are as follows:

- **Deputy General Manager:** Secondary point of contact for the Authority's Accountable Executive and responsible of planning and implementation of all TAM O&M functions including Risk Management, Engineering Support, Quality Assurance and Quality Control, Management Information Systems and Performance Management.

- **Assistant Manager of Engineering and Development**: Responsible for developing, updating and deploying all performance management functions and TAM related activities including the asset condition assessment as well as the development, implementation, monitoring and reporting of other key performance indicators.

- **Maintenance Managers/Assistant Managers**: Responsible for execution and update of maintenance functions and activities including but not limited to the development, implementation and execution of maintenance plans. These individuals will oversee the overall operations and maintenance of the Tren Urbano System with the primary purpose of maintaining assets to provide a safe and reliable service to the public and in a state of good repair.

3.0 Assets Description

3.1 General System Description

The Tren Urbano (TU) system is the centerpiece of a multi-modal master plan for enhancing mobility in the San Juan Metropolitan Area (SJMA), developed by the Puerto Rico Department of Transportation and Public Works (DTOP) and its Integrated Transit Authority (PRITA) and Highway and Transportation Authority (PRHTA).

The Tren Urbano system connects the populous municipality of Bayamón with the Hato Rey district of San Juan, passing through the municipality of Guaynabo and the southern district of San Juan known as Rio Piedras. It serves major medical centers, state first instance courts, university campuses, entertainment venues, the financial district and multiple residential neighborhoods. Figure 3.1 provides an illustration of the Tren Urbano alignment.

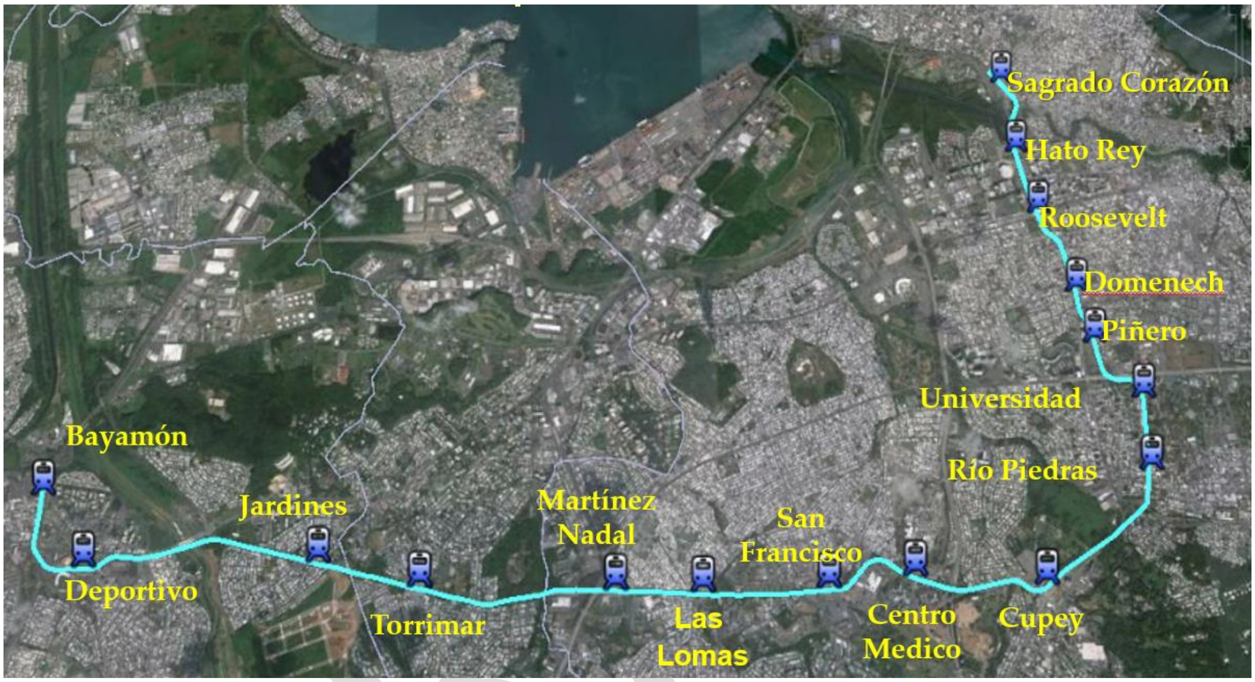

Figure 3.1 Tren Urbano Transit System

The Tren Urbano alignment is 17.2 kilometers end to end and has 16 stations and a centrally located storage and maintenance yard which also houses a 15,000 square meters administrative office and operations center. The alignment is roughly evenly split between at-grade and elevated, with a short section below grade in a retained cut trench and a tunnel section through most of the heavily congested district of Rio Piedras.

Train service includes 166 trips per weekday and 138 on the weekend utilizing 74 Siemens heavy rail transit vehicles. Tren Urbano averages 35,000 passengers a day or a little over 10 million passengers a year. The system operates 18 hours per day, opening at 5:30 AM and closing approximately at 11:30 PM. Train headways vary from 8 minutes in the peak hours to 16 minutes in the off-peak during weekdays. Train headways during weekends and holidays are 16 minutes all day. There are 14 weeks of low ridership throughout the year when weekday trips are served with a reduced schedule providing 152 trips. This seasonal schedule coincides with summer, winter and Easter. Train headways for these weeks vary from 12 minutes in the peak hours to 16 minutes in the off peaks. Extended services are performed on an average of 52 days per year from 11:30 PM up to 3:00 AM.

3.2 Tren Urbano System Assets Description

The FTA TAM Regulation establishes State of Good Repair (SGR) performance measures to be reported to the NTD. Assessment processes and protocols have been clearly defined and implemented. Figure 3.2 provides an illustration of the TU asset hierarchy used in the TAMP for grouping broad asset categories with similar characteristics. Assets are organized in four (4) broad asset categories and asset groups (referred as classes in the TAM Rule). In order to comply with and to facilitate NTD reporting requirements, ACI-Herzog has reconfigured the asset groups and assessment levels in its asset management software tool.

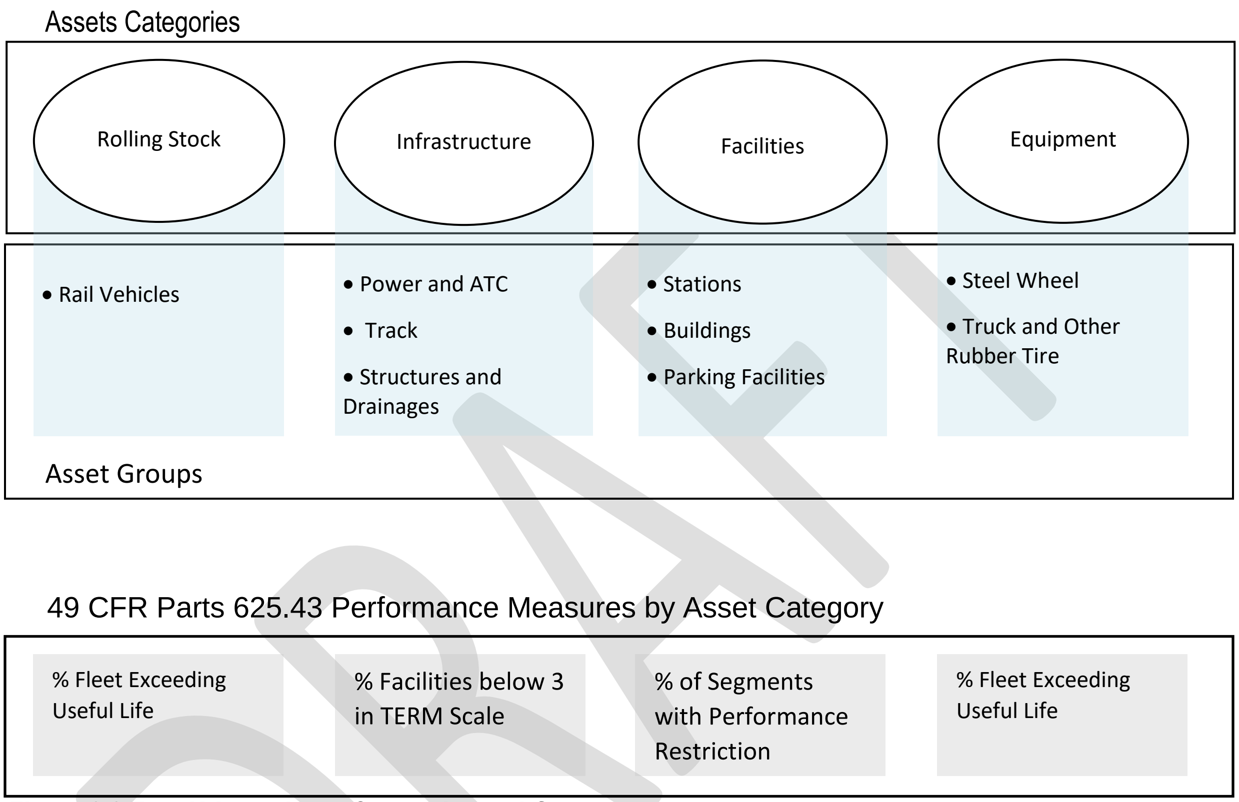

Figure 3.2 Tren Urbano Asset Categories and Groups

3.3 Description of Rolling Stock Assets

Tren Urbano's fleet consists of 74 heavy rail vehicles manufactured by Siemens Transportation Systems. The vehicles are semi-permanently coupled into married pairs with an operating cab at each end, providing 37 operating units (married pairs) for service. Trains may consist of one, two or three married pairs. Each married pair shares a number of components with its partner. As a result, individual "halves" of the pair cannot be operated as single units.

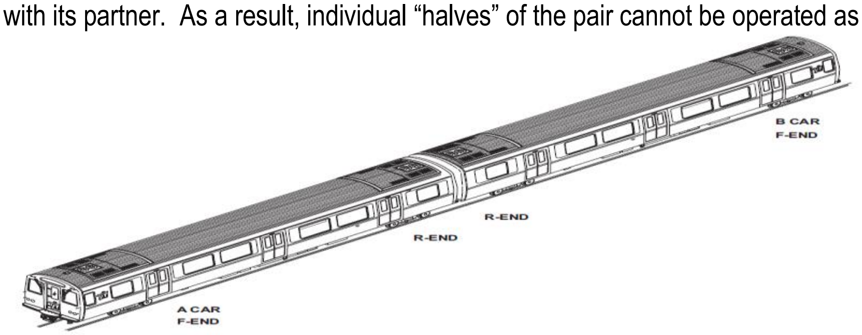

Figure 3.3 Tren Urbano Heavy Rail Vehicle

The vehicles are steel wheel, electrically propelled multiple units of typical heavy rail design. They have a maximum speed of 100 kilometers per hour and can negotiate gradients of up to 6%. The minimum curve radius is 80 meters in the yard and 150 meters on the mainline.

The vehicles offer 72 seats each, have a maximum design capacity of 180 passengers, and run in married pairs. The current train makeup for normal operations is two married pairs (four vehicles) on weekdays until 7:00 P.M. and a single married pair (two vehicles) at all other times. The vehicles are air-conditioned, have large windows to enhance the view for the passengers, and have three wide doors per side to facilitate rapid passenger boarding and alighting.

The suspension system features an air controlled secondary suspension to provide a comfortable ride and allow for train height control for level boarding at the station platforms. The vehicles and the stations meet the requirements of the Americans with Disabilities Act. The vehicles are propelled by three-phase AC induction motors, controlled by microprocessor-based solid-state control units. Power is supplied from a third rail carrying 750 volts DC current, and the running rails serve to provide its return path.

In normal operations, trains run under automatic control. An on-board computer, with knowledge of the location of its train, and of the desired performance at each location, issues commands to the propulsion and braking systems to control vehicle acceleration, cruise and deceleration. The on-board computer receives a continuous command from the wayside, via a special antenna running the length of the alignment, allowing the vehicle to continue its progress. The wayside also provides the vehicle with periodic updates of its exact location along the alignment; in between these update locations the vehicle determines its position via counting the wheel revolutions.

3.4 Description of Infrastructure Assets

Power Systems

The power distribution and traction power system consist of five (5) AC bulk power station substations (BPSS), ten (10) traction power substations (TPSS), six (6) station power substations (SPS), a traction power substation at the yard and shops and a power substation at the yard. The system feeds a total of 40 power mainline sections and 6 power yard sections. A layout diagram, including mainline components of the Tren Urbano power distribution and traction system, is included for reference in the Systems Maintenance Plan.

Each of the five (5) Bulk Power Substations (BPSS) is fed at each location by a 38-kV connection to the Puerto Rico Electric Power Authority (PREPA). Within the BPSS the voltage is reduced to 13.2kV and distributed via AC breakers and AC cables to TPSS and SPSS sites. For enhanced reliability, each TPSS and SPSS has two incoming 13.2kV cables from different BPSS. Within the TPSS the AC power is transformed to 590V and rectified to provide 750 VDC.

Each TPSS consists of eight 13.8KV breakers in the AC switchgear lineup, two transformers, two rectifiers, two cathode breakers, four DC feeder breakers, two station power transformers and a 480V low voltage switchgear lineup. Each traction power substation is fed from two separate BPSS along the right of way. The 750VDC power is distributed to the third rails at each TPSS via four (4) DC breakers and DC cables. For reliability reasons, each power section along the right-of-way is fed by two TPSS, except the end of the line section, which has emergency power crossties inbound and outbound. Traction power is delivered to the vehicles via a third rail system.

Each substation is designed to operate unattended with provisions for manual override and manual operations. The electrical equipment in the BPSS, TPSS and SPSS are tied into a supervisory control and data acquisition (SCADA) system that is wired to the operations control center (OCC), so the equipment can be remotely operated and send data on the stations' status. Figure 2.4 provides a conceptual illustration of the SCADA configuration for power distribution control.

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Figure 3.4 SCADA Power Distribution Control Network

Emergency Trip Stations (ETS) are provided for use during emergencies. The function of the emergency trip system is to allow authorized personnel to disconnect power to a selected section or sections of the third rail. Emergency Trip Stations are located at the end of each station platform, beyond public access areas, at tunnel cross-passages in the underground section, at emergency access locations along the guideway, at all motor operated switch (MOS) locations and in the station control booths. Activating an ETS de-energizes traction power to the associated third rail section by tripping the DC feeder breakers at both ends of the section. Activating any mainline ETS also causes the associated Wayside Control Unit (WCU) to immediately remove running authorization from any train within the section by initiating an emergency brake command. All individual ETS activities are identified and reported to the OCC.

ATC Systems

The purpose of the Automatic Train Control (ATC) system is to control, direct and coordinate all functional operations of the automated Tren Urbano trains. The system consists of equipment installed along the wayside, at the operations control facility, and on-board the trains. The system is subdivided into 14 ATC mainline sections and a yard section. A layout diagram, including main components of the Tren Urbano power distribution and traction system, is included for reference in the Systems Maintenance Plan.

The ATC system is responsible for three primary functions operating with information transmitted by the wayside control unit (WCU) or wayside beacons and processed with microprocessor-based vehicle on-board control units (OBCU).

The Automatic Train Protection (ATP) function processes vital variants and enforces safe and reliable train operations through train detection, interlocking, and speed limit enforcement. Information necessary to maintain safe operating parameters is processed by the WCU and transmitted to the OBCU through wayside loops that run parallel to the tracks (B1 Loop Continuous Transmission). Vehicle-mounted receiver coils inductively couple the information to the OBCU system. The OBCU processes the information and sets safe operating speeds as necessary to safely operate the vehicle. The vital oversight system continuously receives information related to on-board and wayside variables and uses the information to recalculate continuously safe operating parameters. Any train, operating in ATP modes of operation, and detected to be in violation of safe operating requirements is immediately issued an emergency braking command.

The Automatic Train Operation (ATO) function regulates service performance and vehicle operation, within ATP safety limits, with a high level of efficiency including on-train functions of speed regulation, platform berth, and other functions traditionally assigned to the train operator. For example, the ATO system allows for the smooth dynamic control of the train in response to requirements for service schedule management.

The Automatic Train Supervision (ATS) system allows the Operations Control Center (OCC) to view the real time operating conditions of the wayside system and individual consists inclusive of vehicle identification information, train routing, train location, and operating status. The ATS system operates on a schedule developed by the OCC ATS scheduling system. In normal operation, routes will be aligned to accommodate the required operation without the intervention from the Operations Control Center. ATS will automatically, or when required, respond to manual inputs to control routing, modify dwell times, restrict normal speed, modify schedule adherence and order train holds at platforms. Train operation performance is monitored against the schedule and recorded by the OCC ATS software.

Wayside equipment includes components of the system situated along the right-of-way as needed to communicate information to the on-board control systems. These operations include automatic speed regulation, train berthing, vehicle door status monitoring, automatic route selection, automatic train protection, wayside to train communications and train to wayside communications. Figure 2.5 provides an illustration of the WCU interaction with ATC wayside components.

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Figure 3.5 ATC Wayside Components

There are eight (8) Wayside Control Unit (WCU) locations;…Sensitive Security Information – Not available for the public. The WCU microprocessor systems control the vital logic required to operate the wayside systems and the vehicle OBCU. The WCU is utilized to:

- Control train OBCU operations, including safe braking and interlocking operational status
- Determine train position based on track circuit occupancy
- Accept all train control requests from the OCC and process all the information to and from the required vehicle and wayside elements (this includes interfacing of track circuits, B1 Loops, PTI Loops, beacons, switch machines and signals)
- Perform self-diagnostics and maintenance support for system components.

Wayside signals are provided as a visual reference for the train operator to determine current operating conditions. In automatic mode, they serve only as a reference since all commands are controlled systemically. However, during restricted manual mode (RMM) or OBCU bypass operations, the wayside signals function as the primary means for assuring interlocking status. Therefore, the interlocking signal display helps the OCC provide safe train blocking operations during adverse conditions (e.g., On-Board Control Unit failure).

The Yard Control System (YCS) allows controlled train movements in and out of the yard interlocking system. Trains are limited to 25 KPH by the on-board ATP system in Restricted Manual (RMM).

Track

The Tren Urbano corridor consists of a 17.2 km double track heavy rail mainline for metro-type rail vehicles, connecting 16 stations distributed among three municipalities in the San Juan metropolitan area. Approximately, fifty-two percent (52%) of the alignment is on elevated structure, while another forty percent (40%) is at-grade. The underground segment through Río Piedras makes up the remaining eight percent (8%) of the alignment. The track is subdivided into 11 inspection sections composed of two bi-directional tracks and a rail yard.

The track system consists of two classes of track; the mainline track inclusive of tracks carrying revenue passengers and yard and secondary track for the purpose of storage, maintenance, or non-revenue switching of transit vehicles. Track work for these two classes of track is further classified into four basic types including:

- Ballasted Track
- Direct-Fixation Track
- Slab Track

- Embedded or Shop Track

For maintenance purposes, the track system components have been grouped into the following areas: rail, track structure, roadbed, special track work, track work appurtenances and contact rail. The track structure is composed of elements such as rail crossties, wood and concrete, direct fixation fastener support components (plinths) and the fasteners (including plates, tie bolts and clips). The roadbed consists of the ballast, sub-ballast and the observable supporting earthwork. Special track work includes elements such as switches, frogs, crossing diamonds, switch crossties (concrete and wood), restraining rails and emergency guardrails. Track work appurtenances include joints (regular and insulated), bumping posts, switch stands, derailing equipment, crosswalks and vehicular crossings. The contact rail sub-system consists of the contact rail, the support insulators, anchorages and cover boards. The contact rail includes the contact rail, end approaches, splice joints, support and insulator pedestals, cover boards and anchor assemblies.

Structures and Drainages

The Structure and Drainage system consists of bridges, platforms, tunnels, retaining walls, security walls and fences, site drainage, structure drainage, and culverts divided into 16 mainline sections and 1 maintenance facility section. A bridge is any structure that supports the track and spans a distance of 6.10 meters (20 feet) or greater. Therefore, the guideway structure is composed of more than three hundred post-tensioned segmental concrete box spans or bridges. A number of consultants prepared the design and several different contractors performed the construction of these structures. As a result, while the designs are similar, there are differences in the methods of erection and the post-tensioning techniques and workmanship.

The bridges discussed in this Plan are all segmental concrete bridges, except for two structures on the Systems and Test Track Turnkey Line Section 3 (…Sensitive Security Information – Not available for the public). A typical segmental concrete superstructure is comprised of precast elements post-tensioned longitudinally by tendons provided in the deck slab and at support diaphragms. Typical piers consist of single or multiple reinforced concrete columns, some connected with reinforced concrete pier caps. The project also includes C-bent type piers and straddle piers.

Bridge components are separated into three broad groups. The substructure consists of abutments, piers, and foundations. The bearings represent the dividing line between the substructure and the superstructure. The superstructure consists of the bearings and everything supported by the bearings (except stations and track). Some of the major superstructure components are bearings, beams, the deck, and parapet walls. Pier protection consists of any device intended to protect the bridge from a vehicle or marine impact.

A tunnel is the underground structure through which the track passes between stations. Stations are not considered part of the tunnel and have other operation and maintenance requirements. The Río Piedras Tunnel includes a 1.77 km (1.1-mile) subway segment built with a combination of bored tunnel, cut-and-cover construction, Hand Mined: New Austrian Tunneling Method (NATM) and stacked drift construction.

A platform is the structure adjacent to the track located on a bridge, which supports passengers embarking, disembarking or waiting for a train. Platforms are part of the superstructure. However inspected elements are grouped in roof (slab, beams, and truss), columns, walls, floors (paving stones and joints), benches, signs, track drainage, fences, and other findings.

A retaining structure is any retaining wall or crib wall, which is not specifically part of a bridge or tunnel, designed to retain earth. Concrete cast-in-place retaining walls and crib-walls constructed of pre-cast components exist at numerous locations along the at-grade portion of the alignment.

Pre-cast concrete panels placed between soldier piles and chain link fencing provides security along the at-grade portions of the alignment. They are essential to protect the public from the dangers inherent in the operation of Tren Urbano, and to avoid delays in service.

Drainage consists of track-side ditches, catch basins, and culverts located along the at-grade portion of the alignment, and scuppers on some elevated structures. The storm drainage system collects surface storm water runoff and runoff conveyed from the aerial structure portions of the Tren Urbano corridor. The system then conveys this storm water runoff to discharge points, which carry it away from the Tren Urbano corridor. The ability of the site storm drainage system to convey significant storm flows is a requirement for the proper and continued operation of Tren Urbano.

3.5 Description of Facilities Assets

3.5.1 Stations

The main intention of the architectural design of the stations is to respond to its urban context, making all sixteen stations different in design while sharing common system wide elements and aesthetics. The design and construction projects were performed by several different contractors. As a result, there are also differences in the methods of construction and workmanship. While the main purpose of the train stations is passenger entry and exit to the train system, they also have public spaces, public art, and concession areas for visitors and riders to enjoy. Table 3.1 below provides a general description of the design configuration observed on the Tren Urbano stations.

Station	Station Configuration	Platform Configuration	Parking Spaces	Bus stop Canopies	Bus Transfers	Concessions	Platform Benches	Station's Benches	Stairs	Emergency Stairs
BA	Elevated	Central	480	X	X	5	8	48	3	0
DE	Elevated	Split	2500*	X		2	5	7	2	2
JA	At grade	Central	128	X		0	24	28	2	1
TO	At grade	Split	58	X		1	12	20	4	0
MN	At grade	Central	1007	X	X	3	5	37	1	1
LL	Elevated	Split				2	6	11	2	2
SF	Elevated	Central	519	X	X	5	4	16	2	2
CM	At grade	Central		X	X	1	6	24	2	1
CU	Elevated	Split	314		X	2	6	8	5	2
RP	Underground	Central				1	4	4	6	5
UP	Underground	Central				0	3	3	5	4
PI	Elevated	Split		X	X	0	6	10	2	2
DO	Elevated	Split				1	8	8	2	2
RO	Elevated	Split				2	10	15	4	2
HR	Elevated	Central		X		1	6	8	4	0
SC	Elevated	Central	413*	X	X	4	6	17	4	0

*Not owned by PRHTA

Table 3.1 Design Configuration of Tren Urbano Stations

Stations include mechanical and electrical equipment conveyance (e.g. escalators and elevators), plumbing, air conditioning and ventilation, fire protection, low power electrical and distribution, automatic fare collection equipment, safety, security and communications equipment to meet applicable construction codes, state and federal regulations. Table 3.2 below provides an overview of relevant stations equipment.

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Table 3.2 Tren Urbano Stations Equipment Overview

3.5.2 O&A Building

The Operation & Administration building (O&A) is located at the 24 Road 21, Guaynabo on an 18-acre site. The O&A building provides headquarters for Tren Urbano operations, maintenance and administration, providing offices for AHJV and oversight government personnel.

Within the O&A Building, the Operations Control Center (OCC) provides systems integration between train and station operations. The OCC allows operations personnel to control and oversight the following functions:

- Train Operations
- Yard Operations
- Station Operations
- Security Response and Coordination
- Emergency Response and Coordination
- Power System Management

The OCC systems equipment includes:

- A mainline control system to provide train control and Supervisory Control (ATS)
- Data acquisition (SCADA) controls as well as status indications, reports, and alarms.
- Yard control (integral part of the mainline control system) to provide signaling and SCADA controls, status indications, reports, and alarms.
- A Computer Based Dispatching System (CBDS) to instantly establish radio connections to train operators, yard staff, security personnel, police, etc.

The O&A Building is designed to accommodate vehicle storage, inspection and maintenance of 74 vehicles. The overall yard and shop configuration is illustrated in Figure 3.6 below.

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Figure 3.6 O&A Building Yard and Shop

The O&A Building yard consists of seven (7) layover tracks and a running track used for vehicle movement, inspection and testing purposes. The yard is sub-divided in six powered 750VDC sections.

The vehicle maintenance shop is composed of four maintenance tracks and one wash track. Track one (T-1) contains a service and inspection pit with capacity to hold two married pairs. This track is where most of vehicle preventive maintenance is performed. This pit has been equipped with an overhead crane that, along with a portable work platform, provides access for air conditioning maintenance. Track two (T-2) contains a second service and inspection pit with capacity to hold two additional married pairs and is often used for corrective maintenance. Track three (T-3) makes provision for wheel truing equipment and an additional pit for under-floor work. This track also contains portable lift jacks with capacity to lift a single car body. An Overhead Crane provision shared with track four (T-4) allows this area to be used for air conditioning maintenance. Track 4 (T-4) is used for heavy maintenance offering 2 independent Lifting Lines; each Lifting Line has the capacity to manage one married pair. At the building's far end, a wash track makes provision for interior and exterior cleaning and contains an automatic car wash system.

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Table 3.3 Vehicle Maintenance Shop Track Allocation

3.5.3 MOW Building

The Maintenance of Way Building (MOW) is a detached building within the O&A Building premises to support maintenance of track systems and equipment, and for the maintenance of non-revenue vehicles. The MOW building has an additional track for hi-rail vehicles to enter the right-of-way of the Tren Urbano alignment. It also contains cranes, administrative offices and storage area to for track maintenance material.

3.6 Description of Equipment Assets

Tren Urbano has non-revenue service equipment to support maintenance of way (MOW). The equipment includes hi-rail vehicles, trucks, platforms and general heavy equipment used for track and facilities maintenance.

4.0 Condition Assessment

AHJV performs routine assessments of the four asset categories as specified by 49 CFR Part 625.43 (TAM Rule) and National Transit Database guidelines. These condition assessment processes provides valuable insight to the needs each asset category. The results of annual assessments are instrumental in the planning of maintenance efforts and capital improvements. A summary of the TAM Rule assessment approach is included in Table 4.1 and further described in sections below.

Asset Category	Approach	Performance Measure	Frequency
Rolling Stock	Useful Life	% Fleet Exceeding Useful Life	Annually
Infrastructure	Performance	% Facilities below 3 in TERM Scale	Annually
Facilities	Condition	% of Segments with Performance Restriction	Every 4 years
Equipment	Useful Life	% Fleet Exceeding Useful Life	Annually

Table 4.1 Condition Assessment Approach

Useful Life Approach

A key element for consideration in the establishment of asset condition is the current age and life expectancy of the asset. This approach relies on the assumption that most assets provide good service for a predictable period of time after which they should be replaced. Although assets may continue to function safely and effectively at ages beyond this point, it is assumed that failure to replace assets at the end of this period of useful life leads to decreased performance, increased risk of in-service failure, and higher maintenance costs.

The TAM Rule establishes Useful Life Benchmark (ULB) as the SGR performance measure for Rolling Stock and Equipment asset categories. ACI-Herzog has adopted the FTA default ULBs for Rolling Stock and Equipment; 31 years for Heavy Rail Passenger Cars, 25 years for steel wheel vehicles and 14 years for trucks and other rubber vehicles (ref. *NTD 2019 Policy Manual*) performance measures. For the purposes of the NTD, useful life is calculated by deducting the ULB from the year of manufacture for each vehicle.

Performance Based Approach

Another important element for consideration in rating asset condition is asset performance. The performance approach is based on a regular, comprehensive assessment of the asset's performance and relies upon the assumption that as assets age, they become less durable and reliable, resulting in decreased operational performance.

The TAM Rule establishes percentage of rail segments with "performance restrictions" as the SGR performance measure for Infrastructure asset categories. FTA's definition of performance restriction is "*When the maximum speed of vehicles on a fixed guideway segment is below the segment's full service speed*".[1] The calculation of the performance metric is performed through an evaluation and validation of applicable speed restrictions and other performance restrictions (i.e. single track operation) in effect (as recorded by the Automatic Train Supervision system) in any of the 53 Temporary Speed Restriction (TSR) track segments. The metric is monitored on a monthly basis at 9:00 AM local time on the first Wednesday of the month, in conformance with the FTA TAM Infrastructure Performance Measure Reporting Guidebook: Performance Restriction (Slow Zone) Calculation (April 2017). A detailed procedure for the calculation of this performance measure is included in Appendix 1. (Asset Performance Targets (2019 NTD Narrative Report))

Condition Approach

The condition approach is also a useful method used to determine asset condition ratings. This approach is based on periodic condition assessments of assets using a set of standardized procedures and criteria. The TAM rule establishes the percentage of facilities rated below condition 3 on the Transit Economic Requirements Model (TERM) scale as the SGR performance measure for Facilities asset categories. Facilities distributed in primary, secondary and tertiary levels

A detailed procedure to perform the asset assessment activities is included in Appendix 2. (Asset Condition Assessment Procedures: PM-01-02 & PM-01-03) Consistent with TAM Rule support references, Tren Urbano defines State of Good Repair (SGR) as a measured description of the state of an asset that observes a weighted average rating scale of 5 (excellent), 4 (good), 3 (adequate), 2 (marginal) through 1 (poor) based on a predetermined assessment scale, in conformance with the FTA Facility Performance Measure Reporting Guidebook: Condition Assessment Calculation (version 1.2 March 2018).

5.0 Approach to Asset Management

Asset Management involves common activities over the life of a transit system; assets are acquired, utilized, maintained, renewed and replaced. Within each individual asset's lifecycle, subsystems and equipment similarly undergo the same cycle process at different rates; requiring overhaul, updates, retrofit and or replacement throughout the life of the asset. Different life expectancies and update needs for each individual asset, timely identification of requirements or needs for each activity and interdependencies between individual assets are some of the challenges the TAMP is geared to address.

The following section describes the practices and processes used to meet TAM objectives; otherwise known as management system. ACI-Herzog is primarily responsible for the operation and maintenance (O&M) activities of Tren Urbano assets. As O&M contractor ACI-Herzog also plays a supporting role for other lifecycle management activities.

5.1 Operations Management

ACI-Herzog is responsible for Operations Management activities incurred in the utilization of the Tren Urbano assets. In transit services, Operations Management addresses the design, implementation, coordination, execution and control of how assets are utilized to achieve the expected level of service. This process is an important added element of Asset Management, as maintenance alone does not necessarily achieve a safe, reliable and efficient transportation

[1] Reference: FTA TAM "*Condition Assessment & Guideway Peformance Restriction Guidebooks*", July/August 2016

service and preserve long-term value of the investment. Good operations not only prevent abnormal events but can also compensate for the impact of equipment failures. Well managed operations also provide the “eyes on the ground” factor that maintenance requires to stay effective and efficient.

As O&M Contractor for Tren Urbano, one of ACI-Herzog’s primary roles is operational planning and control. Development of operation personnel schedules, daily logistics in the provision of transit services, effective and efficient execution of the operating roles are included as part of this process. The Operations Plan, Operating Rule Book and Revenue Delivery Plans provide a detailed description of operational planning and control functions.

Tactical decisions in the implementation of resources to meet operation requirements and goals are also part of the primary operations role for ACI-Herzog. Common functions related to this process include intermediate-term planning, adjustments and improvement of operation processes, coordination of events and other adjustments required over time, as well as interaction with external agencies. The Revenue Service Delivery Plan provides a description of the resources and processes associated with Tren Urbano operations.

ACI-Herzog also plays a supporting role in Operations Management strategic functions, mostly related with the provision of information. Monitoring of key performance indicators (KPI), analysis of system capacity versus demand and issuance of recommendations for growth or operation adjustments are some of the common responsibilities performed.

5.2 Maintenance Management

Maintenance management is a mission-critical activity that is central to the success of Tren Urbano. ACI-Herzog utilizes a combination of maintenance strategies to balance safe operation, preservation of the asset and cost including corrective, preventive and condition maintenance.

- Corrective Maintenance (CM) - Maintenance is carried out following detection of an anomaly and aimed at restoring normal operating conditions. This approach is typically assigned where failures do not compromise safety or where the costs sustained for downtime and repair in case of fault are lower than the investment required for a routine maintenance program.
- Preventive Maintenance (PM) – Maintenance is carried out at predetermined intervals or as part of a specific program or project, aimed at reducing the failure risk or performance degradation of the equipment. The maintenance cycles are planned according to the need to take the device out of service.
- Condition-based Maintenance (CBM) - Maintenance based on the monitoring of equipment symptoms and wear through a number of tools and techniques. Follow up actions are carried out as wear indicators give signal that the equipment is deteriorating, and the failure probability is increasing.

Overhauls, design modifications, upgrades and subsystem replacement system-wide are considered Capital Projects. As a lifecycle stage requiring Capital Project approaches with the potential to affect the operations and maintenance management functions (e.g. spares or support availability), ACI-Herzog’s role is one of risk management.

Maintenance of Rolling Stock Assets

The maintenance regimen applied to the Tren Urbano fleet is described in detail in the Vehicle Maintenance Plan. Key elements of the approach to maintenance include a hierarchical periodic maintenance program, a class based cleaning program, running repairs and corrective maintenance, programmed component replacements and rebuilds. The maintenance program is built around two defining elements:

- Preventive maintenance and inspection focused on maximizing reliability.
- LCM resulting in continuous fleet renewal. Vehicles are scheduled for maintenance at times and in quantities that maintain service requirements and evenly distribute manpower and shop resources, eliminating bottlenecks and optimizing efficiency. The program includes mid-life overhauls and system/component replacement activities until vehicle end-of-life.

The Vehicle Maintenance Plan incorporates original equipment manufacturer (OEM), O&M experience and PRITA and PRHTA maintenance requirements, cleaning standards, and historical data. The Tren Urbano LCM requires routine service and inspection intervals based on a recurring 7,500 km cycle, or 90 days, whichever comes first and additional heavy maintenance tasks introduced at reoccurring 90,000 km intervals. Currently the fleet is undergoing the 720,000 km Heavy PM program.

The maintenance approach is revised based on conditions observed during vehicle maintenance and asset performance history, allowing for adjustments in maintenance frequencies or rehabilitation activities as necessary to ensure safety and meet equipment performance requirements. This could mean increasing or decreasing frequencies or activities.

To facilitate building and maintaining an accurate LCM all maintenance actions are recorded in Trapeze to support asset management responsibilities, warranty tracking, reporting and trend analysis. For each maintenance interval, procedures and checklists are utilized to ensure consistency and completeness.

Maintenance of Facility Assets

The Fixed Facilities Plan serves as the cornerstone for maintenance of Tren Urbano stations and buildings. Maintenance activities adhere to strict preventive maintenance cycles, inspection and assessment results, OEM recommendations and performance.

All facilities, equipment and stations are inspected regularly and incorporate elements from both operations and maintenance personnel. Results are used to develop and prioritize work plans. Maintenance tasks and schedules are clearly defined with the goal of maximizing the life expectancy of Tren Urbano fixed facilities. Maintenance procedures are based on a combination of industry accepted practices and manufacturer's published instructions compiled in a Master Manual and revised based on manufacturer updates or actual experience. The Fixed Facilities plan includes a complete Fixed Facilities Asset List, outlining the equipment asset details (description, type, manufacturer, model ID, serial number), its location, equipment status, and frequency of inspection.

Routine maintenance tasks are scheduled on a progressive time basis (weekly, monthly, semiannually, annually, etc.) depending on the facility subdivision or equipment. Schedules are monitored through the maintenance management software. Corrective maintenance consists of troubleshooting, repairing an asset, and returning it to service.

Plans and programs have been developed for rehabilitation and reconditioning of facilities, equipment and stations based primarily on subsystem renewal at prescribed intervals, thus avoiding disruptive larger scale replacement programs. Subsystem examples include roof elements, air conditioning units, elevators and escalators, pumps, rolling doors and fire suppression units. Some of these elements have reached their life expectancy in certain cases, such as roofing treatments, while others will require more detailed plans for periodic replacement of asset group elements such as escalators and elevators.

An important dimension of the facilities maintenance approach is addressing obsolescence proactively through innovative, cost effective and technically viable solutions. Obsolescence is a major issue for some facilities equipment, where serial point-to-point communication links, proprietary software modules and a lack of operating system upgrades have resulted in out-of-date dependent application software architectures and limited security upgrades. In general, obsolete systems hardware suffers, in various degrees, from unavailability of spares and lack of support from original equipment manufacturers (OEM).

To address obsolescence two federal grants totaling $21.4 million have been obtained to upgrade the automatic fare collection and OCC/Communications systems. These types of efforts will be continued in the future to address the necessary system upgrades and replacements that will provide the highest level of sustained system operability and minimize impacts to operations.

Back to back Force Majeure weather events also caused severe damage and deterioration on facilities and their equipment. Multiple grants exceeding $25 million have been awarded to repair damages, with additional grants funds pending evaluation and approval.

Maintenance of Infrastructure Assets

Maintenance of Tren Urbano structures and the Track system is achieved through preventive maintenance and is informed by regular inspections, geometry car runs and ultrasonic testing. Most components have considerable remaining life expectancy, so maintenance activities are primarily driven by preventive measures along with spot maintenance/repairs/replacement of components including frogs, ties, OTM, turnouts, bridges and other drainage related facilities. Rail grinding is also performed at prescribed intervals and rail replacement is scheduled for replacement at prescribed intervals. Repair efforts follow a strict coordination and prioritization process compliant with industry standards.

Maintenance activities follow industry best practices outlined in the Track Maintenance, and Structure and Drainage Plans. These plans establish maintenance tasks and schedules executed via work orders.

A rigorous process has been established to authorize any work on the right-of-way (ROW) through the track allocation process. This process not only serves as corroboration for compliance with task pre-requisite requirements (e.g. certifications, job hazard analysis, etc.) it also generates historical data of work performed and allows for operational control of tasks to be performed (location, duration, etc.).

The approach applied to power and automatic train control (ATC) systems maintenance activities includes a combination of preventive maintenance systems monitoring and rapid response in the event of a trouble call and/or alert. Full details of systems maintenance activities are described in the Systems Maintenance Plan.

Maintenance and inspection intervals are based on original equipment manufacturer (OEM) recommendations and updated based on experience, manufacturer updates and regulatory requirements as applicable. Preventive maintenance and inspection tasks are grouped in service assignments that are scheduled at specified time intervals and performed periodically. Preventive maintenance is hierarchical, with distinct cycles of increasing intensity. Similarly, common equipment is grouped by equipment type and/or location as applicable to facilitate allocation of resources. System maintenance strategies are aimed at minimizing service disruptions while preserving safety by maintaining assets in a state of good repair.

Tren Urbano systems are subject to the use of an integrated management system to track maintenance, repair and replacement efforts. Good stewardship of these assets is vital for sustaining the high-performance results passengers have grown accustomed to. A trade-off balance between priorities, cost and risk over each stage of the life cycle of these assets requires careful attention.

System maintenance strategies are aimed at minimizing service disruptions while preserving safety by maintaining assets in a state of good repair. Sustained operation is achieved through regular inspections, expedited repairs, adherence to preventive maintenance schedules and component replacement intervals, equipment and system condition monitoring, and risk management.

Maintenance of Equipment Assets

The maintenance regimen applied to the Tren Urbano support vehicle fleet is described in detail in the Non-Revenue Vehicles Maintenance Plan. Routine maintenance tasks are scheduled on a progressive time basis (quarterly, annually, etc.) depending on equipment. Maintenance procedures are based on manufacturer's manuals. Schedules are monitored through the maintenance management software.

6.0 Performance Measures

ACI-Herzog utilizes performance measures to link strategic mission, goals and objectives, and service delivery to data-driven metrics or outcomes. It relies on decision support tools and processes Management, Information and Decision Support System (MIDSS) to gather, store and utilize performance data from the assets described in Section 7 of this document.

Tren Urbano utilizes a balanced scorecard approach, tracking performance through a variety of metrics for transit services. The main goal of this approach is to avoid optimization of a single area at the expense of another. Balanced scorecards provide a clear and effective approach to capturing a high-level view of the service's critical success factors (i.e. financial, safety, customer satisfaction) as they relate to asset performance (i.e. utilization, maintenance). A description of regulatory, contractual and end customer performance measures is provided in Appendix 3. (Level of Service and Performance Measures)

The TAM Rule establishes the following SGR performance measures for each asset category:

- **Rolling Stock:**
  Useful Life Remaining – percentage of the remaining useful life of the fleet based on the Useful Life Benchmark (ULB) for the asset
- **Facilities:**
  Performance restrictions – percentage of facilities within an asset group below condition 3 on the TERM scale
- **Infrastructure:**
  Performance restrictions – percentage of fixed guideway where the maximum permissible speed of transit vehicles is set to a value that is below the guideway's design speed within
- **Equipment:**
  Useful Life Remaining – percentage of the remaining useful life of the support fleet based on the Useful Life Benchmark (ULB) for the asset

7.0 Decision Support Tools and Processes

The section below describes decision support tools that are in place for some of the key elements of the asset management process. It also identifies capabilities that PRITA and PRHTA may want to consider over the longer term to address FTA asset management requirements in the areas of economic forecasting, risk evaluation and project prioritization. These capabilities are described for informational purposes only and represent asset management best practices. In the event that PRITA and/or PRHTA decides to implement additional decision support tools for the asset management process, ACI-Herzog will provide support for these activities' pursuant contractual requirements.

Sophisticated automated management tools and business management processes are a critical component of asset management. It is extremely important to have understandable information related to asset characteristics (age, life expectancy, preventive and periodic maintenance schedules and procedures, condition, cost, replacement cost) and actual maintenance activities performed on the asset (inspections, maintenance, repairs, overhauls etc.). The processes that enable evaluation and analysis of gathered data provide valuable insight to the actual condition of the asset and associated risk.

Effective asset management systems also require the ability to forecast the future performance of assets both individually and in an aggregate manner, to accurately assess the costs associated with maintaining SGR. More advanced systems utilize real time component health monitoring information to better understand precursors to component failure to promote service reliability and the cost effectiveness of maintenance strategies. There are also a wide variety of inputs that are useful in the asset management process that require information from a variety of sources and systems including agency future year budget projections, risk factors, component/system obsolescence, quality control data and ridership projections to name a few.

In order to meet the FTA asset management needs of Tren Urbano several systems have been deployed to address portions of the asset management process. PRHTA and PRITA are considering the development of additional capabilities as the asset management process matures. The discussion below describes the information and analytical capabilities needed to support the asset management process. Current capabilities are described along with potential enhancements that can produce additional information to inform and improve the decision-making process.

7.1 Asset Management Software

ACI-Herzog utilizes Trapeze, an asset and maintenance management software (AMMS) as the core element of its Management Information and Decision Support Systems (MIDSS). Trapeze is specifically designed to support the maintenance of trains and non-revenue vehicles as well as, facilities, shop equipment, track, and rail network systems. It also includes inventory management, replenishment and procurement functionalities. Trapeze s is currently the central repository for information on maintenance, asset inventory and asset condition for Tren Urbano. Trapeze includes a number of features germane to the asset management process including:

- Complete Equipment Lifecycle Management including acquisition, campaigns and disposal management
- Asset configuration management and condition tracking
- Rail fleet maintenance management
- Rail infrastructure (track, signal, communications) and facility maintenance
- Maintenance scheduling and compliance reporting
- Robust Work Order Functionality
- Shop Planning Module
- Purchasing and Materials Inventory Management
- Purchase Requisition Management
- Asset Availability Tracking and Real-time Status
- Serialized component configuration management and history
- Component Rebuild Management
- Complete Warranty and Claims tracking
- Wheel measurement tracking
- Diagnostic Test Result tracking
- Equipment calibration tracking

Trapeze records each asset, whether a railcar or electronic board in a signal house from acquisition to disposition. For each equipment unit, EAM tracks life-cycle status, location, department assignment, availability for use, warranty, next inspection due, life expectancy, renewal plan and other status information.

Trapeze tracks component part numbers, manufacturers and system stock numbers, component repair records, and equipment installation dates and related installation measurements and other information as required. With this information, technicians can quickly find the maintenance history and inspection data which allows them to refine current preventive maintenance procedures and to minimize or prevent unexpected and catastrophic part failures.

It is also used to generate statistical data on component performance including parts or subsystems with high failure rates.

While the asset file stores all critical information about each piece of equipment (identifiers, build date, last overhaul, dates out of service, warranty terms, etc.), the work order files are the repository for all maintenance history including date/time work started, work location, failure description, functions accomplished, labor hours and parts used, corrective actions taken, supervisor sign off and when the asset was returned to service.

Trapeze automatically schedules preventive maintenance (PM) for all equipment units based on PM programs defined for equipment PM classes or for individual units. The scheduling module analyzes and reports on PM and inspection schedules, equipment availability and support equipment availability required to complete each work order.

Trapeze provides the foundation and an important starting point for current asset management requirements. It is the primary source for the asset inventory and condition assessment and can provide a framework for linear forecasting based on asset lifecycles. It can also house more sophisticated methods for asset inventory and condition assessments in the event additional attributes need to be added for future purposes.

7.2 Asset Inventory Process

An accurate asset definition and comprehensive listing of assets is the foundation of asset management implementation. ACI-Herzog will has correlated the framework of administrative and finance Property Plant and Equipment (PPE) asset inventory for Service Property to be in line with the framework parent-component relationships used as part of the maintenance management efforts. This effort provides improved synergy between administrative and maintenance efforts, as well as understanding and control of asset costs and needs as part of the lifecycle management strategy.

PPE inventories ascertain existence, changes and service status of Tren Urbano assets. The primary purpose of PPE inventory is to account for all property items. As a result, property and financial records can be reconciled with the physical property. This process is critical for the fulfillment of accountability obligations under law, obtaining a clean audit opinion of financial statements as required by law and maintaining the public's trust.

ACI-Herzog utilizes Trapeze as the baseline reference for PPE inventory. The tool enables the organization to keep record and track detailed asset information used both by administrative and maintenance areas. PPE inventory information currently derived from the database software tool includes asset identification number, description, type, location, year of manufacture, manufacturer, model and serial number. Once available to ACI-Herzog, future PPE inventories will also include original cost, federal share, grant number and estimated replacement (e.g. life expectancy).

ACI-Herzog will perform PPE inventory on a triennial basis following these general guidelines:

- Inventory personnel will receive a list of specific items (e.g. equipment or assets) to be accounted for.
- Once located, the inventory item will be physically tagged. A tag contains detailed information of the process including inventory date, item description, service status (in service or out of service), model, serial number and a unique tag number that ties to a unique equipment identification number. New tags are created for items not listed (i.e. new equipment, equipment replacements) as part of the tagging process.
- Physical inventory field information is consolidated, and asset management databases are updated with inventory information in our maintenance management system.

7.3 Performance Management

As data is collected, performance measures are contrasted with the goal or baseline and historic values and outcomes are distributed in reports; allowing forecasting of trends and initiation of improvement processes as needed. Altogether, these reporting performance actions allow a sense of accuracy (closeness to the target) and precision (consistency in the results) in the successful deployment of transit services.

Tren Urbano utilizes automated management tools in support of its performance management process. The Management Information and Decision Support Systems (MIDSS) is a combination of hardware and software Management Information Systems (MIS) elements that collect, store, analyze and report information in support of the transit services. The elements that comprise the MIDSS are further described in the MIS plan. Figure 6.1 below provides a high-level illustration of the data collection sources, including Automatic Train Control, OCC, Communications and Automatic Fare Collection asset groups; as well as the MIDSS reporting structure feeding the performance management process.

Sensitive Security Information – Not Available for the public

Figure 7.1 MIDSS Reporting Structure

7.4 Risk Management

Risk Management is a set of coordinated activities to direct and control an organization with regard to risk. In practice, the ability to evaluate and forecast potential risk to avoid or minimize its impact is a key element to asset management. The Risk Management process is implemented taking into account asset monitoring and review activities made possible by ACI-Herzog's technical knowledge, on-the-ground execution, evaluation and analysis based on O&M experience as well as the access to historical asset performance information to characterize potential risks.

ACI-Herzog will assist the Authority in Risk Management functions by performing risk identification and analysis, communicating results from an O&M perspective. These tasks will be performed using our knowledge and on-the-ground experience with Tren Urbano along with historical performance information from EAM and other client properties to characterize potential risks. We will continue to monitor and assess the status of each asset through its lifecycle and implications of high-risk stages such as obsolescence.

ACI-Herzog's approach towards risk analysis is qualitative, utilizing as a basis the following elements:

- Vulnerability – Influenced by *Combined Asset Condition Rating*, vulnerability expresses likelihood of failure of an asset, ranging from Very Low to Very High in 5 color coded levels
- Criticality – Assigned representation of the potential impact of asset failure to the provision of transportation services as the primary mission of the Tren Urbano assets, ranging from Very Low to Very High in 5 color coded levels
- Visibility – Assigned representation of the relevance of the asset to stakeholders such as passengers, authority or regulatory entities regardless of criticality and ranging from Very Low to Very High in 5 color coded levels

Communication of analysis results and baseline variances will be formally presented through status meetings and formal communication. These assessments will qualitatively address potential changes to performance measures based on the outcomes of the investment scenario and clearly identify any areas that present unacceptable or high-risk implications for safety.

ACI-Herzog will also be a partner in the Authority's process of risk evaluation. ACI-Herzog will communicate recommendations and support the Authority in its determination of the determination for the need or initiation of a Capital Improvement project as needed. A copy of ACI-Herzog's risk assessment and recommendations for project prioritization is included in Appendix 4. (Project Prioritization List)

ACI-Herzog is also responsible for O&M related risk response (also known as risk treatment) functions. The System Security and Emergency Preparedness Plan (SSEPP) and the Abnormal and Emergency Operations Plan provide detail description of the management system in place for the prevention, analysis and response to failure and emergency events. Maintenance risk responses include actions not requiring or leading to asset upgrade or replacement in a Capital Improvement scale. Response actions may include one or a combination of the following:

- Risk Avoidance – the task or element giving rise to the risk or opportunity is not initiated or continued
- Risk Removal – risk source is removed (e.g. equipment removed from service)
- Modification of Likelihood – efforts that will reduce the probability of risk (e.g. introduction or modification of maintenance or inspection task or frequency)
- Consequence Alteration – efforts to reduce the risk outcome (e.g. processes or equipment that provide an equivalent function)
- Risk Assumption – acknowledging and retaining risks as an informed decision

ACI-Herzog does not have automated tools for risk management. PRITA and PRHTA will consider the development of additional risk management tool capabilities as the asset management process matures.

7.5 Project Prioritization

ACI-Herzog will support PRITA's and PRHTA's project prioritization process mainly through the identification of projects requiring SGR capital investments and the issuance O&M recommendations. A list of project factors and ratings used as part of ACI-Herzog's recommendations is included in Table 7.1. The project prioritization process will be framed ultimately by PRITA and PRHTA goals and objectives. Individual projects will be ranked by ACI-Herzog based on the project ranking factors selected by the Authority (PRITA).

Project Factors	Brief Description	Ratings	Score
Life Safety Score	Risk or potential impact on passenger or worker safety	Critical	5
		Serious	4
		Moderate	3
		Minor	2
		Negligible	1
Mission Critical	Risk or potential impact on Agency's ability to transport passengers	Full Disruption	5
		Partial Disruption	4
		Degraded Operation	3
		Redundancy Loss	2
		No Service Disruption	1
Regulatory	Risk or potential impact on Agency's ability to meet local, state or federal regulations	Full Disruption/No Compliance	5
		Partial Disruption/Audit Finding	4
		Degraded Operation/Audit Observation	3
		Minimal Impact/Audit Comments	2
		No Impact/Compliance	1
Level of Service	Risk or potential impact on Agency's ability to meet transportation system performance standards	Full Disruption	5
		Partial Disruption	4
		Degraded Operation	3
		Minimal Impact	2
		No Impact	1
Financial	Financial impact including project cost, cost of opportunity, or loss of fare or business	Critical	5
		Serious	4
		Moderate	3
		Minor	2
		Negligible	1
Vulnerability	Susceptibility to failure based on current condition	Full Disruption	5
		Partial Disruption	4
		Degraded Operation	3
		Redundancy Loss	2
		No Functionality Loss	1
Probability	Likeliness of failure based on system reliability	Certain	5
		Frequent	4
		Likely	3
		Ocassional	2
		Unlikely	1
Implementation speed	Estimated time of completion upon notice to proceed	Less than 6 months	5
		6 months to 1 year	4
		1 to 2 years	3
		2 to 5 years	2
		> 5 years	1

Table 7.1 Project Factors and Ratings

A copy of ACI-Herzog's project prioritization recommendations for ongoing projects is included in Appendix 4. (Project Prioritization List)

Overall, ACI-Herzog will work with PRITA and PRHTA to improve the project prioritization process over time. Utilizing the tools described previously, and our longstanding experience with Tren Urbano assets we are prepared to support efforts to develop a more quantitative basis for evaluating potential projects through a more robust analytical process utilizing the information available to quantify benefits and impacts to important factors including:

- Safety
- Service reliability
- Service quality
- O&M costs

7.6 Economic Forecasting

A fundamental component of asset management is maintaining the capability to assess the level of capital investment required to produce desired performance levels and asset SGR. This is typically achieved by forecasting capital needs based on the current condition of the assets combined with other factors like asset age, planned rehabilitation efforts and ultimate asset life expectancy. While Trapeze and LCM analysis prepared for the Tren Urbano service can be used to forecast capital needs, PRITA and PRHTA are considering the deployment of a more robust forecasting environment to analyze future alternatives.

This may include economic forecasting models like FTA's Transit Economics Requirements Model (TERM Lite) for forecasting capital investment needs over the long term. The model output also includes estimates of the physical condition of the agency's transit asset base both for the current year and for a 20 or 30-year forecast period. Asset condition forecasts are directly impacted by the asset condition replacement policies applied by the user providing an efficient and consistent framework for alternatives analysis. The TERM Lite design allows the user to control a wide range of model input parameters (e.g., asset replacement and rehabilitation assumptions, and financial assumptions) to facilitate the analysis of a wide range of investment scenarios. It can also be used to assess SGR backlogs and run multiple alternatives based on changes in user inputs including budget forecasts.

7.7 Investment Prioritization

A key element of effective asset management is forecasting when best to rehabilitate or replace assets based and projecting future costs.

An important step which PRITA and PRHTA consider in the asset management process is performing an analysis of short and long term alternatives to provide a broader perspective on the project prioritization process and to generate additional information that can be fed back into the process. Alternatives analysis can be performed using a variety of inputs including different maintenance strategy assumptions, rehabilitation and replacement costs, budget alternatives and differing out year scenarios. The alternatives analysis process may also generate an SGR backlog (projects that cannot be funded in the required time frame due to budget constraints but are necessary to maintain SGR). The SGR backlog can then be evaluated from a risk perspective. If this step produces unacceptable results, inputs to the project ranking and/or alternatives analysis can be adjusted and additional alternatives can be developed. In addition, results from alternative analysis can be further evaluated based on broader considerations (engineering, procurement, etc.) including:

- Ability to choose the most cost effective/biggest bang projects from the list of pending projects each year.
- Opportunities to combine like projects based on forecasted condition to use economies of scale by doing multiple like projects.
- Reduce cost of ownership through procurement and engineering feedback as part of the process.

These factors can also be fed back into the analysis of alternatives and project selection process to generate optimal short and long term capital investment strategies.

Figure 7.2 presents a schematic of the potential steps involved in the investment prioritization process. ACI-Herzog will play a supporting role in this process as required by the Authority.

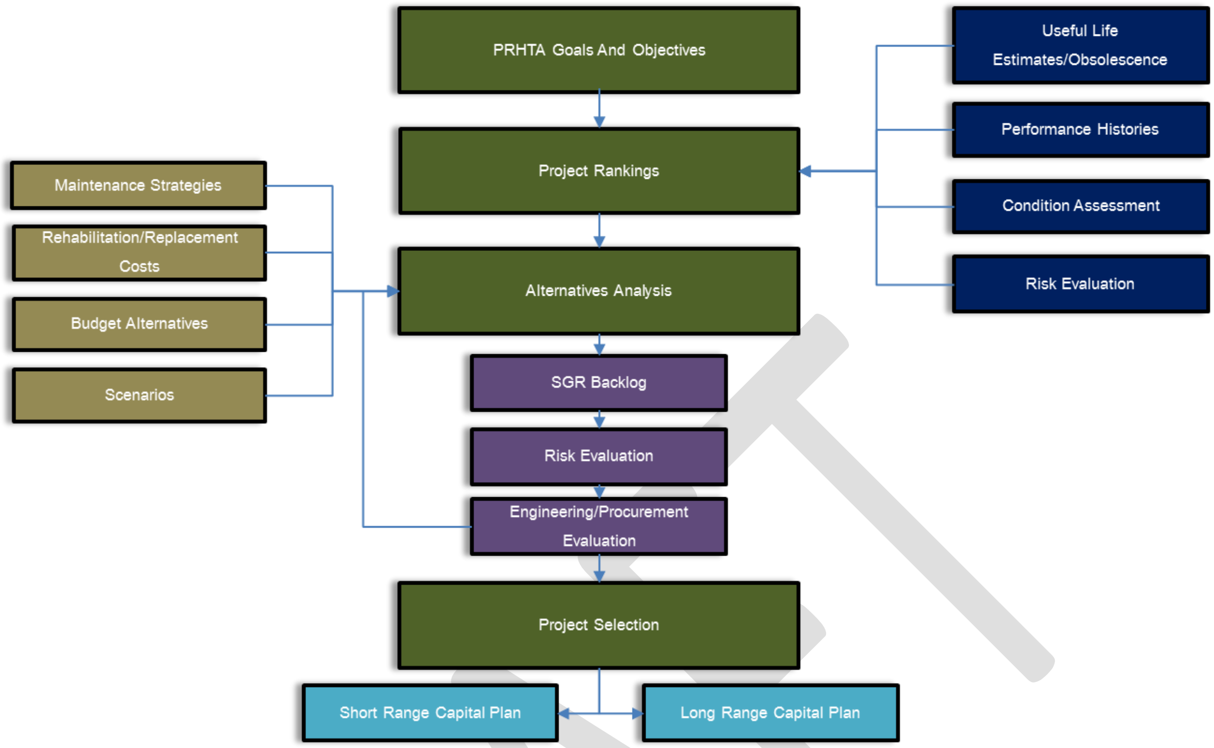

Figure 7.2 Investment Prioritization Schematic

ACI-Herzog will support the Authority's Accountable Executive in a number of ways. First, using the tools and processes described previously, we will generate most of the data needed to support project rankings. We will issue recommendations as part of the analysis of alternatives including rehabilitation and replacement costs, maintenance strategies. ACI-Herzog will participate in other support (specification, engineering, procurement) as requested by PRITA and/or PRHTA.

8.0 Improvement Plan

The following section focuses on the process in place by ACI-Herzog to improve asset management practices.

8.1 Preventive Measures

A proactive approach is used to identify potential non-conformities. Since success is defined as compliance with the mission and objectives measured through the balanced scorecard approach, ACI-Herzog will pay close attention to the interrelated activities and performance measures that affect the asset management process. A continuous evaluation of performance measures, root cause and trend analysis will be used to identify potential issues or non-conformance before they occur. Once identified, potential failures follow the structured approach described on the following section for resolution.

Upon identification of potential non-conformities ACI-Herzog will perform the following structured actions:

- Analyze the event to understand potential underlying causes
- Identify potential and necessary actions to correct or improve results

- Implement corrective actions required to improve results
- Address resulting consequences of the non-conformity
- Evaluate effectiveness of actions performed
- Incorporate changes to asset management practices as applicable

Pursuing corrective actions to non-conformity will be based on the following priorities:

- Safety
- Service continuity and reliability
- Asset preservation
- Benefit/costs

A detailed description of the process followed for changes resulting from response to non-conformities is included in the Configuration Control Plan.

8.2 Continuous Improvement

In its Transit Asset Management (TAM) implementation, Tren Urbano utilizes the Plan-Do-Check-Act cycle (PDCA, also known as Deming cycle), a continuous improvement data-driven strategy to monitor and improve asset management and transit services. The following recurrent elements or steps describe the model:

- **Plan** the processes, activities, goals, customer requirements and metrics
- **Do** or execute processes and activities
- **Check** performance through key performance indicators (KPIs); analyzing results of the process, identifying the sources or causes of problems, opportunities and overall variation from desired results
- **Act** upon results, by controlling process performance, correcting problems or targeting opportunities

8.3 Program Improvements

On a more global level, future steps in the asset management development process are highly dependent on policy decisions and the continuous improvement vision formulated by PRITA and PRHTA. As the operations and maintenance contractor for Tren Urbano, we will work cooperatively with PRITA and PRHTA to assist in the current process, and proactively to establish and implement a joint short- and long-term goals and objectives for the benefit of the Tren Urbano system. As the process evolves, we will work with PRITA and PRHTA to ensure that ACI-Herzog asset management practices are consistent with those identified by PRITA and/or PRHTA and to provide high quality information (as applicable) to support the PRITA and PRHTA asset management process.

Appendix 1 - Asset Performance Targets (2019 NTD Narrative Report)

Sensitive Security Information – Not Available for the public

Appendix 2 - Asset Condition Assessment Procedures:

PM-01-02 ***NTD Performance Restriction (Slow Zone Calculation)***

PM-01-03 ***NTD Facilities Condition Assessment Calculation***

Appendix 3 – Level of Service and Performance Measures

Federal Regulation Performance Measures

Tren Urbano monitors the following performance measures in compliance with Federal Transit Agency (FTA) and State regulations and requirements.

The National Transit Database (NTD) is the repository of data about the financial, operating and asset conditions of U.S. transit systems. The NTD information supports local, state and regional planning efforts and helps decision-makers make multi-year comparisons and perform trend analyses with standardized KPIs. It contains a wealth of information such as agency funding sources, inventories of vehicles and maintenance facilities, safety event reports and measures of transit service provided. As a recipient of FTA funding, Tren Urbano is required to submit data to the NTD in uniform categories. Additional metrics required and submitted to the NTD on a monthly and annual basis beyond those described under the O&M Contract Performance Measures are described below.

Basic Information Requirements

Basic information includes information that helps the NTD to identify the system, contractual relationship with the transit agency and key financial and operating data for purchased transportation systems like the Tren Urbano. The NTD required information includes:

- **Fare Revenue:** includes all fare revenues collected during the reporting period.
- **Total Contract Operating Expenses**: it is the total operating costs of the contact.
- **Net Contract Expenditures:** payments and accruals due the seller for providing the transit services under the contractual agreement after fare revenues have been deducted.

$$Net\_Contract\_Expenditure = Total\_Contract\_Operating\_Expences - Fare\_\mathrm{Re}venue$$

Service Information

Service indicators are used to measure the transit service provided and the service consumed by passengers on the systems. The service information requirements include the following information:

- **Vehicles Operated in Annual Maximum Service (VOMS)** - The number of vehicles operated on the maximum day of the year to provide peak period service.
- **Vehicles Available for Annual Maximum Service** - the number of vehicles available on the maximum day of the year to provide peak period service (i.e., VOMS) plus spares, out of service vehicles, and vehicles in or awaiting maintenance; and excluding vehicles awaiting sale or emergency contingency fleet).
- **Time Service Begins –** Time when service begins for weekday, Saturday and Sunday schedules.
- **Time Service Ends** - The time service ends for weekday, Saturday and Sunday schedules.
- **Trains in Operation -** Number of trains in operation for an average weekday, Saturday and Sunday schedules.
- **Vehicles/Passenger Cars in Operation-** Number of vehicles/passenger cars in operation for an average weekday, Saturday and Sunday schedules.
- **Average day Total Actual Train Miles** - Revenue and deadhead miles operated for an average Weekday, Saturday and Sunday. This metric does not include extra service operated for special

events.

- **Annual/Monthly Total Actual Train Miles –** The aggregate off all revenue and deadhead miles operated by trains during the reporting period. This metric includes extra service operated for special events such as concerts and festivals.
- **Average day Total Actual Train Hours -** All revenue and deadhead hours that the trains operated for an average Weekday, Saturday and Sunday schedule. This metric does not include extra service operated for special events.
- **Annual/Monthly Total Actual Train Hours-** The aggregate of all revenue and deadhead hours operated during the reporting period. This metric includes extra service operated for special events.
- **Average Total Actual Train Revenue Mile-** All the miles that trains operated in revenue service for weekday, Saturday and Sunday schedules. Revenue miles are the miles operated when are providing public transportation and the vehicle is available to carry passengers. This metric does not include extra service operated for special events.
- **Annual/Monthly Total Actual Train Revenue Mile**- The aggregate of all revenue miles operated during the reporting period. This metric includes extra service operated for special events.
- **Average Total Actual Train Deadhead Mile-** Total distance the trains operated in revenue service for an average Weekday, Saturday and Sunday schedule. Deadhead miles are miles operated without being offering transportation service to the passengers such as moving a train out of service from one terminal to the other, moving a train from the yard to the point where start revenue service, or from the point where the train ends revenue service to the yard.
- **Annual/Monthly Total Actual Train Deadhead Mile**- The aggregate of all deadhead miles operated during the reporting period.
- **Average Total Actual Train Revenue Hours**- Total hours that the trains operated in revenue service for an average weekday, Saturday and Sunday schedule. This metric does not include extra service operated for special events.
- **Annual/Monthly Total Actual Train Revenue Hours**- This is the aggregate of all revenue miles operated during the reporting period. This metric includes extra service operated for special events.
- **Average Total Actual Train Deadhead Hours-** Total hours the trains operated in revenue service for an average weekday, Saturday and Sunday schedule.
- **Annual/Monthly Total Actual Train Deadhead Hours**- The aggregate of all deadhead hours operated during the reporting period.
- **Average Total Actual Passenger Car Miles**- Total revenue and deadhead miles that the vehicle/passenger cars operated for an average weekday, Saturday and Sunday. This metric does not include extra service operated for special events such as concerts and festivals like the San Sebastian Fest.
- **Annual/Monthly Total Actual Passenger Car Miles**- The aggregate of all the revenue and deadhead miles that the vehicle/passenger cars operated during the reporting period. This metric include extra service operated for special events such as concerts and festivals like the San Sebastian Fest.
- **Average Total Actual Passenger Car Revenue Miles** - Total miles that the vehicle/passenger cars operated in revenue service for an average weekday, Saturday and Sunday. This metric does not include extra service operated for special events.

- **Annual/Monthly Total Actual Passenger Car Revenue Miles**- The aggregate of all the revenue miles that the vehicle/passenger cars operated during the reporting period. This metric include extra service operated for special events.
- **Average Total Actual Passenger Cars Deadhead Miles**- This is all the miles that the vehicle/passenger cars in deadhead for an average weekday, Saturday and Sunday schedule.
- **Annual/Monthly Total Actual Passenger Cars Deadhead Miles**- The aggregate of all passenger cars deadhead miles operated during the reporting period.
- **Average Total Scheduled Passenger Car Revenue Miles**- Total miles that the vehicle/passenger cars were scheduled to operate in revenue service for an average weekday, Saturday and Sunday schedule.
- **Annual/Monthly Total Scheduled Passenger Car Revenue Miles**- The aggregate of all the miles that the vehicle/passenger cars were scheduled to operate in revenue service during the evaluated period. Equal to the sum of average weekday schedule, Saturday and Sunday scheduled service multiplied by the respective days operated during the reporting period.
- **Average Total Actual Passenger Car Revenue Hours** – Total hours that the vehicle/passenger cars operated in revenue service for an average weekday, Saturday and Sunday. This metric does not include extra service operated for special events.
- **Annual/Monthly Total Actual Passenger Car Revenue Hours**- The aggregate of all the revenue hours that the vehicle/passenger cars operated during the reporting period. This metric include extra service operated for special events.
- **Average Total Actual Passenger Cars Deadhead Hours**- Total hours that the vehicle/passenger cars are in deadhead for an average weekday, Saturday and Sunday schedule.
- **Annual/Monthly Total Actual Passenger Cars Deadhead Hours**- The aggregate of all passenger cars deadhead hours operated during the reporting period.
- **Average Passenger Speed (APS)**- Average speed that the system operates while the vehicles are in revenue service. It is measured using the following equation:

$$APS = \frac{\sum \text{Passenger Cars Revenu Miles}}{\sum \text{Passenger Cars Revenue Hours}}$$

- **Average Deadhead Speed (ADS)**- Average speed that the system operates while the vehicles are in deadhead. It is measured using the following equation:

$$ADS = \frac{\sum \text{Passenger Cars Deadhead Miles}}{\sum \text{Passenger Cars Deadhead\_Hours}}$$

- **Average Actual Speed(AAS)-** Average speed that the system operates. It is measured using the following equation:

$$AAS = \frac{\sum \text{Passenger Cars Total Miles}}{\sum \text{Passenger Cars Total Hours}}$$

- **Unlinked Passenger Trips (UPT)**- UPT are the number of passengers who board the public transportation vehicles. This metrics count passengers each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.
- **Passenger Miles Traveled (PMT)** - PMT is a measure of service consumed by transit users. This metric track the distance traveled by each passenger, i.e., the distance from the time he boards until he gets off the vehicle. PMT are the cumulative sum of the distances ridden by each passenger.
- **Load Factor (LF)** - It is the ratio of passenger miles traveled per vehicles revenue miles. It is measured using the following equation:

$$LF = \frac{\text{PMT}}{\text{Vehicles Revenu Miles}}$$

- **Days Operated** - Is required to report the amount of days that service was actually operated for a weekday, Saturday and Sunday schedule, and the annual total.
- **Days not Operated due to Strikes** - Reports the amount of days that service would normally have operated but did not operate due to a transit labor strike.
- **Days not Operated due to an officially declared emergency** – Reports the amount of days that service would normally have operated but did not operate due to an officially declared emergency.

Safety Information

The NTD Safety indicators are used as an indicator of Transit Systems Safety and Security practices. NTD Safety reporting is focused on collecting detailed information for Major Events and summary information for Non-Major Events. Major events are the most severe safety and security incidents occurring in the transit system. The Non-Major events are the less severe safety and security-related incidents. The followings metrics are required:

- **Total Incidents** - Amount of NTD reportable events occurred in the system during the reported period. The indicator is divided into the following categories:
  - Collision,
  - Derailment,
  - Security,
  - Fire
  - “Not otherwise classified”(NOC) - The NOC events include slips, trips and falls; electric shocks; suicides; vehicles leaving roadway; and other events that are not reported on previous categories
  - Annual Total Incidents - The aggregate of all the reportable incidents, occurred during the evaluated period
- **Fatalities-** The amount of fatalities occurred in the system during the reporting period. The Fatalities considers confirmed deaths within 30 days including suicide, but excluding deaths by illness or natural causes, or deaths not associated to an event. Fatalities data is classified into the following categories based on the deceased person relationship to the system:
- **Injuries-** The amount of injuries occurred in the system during the reporting period. The metric

considers each person immediately transported away from the scene for medical attention. Transport may be by any means, e.g. emergency personnel, transit supervisor, personal vehicle. Excluded from the metric are illnesses requiring transport for medical attention and person seeking medical attention under his or her own power, e.g. walks away to seek medical attention.

Asset Inventory Module (AIM)

The National Transit Database (NTD) program's Asset Inventory Module (AIM) is designed to collect basic information on assets and infrastructure applied by U.S. transit agencies to deliver service. The TAM Rule establishes the following SGR performance measures for each asset category:

- **Rolling Stock:**

  Useful Life Remaining – percentage of the remaining useful life of the fleet based on the Useful Life Benchmark (ULB) for the asset

- **Facilities:**

  Performance restrictions – percentage of facilities within an asset group below condition 3 on the TERM scale based on the *Asset Inventory Condition* column on Table 3.2 Combined Asset Condition Rating – General Scoring System

- **Infrastructure:**

  Performance restrictions – percentage of fixed guideway where the maximum permissible speed of transit vehicles is set to a value that is below the guideway's design speed within

- **Equipment:**

  Useful Life Remaining – percentage of the remaining useful life of the support fleet based on the Useful Life Benchmark (ULB) for the asset

8.4 State Performance Measures

As per PR State Law 1-2015 of January 15, 2015, the Puerto Rico Integrated Transit Authority (PRITA) is required to submit a quarterly report with transit KPIs. This information supports state planning efforts and help decision-makers make multi-year comparisons. It provides information such as agency funding sources and operation costs in relation to the transit service provided. Additional asset management related metrics required and submitted to PRITA on a quarterly and annual basis beyond those described under the O&M Contract Performance Measures are described below:

- **Transportation Cost per User**

  The Transportation Cost per User KPI provides a relation of the total cost of the transit service per transported passenger. ACI-Herzog provides O&M and private security costs to PRITA as part of the cost evaluation.

- **Cost per Trip**

  The Cost per Trip KPI provides a relation of the total cost for performing a transit trip. ACI-Herzog provides O&M and private security costs to PRITA as part of the cost evaluation.

- **Farebox Recovery Ratio**

The Farebox Recovery Ratio KPI provides a relationship between total income from Tren Urbano service and the total cost of providing transit service.

- **Passenger Employee Ratio**

  The Passenger Employee Ratio KPI provides a comparison between total passengers served and transit employees. ACI-Herzog provides information of direct O&M employees.

- **Vehicle Employee Ratio**

  The Vehicle Employee Ratio KPI provides a comparison between vehicle units in service and transit employees. ACI-Herzog provides information of direct O&M employees.

- **Vehicle Out-of-Service Rate**

  The Vehicle Out-of-Service Rate KPI provides an average time a transit unit remains unavailable for service.

8.5 O&M Contract Performance Measures

Tren Urbano has established a number of performance measures requirements as part of its O&M Contract.

General Service Performance Measure

- **On-Time Performance – Goal: 98.5%**

  OTP measures actual train arrival and departure times in comparison to a scheduled service. It is a measurement of the punctuality of ACI-Herzog transit services. The OTP metrics also provide feedback of vehicle and systems maintenance services effectiveness.

  The On-time performance is affected by delays or disruptions caused by internal and external factors. Internal factors include but are not limited to vehicle and systems maintenance failures. External factors include fire, whether conditions, earthquakes, suicides, public manifestations, third party events, programmed heavy corrective and preventive maintenances that cannot be performed during non-revenue hours. Delays caused by external factors are considered an exception and are not included in the OTP metric.

  OTP is measured as the percentage of scheduled trips that arrive on time to a terminal station. A train is deemed off-schedule if:

  - A train completes its trip (arrives at the terminal station) more than one (1) minute prior to the scheduled trip time, or more than four (4) minutes after the scheduled trip time.
  - If a train skips one or more stations on any trip, each station skipped is counted as an off-schedule train.
  - Trains that are counted as missed trips (arrives to a terminal station more than 30 minutes late) shall not be counted as off-schedule trains.

  OTP is evaluated on a daily, monthly and yearly basis using the following equation:

$$OTP = \left(1 - \frac{\sum Off - ScheduleTrips}{\sum Scheduled\_Trips}\right) \times 100$$

ACI-Herzog operational goal is to operate the transit service punctual with a monthly OTP of more than 98.5%.

- **Trip Completion Rate (TCR) - Goal: 30 missed trips/month**

  TCR is a measurement of the ACI-Herzog efficiency to complete scheduled trips. It is an indicator of the operation, vehicles and system reliability. TCR is also affected by disruptions caused by internal factors such as vehicle and systems maintenance failures. TCR can also be affected by the external factors described previously. Delays caused by external factors are considered an exception and are not included in the TCR metric.

  TCR is measured as the percentage of successfully completed scheduled trips. A scheduled trip is not completed if:

  - A trip it is cancelled or dropped from the schedule.
  - The train running the trip is removed from service before completing the trip (arriving at the terminal station).
  - The train running the trip arrives at the terminal station more than one-half (1/2) hour after the scheduled trip time.
  - A train not containing the scheduled consist (but completing its trip) shall be counted as one-half of a missed trip.

  TCR is evaluated on a daily, monthly and yearly basis using the following equation:

$$TCR = \left(1 - \frac{\sum Missed\_Trips}{\sum Scheduled\_Trips}\right) \times 100$$

  ACI-Herzog operational goal is to operate the service whit less than 30 missed trips per month.

- **Service Usage (e.g. Ridership)**

  Service usage KPIs monitor passenger usage of transportation services. These KPIs provide information necessary for O&M and strategic service planning. O&M performance influences this KPI although many external factors also play a strong role on passenger usage of the system.

  There are multiple variations used for the evaluation of this KPI evaluated on a hourly, daily, monthly and annual basis. Some of the most common are total entries per year, Monthly Daily Average, Weekday Daily Average, total entries per station and time of day entries.

- **FTA Reportable Events – Goal: 0 events**

  The FTA Reportable Events Level-of-Service (LOS) establishes requirement for zero incident culture. Reportable incidents are defined under 49 CFR 659 as follows:

  - A fatality, where an individual is confirmed dead within thirty (30) days of a transit-related incident, excluding suicides and deaths from illness;

- Injuries requiring immediate medical attention away from the scene for two or more individuals;
- Property damage to rail transit vehicles, non-rail transit vehicles, other rail transit property or facilities that equals or exceeds $25,000;
- An evacuation due to life safety reasons; or
- A main-line derailment

- **On-the-job Injuries – Goal: No on the job injuries**

On-the-Job Incident rate KPIs are an indication of how many incidents have occurred, or how severe they were. The Occupational Safety and Health Administration (OSHA) established Incident Recordable Rate (IR) and Lost Time Incident Rate (LTC) as a standard KPI for comparison within and across industries. In Urban Transit Systems (NAICS Code 4851), the 2015 Incident Recordable Rate (IR) and Lost Time Rate (LTC) were respectively 6.7 and 4.9.

The Incident Recordable Rate (IR) is a mathematical calculation that describes the number of recordable incidents that a company experiences per 100 full-time employees in any given timeframe. Recordable incidents are incidents that resulted from an exposure or event in the workplace and that resulted in death, loss of consciousness, restriction of work or motion, or required some type of medical treatment or first-aid. The OSHA Recordable Incident Rate (or Incident Rate) is calculated on a monthly and yearly basis using the following equation:

$$IR = \left(\frac{\sum OSHA\_Recordable\_Cases \times 200{,}000}{\sum Employee\_Labor\_Hours\_Worked} \right)$$

The Lost Time Case Rate (LCT) is a mathematical calculation that describes the number of lost time cases per 100 full-time employees in any given time frame. A lost time case is any occupational injury or illness which results in an employee being unable to work a full assigned work shift. A fatality is not considered a LTC. Incidents that have lost time occurring over a longer period of time, weekends are counted as working days, and the number of lost days is capped at 180 days. The Lost Time Case Rate (or Lost Time Rate) is calculated on a monthly and yearly basis using the following equation:

$$LCT = \left(\frac{\sum Lost\_Time\_Cases \times 200{,}000}{\sum Employee\_Labor\_Hours\_Worked} \right)$$

- **Costumer Injuries – Goal Injuries: 0 events**

The Customer Injuries Level-of-Service (LOS) establishes requirement for zero incident culture. The National Transit Database defines Injuries as follows:

"Any damage or harm to persons as a result of an event that requires immediate medical attention away from the scene."

- **Emergency Incident Response Time – Goal: 30 minutes**

The Emergency Incident Response Time Level-of-Service (LOS) establishes response time requirements for incidents that impact train service and/or the ability to keep a station open. Response time is measured as response personnel working onsite at the location of the event.

Asset Investment Prioritization

- **Combined Asset Condition Rating – Goal: 3.0 or greater in a TERM scale**

  The Combined Asset Condition Rating is determined by a weighted combination function. This performance measure assigns a value from 0 to 5 using the evaluation guidelines in Table 3.2. ACI-Herzog will use this performance measure as one of the primary evaluation criteria to issue O&M recommendations to the Authority for asset investment prioritization. A copy of the detailed procedure to perform asset assessment activities is included in Appendix 2.

Rolling Stock Assets KPIs

- **Vehicles Fleet Wide Mean Distance between Failures (MDBF) – Goal: 60,000 km**

  MDBF is a transit industry standard that measures the reliability of the revenue vehicles fleet by tracking the mean distance traveled between each train failure. A failure occurs when a mechanical element of the revenue service vehicle prevents the train from completing a scheduled revenue trip or from starting the next scheduled revenue trip because movement is limited or due to because of safety concerns.

  Vehicle MDBF reflects the success of the maintenance programs and vehicle reliability. When vehicles break down, interruptions in service and delays for transit passengers typically occur. Vehicle MDBF is measured on a monthly and annual basis using the following equation:

$$\mathrm{MDBF} = \left(\frac{\sum Fleet\_Wide\_Distance\_KM}{\sum Failure\_in\_service} \right)$$

  ACI-Herzog operational goal is to provide a high reliable transit services with an annual vehicle MDBF of more than 60,000 km.

- **Train Air Conditioning Fleet Wide MDBF - Goal: More than 225,000 km**

  The Train Air Conditioning MDBF is a metric that measures the mechanical reliability of the revenue vehicles air conditioning units. A train air conditioning failure is defined as a failure of air-conditioning equipment resulting in the failure to maintain an ambient temperature inside the vehicle equal to or less than twenty-seven (27) degrees Celsius. Events are logged in the revenue vehicle health and monitoring system (VH&M) through a “Hot Car” alarm indication. The train air conditioning MDBF is evaluated on a monthly and yearly basis using the following equation:

$$\mathrm{MDBF} = \left(\frac{\sum Fleet\_Wide\_Distance\_KM}{\sum Train\_HVAC\_Failure\_in\_Service} \right)$$

  ACI-Herzog operational goal is to provide a high reliable transit services with an annual Train Air Conditioning MDBF of more than 225,000 km.

- **Vehicle Preventive Maintenance Compliance (VPMC) - Goal: 100%**

  The VPMC KPI measures ACI-Herzog’s ability to meet preventive maintenance (PM) program schedules as specified in the Vehicle Maintenance Plan.

VPMC examines the number of vehicles PM's scheduled work orders (WO) completed on time compared to the total number of scheduled Vehicle PM's WO. The results are expressed as a percentage. VPMC is evaluated on a monthly and yearly basis using the following equation:

$$\text{V}PMC = \left(\frac{\sum Scheduled\_PM - \sum Late\_PM}{\sum Scheduled\_PM} \right) \times 100$$

The vehicle PM program observes three types of PM. The criterion to evaluate compliance varies based on the PM type as described below:

Regular PM is completed within 7,500 km (distance travel) or 90 days (time elapsed) since completion of previous PM. A PM is considered late if:

- It is completed more than 8250 KM from previous PM
- It is completed earlier than 6,000 KM from previous PM
- Completed after 90 Days since completion off previous PM
- Completed earlier than 81 since completion off previous PM

Vehicle undergoing Heavy Repairs (ex. warranty, wheel replacement) or Overhaul in excess of 30 days from the initiation of the work are exempted from this metric and receive their next PM due prior returning to service. In such circumstances the PM will be considered late if not completed prior vehicles return to service. When such efforts are completed within 30 days or less, the PM is completed as scheduled.

Out of service PM shall be completed on vehicles after 60 consecutive days in Out of Service status or 90 days after the previous regular PM whatever come first. A PM is considered late if:

- The PM is completed in excess of 92 days since the previous regular PM or excess 62 days from the vehicle was assigned an out of service status in the Availability Report, or as applicable, the date previous Out-of-Service PM had been completed.

Vehicles in out-of-service status but undergoing Heavy Repairs receive their next Regular PM due prior returning to service and are exempted from the metric. The PM is considered late if the Regular PM is not completed prior vehicles return to service.

Heavy PM is completed every 90,000 km. A PM is considered late if the PM is completed exceeding the following tolerance:

- 10% of the target distance for the PM

- **Vehicle Cleaning Completion Rate (CCR) - Goal: 100%**

  The Vehicle CCR KPI measures ACI-Herzog's ability meet cleaning program schedules. This metric examines the number of vehicles cleaning completed on time compared to the total number of scheduled vehicles cleaning. The results are expressed as a percentage. Cleaning completion rate is evaluated for each cleaning category (Interior, Exterior and Heavy Cleaning) on a monthly and yearly basis using the following equation:

$$CCR = \left(\frac{\sum Scheduled\_Cleaning - \sum Missed\_Cleaning}{\sum Scheduled\_Cleaning} \right) \times 100$$

Interior cleaning is considered as missed if:

- A rail vehicle not cleaned between 5:00 AM and 5:00 AM next day of the day scheduled for completion
- Out-of-Service vehicle every 60 days and prior entering revenue service

Vehicles under heavy repairs or heavy preventive maintenance are excluded from this metric and are cleaned prior entering service.

The Tren Urbano fleet is scheduled to receive an exterior cleaning every 5 days. An exterior cleaning is considered missed if:

- The exterior cleaning is not performed every 5 days, between 5am and 5am next day with a tolerance of 24 hours after the scheduled time of completion.
- The exterior cleaning of Out-of-Service vehicles capable of self-movement are completed every 60 days and prior entering to service.

Vehicles under heavy repairs or heavy preventive maintenance are excluded from this metric and are cleaned prior entering service.

The Tren Urbano fleet is scheduled to receive a heavy cleaning every 60 days. A heavy cleaning is considered as missed if it is not completed within the scheduled programs. Vehicles under heavy repairs or heavy preventive maintenance are excluded from this metric and are cleaned prior entering service. Heavy cleaning treatments such as front mask buffing and carbody treatments are performed in a project basis and are also excluded from this metric.

For contractual evaluation of offsets, CCR is measured as the amount of missed or late cleaning WOs. ACI-Herzog operational goal is to complete all cleaning WOs on time within the schedule cleaning programs.

- **Layover Cleaning - Goal: 98% of the trips**

  The Layover Cleaning KPI measures ACI-Herzog's ability to meet its vehicle cleaning program on revenue service vehicles. Layover cleaning services are performed in one of the Terminal Stations for each scheduled revenue service trip. In the evaluation of contractual offsets Layover Cleaning is evaluated based on confirmed missed services as a result of spot checks or inspections at the terminal.

- **Graffiti removed before vehicle enters service**

  This KPI measures compliance of level of service requirements as part of daily maintenance activities.

Facility Assets KPIs

- **Facilities PM Compliance (FPMC) - Goal: 100%**

  The FPMC KPI measures ACI-Herzog's ability meet PM program schedules as specified in the Facilities Maintenance Plan.

  The FPMC examines the number of PM's scheduled WOs completed on time compared to the total number of scheduled Facilities PM's WO. The results are expressed as a percentage. FPMC is evaluated on a monthly and yearly basis using the following equation:

$$\mathrm{F}PMC = \left(\frac{\sum Scheduled\_PM - \sum Late\_PM}{\sum Scheduled\_PM} \right) \times 100$$

  The Facilities and Station Preventive Maintenance Compliance is evaluated as the amount of missed or late Preventive Maintenance work orders. This metric is measured jointly with Systems and Track PM WOs.

  ACI-Herzog operational goal is to complete all PM tasks on time within the specified PM program schedules.

- **Station Heavy Cleaning Completion Rate (CCR) – Goal : 100%**

  Station Heavy Cleaning Completion Rate (CCR) measures the compliance with the programed station heavy cleaning. This metric examines the number of scheduled number of station heavy cleaning services completed on time compared to the total scheduled. The results are expressed as a percentage. This metric is evaluated on a monthly and yearly basis using the following equation:

$$CCR = \left(\frac{\sum Scheduled\_Cleaning - \sum Missed\_Cleaning}{\sum Scheduled\_Cleaning} \right) \times 100$$

  The heavy cleaning frequencies vary depending on the station and usage. A station heavy cleaning service is considered as missed if it is not completed within the scheduled programs.

- **Elevators and Escalators Mean Time between Failures (MTBF) - Goal: 350 hrs**

  The Elevators and Escalators MTBF is a measure of the reliability of Tren Urbano elevator and escalators systems. It is measured as the mean operational time between elevator and escalator failure. A failure is measured as any equipment malfunction that causes that the elevator or escalator to be unavailable for service during revenue hours.

  This metric is calculated separately for elevator and escalators. It is evaluated on a monthly and yearly basis using the following equations:

$$\text{Elevator M}TBF = \left(\frac{\sum Elevator\_Operational\_Hours}{\sum Elevator\_Failure\_in\_Service} \right)$$

$$\text{Escalator MTBF} = \left(\frac{\sum Escalators\_Operational\_Hours}{\sum Escalator\_Failure\_in\_Service} \right)$$

- **Restoration of Elevator Service after Emergency Shut-down - Goal: 10 minutes**

  The Elevators Restoration Level-of-Service (LOS) establishes a minimum required restoration time to operations personnel once the emergency has been addressed.

- **Station Trash Receptacles - Goal: none overflowing**

  The Station Trash Receptacle Level-of-Service (LOS) establishes a requirement for cleaning personnel at stations.

Infrastructure Assets KPIs

- **Infrastructure PM (IPM) – Goal: 100%**

  The Infrastructure PM compliance measures ACI-Herzog adherence to the guideway elements Preventive Maintenance and inspections programs described in the maintenance plans on each asset group. It is measured in a similar way to the Facilities and Station PM Compliance discussed in section previously. TPM is evaluated through the amount of missed or late PM WOs and it is measured jointly with Systems and Facilities PM WOs.

  The IMC examines the number of PM's scheduled WOs completed on time compared to the total number of scheduled PM's WO. The results are expressed as a percentage. SPMC is evaluated on a monthly and yearly basis using the following equation:

$$IPM = \left(\frac{\sum Scheduled\_PM - \sum Late\_PM}{\sum Scheduled\_PM} \right) \times 100$$

  The Infrastructure PM Compliance is evaluated as the percentage of missed or late PM WOs. This metric is measured jointly with Facilities and Track PM WOs.

- **AFC System Mean Transactions between Failures – Turnstiles Goal: 20,000 Transactions; TVM Goal: 8,000 Transactions**

  The AFC Mean Transactions between Failures is a measure of the reliability of Tren Urbano Entrance Turnstiles and Fare Vending Machine systems. It is measured as the mean number of transactions between AFC equipment's failures. A failure is equipment malfunction that caused a TVM or turnstile to be out of service. For the purposes of calculating the metric for turnstiles, a recordable failure event is a failure that completely disables the turnstile functionality, such that it cannot be used for station entry and exit. If the turnstile is operating in a degraded service mode and can be used for entry or exit, it will be considered as in service and the failure will not count for MTBF metric. Similarly for TVMs, a recordable failure is an event that completely disables the Ticket Vending Machine's (TVM) functionality to sell and recharge tickets. If the TVM is operating in a degraded service mode, it will be considered as in service and the failure will not count for the metric.

  The Fare Vending Machine and Entrance Turnstiles mean transaction between failures metrics are measured on a monthly and yearly basis using the following equations:

$$\text{TVM MTBF} = \left(\frac{\sum Fare\_Vending\_Machine\_Transactions}{\sum Fare\_Vending\_Machine\_Failure\_in\_Service} \right)$$

$$\text{Turnstile MTBF} = \left(\frac{\sum Entrance\_Turnstiles\_Transactions}{\sum Entrance\_Tursnstile\_Failure\_in\_Service} \right)$$

8.6 End Customer Performance Measures

Passenger comfort and perception is an important part for evaluation of service and asset performance and compliance with mission statement and objectives. Users' metrics provide insight on how passengers perceive the quality of service received, the maintenance or condition of assets and operative aspects of the Urban Train. The users' perception is measured with Users Level of Satisfaction Surveys. Surveys are performed on a triennial basis or at the request of ACI-Herzog General Manager.

- **Passenger Load - Peak Hour Goal: 0.40 m2 per passenger (2.5 passengers per m2)**

  Passenger Load Level-of-Service (LOS) measures transit occupancy. This service capacity metric provides reference to service frequency, service span, reliability and travel time useful for determination of offer versus demand adequacy.

  Passenger load for vehicles is based on vehicle passengers standing and is categorized in 6 QoS levels:

  - > 1.0 m2 per passenger
  - 0.5 to 1.0 m2 per passenger
  - 0.4 to 0.49 m2 per passenger
  - 0.3 to 0.39 m2 per passenger
  - 0.2 to 0.29 m2 per passenger
  - < 0.2 m2 per passenger

  Passenger Load is measured using peak hour service parameters and the following equations:

$$PassengerLoad = \left(\frac{\sum S\tan ding\_Passenger\_Area}{\sum Peak\_Occupation - Total\_Seats} \right)$$, where

$$S\tan dingPassengerArea = \left(\frac{60}{Headway} \right) \times \frac{TotalCars}{Trains} \times AreaforS\tan dingPassenges$$

$$TotalSeats = \left(\frac{60}{Headway} \right) \times \frac{TotalCars}{Trains} \times SeatsPerCar$$

- **Users Characteristics**

These indicators summarize several characteristics of the Tren Urbano users that provide an idea of who is using the Tren Urbano. This metric includes at minimum the following parameters:

- User gender and age
- Users personal car ownership
- Fare Plan usage
- Which mode of transportation used the person to arrive to the Tren Urbano
- Trip purpose
- Travel frequency
- Reasons to use the Tren Urbano

- **Level of Satisfaction**

  The Level of Satisfaction LOS indicates how satisfied the users are with received services. These metrics evaluate the users experience with the system. The level of satisfaction is measured by interviews where the users rate the evaluated parameters as Excellent, Good, Average or Deficient. This metric includes at minimum the following parameters:

  - Overall Travel experience
  - Coordination with other transit modes
  - On-time performance and reliability
  - TU personnel appearance and availability
  - Treatment of employee to users
  - System safety and security
  - Concessions at the Stations
  - Stations entries and accessibility
  - Information availability
  - Station cleaning
  - Stations parking facilities
  - Signage and notices at TU vehicles
  - Vehicles Cleaning
  - Vehicle comfort

- **Net Promoter Score (NPS)**

  The NPS LOS is a customer loyalty metric developed and a registered trademark of Fred Reichheld, Bain & Company, and Satmetrix. The metric results from the user's answer to the following question: "In a scale of 0 to 10, would you recommend the Tren Urbano to a family or a Friend?" allows the operator to take a quick measurement of customers feeling and attitudes.

  To estimate the NPS, the answers to the question were categorized in the following three groups:

- Promoters: Users who answered 10 or 9 to the question; the promoters are loyal enthusiasts customers who will keep using the service and refer it others, fueling growth.
- Passives: Users who answered 8 or 7 to the question, they are satisfied but unenthusiastic customers.
- Detractors: Users who answered 6 to 0 to the question;. They are unhappy customers who can damage the brand and impede growth through negative word-of-mouth

The Net Promoter Score™ is calculated by subtracting the percentage of Detractors from the percentage of Promoters.

- **Intermodal Mobility**

As part of the gap analysis for Tren Urbano and its feeders, one of the opportunities identified is the definition of a KPI and development of a baseline goal for intermodal mobility through the measurements of train-to-bus and bus-to-train transfer time.

ACI-Herzog recommends performing these measures upon completion of the AFC System Upgrade. The train-bus average transfer time can be determined by correlating passenger card usage, train exit time and bus boarding data for transfers (card number, bus route and time). The bus-train average transfer time can be determined by correlating bus GPS data (arrival time), bus and train passenger card usage, train entry time and train departure time data (analysis of train direction for each card is required) for transfers.

Appendix 4 – Project Prioritization List