

**Module 2B:
Bus and Rail Operations & Maintenance**

BUS AND RAIL OPERATIONS & MAINTENANCE

Introduction

The Transit Finance Learning Exchange (TFLEx) – created and run by your transit finance colleagues – exists as a strategic alliance of transit agencies. TFLEx has developed a body of reference material (“TFLEx Guide for Transit Newbies”) to educate finance staff in the field of transit without extensive costs. This coursework can be accessed at www.TFLEx.org.

Welcome to Module 2B: Bus and Rail Operations & Maintenance

This module will give you an overview of bus and rail operations and maintenance activities

After completing this module, you will be able to:

- Identify the pros and cons of organizational structure decisions
- Discuss the major Transportation functions
- Define the different categories of maintenance

Additional Information

Field of Study:	Finance
Prerequisites:	Module 2A – Bus and Rail Planning & Scheduling
Advanced Preparation:	None
Program Level:	Basic Delivery Method: QAS Self-study
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CPE Credits

TFLEx members will earn 1.0 CPE credit upon successfully completing a knowledge test (qualified assessment) for this module (Bus and Rail Operations & Maintenance).

Upon gaining an understanding of the material in this work and completing the review questions, contact Joe Costello, TFLEx Executive Director, at CostelloConsultingCorporation@gmail.com. He will provide you with a final knowledge test. You will have 30 days to send your answers to Mr. Costello. Upon answering at least 70% of these questions correctly, you will receive a certificate of completion for the 1.0 CPE credit, as well as evaluative feedback.

Not a member of TFLEx? Please reach out to Joe Costello, TFLEx Executive Director, at CostelloConsultingCorporation@gmail.com to find out how your agency can join. We encourage you to do so. We know you would get great value in being part of this organization!

About TFLEx

The Transit Finance Learning Exchange was founded in 1999 by a number of transit agencies and continues to be run by your transit agency colleagues.

TFLEx offers semi-annual workshops, Forum and Special Interest Group Calls, training and professional development, comparative metrics, and, of course, invaluable networking. Of note, TFLEx members meet twice annually to explore topics of mutual interest, share relevant experiences, and develop best practices. These are facilitated workshops where all attendees participate in the discussions. As TFLEx is run by your transit finance colleagues, the workshops offer an opportunity for further follow up at the next workshop and Forum and SIG (special interest group) calls – Zoom calls on topics of interest held between workshops. The workshops and calls provide continuing education credits.

Visit www.tflex.org for more information and dates of upcoming calls and workshops.

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OVERVIEW

This section discusses the heart and soul of large transit agencies – Bus and Rail Operations & Maintenance. Operations and Maintenance work hand-in-hand to deliver comfortable, safe, reliable, timely transportation services within the service area of the transit agency. Transit agencies may provide services beyond bus and rail such as demand response (including paratransit), ferry or cable car services. In fact, approximately five times as many organizations provide demand response services compared to the number that provide fixed route services. Despite this, bus and rail form the backbone of transit service in major urban areas.

But before you can operate the service, you have to plan it and schedule it. If you have not already done so, please read Module 2A – Bus and Rail Planning and Scheduling.

The Organizational Structure section discusses the hierarchy of transit agency operations and the pros and cons based on whether they are primarily organized by mode or by function.

The Bus and Rail Operations (Transportation) section of this module deals with the following areas:

- Labor/Workforce Management
- Yard and Fleet Management
- Dispatch
- Field Operations

The Bus and Rail Maintenance section will discuss these areas:

- Asset Classification
- Maintenance Processes
- Transit Asset Management

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ORGANIZATIONAL STRUCTURE

Before we start discussing operations and maintenance in additional depth, let's take a moment to discuss organizational structure.

Some transit agencies organize their operations primarily by mode – bus operations and maintenance report through a single organization and rail operations and maintenance report along a separate structure. Some of the agencies that are organized modally include:

- Washington Metropolitan Area Transit Authority (WMATA) – Washington, DC
- Southeastern Pennsylvania Transportation Authority (SEPTA) – Philadelphia, PA
- Massachusetts Bay Transportation Authority (MBTA) – Boston, MA

Other agencies are primarily organized along functional lines, with both bus operations and rail operations contained within a single department (often called “Transportation” or similar) and bus and rail maintenance in a maintenance department. Some of the agencies that are organized functionally include:

- Los Angeles County Metropolitan Transportation Authority (LA Metro)
- Metropolitan Transit Authority of Harris County (Houston METRO)
- Sound Transit – Seattle, WA

Both structures have their advocates and their detractors, and there are real advantages and disadvantages to each structure.

Modal Alignment Structure

While both bus and rail service are delivered by a driver operating a vehicle, they are radically different services. Rail service operates on a guideway that is usually mostly separated from other vehicle traffic. They have complicated systems & signals and unique right-of-way maintenance. Plus, rail operators generally have limited interactions with passengers.

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Conversely, bus operators deal with regular traffic issues, just like you and me. Vehicles are relatively simple (to the degree that ANY vehicle today can be considered simple with all of the technology on board) compared to rail vehicles. Right-of-Way is public and generally the responsibility of the state or municipality. And a bus operator is the face of the agency for most transit customers. Managing that customer interaction is very important.

To the modal thinkers, accountability is king. If there are service issues, the problem falls to one department. And whether the problem is operations, maintenance, or a combination of both, there is one department, one single chain of command, charged with fixing it. This eliminates some of the finger-pointing that can happen sometimes in a functional organization. And a modal organization is more likely to be able to produce a faster, more coordinated response to service issues affecting one of those modes as they arise.

One major disadvantage of the modal organization centers around internal promotions. The level of specialized knowledge to each mode is significant. Often when there is a transition in leadership and someone is promoted from within, they have come from the bus side or the rail side and may have a bias for or against one of those modes, or may not immediately have the expertise needed to effectively manage the other mode.

Functional Alignment Structure

The primary advantages of using a functional alignment are employee management and efficiency.

Yes, bus and rail operators have different (but similar) job duties. Yes, maintaining a bus and maintaining a rail vehicle are very different things. But it boils down to that core functionality. There are issues that are common to operators, regardless of mode, such as:

- Schedule adherence/complaints about unrealistic schedules
- Poor shifts for low seniority employees (split shifts, late nights/weekends, dangerous areas of the city, etc.)
- Safety/security concerns in dealing with the public
- Operator complaints about management not knowing what it's like 'on the road'
- Equipment malfunctions
- High absenteeism

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And, like operators, bus mechanics are also dealing with similar issues to rail mechanics:

- Chronic understaffing
- Reduced budgets resulting in deferred maintenance without allowance for its effect on vehicle availability and reliability
- Parts/supply chain issues
- Constant training as equipment and technology becomes obsolete and new technology takes its place

Transportation management understands operator issues better. Maintenance management understands the issues mechanics face better.

Another primary benefit of a functional organization is efficiency. Modal organizations often have a lot more duplication of overhead and other responsibilities than agencies that are managed along functional lines. Areas like training, inventory management, operational safety may be duplicated in each mode.

Also, employee performance and behavior issues may be handled very differently in modal agencies, leading to complaints of inconsistent treatment among similar classes of employees. There is less complaining among the rank and file if all employees are treated the same.

Coordination for major events involving both modes and other cross-functional coordination will likely be better in an agency that is organized by function.

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Review Questions

1. Which of the following is an advantage of Modal alignment?
 - a. A single chain of command
 - b. Efficiency
 - c. Consistent treatment of employees
 - d. Location
2. Which of the following is an advantage of Functional alignment?
 - a. A single chain of command
 - b. Accountability
 - c. Consistent treatment of employees
 - d. A more coordinated response to service issues
3. Which of the following major transit systems is organized along functional lines (Transportation and Maintenance divisions as opposed to Bus and Rail divisions)?
 - a. MBTA (Boston)
 - b. WMATA (Washington DC)
 - c. Sound Transit (Seattle)
 - d. SEPTA (Philadelphia)

Answers

1. The correct answer is A. Having one department over all facets of a single mode enhances accountability and reduces finger-pointing.
2. The correct answer is C. Functional alignment has greater employee management consistency regardless of mode.
3. The correct answer is C. The other three transit authorities are specifically noted as being organized by mode.

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BUS AND RAIL OPERATIONS (Transportation)

Bus and rail operations form the backbone of public transportation systems around the world, moving billions of passengers annually. While passengers often experience transit as a simple matter of waiting, boarding, and alighting, the underlying operational systems are complex, data-driven, safety-critical enterprises that require meticulous planning, coordination, and continuous improvement.

Transportation operations are the public face of the service. The operator, and occasionally the field supervision or security personnel, represent the organization to the transit user. This section will take a look at the major components of the transportation services function.

Labor/Workforce Management

In most major US transit systems, labor (including benefits) makes up 65%-75% of total operating expenses. Inside the budget of a Transportation department, that figure can be as high as 99% labor.

In agencies where that percentage is lower, it's likely that they have a higher percentage of purchased transportation. But if you were to be able to look at a consolidated budget in which the purchased transportation cost was also broken down into labor, benefits, materials & supplies, etc. and merged with the agency's own budget, you'd find that the labor percentages returned to those higher percentages.

Workforce management in bus and rail transit is one of the most structurally important — and operationally difficult — functions inside a transit agency. The reliability of service delivery is directly tied to whether enough qualified employees are available to operate, maintain, and supervise service every day. Unlike many industries, Transit operations are not just 8 AM to 5 PM, five days a week. Transit must deliver service continuously across early mornings, late nights, weekends, and holidays. And they must do so within highly structured union environments and strict safety regulations. As a result, workforce management is not simply an HR function; it is an operational control system that determines whether service actually runs.

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Large agencies such as the Metropolitan Transportation Authority, the Chicago Transit Authority, and the Los Angeles County Metropolitan Transportation Authority illustrate the scale of the challenge. These organizations employ tens of thousands of workers across operations, maintenance, supervision, and support functions. Small shifts in workforce stability can translate into large swings in service reliability and budget performance.

Keeping sufficient numbers of trained bus and rail operators is quite the challenge. The transportation function is constantly being squeezed by multiple factors:

Turnover – The government sector, including public transit generally has a low turnover rate as compared to the general economy. According to Bureau of Labor Statistics data, the average turnover averaged 45% annually between 2021 and 2023. Of nine industry classifications, Government turnover was by far the lowest at 19%, with Financial Activities classification a distant second at 29%.

Bus and rail operators do not follow the trends as the rest of government employees when it comes to turnover. 30%, 40%, even 50% of operators hired may not see their first anniversary in those jobs. Reasons for the high early-tenure turnover rates include:

- Training washouts – workers unable to obtain a commercial driver's license or their inability operate a vehicle consistently and safely.
- Unfavorable shift assignments – In the ranks of bus and rail operators, seniority rules. Every three - six months, operators participate in what is commonly called the 'Mark-up' process. They essentially get to choose the shift assignment they will operate until the next mark-up. The mark-up is done in seniority order so new operators are often stuck with the worst shifts. Shifts with lower hours or less overtime (therefore lower pay), split shifts (discussed in module 2A – Bus and Rail Planning and Scheduling), late nights, weekends, undesirable neighborhoods, etc. Being stuck with the worst shifts for a few mark-up periods can be very disruptive to someone's life and be very discouraging. Many people may not be able to make it work, given their other life responsibilities (family, childcare, etc.).
- Retirements/aging of the population – In 1980, the median age of the US population was 30.0 years. By the year 2000, it had risen to 35.3 years and by 2024, the median age was 39.1 years. This increase in median age is a reflection of the 'swell' of the Baby Boomers (babies born between 1946 and 1964) moving through their adult years and reaching retirement age.

However, those operators who can make it through the first few turbulent years, often settle in for long-term, perhaps even lifetime employment in transit.

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Recruitment and Hiring – The pool of the population that transit agencies have to choose from is shrinking. Compounding the issue of escalating retirements discussed above, these workers are not being replaced in the population. Birth rates in the 1980s and 1990s were between 15.1-15.9 births per 1,000 people. This has dropped by more than 25% in the last 25 years and currently stands at approximately 11 per 1,000 during the 2020s.

Training Capacity Limits – Even if an agency could hire all of the operators they need, there is a limit to the number that can be trained at any given time. Limits of equipment and training staff all restrict the number of new operators that can be processed through that pipeline in a short timeframe.

Budget Constraints – This is a constant wall of resistance, particularly in government organizations. When revenues fall short of expectation and cuts are made, Transportation departments usually have nothing to cut. As mentioned above, the budget of the Transportation is made up almost entirely of labor. Cut the budget, you must cut the number of operators which means you must cut service. There aren't a lot of economies of scale that can be found to deal with budget cuts here. It still takes one operator one hour of time to operate one hour of revenue service. Is it possible that some minor scheduling efficiencies could be found (a little less overtime, minor savings from transfers, or recovery time, etc.), but the Planning and Scheduling groups are always trying to squeeze a few more drops of efficiency every time they create a new run cut so the chances of major savings there are unlikely.

High Absenteeism – High absenteeism among operators is driven by a combination of factors such as:

- Irregular and fatiguing work schedules – long shifts, early morning or late nights, constantly rotating assignments on the extraboard, etc.
- Stress and Working Conditions – passenger conflict, constant traffic/road stress, tight running times, inability to use restrooms as needed, enforced overtime, burnout, etc.
- Health factors – both bus and rail operators spend long hours in their vehicles with no option of standing or moving around. This can lead to multiple maladies including lower back pain, neck strain, shoulder and wrist stress injuries

An acute issue in any of the areas above puts increased stress on the labor force, exacerbating any weaknesses in the labor supply chain. Chronic labor shortages lead to

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more overtime, which leads to increased burnout which in turn leads to increased absenteeism and the problems can snowball.

Yard and Fleet Management

Public transportation yard and fleet management functions sit behind what the public sees in service. While riders experience service through vehicles on the street or on the tracks, the reliability, safety, and cost-effectiveness of that service are largely determined inside yards, depots, garages, and rail maintenance facilities. These locations serve as the logistical hubs where vehicles are stored, inspected, repaired, dispatched, cleaned, fueled or charged, and prepared for daily service.

Yard management ensures that the correct number of vehicles are ready for daily pullout. For bus systems, this means aligning fleet availability with the scheduled number of blocks or runs. Working in concert with dispatchers and maintenance supervisors, they coordinate to release buses that have passed required inspections and are free of safety defects and have them properly aligned prior to the start of service. Rail yards perform a similar function, assembling train consists, conducting brake tests, and verifying signal and propulsion systems before trains enter mainline service. Vehicles need to be aligned correctly for pullout, so the right bus is ready for the right operator at the right time, and not blocked in by other vehicles. The precision of this process directly affects on-time departures at the start of service, which sets the tone for the rest of the day.

Yard management functions also include fueling, charging, and energy management functions. Traditional diesel yards manage fuel storage, environmental compliance, and consumption tracking. With the expansion of electric buses and electrified rail systems, yards must also manage charging infrastructure, power demand, battery health monitoring, and coordination with utility providers. Precise management of charging and fueling schedules must align with service assignments and vehicle availability to ensure vehicles have sufficient range to complete their daily runs.

Vehicle assignment and block allocation connect yard functions to service planning. Fleet managers must ensure the right vehicles, in terms of capacity, accessibility, grade requirements, and range limitations, are assigned to the right runs and aligned to pull out on time and in the proper sequence. Rail systems may need to assign specific trainsets based on platform lengths or signaling compatibility. Special events, weather forecasts, and construction projects further complicate daily allocation decisions.

There is also a revenue function tied to yard operations which includes farebox probing and revenue handling. In bus systems, fareboxes are electronically “probed” or

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downloaded at the end of service to extract transaction data, verify fare media performance, and reconcile cash totals. Cash is removed under controlled procedures, counted, secured, and transported according to strict chain-of-custody protocols to

reduce loss risk. Rail systems follow similar processes through station vaults or fare collection rooms, where revenue data and physical currency are reconciled to ridership reports. Accurate revenue handling supports financial integrity, fraud prevention, and performance analysis across the system.

Finally, yard safety and compliance are constant concerns. Facilities must adhere to occupational safety regulations, environmental standards, and federal transit oversight requirements. Safe movement of vehicles within confined yard spaces, proper lockout procedures for high-voltage systems, and hazardous material handling protocols are integral to daily operations.

In summary, yard and fleet management functions provide the internal logistics required to set up each day's service for success.

Dispatch

Bus and rail dispatch are the real-time control centers of public transportation systems. While schedules define intended service, dispatch ensures that service actually operates as planned — and adapts when it does not. Dispatchers monitor vehicle movement, manage operator assignments, respond to changing field conditions, and intervene to maintain reliability, safety, and service continuity. In both bus and rail operations, dispatch represents the bridge between the service that is planned and the service that is executed.

In bus systems, dispatch typically occurs within an operations control center linked to computer-aided dispatch and automatic vehicle location (CAD/AVL) systems. These platforms display real-time vehicle positions, schedule adherence, headway spacing, and operator status. Dispatchers monitor on-time performance and identify emerging problems such as traffic congestion, bus bunching, missed pullouts, operator call-outs, etc. When disruptions occur, they may instruct operators to hold at timepoints, short-turn to restore headways, deadhead to cover a gap, or swap vehicles if mechanical issues arise. Because buses operate in mixed traffic, dispatch must constantly react to external conditions such as accidents, weather, road closures, etc. Communication is continuous,

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typically through radio and digital messaging systems, and decisions must balance schedule recovery with customer impact.

Operator management is also a core bus dispatch function. When an operator calls out sick, dispatch must identify a replacement, usually from the extraboard (see Module 2A). If no spare operator is available, a trip cancellation decision may be required. Dispatchers coordinate with supervisors in the field to verify relief points, confirm operator check-ins, and ensure compliance with hours-of-service rules. In systems with large workforces, these decisions occur dozens of times per shift. Effective dispatch depends not only on technology but also on institutional knowledge. Experienced dispatchers understand route characteristics, congestion patterns, and operator performance tendencies.

Rail dispatch functions are structurally similar but technically distinct due to the controlled right-of-way and safety-critical signaling environment. Rail operations control centers monitor train locations through signaling systems and track circuits rather than GPS alone. Dispatchers regulate train spacing, manage interlockings and switches, and maintain safe separation between train movements. Unlike bus operations, rail dispatch decisions often have system-wide implications. You can't reroute a train to the next street over to avoid a traffic jam. And because lines are interdependent any service slowdown or interruption can cascade quickly across the entire service. A single stalled train at a key junction may affect multiple branches within minutes.

Both bus and rail dispatch increasingly rely on data analytics. Real-time dashboards display performance metrics, while predictive tools estimate arrival times and passenger loads. Some agencies use headway-based management strategies rather than strict schedule adherence on high-frequency routes. Dispatchers must therefore make judgment calls about whether to prioritize even spacing or terminal on-time departures.

Ultimately, dispatch is the operational nerve center of transit service. It integrates workforce availability, vehicle condition, infrastructure status, and external conditions that affect service into minute-by-minute decisions. When functioning effectively, dispatch mitigates disruption, stabilizes service, and enhances safety. When understaffed or technologically limited, small problems can escalate into widespread delays.

Field Operations

As you might infer from the name, field operations are personnel that are the active, field-level operations management layer. Field operations place supervisory personnel directly in the operating environment to observe, intervene, and support the service and the operators in real time. This function is especially critical in large bus and rail networks

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where dynamic conditions can quickly degrade schedule adherence and passenger experience.

Field supervision typically consists of road supervisors, transit center/rail station supervisors, and mobile operations managers deployed strategically across the network.

In bus systems, road supervisors are assigned geographic territories or major corridors and are equipped with vehicles, communication tools, and access to real-time performance data. Their role is to monitor headways, verify operator compliance with route instructions, assist with service adjustments directed by dispatch, and provide on-scene management during service disruptions. They function as a bridge between dispatch and the operators. They may implement short turns, direct bus bridging during rail interruptions, manage detours around construction, or physically space buses to prevent bunching. Because buses operate in mixed traffic, field supervisors often serve as the immediate response mechanism when congestion, special events, or unexpected ridership surges occur.

Transit center supervision adds another layer of coordination, particularly in systems with timed-transfer hubs. Supervisors stationed at major terminals oversee vehicle arrivals and departures to preserve connection reliability. They may hold a bus briefly to protect a key transfer or coordinate platform assignments to minimize passenger confusion. In high-volume facilities, transit center supervisors also manage bay assignments, staging areas, and layover utilization to prevent operational conflicts. Effective terminal supervision reduces cascading delays and improves the consistency of passenger transfers across routes. They may also answer customer questions, assist them in understanding and paying for the proper fare via TVMs (ticket vending machines) or the transit agency's fare payment app.

In rail systems, field operations may include line controllers, yardmasters outside the control center environment, and terminal supervisors responsible for platform management and train turnarounds. These supervisors ensure that train crews are properly positioned, that consists are assembled as planned, and that terminal dwell times remain within acceptable limits. Because rail networks are less flexible than bus systems, field supervision often focuses on maintaining flow through key junctions and ensuring that schedule adjustments authorized by rail dispatch are executed correctly at the ground level.

Another major component of field operations is performance monitoring and data validation. Supervisors verify automated performance reports by observing actual conditions in the field. For example, automated systems may flag early departures or missed stops, but field personnel can provide context and correct data discrepancies.

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This feedback loop improves the accuracy of performance metrics and informs schedule adjustments in future service changes.

Field operations also encompass operator support and workforce coordination during daily service. Supervisors may deliver relief operators to disabled vehicles, coordinate vehicle swaps when mechanical issues arise, or assist with operator check-ins at relief points.

Beyond supervision and transit center management, additional components of field operations may include special event coordination, service quality auditing, construction and detour planning support, and real-time passenger communication coordination.

Overall, field operations provide the tactical flexibility that allows transit agencies to dynamically adjust to changing conditions. Without this distributed supervisory presence, centralized dispatch would struggle to implement corrective actions effectively. Field supervision, transit center oversight, and real-time operational support together form the practical execution arm of daily transit service delivery.

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Review Questions

1. Which of the following is NOT one of the areas discussed in this section?
 - a. Dispatch
 - b. Yard and fleet management
 - c. Transportation administration
 - d. Labor/workforce management
2. Dispatch uses which of the following tools in the performance of their duties?
 - a. CAD/AVL
 - b. Human Resources Portal
 - c. Runcutting software
 - d. FIFO Inventory Management System
3. Field Operations personnel include all but which of the following?
 - a. Road supervisors
 - b. Station office personnel
 - c. Mobile operations managers
 - d. Transit center supervisors

Answers

1. The correct answer is C. Transit administration is not discussed in the section.
2. The correct answer is A. Dispatch uses CAD/AVL systems.
3. The correct answer is B. Station office personnel are not included in field operations.

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BUS AND RAIL MAINTENANCE

Public transit systems depend on the continuous and reliable performance of a vast fleet of buses, rail cars, support vehicles, and associated infrastructure. The ability of a transit agency to deliver safe, frequent, and dependable service hinges on the health of its assets. Vehicles must be ready to leave the operating facility each morning, maintenance facilities must be equipped and staffed to handle both routine servicing and unexpected failures, and infrastructure must be monitored and repaired to prevent disruptions. Maintenance is therefore one of the most critical components of public transit operations. While passengers and policymakers often focus on service frequency, vehicle appearance, or customer amenities, the beneath-the-surface world of maintenance determines how well the service functions, or if it even functions at all. Stated another way, scheduling determines what service should run, operations determine what service will run, maintenance determines whether the service can run.

Proper maintenance ensures that vehicles remain mechanically sound, facilities remain safe and functional, and both bus and rail operations meet regulatory standards, minimize asset downtime, and control long-term costs.

From the previous module (Module 2A – Bus and Rail Planning & Scheduling), it was shown that maintenance, in their responsibilities for the factors of comfort, cleanliness and vehicle reliability, is one of the three critical transit success factors.

ASSET CLASSIFICATION

Maintenance is usually split into two primary asset categories – vehicle maintenance and non-vehicle maintenance, and two maintenance processes – preventive and corrective maintenance.

Transit vehicle maintenance, as defined by the National Transit Database (NTD), refers only to maintenance of revenue vehicles. Maintenance of non-revenue vehicles such as police vehicles, mobile equipment (e.g. tow-trucks, utility vans, hi-rail vehicles, bucket trucks, forklifts, etc.), supervisor's vehicles, pool cars, etc. is considered non-vehicle maintenance for National Transit Database (NTD) reporting purposes.

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Non-vehicle maintenance is maintenance on all physical assets that are not classified as revenue vehicles, such as:

- Equipment
 - Non-revenue vehicles,
 - Maintenance equipment above a certain value
- Ways, Structures and Amenities
 - “Ways” includes maintenance of property and rights-of-way, including rail tracks systems and signals
 - “Structures” includes maintenance of buildings (administrative, operating and maintenance facilities, etc.)
 - “Amenities” includes passenger facilities such as rail stations, transit centers, bus shelters, etc.

The goal of maintenance, both vehicle and non-vehicle maintenance, is to ensure that an asset remains in good working order and is able to perform its function satisfactorily for a term no less than that asset’s expected life.

Maintenance departments are usually organized into functional units based on asset type and skill specialization. Bus and rail maintenance are usually in separate divisions due to the specialized knowledge required for each mode.

A typical bus maintenance division includes mechanics, technicians, utility service workers, parts clerks, shop supervisors, quality assurance personnel, and personnel who specialize in HVAC systems, engines, transmissions, electrical systems, etc. Smaller agencies may employ generalist technicians capable of handling multiple disciplines because they may not have the manpower required to support each of these specialties.

Rail maintenance is even more of a specialized skill. Rail technicians must understand propulsion, braking, automatic train control systems, auxiliary power systems, HVAC, and door systems, among others. Track and wayside maintenance involve track inspectors, welders, power distribution staff, substation technicians, signal maintainers, and engineering supervisors.

The maintenance department in some transit agencies also contains the materials management function. In other agencies, it can be aligned under procurement or finance.

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Vehicle Maintenance

Transit fleets, whether composed of diesel buses, battery-electric buses, light rail vehicles or commuter rail locomotives, operate under demanding conditions. Vehicles accumulate mileage at a rapid pace. Some may run multiple hundreds of miles per day. They run for long hours, brake and accelerate more frequently than standard commercial vehicles, endure a wide range of weather conditions, and may navigate dense urban environments. They also endure a steady stream of passengers boarding and alighting that may or may not care about treating the vehicle respectfully. They may spill food or drinks. They may vandalize or otherwise damage the vehicle, either intentionally or unintentionally. For all of these reasons, maintaining vehicles presentable, and in good working order is not a simple thing. It is a constant process of preventive care, inspection, adjustment, repair and rehabilitation.

Vehicle maintenance includes routine, periodic, and unscheduled work performed on buses, light rail vehicles (LRVs), heavy rail cars, commuter trains, paratransit vehicles, and other revenue vehicles. It is typically divided into categories such as:

- Daily inspections and servicing (e.g., pre-trip and post-trip checks, fluid top-offs, visual safety inspections)
- Preventive maintenance (PM) at prescribed intervals
- Condition-based maintenance (CBM) when an inspection reveals a component may be nearing end-of-life
- Corrective maintenance when failures occur
- Overhaul and mid-life rehabilitation programs for major systems (engines, transmissions, traction motors, doors, HVAC, etc.)

Mechanics and technicians in vehicle maintenance work on propulsion systems, brakes, suspension, steering and chassis components, electrical systems, HVAC, accessibility devices (e.g., wheelchair lifts or ramps), couplers and articulation joints, and many other subsystems. Heavy transit vehicles are complex machines with thousands of parts, integrated control systems, and safety-critical functions. In rail systems, this includes not only the vehicle propulsion and trainline subsystems, but also wheelsets, trucks, pantographs or third-rail collector shoes, onboard safety systems, and passenger environment systems.

Vehicle maintenance is labor-intensive and must be highly organized. Agencies typically have separate shops for light work (e.g., daily PM, filter changes, brake inspections) and

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heavy work (e.g., engine rebuilds, transmission replacement). Scheduling of maintenance is directly tied to the service plan. The allowance for spare vehicles (discussed in module 2A) allows for vehicles to be out of service for maintenance without impacting service levels.

Non-Vehicle Maintenance

Non-vehicle maintenance covers the physical infrastructure that supports transit operations. This includes:

- Track and right-of-way maintenance (rail alignment, rail welding, tamping, ballast work)
- Signal systems and interlocking maintenance
- Traction power systems (overhead catenary, third rail, substations)
- Yard and shop facilities (buildings, pits, hoists, lifts, fueling and charging systems)
- Stations and platforms
- Fare collection hardware
- Communications, dispatch, and control systems

In bus systems, non-vehicle maintenance includes the upkeep of bus garages, fueling stations, compressed natural gas (CNG) stations, electric charging infrastructure, bus stops and shelters, lift ramps, and more. Though often less visible than vehicle maintenance, these functions are critical. A poorly maintained signaling system can degrade rail headways and safety margins. A failing track can force speed restrictions or service suspensions. Faulty charging infrastructure can prevent electric buses from completing their duty cycles.

Non-vehicle maintenance tends to be more specialized and can require distinct trades (track workers, signal technicians, power electricians, communications engineers) who often are not interchangeable with vehicle mechanics. Planning this work requires coordination with operations so that outages or slow orders do not undermine revenue service.

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MAINTENANCE PROCESSES

Preventive Maintenance

Preventive maintenance refers to work performed regularly and systematically to reduce the likelihood of equipment failure. It is based on the understanding that components deteriorate over time or with use, and that orderly inspection and service prolong asset life and improve reliability. Examples of PM in transit include:

- Changing engine oil and filters every prescribed mileage interval
- Inspecting brake linings, pads, and rotors
- Checking HVAC filters and belts
- Exercising doors and inspecting seals
- Inspecting traction motors and gearboxes
- Replacing light bulbs and testing emergency systems

Vehicle preventive maintenance is often driven by manufacturer recommendations, safety mandates, and historical failure patterns. Agencies build PM intervals to ensure that parts are serviced before they fail in service. Intervals are usually expressed in miles, but they can also be based on hours of operation (which might be more appropriate for vehicles that experience a lot of dwell time, thus keeping mileage relatively low) or time. For example, a transit bus might receive a light PM every 3,000 miles, a more extensive PM at 12,000 miles, and a major inspection every 36,000 miles, but certain components may undergo PM once per year.

In infrastructure contexts, preventive maintenance includes items such as:

- Regular track inspection and rail grinding to prevent rail defects
- Testing and calibrating signals
- Lubricating switches
- Exercising breakers and protective relays in power substations
- Inspecting and cleaning drains in yards and tunnels

The core principle behind preventive maintenance is to maintain assets in a state of good repair, reduce unexpected failures, and optimize lifecycle costs. Though it consumes labor and resources on a regular basis, well-designed PM programs save money by avoiding the higher costs associated with emergency repairs and service disruptions.

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Condition-Based Maintenance

Part of the PM is done at each designated interval for that process. For a particular bus model, the PM might call for an oil change every 5,000 miles and that will be done at, or as close to that interval as possible. Other components may be inspected as a part of the PM, but not replaced if they are in good working order. So, rather than purely replacing it based on a certain time or mileage interval they are repaired or replaced when their condition indicates the need. This is condition-based maintenance (CBM). Different than corrective maintenance (discussed below), a failure of this component has not yet occurred however an inspection of it may indicate that component is nearing the end of its useful life and is replaced before any failure can occur. CBM leverages technology — sensors, onboard diagnostic systems, vehicle telematics, vibration analysis, thermal imaging, and more — to monitor the actual health of components. For example:

- A temperature sensor on a traction motor bearing indicates rising heat levels, signaling imminent wear
- Vibration data from a wheelset suggests a developing flat spot
- Battery health monitors report declining capacity in an electric bus
- Brake linings show thickness approaching failure thresholds before the scheduled interval

When these conditions are detected, maintenance is triggered. CBM can reduce unnecessary PM, redirect labor to where it is most needed, and catch potential failures before they become service disruptions.

Corrective Maintenance

Corrective maintenance occurs after a fault or failure is detected. It involves repairing or replacement of a failed component or system. Corrective maintenance can range from minor fixes — such as replacing a broken light or repairing a malfunctioning door — to major repairs such as rebuilding a traction motor or replacing a section of rail that has cracked.

Corrective work is inherently reactive, and while agencies do their best to anticipate failures through PM, corrective maintenance will always exist because not all failures can be predicted. Corrective maintenance work may be initiated in several ways:

- A vehicle is pulled out of service due to a defect found during pre-trip inspection
- A road call occurs when a bus or train experiences a fault in service
- Infra-red or vibration analysis identifies a bearing hotspot that requires intervention

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- A safety system fault is logged by onboard diagnostics

In many agencies, corrective maintenance processes are prioritized so that safety-critical defects are addressed immediately, while less urgent items are scheduled into the maintenance queue. Triage is important because resources are finite and not all corrective tasks carry the same operational risk.

Maintenance organizations strive to balance preventive and corrective work such that corrective labor is minimized without overspending on preventive tasks that provide little incremental benefit. Too much reactive maintenance indicates that PM is insufficient; too much PM can waste resources on replacing components that still had remaining useful life. And the cost of those wasted resources includes both the cost of the replacement part and the labor to install it.

Overhaul and Mid-Life Rehabilitation

Overhaul and mid-life rehabilitation refer to major rebuilding efforts undertaken roughly halfway through an asset's expected service life to restore performance, reliability, safety, and passenger comfort. Unlike routine preventive or corrective maintenance, mid-life work is comprehensive and often involves removing vehicles from service for extended periods. The goal is not merely to fix defects, but to reset the asset's lifecycle and defer full replacement and the associated cost.

For transit buses, mid-life rehabilitation—often occurring around year 6 to 8 of a 12-year federally defined useful life in the United States—may include engine rebuilds or replacements, transmission overhauls, structural corrosion repair, suspension renewal, HVAC replacement, electrical system upgrades, repainting, and interior refurbishment. Increasingly, agencies also retrofit technology upgrades such as improved telematics, camera systems, or updated fare equipment during this phase.

Rail vehicles typically undergo mid-life overhaul between 15 and 20 years of service, depending on fleet design. Work may include truck (wheel assembly) rebuilding, traction motor overhaul, propulsion system modernization, door mechanism replacement, interior modernization, and control system upgrades.

Mid-life rehabilitation is capital-intensive but significantly less expensive than procuring new vehicles. It also reduces operational risk by improving mean distance between failures (MDBF), enhancing safety systems, and addressing wear-related structural and cosmetic issues. When properly timed and executed, overhaul programs stabilize fleet performance and allow agencies to align vehicle replacement with long-term capital funding cycles.

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Capital Renewal and State of Good Repair (SGR)

Capital renewal, often described under the broader concept of “State of Good Repair” (SGR), involves large-scale replacement or reconstruction of major infrastructure and systems that have reached the end of their useful life. While overhaul focuses primarily on individual vehicles, capital renewal typically addresses network-level assets such as track, signals, power systems, bridges, stations, and maintenance facilities.

State of Good Repair is both a technical and policy concept. Technically, it means assets are functioning as designed, within acceptable reliability thresholds, and not subject to excessive failure risk. From a governance perspective, SGR programs prioritize investments to reduce deferred maintenance backlogs and prevent catastrophic failures.

Rail systems are particularly capital-intensive due to their fixed guideway infrastructure. Signal modernization projects, for example, may replace decades-old fixed-block systems with communications-based train control (CBTC) technology to increase reliability and capacity. New York City Transit has invested billions in capital programs to replace aging signals, track, and power systems as part of its effort to address historical underinvestment.

In bus systems, capital renewal may involve depot reconstruction, fueling or charging infrastructure upgrades, and facility modernization to accommodate zero-emission fleets.

Capital renewal differs from routine maintenance because it restores or replaces entire asset classes rather than individual components. Sustained investment in State of Good Repair programs directly affects operational reliability, safety, and long-term cost control, making it a cornerstone of effective transit system management.

TRANSIT ASSET MANAGEMENT

Over the past two decades, public transportation agencies have increasingly shifted from reactive maintenance practices toward a formalized Transit Asset Management (TAM) approach. This shift was driven by aging infrastructure, constrained funding, and growing recognition that deferred maintenance leads to escalating long-term costs and declining reliability. Rather than focusing solely on fixing failures as they occur, TAM emphasizes systematic lifecycle planning, risk assessment, performance monitoring, and capital prioritization.

In the United States, the rise of TAM was institutionalized through the Moving Ahead for Progress in the 21st Century Act (MAP-21) in 2012 and reinforced under the FAST Act

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(Fixing America's Surface Transportation Act) in 2015. These laws required transit agencies receiving federal funds to develop TAM plans that inventory assets, assess condition, define performance targets, and prioritize investments to achieve or maintain a State of Good Repair. The framework encourages agencies to evaluate assets—such as vehicles, facilities, track, signals, and equipment—based on condition ratings and useful life benchmarks rather than age alone.

A key mechanism for implementing TAM nationally is the National Transit Database (NTD), administered by the Federal Transit Administration. The NTD collects standardized data on asset inventories, condition assessments, and performance measures from transit providers across the country. Agencies report metrics such as the percentage of vehicles exceeding useful life benchmarks and the condition ratings of facilities and guideway elements.

This standardized reporting has several effects. It increases transparency, enables national benchmarking, supports federal funding allocation decisions, and encourages data-driven capital planning. By tying asset condition reporting to federal oversight, the TAM framework has shifted transit management culture toward proactive lifecycle management and long-term reliability planning.

Review Questions

1. Which of the following is NOT one of the areas discussed in this section?
 - a. Vehicle maintenance
 - b. System-level maintenance
 - c. Preventive maintenance (PM)
 - d. State of Good Repair (SGR)
2. Which of the following takes place after a component has failed?
 - a. Condition-based maintenance (CBM)
 - b. Corrective maintenance
 - c. Preventive maintenance (PM)
 - d. Overhaul and rehabilitation

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3. Which of the following pieces of legislation institutionalized Transit Asset Management?
 - a. Transportation Equity Act for the 21st Century (TEA-21)
 - b. Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)
 - c. Moving Ahead for Progress in the 21st Century Act (MAP-21)
 - d. Fixing America's Surface Transportation Act (FAST Act)
4. Condition-based maintenance:
 - a. Refers to work performed regularly and systematically to reduce the likelihood of equipment failure.
 - b. Involves repairing or replacement of a failed component or system
 - c. Replacing a component because an inspection of it may indicates it is nearing the end of its useful life.
 - d. Is another name for procuring a new vehicle.

Answers

1. The correct answer is B. System-level maintenance is not discussed in the section.
2. The correct answer is B. Corrective maintenance is the procedure used to describe replacement of parts that have failed.
3. The correct answer is C. CBM refers to an inspection of a component that indicates it nearing the end of its useful life and so replaced before any failure can occur.
4. The correct answer is C. MAP-21, passed in 2012 codified the use of Transit Asset Management Planning.

**Module 2B:
Bus and Rail Operations & Maintenance**

CONCLUSION

Congratulations! You have completed the **Bus and Rail Operations and Maintenance** module. You should now know how to:

- Identify the pros and cons of organizational structure decisions
- Discuss the major Transportation functions
- Define the different categories of maintenance

For further information, review the remaining modules in the TFLEEx website www.TFLEEx.org, and the information under “Additional Resources.”

GLOSSARY

CAD/AVL: Computer-aided dispatch and automatic vehicle location systems

CBM: Condition-Based Maintenance

CBTC: Communications-based train control

CNG: Compressed Natural Gas

Corrective Maintenance: repair or replacement of a failed component or system

Extraboard: The Extraboard is a work assignment used to fill in for absences, missed trips and fill-ins.

FAST Act: Fixing America's Surface Transportation Act (2015)

Functional Alignment: An operational alignment where the primary chain of command is by function (having a transportation department and a maintenance department).

HVAC: Heating, Ventilation, and Air Conditioning

LRVs: Light Rail Vehicles

MAP-21: Moving Ahead for Progress in the 21st Century Act (2012)

MBTA: Massachusetts Bay Transportation Authority in Boston MA

MDBF: Mean distance between failures; a measurement of maintenance effectiveness

Modal Alignment: An operational alignment where the primary chain of command is by mode (having a bus department and a rail department).

NRVs: Non-revenue vehicles

NTD: National Transit Database

PM: Preventive maintenance

SEPTA: Southeastern Pennsylvania Transportation Authority in Philadelphia PA

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Module 2B:

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SGR: State of Good Repair

TFLEx: Transit Finance Learning Exchange

TAM: Transit Asset Management

TVMs: Ticket Vending Machines

WMATA: Washington Metropolitan Area Transit Authority in Washington DC

WSA: Ways, Structures and Amenities