6-1-2016

State of Good Repair Performance Measures: Assessing Asset Condition, Age, and Performance Data

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DOI: <https://doi.org/10.5038/CUTR-NCTR-RR-2016-09>

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**State of Good Repair Performance Measures:
Assessing Asset Condition, Age,
and Performance Data**

Final Report

June 2016

Project No. 2117-9060-02-B

PREPARED FOR

National Center for Transit Research (NCTR)

State of Good Repair Performance Measures: Assessing Asset Condition, Age, and Performance Data

Final Report

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June 2016

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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle State of Good Repair Performance Measures: Assessing Asset Condition, Age, and Performance Data		5. Report Date June 2016	
		6. Performing Organization Code	
7. Author(s) Fabian Cevallos, Ph.D.		8. Performing Organization Report No.	
9. Performing Organization Name and Address Lehman Center for Transportation Research (LCTR) Florida International University (FIU) 10555 West Flagler Street, EC 3609 Miami, FL 33174		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. FIU 2117-9060-02-B	
12. Sponsoring Agency Name and Address National Center for Transit Research Center for Urban Transportation Research University of South Florida 4202 East Fowler Avenue, CUT100, Tampa, FL 33620-5375		13. Type of Report and Period Covered	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract This project developed a web-based software application that transit agencies can use for the collection, storage, analysis, and reporting of transit assets. The idea is to develop a system in which different departments at transit agencies can access the system for entering data, reporting, or retrieving information. Therefore, this tool can assist transit agencies in evaluating and assessing transit asset data with regards to age and condition against established performance targets, as well as offer an approach for project prioritization based on budget data and asset rehabilitation/replacement alternatives.			
17. Key Words State of Good Repair, transit asset management, transit rehabilitation		18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 73	22. Price

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

- 1 inch (in) = 2.5 centimeters (cm)
- 1 foot (ft) = 30 centimeters (cm)
- 1 yard (yd) = 0.9 meter (m)
- 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

- 1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
- 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
- 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
- 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
- 1 acre = 0.4 hectare (he) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

- 1 ounce (oz) = 28 grams (gm)
- 1 pound (lb) = 0.45 kilogram (kg)
- 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

- 1 teaspoon (tsp) = 5 milliliters (ml)
- 1 tablespoon (tbsp) = 15 milliliters (ml)
- 1 fluid ounce (fl oz) = 30 milliliters (ml)
- 1 cup (c) = 0.24 liter (l)
- 1 pint (pt) = 0.47 liter (l)
- 1 quart (qt) = 0.96 liter (l)
- 1 gallon (gal) = 3.8 liters (l)
- 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
- 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$$[(x-32)(5/9)]^{\circ}\text{F} = y^{\circ}\text{C}$$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

- 1 millimeter (mm) = 0.04 inch (in)
- 1 centimeter (cm) = 0.4 inch (in)
- 1 meter (m) = 3.3 feet (ft)
- 1 meter (m) = 1.1 yards (yd)
- 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

- 1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
- 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
- 1 square kilometer (km²) = 0.4 square mile (sq mi, mi²)
- 10,000 square meters (m²) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

- 1 gram (gm) = 0.036 ounce (oz)
- 1 kilogram (kg) = 2.2 pounds (lb)
- 1 tonne (t) = 1,000 kilograms (kg)
- = 1.1 short tons

VOLUME (APPROXIMATE)

- 1 milliliter (ml) = 0.03 fluid ounce (fl oz)
- 1 liter (l) = 2.1 pints (pt)
- 1 liter (l) = 1.06 quarts (qt)
- 1 liter (l) = 0.26 gallon (gal)
- 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
- 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

TEMPERATURE (EXACT)

$$[(9/5)y + 32]^{\circ}\text{C} = x^{\circ}\text{F}$$

QUICK INCH - CENTIMETER LENGTH CONVERSION

QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures.
Price \$2.50 SD Catalog No. C13 10286

Updated 6/17/98

ACKNOWLEDGMENT

This research was managed and funded by the National Center for Transportation Research (NCTR) under the direction of Mr. Joel Volinski. We would like to thank Mr. Haifeng Wang, Senior Programmer at the Lehman Center for Transportation Research (LCTR) at Florida International University (FIU), for the software development and database setup; Ms. Thalia Pickering, LCTR Web Designer, for the design of the user interface and for her assistance with the documentation; Ms. Natalie Defraene, Editor, for her assistance with the proofreading; and many special thanks to Ms. Yasamin Amirpour, former FIU graduate student, for helping with the literature review.

The project team would also like to thank Mr. Robert Guptil and Mr. Victor Rivas with MBTA (Boston, MA) for graciously sharing their knowledge and experience with the research team.

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BACKGROUND

Public transportation plays a vital role in providing mobility and accessibility while supporting the growth and development of communities across the country. It also provides transportation alternatives, helps reduce greenhouse gas (GHG) emissions, and enhances the quality of life of citizens. To maintain an efficient public transportation system, there is a need to keep the existing infrastructure in proper condition. However, there is growing concern that a significant portion of US public transportation assets are in need of capital reinvestment to maintain these infrastructures in working condition. This concern is not just for public transportation assets, but also for many other transportation infrastructures such as highways, bridges, and tunnels.

The Federal Transit Administration (FTA) recognizes the importance of mobility, the impacts on the environment, and the energy demands on public transportation. FTA studies indicate that a large number of US transit assets are in critical or poor condition, meaning that assets are past their useful life and in need of immediate repair or replacement; the agency is committed to maintaining the nation's transit systems in a State of Good Repair (SGR). FTA is leading the nation's effort to address these issues by collaborating with the industry to evaluate the magnitude of these issues and implement meaningful solutions. This is crucial for allowing public transportation systems to continue providing safe and reliable service.

Maintaining public transit facilities and equipment in an SGR is essential to providing efficient, reliable, and safe service to millions of transit riders. Furthermore, transit agencies must comply with mandatory requirements when seeking funding to keep their assets in good repair. For these reasons, transit agencies need solutions on how to best manage assets and prioritize capital and replacement needs. To address this critical problem, many transit agencies have invested in systems to manage their physical assets. These systems use databases, including condition data and quality inventory, for identifying and prioritizing capital needs. Nevertheless, many agencies do not have the resources to develop such systems. There is also a need for improvement in data collection and asset management methodologies, as well as the use of effective performance measures. Transit agencies must be able to monitor and evaluate the conditions of their assets, enabling them to prioritize their limited resources for transit capital and operating investments.

Having an asset management system can also help agencies evaluate the request for funding based on key measures such as age, condition, and costs. Transit agencies also need to identify and prioritize replacement actions to bring existing capital assets to an SGR to improve capital and operating efficiencies. Collecting, storing, and managing their assets can also be a challenge for transit authorities. Therefore, there is a need for a software tool that can help transit agencies collect, store, organize, query, and report various types of information regarding their capital assets.

PROJECT OBJECTIVES

Section 5326 of Federal transportation legislation Moving Ahead for Progress in the 21st Century (MAP-21) requires FTA to establish performance measures based on standards established in the SGR definition, directing that FTA establish a definition of the term “state of good repair” that includes objective standards for measuring the condition of capital assets of recipients, including equipment, rolling stock, infrastructure, and facilities. FTA will also require each recipient to establish performance targets according to FTA-established performance measures and to submit an annual report that describes their progress toward meeting the performance targets. In addition, each recipient, and each subrecipient, must also maintain a Transit Asset Management (TAM) Plan to include capital asset inventories, condition assessments, and decision support tools.

This research is intended to facilitate this process by recognizing the need to improve efficiencies by the use of a software application to support an ongoing and efficient asset management process. Using data in an asset management system can help prioritize investments based on limited resources and condition of assets.

The main objective of this project is to develop a web-based software application that transit agencies can use for the collection, storage, analysis, and reporting of transit assets. The idea is to develop a system in which different departments at transit agencies can access the system for entering data, reporting, or retrieving information. Therefore, this tool can assist transit agencies in evaluating and assessing transit asset data with regards to age and condition against established performance targets, as well as offer an approach for project prioritization based on budget data and asset rehabilitation/replacement alternatives.

To achieve this goal, the Florida International University (FIU) research team conducted a series of work tasks that included conducting a literature review, assessing transit condition databases (especially for rolling stock and infrastructure), developing a methodology, creating a framework, developing a web-based software application, testing the software, preparing training materials, and producing a final report.

TRANSIT ASSET MANAGEMENT

Asset Management Definition

Asset management has many definitions. Currently, there is no universally-accepted definition of “state of good repair” for public transit assets. Transit agencies may use their own definitions, which can vary from one agency to another.

MAP-21 Section 1103 defines asset management as a set of “actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost.” Another definition, as mentioned in several publications, including “Asset Management Data Collection for Supporting Decision Processes; Asset Management Primer” (FHWA, 1999) and “Asset Management: Advancing the State of the Art into the 21st Century through Public-Private Dialogue” (FHWA and AASHTO, 1996), is as follows:

Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.

The AASHTO Standing Committee on Highways, in its Motion to Amend the Definition to Advocate the Principles of Transportation Asset Management (AASHTO, 2006), provides the following definition:

Transportation asset management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well-defined objectives.

In short, transit asset management is a systematic process that helps manage assets and improve decision-making for allocating resources. The word “systematic” implies an orderly and proactive process rather than unplanned and reactive decisions that may not work out well in the long-run. The goal of asset management is to manage transit assets and achieve SGR. Asset management supports capital investment planning and programming through evaluation, and improvement of the decision-making process by focusing on resource allocation and utilization. The important decision in asset management involves selecting the best way to leverage a limited amount of funding and obtain the best possible result. Functionality and effectiveness of a transit asset management system highly depends on defined objectives, and accurate, timely, complete, and current data.

An asset management plan delineates the way people, processes, activities, and tools work together to meet an agency’s goals, objectives, and policies. Successful implementation of asset management leads transit systems to long-term economic success by enabling transit executives to make better investment decisions based on objective data. Asset management practices and their complexity and maturity vary between transit agencies, and there is no single solution that fits all agencies. Therefore, each transit agency needs to evaluate its system and find a strategic

roadmap that precisely describes its high-level activities and overall goals. The main features that any transit asset management system should possess include:

- **Holistic:** Asset management requires consideration of both short- and long-term objectives, and integration of business and technology strategies with a comprehensive lifecycle asset plan.
- **Policy-Driven:** Investment and resource allocation decisions should be made based on a clear set of policies, goals, and objectives that define the desired level of condition and performance determined by transit agency leaders.
- **Performance-Based:** Transit agencies should establish performance targets for the condition of assets and service delivery to the public. The established performance targets assist agencies in measuring the progress of the implementation of the asset management plan.
- **Analyze Options:** Comprehensive evaluation and tradeoffs are required at each level of decision-making for selecting the optimal allocation of limited funds.
- **Interdisciplinary:** Investment and resource allocation decisions may be made based upon the knowledge and judgment of several departments of the transit agency.
- **Data-Driven:** Quality data and data analysis are critical to effective asset management implementation. Asset management should support decision-making processes through providing accurate and sufficient amounts of information, and using proper data analysis tools.
- **Maximize Value:** The goal of implementing transit asset management is to obtain targeted asset condition and performance by managing risks and maximizing the value of assets over their lifecycle.
- **Transparent:** An asset management process should be a transparent process and have clear criteria that are understood at all levels of the organization and general public.

State of Good Repair Definition

Similarly to asset management, there is no single consistent and industry-accepted definition of SGR. In other words, each transit agency has its own definition. SGR is a targeted asset condition. According to “Transit Asset Management Practices” (FTA, 2010), SGR is defined as “a state in which a transit agency preserves its physical assets in compliance with a policy that minimizes asset life-cycle costs while preventing adverse consequential impacts to its service.” New Jersey Transit’s definition of SGR implies that SGR implementation requires replacing the infrastructure components on a schedule that is consistent with their life expectancy.

The Transit Asset Management Working Group (Standards Development Program) of the American Public Transportation Association (APTA) has developed the following definition for SGR: “SGR is a condition in which assets are fit for the purpose for which they were intended” (APTA, 2013). The second critical definition for an agency, then, is to determine what it

considers an asset to be. The APTA SGR Committee has borrowed the definition from the FTA “Transit Asset Management Guide,” which refers to transit assets as rolling stock, right-of-way, stations, facilities, systems and equipment. It goes on to define both “asset category” and “asset class”: an asset category is defined as a primary grouping of asset classes. For example, “vehicles” is the asset category for two asset classes (rail and rubber-wheeled vehicles).

Additionally, the Guide defines transit asset management as a strategic and systematic process through which an organization procures, operates, maintains, rehabilitates, and replaces transit assets to manage their performance, risks, and costs over their lifecycle to provide safe, cost-effective, reliable service to current and future customers (FTA, 2012).

The FTA 2008 State of Good Repair Summit, as reported in TCRP Report 157, provides several agency definitions of transit asset management, as shown in Table 1.

Table 1: Alternative Definitions of State of Good Repair

Agency	Definition
Chicago Transit Authority (CTA) Illinois	CTA defines SGR primarily in terms of standards: Rail lines should be free of slow zones and have reliable signals. Buses should be rehabbed at six years and replaced at 12 years. Rail cars should be rehabbed at quarter- and half-life intervals and replaced at 25 years. Maintenance facilities should be replaced at 40 years (70 years if rehabbed).
Cleveland Regional Transit Authority (RTA) Ohio	State of good repair projects are those needed to bring the system to a consistent, high quality condition system-wide.
Massachusetts Bay Transportation Authority (MBTA) Massachusetts	A state of good repair standard [is where] all capital assets are functioning at their ideal capacity within their design life.
New Jersey Transit (NJ Transit) New Jersey	State of good repair is achieved when the infrastructure components are replaced on a schedule consistent with their life expectancy.
New York City Transit (NYCT) New York	Investments that address deteriorated conditions and make up for past disinvestment.
Southeastern Pennsylvania Transportation Authority (SEPTA) Pennsylvania	An asset or system is in a state of good repair when no backlog of needs exists and no component is beyond its useful life. State of good repair projects correct past deferred maintenance, or replace capital assets that have exceeded their useful life.

Surprisingly, no two agencies defined the term in the same manner, but all definitions emphasized one or more of the following concepts:

- Maintaining an agency’s rolling stock and infrastructure as needed to meet a certain level of service (e.g., avoiding slow zones on a rail system).
- Performing maintenance, repair, rehabilitation, and renewal according to agency policy (e.g., replacing buses according to a set time interval).
- Reducing or eliminating an agency’s backlog of unmet capital needs.

Why Do Transit Agencies Need to Develop a Transit Asset Management System?

- **It is a Federal Transit Administration (FTA) requirement.** MAP-21 is a funding and authorization bill that governs US federal surface transportation spending. According to MAP-21 policy, transit agencies must develop an asset management system that contains asset inventory, condition assessment, decision-making support tools, and investment prioritization and must report the condition of assets in their inventory.
- **It benefits transit agencies.** Implementing a comprehensive and integrated asset management system provides the basis to find a balance between expansions of fleet and facilities and maintaining SGR. Developing an asset management program helps agencies support investment decision-making processes. Asset management can help transit agencies make better cases for requesting needed funds for asset management investments. This may include the rehabilitation of existing assets or the replacements of assets.

Asset Management Challenges

Transit agencies may face different asset management challenges, such as:

- Incurring increasing costs
- Accessibility to limited funding
- Complying with SGR requirements
- Degrading services (availability, safety, quality, reliability) as the result of asset condition
- Lacking adequate knowledge of asset management and its philosophy across the agency

Expected Benefits of Asset Management for Transit Agencies

An efficient transit asset management program benefits transit systems in different ways, including:

- **Improving customer service:** Asset management enhances transit service by improving on-time performance and vehicle and facility cleanliness and by reducing missed trips and service shutdowns. In addition, it also improves accountability, safety, and risk management.
- **Determining the level of requisiteness for investments:** Performing a comprehensive analysis of infrastructure needs allows assessment of the required funding to cover the expenses of asset replacement, rehabilitation, and backlog needs. An efficient transit asset management system improves an agency's ability to respond better to budget fluctuations, and also make stronger cases for funding requests submitted to FTA.
- **Optimizing resource allocation:** When sufficient funding is not available to cover the expenses of all infrastructure needs, a systematic method based on clear and defined organizational objectives and supported by accurate data can help prioritize the investments. The use of such methods is beneficial because it helps transit agencies

increase transparency, and promotes better decision-making, which maximizes the efficiency of allocated funds.

- **Improving performance while reducing costs:** Effective implementation of transit asset management through employing predictive and preventative maintenance approaches can assist in reducing long-term costs for asset preservation, while improving service delivery and increasing performance consistency.

Asset Management as an Integrated Part of Strategic Management

Asset management is an integrated part of a transit agency's strategic management. Therefore, to achieve effectiveness and a high level of performance, transit agencies should combine asset management with risk management and performance management to shape the agency's strategic management. Figure 1 illustrates the interaction of the different components of the agency's strategic management, which can help improve overall efficiency.

Figure 1: Components of an Agency's Strategic Management

Transit Asset Management Framework

Figure 2 summarizes the general steps of an asset management process for resource allocation and utilization. This process is systematic and leverages knowledge, skills, competencies, and attitudes of the people within an organization. The first step of the asset management process is setting organizational policies, goals, and objectives. Transit agencies' leaders should develop agency goals and policies in the form of strategic statements that address key desired conditions and performance of the system, in conjunction with both internal and external stakeholders. Agencies need to establish performance targets and performance measures that reflect their agency goals, policies, and objectives, and later assist in evaluating and monitoring performance.

Figure 2: Transportation Asset Management Process
(Source: FHWA Asset Management Primer)

As the Figure 2 shows, the second step of the asset management process is developing an asset inventory. An asset inventory, as a repository or database of the agency’s assets, must contain current information on the condition and performance of the existing assets. To effectively support capital programming, operations, and maintenance budgeting, asset inventory should provide consistent information across all asset classes. According to the FTA “Transit Asset Management Guide” (2012), “transit agencies should establish enterprise-wide policy and business requirements for the inventory process that results in a single inventory and data definitions for the various data items collected and maintained.”

In the third step, transit agencies are required to establish performance measures and conduct condition assessment and performance modeling. Conducting a condition assessment of assets helps agencies measure the overall SGR and gather the required information for determining asset rehabilitation and replacement needs. Establishing performance measures allows agencies to measure the progress of the actual performance by comparing it with the target performance. Condition assessment and performance monitoring proactively address an agency’s critical issues, identify maintenance or rehabilitation needs, and collect data for scenario evaluation and performance modeling.

As the fourth step, the asset management process requires an evaluation of alternatives and optimization of the program to identify the optimum method for allocating resources and managing the assets based on an agency’s defined goals, which typically include replacing worn-out assets, enhancing performance, and reducing costs. The use of analytical tools and economic trade-offs helps agencies analyze the impacts of different funding levels of system performance and estimate the required investment to achieve the desired outcomes.

In the fifth step, budget allocation should be finalized. In this regard, transit agencies need to determine a strategy to develop programs and prioritize projects. They need to develop short-term and long-term plans. A comprehensive long-term plan functions as a road map that contains an agency's goals, policies, objectives, strategies, and also functions as a financial document of the overall asset management program.

After selecting and prioritizing projects, the process runs through implementation, and then requires continuous performance monitoring, which provides current information on the transit system's condition and service levels. Documenting accurate and reliable performance-monitoring data and findings function as effective feedback, which helps transit agencies incorporate necessary changes in their policies, goals, and objectives.

ASSET INVENTORY DEVELOPMENT

Federal regulatory agencies require transit agencies to use a data-driven approach for measuring SGR and forecasting reinvestment needs. In this regard, transit agencies need to have a comprehensive asset inventory, which functions as the main source of data. A transit asset inventory must contain detailed, precise, and updated information on all of the agency's main assets, their location, and other key attributes, including type of asset, age, expected useful life, and various lifecycle costs such as estimated renewal cost.

The FTA Transit Asset Management (TAM) Pilot Program was published in 2013. The key steps of asset inventory development are shown in Figure 3. This process focuses on identifying, organizing, and maintaining a current asset inventory. The first step of developing an asset inventory requires that agencies develop their organizational high-level asset class hierarchy. The second step is identifying the data requirements for the database. After identifying data requirements, data collection should be started. Data collection requires evaluating data availability, accuracy, and collection methods.

Once the necessary data are collected, agencies need to determine the useful life and cost factors for their asset types. After developing the asset inventory, it is important that agencies conduct periodic quality checks to ensure data accuracy and consistency of the system. As the next step, continual improvement should be implemented to help data maintenance and continuous evaluation of inventory requirements.

Figure 3: Key Steps of Asset Inventory Development

Defining an Agency's High-Level Asset Class Hierarchy

Since assets and their components may be in different conditions and have different life cycle needs, it is essential that agencies aggregate and disaggregate asset data to be able to track the condition of the assets. Therefore, once a transit agency has defined its high-level asset hierarchy, it should start breaking down each main category into sub-categories. For instance, an agency that possesses both buses and railroad cars needs to break down the vehicle category into two sub-categories: buses and railroad cars. Next, sub-categories must be disaggregated to elements, and then to sub-elements.

Figure 4 shows the four levels of the asset inventory breakdown process. Using sub-categories, elements, and sub-elements allows transit agencies to classify assets into higher-level categories and also keep records of individual assets and their components.

Figure 4: Four Levels of Asset Inventory Breakdown

Table 2, based on information from the APTA Capital Asset Inventory and Condition Assessment (APTA, 2013), presents the main transit asset inventory categories and sub-categories. It is highly essential that asset inventory always be valid and complete. In this regard, an asset inventory requires constant maintenance and updating of information. Transit agencies need to implement a long-term methodology to maintain the integrity of their asset inventory data.

Table 2: Classification of Transit Assets

Vehicles (Rolling Stock) Revenue and Nonrevenue	Facilities	Stations	Guideway Elements	Systems
<ul style="list-style-type: none"> • Heavy Rail • Light Rail • Streetcars • Buses • Paratransit • Ferryboats • Service Vehicles • Yard Tugs • Street Supervisor Vehicles 	<ul style="list-style-type: none"> • Admin Buildings • Operation Buildings • Service Facilities • Rail Vehicle Maintenance Facilities • Rubber-tire Maintenance Facilities • Fueling and Washing Facilities • Yards 	<ul style="list-style-type: none"> • Bus • Station Structures • Rail • Station Structures • Elevators/Escalators • Passenger Waiting Areas 	<ul style="list-style-type: none"> • Tracks • Above-grade Structures (Bridges) • Below-grade Structures (Tunnels) • Ancillary Structures (Passenger and Maintenance Access and Retaining Walls) 	<ul style="list-style-type: none"> • Monitoring/Control/Communications • Revenue Collection • Security & Safety Controls • (Radio, GPS, Video Surveillance, Farebox, and Wireless) • Power (Substations, Third rail, Catenaries, etc.)

Identifying Data Requirements

An asset inventory requires certain data to effectively support the agency's asset management processes. Using TAM software enables transit agencies to facilitate capturing asset data and manage assets. TAM is a type of information technology that assembles information allows more efficient data collection, storage, retrieving, analysis, and reporting. Therefore, a software tool can help transit agencies prioritize their capital investment needs. With TAM software, transit agencies can also assess their asset information with regard to age, condition, and actual performance against established performance targets and then prioritize their projects based on available resources, budget, and rehabilitation/replacement alternatives.

Developing a comprehensive TAM software application involves creating a database for quantifying and tracking all agency assets, including equipment, rolling stock, infrastructure, and facilities. The degree of detail and depth of data requirements for this database vary depending on the agency's intended use of data and hierarchical level of assets.

Collecting Data

As an integral part of an asset management framework, data collection is critical to its success. Collecting accurate and timely data supports the decision-making process. Since data collection can be costly, transit agencies attempt to make it cost-effective by examining available data and identifying the data that can be collected as part of an agency's regular processes such as maintenance activities.

Primary Sources of Asset Inventory Data

Once data requirements for developing a baseline transit inventory database are identified, the agency must determine the available inventory data sources. According to Transit Cooperative Research Program (TCRP) Synthesis 92 (2011), the results of a survey on industry practice in transit asset management show that the most popular sources for data collection that are used by agencies are:

- Asset Condition Assessments
- Financial Records / Fixed Asset Ledger
- Computerized Maintenance Management System (CMMS)

Other data sources may include:

- Existing asset inventory register
- CAD Drawings/As-builts
- Contracts
- Insurance Policies

Figure 5: Primary Sources of Asset Inventory Data

Asset Condition Assessments

The foundation of the condition assessment process is providing a detailed asset inventory that documents the transit assets. Transit agencies perform comprehensive condition assessments through inspecting and analyzing the physical condition of assets. Proper implementation of condition assessments enables transit agencies to develop or maintain a comprehensive knowledge of the current conditions of all assets, measure the overall SGR, determine capital needs, and prioritize rehabilitation/replacement projects.

Generally, condition assessments provide more appropriate levels of detailed information for long-term capital planning than asset ledger and maintenance management systems. However, the process is costly because a comprehensive condition assessment must be periodically repeated.

Financial Accounting System or Fixed Asset Ledger

Accounting departments may maintain a fixed assets ledger that records asset information, including title, description, tag number, identification number, date purchased, date in-service, cost, funding sources, depreciation, location, use, condition, useful life, and expected replacement date. Although financial accounting systems are useful sources of inventory data, their level of usefulness highly depends on their level of completeness. For example, a financial accounting system may record the number of units purchased, but it may not record more detailed information such as location, condition, etc.

Computerized Maintenance Management Systems

Computerized maintenance systems management (CMMS) is software that maintains a record of assets, schedule, and track maintenance activities and keeps a history of performed tasks. Transit agencies that use CMMS tools are able to obtain information on their asset holdings. Although CMMS systems are useful sources for collecting inventory data, due to the fact that they mostly record fleet vehicle and maintenance facility assets, they contain a very detailed level of asset holdings.

Setting Lifecycle & Cost Assumptions

Developing life cycle management plans for all asset classes allows transit agencies to document the lifecycle costs, performance, and risks associated with each category. Figure 6 shows the different stages of the asset lifecycle management process. The process requires asset data as input to improve the decision-making process for lifecycle management activities such as maintenance, rehabilitation, and replacement activities. Improving decision-making results

produces better outcomes, such as increased safety, reliability, and customer satisfaction or minimized risk of failure.

Figure 6: Asset Lifecycle Management Process

I. Age and Useful Life of Asset

An asset's useful life is an important asset attribute that must be taken into consideration in capital reinvestment needs analysis. Therefore, an asset inventory should include estimated useful life for all of its asset classes.

The essence of SGR implies that assets should be replaced before their useful life ends. Therefore, implementation of SGR through an age-based approach relies on the assumption that assets provide good service for a predictable period, and afterward must be replaced.

Transit agencies can use regional and national data, as well as industry standards and manufacture recommendations to develop assumptions for their assets' useful life, rehabilitation age, replacement age, and contingency costs. However, in order to precisely predict the reinvestment needs, agencies may need to adjust these assumptions based on various factors, including the quality of maintenance, climate, mileage, annual hours of service, level of usage, operating environment, and experience.

II. Replacement Costs

An asset inventory database should contain information on estimated replacement costs for inventory assets. Due to the variation and fluctuation of prices, it is challenging to predict the future replacement cost of assets. Transit agencies need to record the procurement date of assets

and use it as a date point to determine the approximate replacement time and then forecast the expected replacement cost according to the future cost inflation rate.

Implementing Continuous Improvement

Transit agencies should implement continuous improvements in the asset management process. Any asset inventory that successfully supports asset management is built based on an established process for keeping the inventory data current. Inventory should constantly be maintained and updated to ensure that predictions and decisions are made based on up-to-date information on current assets, as well as new or overhauled assets. In this regard, inventory updates must reflect any recent changes, including:

- **Adding assets:** Transit agencies need to enter newly purchased assets into their inventory systems.
- **Removing assets:** Transit agencies need to ensure that recently retired assets are removed from the inventory data.
- **Modifying assets:** Transit agencies must update changes in attributes or in the condition of assets that significantly alter the asset record.

In addition, asset management program managers should periodically evaluate the effectiveness and accuracy of the performing program and look for possible solutions to collect more data in a cost-effective manner. Before blindly purchasing new technology to address the inventory problems, managers must determine the business requirements and then define how the new technology will improve the system.

Expansion of Capital Asset Reporting

Currently, FTA's National Transit Database (NTD) collects asset inventory information on revenue vehicles. The NTD collects only summary counts for other asset categories, such as maintenance facilities and fixed guideway. For some assets, such as signaling and telecommunications systems, NTD collects no data at all. FTA proposes to collect additional asset inventory data to remedy this situation and to meet the baseline asset condition reporting requirements required by MAP-21. These changes are proposed pursuant to 49 U.S.C. 5335(c), which requires grantees to report to the NTD any information relating to a transit asset inventory or condition assessment conducted by the recipient; and pursuant to 49 U.S.C. 5326(b)(3), which establishes new requirements for reporting on the condition of assets to FTA.

The proposed NTD Asset Inventory Module will support a collection of national-scale information about the quantity, replacement values, and condition of transit capital assets. Data reported to this module will come from transit agency asset inventories. Assembling a nationwide inventory of asset conditions will improve FTA's ability to project future costs for the replacement and renewal of transit capital assets as reported in the US Department of Transportation's biennial Conditions and Performance Report to Congress. The information

reported in the module will facilitate analysis using both the Federal version of the Transit Economic Requirements Model (TERM), the analysis tool used for Conditions and Performance Report investment scenarios, and TERM-Lite, a capital needs tool based on the Federal version designed for use by local agencies. This is not intended to establish a definition for state of good repair nor define official performance measures. Agencies interested in these topics are encouraged to seek information in the FTA Notice of Proposed Rulemaking (NPRM) or the future FTA Final Rule on Transit Asset Management.

As NTD incorporates the new Asset Inventory Module (AIM), updates to NTD's "Annual Reporting Manual" will be added to FTA's annual NTD reporting requirement for urban agencies. In subsequent years, the AIM is also expected to be incorporated into NTD's internet-based submittal format and will also be required of rural reporters.

FTA aims to minimize the reporting burden on the transit industry while still meeting MAP-21 mandates by collecting data at the minimum level of detail required to provide accurate needs forecasts. The data requested in the AIM will consist of objective and verifiable aspects of assets that represent significant capital costs. The data collection is also designed to require minimal updates from year to year once it is originally submitted. The proposed AIM consists of a series of electronic forms that grantees will use to report categories of asset condition data. AIM forms include:

- **Agency Identification** – collects organizational and contact information. This form will apply only to the spreadsheet version of the data collection (2014 collection cycle).
- **Administrative and Maintenance Facilities** – collects information on administrative and maintenance facilities used to supply transit service. For each facility, the facility's name, street address, square footage, year built or substantially reconstructed, primary transit mode supported, and estimated cost are collected.
- **Passenger and Parking Facilities** – collects information on passenger and passenger parking facilities used to supply transit service. For each facility, the facility's name, street address, square footage, number of parking spaces, year built or substantially reconstructed, primary mode, and estimated cost are collected.
- **Rail Fixed Guideway** – collects data on linear guideway assets and power and signal equipment, including the length of specific types of guideway and corresponding equipment reported as network totals by mode and operating agreement. The data include quantity, expected service years, date of construction or major rehabilitation (within a 10-year window), and estimated cost.
- **Track** – collects data on track assets, including length and total number of track special work reported as network totals by rail mode and operating agreement. The data include expected service years and date of construction or major rehabilitation.

- **Service Vehicles** – collects data on service vehicles that support transit service delivery, maintain revenue vehicles, and perform administrative activities. The data include quantity, expected service life, year of manufacture, and estimated cost.

Appendix A presents NTD’s new AIM as proposed in the TAM rule. FTA is combining the NTD and TAM statutes into a single set of NTD reporting requirements (see TAM/NTD Guidance in Appendix B).

According to NTD’s “Asset Inventory Module Reporting Manual” (2012), an asset inventory module may contain the following data categories:

- Agency Identification
- Administrative and Maintenance Facilities
- Passenger and Parking Facilities
- Rail Fixed Guideway
- Track
- Service Vehicle
- Revenue Vehicle

A list of required information for each of these categories is provided below.

- Agency Identification
 - NTD ID Number
 - Agency Name and Acronym
 - Mailing Address
 - City
 - State
 - ZIP Code
 - Notes
- Administrative and Maintenance Facilities
 - Facility Name
 - Section of a Larger Facility
 - Street Address
 - City
 - State
 - ZIP Code
 - Primary Mode
 - Facility Type
 - Year Built or Replaced
 - Size (Square Feet)
 - Estimated Cost

- Year of Estimated Cost
 - Notes
- Passenger and Parking Facilities
 - Facility Name
 - Section of a Larger Facility
 - Street Address
 - City
 - State
 - ZIP Code
 - Latitude
 - Longitude
 - Primary Mode
 - Facility Type
 - Year Built or Replaced
 - Size (Square Feet) or Parking Space
 - Estimated Cost
 - Year of Estimated Cost
 - Notes
- Rail Fixed Guideway
 - Primary Mode (Rail)
 - Asset Name
 - Quantity- Linear Feet
 - Quantity-Track Feet
 - Average Estimated Service Years
 - Allocation Unit
 - Year of Construction or Rehab
 - Total Quantity
 - Notes
- Track
 - Rail mode type
 - Track Element
 - Quantity
 - Units
 - Average Expected Service Years
 - Notes
- Service Vehicle
 - Service Vehicle Fleet
 - Type of Service Vehicle
 - Number of Vehicles in Fleet

- Average Expected Service Years When New
- Year of Manufacture
- Estimated Cost
- Year of Estimated Cost
- Notes
- Revenue Vehicle
 - Unique Name, ID number, Description
 - Mode (e.g., bus, subway)
 - Asset Nameplate (model, serial)
 - Location Identifiers
 - Purchasing Information (including vendor, data, contract, price, manufacturer code, warranty)
 - Funding Source
 - Year of Manufacture
 - Date In-service
 - Year of Last Rehabilitation Activity
 - Type of Last Rehabilitation Activity
 - Estimated Rehabilitation Cost
 - Year of Estimated Rehabilitation Cost
 - Estimated Replacement Cost (value, consumer price index)
 - Year of Estimated Replacement Cost
 - Parts
 - Warranty
 - Fuel Type Code
 - Vehicle length
 - Seating Capacity
 - Standing Capacity
 - Total Miles on Active during Period
 - Unit Quantities
 - Expected Useful Life
 - Asset Criticality
 - Asset Condition
 - Notes

APPROACHES TO ACHIEVE SGR

The FTA white paper titled “Defining State of Good Repair” lists the following four approaches that can be used by transit agencies to move toward achieving SGR. These methods contain objective standards that assess the condition of assets, and make well-informed decisions based on the results of performed assessments.

- Age-based
- Condition-based
- Performance-based
- Comprehensive Assessment

None of these methods represents an ideal way of defining and measuring SGR. Each transit agency needs to determine which method has the most compatibility with its system. As Figure 6 shows, the level of complexity and the degree of accuracy vary between these approaches. In general, from left to right, as the complexity of the methods increases, their accuracy improves (Figure 7).

Figure 7: Four Methods to Define and Measure SGR

Age-based

Age-based condition assessment, which is established by FTA as a part of TERM documentation, is used for the baseline condition assessment. This method can be used when an agency is lacking more detailed information to assess the condition of its assets. Age-based assessment is a method based on the assumption that assets provide service for a particular amount of time, and after that they need to be replaced. Therefore, assets that reach a certain maximum age should be scheduled for replacement.

Although the fact that assets deteriorate as they age makes the predicted useful life of assets an important piece of information, focusing too much on “age” may initiate overstating the need for funding and eventually leads to not implementing proper maintenance practices. Implementing an effective preventive maintenance helps extend the useful life of assets and postpones the need for funding. Therefore, depending on various factors such as maintenance practices and mileage, the condition of two identical assets with the same age may differ. Hence, assessing the condition of assets solely based on their age may not be the most accurate condition assessment method, especially in cases where assets are relatively diverse, even within a certain asset class.

Decay Curves

FTA has developed transit asset decay curves for major asset types. These decay curves are regressions that are built based on the collected data from transit nationwide. Although the shape

of decay curves varies depending on their empirical data, all of them are created based on the same notion. All decay curves have four main defining features: start point, first spline, discontinuity point, and second spline.

Decay curves estimate the condition of an asset on the 5-point scale. At the start point, the asset is brand-new, and the condition rate is 5 out of 5. After the start point, empirical asset condition data is required for developing the right decay curve. Since brand new vehicles have a higher level of utilization and consequently, greater physical deterioration, the first spline's slope is greater than the second spline's slope. The asset's deterioration rate changes at the discontinuity point. Instead of using FTA decay curves, transit agencies can develop decay curves based on their collected data to forecast the condition of their assets more accurately.

Since implementing preventive maintenance affects asset condition and asset life expectancy, it has a significant impact on decay curves. Transit assets that are subject to higher levels of preventative maintenance tend to be in a better physical condition and have a longer life span, compared to similar assets subject to less preventative maintenance. The discontinuity point and the slope of splines can either improve or deteriorate, depending on the agency's preventative maintenance. Figure 8 illustrates the FTA TERM asset decay curve for 40-ft buses.

Figure 8: Observed Physical Condition vs. Age for 40-ft Buses

Condition-Based

Transit agencies need to use a set of standard procedures to perform condition assessments. Each transit asset class has specific requirements for condition inspection and monitoring depending on performance characteristics, risks, and impacts of failure. Gathering condition information requires regular inspections, analysis, and testing of assets. Transit agencies need to schedule condition assessments on a regular basis. Since a condition assessment may involve costly data

collection procedures, transit agencies attempt to employ strategic data collection approaches that

There are various standard practices for inspecting and monitoring the condition of transit assets. Most of the time, transit agencies do not have enough resources available to collect the condition information of all assets. In these cases, only inspecting a sample size of each asset class may be adequate. However, when agencies use sampling, they need to pay particular attention to the statistical considerations. To conduct condition assessments, an agency's condition expert can visit sites to take sample observations of the actual physical assets and then apply the average condition of the sample to all assets in the same category. In a sampling process, the samples must be selected randomly to adequately represent the entire population of assets. Using on-site sampling along with an age-based condition assessment and decay curves allows agencies to improve the accuracy of asset condition evaluation.

Collecting reliable condition assessment data allows agencies to anticipate failure, address critical issues, and plan for investments required to maintain good performance. The frequency of inspections and the number of samples that must be inspected to achieve the desired precision and confidence level vary depending on the level of risk associated with the asset. In general, assets such as buildings, with a longer useful life, can be inspected less frequently than assets with a shorter useful life, such as vehicles.

FTA defines a five-level condition rating process for estimating the condition of individual assets based on asset type, age, and other factors. By adopting the condition rating levels, transit agencies can ensure compatibility of its condition assessment with MAP-21 (FTA, 2013). If decay curves are available, they can be used to estimate the condition rating of a particular asset. If not, agencies may have to assess the condition of an asset based on staff experience and information available. In this approach, the assets are divided into five quintiles (Table 3).

Table 3: FTA Asset Condition Ratings

Normalized Asset Lifecycle	Quintile	Condition Rating	Condition
0% - 25%	1 th	5	Excellent
25% - 50%	2 nd	4	Good
50% - 75%	3 rd	3	Adequate
75% - 100%	4 th	2	Marginal
100% <	5 th	1	Worn

As the table shows, condition ratings range from 1 (asset is considered worn as its age exceeds its expected useful life) to 5 (new asset in excellent condition). In this baseline assessment, SGR is achieved when the condition rating is 3 (adequate) or higher.

Performance-Based

Conducting performance measurements helps transit agencies measure their asset management and service delivery, as well as monitor the progress to ensure that advances are compatible with an agency's established goals. MAP-21 mandates transit agencies that receive Federal support to develop performance targets for state of good repair. Per MAP-21 requirements, transit agencies are obligated to submit an annual report that explains the progress made toward their established performance targets, and includes new performance targets for the next fiscal year. To comply with these reporting and regulatory requirements, transit agencies that handle planning, funding, and operations need to incorporate proper performance measures into their capital planning processes and periodically gauge the progress toward the achievement of goals.

An effective performance management system addresses the critical issues that the transit agency is facing. Therefore, the functionality of a Performance Management System is critical to transportation systems. Performance management data and outcomes support strategic planning and reporting. Conducting performance measurements as a data collection process and using its outcomes allows transportation managers to make better decisions regarding investments, policy approaches, and the need for maintenance, upgrades, or replacement of assets.

According to Transit Cooperative Research Program (TCRP) Report 88, developing a performance measurement program requires a progressive process. This report describes the key features of an effective performance measurement system, as follows:

- Stakeholder acceptance
- Linkage to agency and community goals
- Clarity
- Reliability and credibility
- Variety of measures
- Level of details
- Flexibility
- Realism of goals and targets
- Timeliness
- Integration into agency decision-making

Data availability, quality, and affordability are critical to performance measurement. Affordability mostly refers to the amount of data gathered rather than the cost of data collection. The process of collecting performance data requires some trade-offs. For example, transit agencies have to pay particular attention to the level of details and the number of their performance measures. Using too few performance measures may not precisely address the agency's established goals and objectives, while using too many is not only expensive, but may be overwhelming and confusing. The level of detail also varies between different performance

measures. In general, some measures are relatively easy to track, and some have a greater number of factors, which makes the measuring process more difficult and time-consuming.

Transit performance has many dimensions and may be gauged at different levels. Therefore, it is essential that transit agencies select specific performance measures based on their agency's goals and objectives. Common performance measures used by transit agencies include:

- Maintenance cost per vehicle mile
- Percentage of useful life
- Mean distance between failure
- One-time performance & capacity
- Ridership
- Customer service
- Ride quality
- Backlog projections per year

According to NCHRP Report 551, performance measures that are used by transportation systems may be categorized as shown in Table 4.

Table 4: Categories of Transit Performance Measures

Category	Description
Accessibility	Analysis of data related to the ability of passengers and goods to access transportation service and reach destinations.
Preservation	Analysis of data on the condition of the transit system, maintenance, and actions to keep the system in a state of good repair. Performance measures in this category are often specific to the type of asset.
Mobility	Analysis of data on traffic congestion, travel times, vehicle times, cost, speeds, system usage capacities. Mobility incorporates the relative ease or difficulty with which the trip is made.
Operations & Maintenance	Analyzing the effectiveness of the transit system in terms of throughput, travel costs, and revenues from a system perspective and maintenance level of service, particularly the customer experience of the system.
Safety	Analysis of data on incidents that are harmful to people and damaging to freight, vehicles, and transportation infrastructure.
Environmental Impacts	Analysis of data related to environmental impacts of transportation on key areas such as air quality, groundwater, protected species, noise, and natural vistas.
Economic Development	Analysis of data on direct and indirect impacts of transportation on the economy.
Social Impacts	Analysis of data on the effects of transportation on society or population groups.
Security	Analysis of data on protection of travelers, goods, vehicles, and infrastructure from terrorist activities.
Service Delivery	Analysis of data on the delivery of transportation projects and services to public.

Performance-based Planning and Programming (PBPP)

PBPP is employment of performance management within the planning and programming processes to obtain preferred performance results. PBPP allows increasing transparency for making resource allocation decisions based on the ability of projects to meet established goals.

According to the FHWA Guidebook (FHWA, 2013), there are different factors that transit systems need to consider while selecting performance measures for planning and programming:

- **Measures must reflect key issues:** There are many potential performance measures from which transit systems can collect data, yet it is essential that performance measures be chosen carefully to represent the main concerns of the public.
- **Measures should be clear to transit professionals, policy-makers, and the public.** It is preferable to select clear performance measures without technical terms.
- **It should be feasible to collect data related to the selected measures.** It is important that transit staff check whether it is practical to collect, store, and analyze data for the chosen performance measures.
- **Transportation staff need to check if the performance measures are predictable.** Transit systems need to be able to use some type of forecasting models, strategies, and tools.
- **Selected measures should be affected by investment decisions.** Using PBPP requires selecting performance measures that support investment decision-making.
- **Improving directions should be clearly stated.** Although for some performance measures, such as the number of accidents or the number of fatalities and serious injuries, the desired improvement direction is obvious (lower), for others it may be confusing and complicated. Therefore, transit systems need to determine and justify their preferred and improved directions for performance measures.

Data and analysis tools are important parts of PBPP. By collecting historical data, agencies can investigate the cause of problems, address their location, and then assess the needed improvements and prioritize the required investments. Analyses of alternative investments or scenarios and the use of forecasting models as forward-looking analyses approaches help visualize and predict the performance of the system for different future investment scenarios. Establishing future investment scenarios allows examining the process of utilizing network performance measures to make funding decisions and prioritize projects while considering the contribution of each investment to the performance of the system.

TCRP Report 157 (2012) recommends a minimum set of key performance measures that transit agencies can use to support asset rehabilitation and replacement decisions in their organizations (Table 5).

Table 5: Performance Measures for Asset Rehabilitation and Replacement

Measures	Use For	Notes
Percentage of assets in good/fair/poor condition	All assets, including facilities	Useful for reporting and analysis. Threshold for poor condition should coincide with recommended threshold for rehabilitation/replacement.
Asset availability	All assets excluding those for which availability can be related to delay	Useful for reporting, particularly in cases where it is difficult to relate asset service to delay.
Agency cost	All assets	Useful for analysis. Should include transit agency life cycle maintenance costs, and other costs that vary with asset condition.
User cost	All assets with direct impact on system performance	Useful for analysis. Should include delay costs and other user costs.
Hours of delay	Vehicles, guideway	Useful for analysis and reporting. Hours can be converted to costs for analysis.
Percentage of assets enhanced/improved	All assets	Useful for analysis and reporting. Useful for measuring the extent of improvements to existing assets, such as percentage of buses with low emissions or improved technology.

(Source: TCRP Report 157)

Performance Management Cycle

Figure 9 illustrates the basic structure of a performance management system. Performance management as a continuous cycle must be carried out periodically to keep track of the actual performance over time. As Figure 8 shows, a performance management system has four major steps: selecting measures, setting targets, applying measures in the decision-making process, and evaluating the system.

Figure 9: Performance Management Cycle

1. Selecting Measures

Performance measures function as the cornerstones of any performance management program. Transit agencies develop system-level performance measures to track the impacts of investments, improvement of operations, and maintenance activities on the system. Each transit agency should carefully identify a particular set of performance measures that establish a link between its established organizational goals and processes. Measures must reflect the agency's policy and objectives, and be consistent with the criteria that the agency uses for making resource allocation decisions. It should be feasible to incrementally track the selected measures and compare them with the performance targets. Transit agencies need to periodically update their performance measures to make sure that measures are consistent with agency priorities and strategic plans. However, measures should only be updated if the new measure(s) add value to the decision-making process. Retaining and using the same measures for several years provides an opportunity for the agency to conduct an in-depth analysis of long-term trends. Figure 10 shows the necessary steps that should be taken for identifying the right performance measures.

Figure 10: Required Steps for Selecting Performance Measures

A brief explanation for each step is provided below.

- Assess existing performance measures to evaluate their functionality and the way they used.
- Conduct a gap analysis to determine the most important outcomes that should be attained, and then examine the existing measures to find out if they adequately cover these outcomes.
- Define criteria for selecting new performance measures such as feasibility, usefulness for decision support, and compatibility with established goals and policy.
- Develop a set of candidate measures that improves the decision-making process for resource allocation.
- Evaluate the candidate measures based on the selected criteria, finalize the selection of measures, and document a clear definition of the selected measures.

2. Identifying Targets

Transit agencies need to develop performance targets to measure the progress toward the achievement of goals. For developing performance targets, agencies should take the following performance target attributes into consideration.

- **Ambitious and Realistic:** Performance targets must be ambitious, and at the same time realistic to provide a basis for assessing and tracking progress against a target that is attainable. Realistic performance targets take into account available funding and resources, policies and goals, priorities, risks, economic efficiency, current and future conditions, and other factors that may affect performance.
- **Aspirational:** To emphasize the importance of an issue such as policy priority or reflect a broader societal target, transit agencies may develop aspirational targets. For example, “zero fatalities” is an aspirational target. Even if it may not be a realistic target for transportation, it reflects that nobody should be killed due to an accident. Aspirational targets can be viewed as a way of thinking rather than a numerical goal; this proposes that all accidents can be prevented. When the system does not approve accidents, this provides a basis for learning from accidents and improving processes.
- **Directional:** To avoid confusion, agencies may need to specify directions for their performance targets. Simple examples of directional targets are “improving on-time performance” and “reducing the number of highway fatalities.”
- **Have a Time Horizon:** From the standpoint of accounting, finance, or risk management, it is important that agencies specify time horizons for their performance targets. Time horizons often are short enough that progress can be gauged monthly, quarterly, or yearly.

3. Using Measures in Decision-Making Processes

Transit agencies can use performance measures for various management decision-making processes within their organizations. Capturing information from performance expands the vision of decision makers and enhances their understanding of potential outcomes and consequences associated with different options such as future investments. According to NCHRP Report 660 (2010), the management decision types that can benefit from using performance measures include:

- Strategy Decisions
- Resource Allocation and Programming Decisions
- Operational Decisions
- Human Resource Decisions

4. Evaluating the System

Periodic evaluation of the performance management system improves the system by incorporating necessary changes. In addition, adopting new technologies and receiving feedback from agency staff and external sources may improve the system by upgrading data collection methods and/or improving measures.

Comprehensive Assessment

Using comprehensive assessment is another approach to defining SGR. This method is comprehensive, and the assessment is based on a combination of different factors, including age and condition, as well as the performance data and maintenance history of assets. In this approach, condition ratings are a weighted combination of metrics for all considered factors. Compared to other methods, this approach is more complicated and data-intensive. However, it is the most accurate condition assessment method. The agencies that effectively implemented this approach have achieved a high level of asset management maturity, which enabled them to self-certify compliance with SGR requirements (“Defining State of Good Repair,” 2013).

ASSET MAINTENANCE

An asset maintenance strategy is a process of tracking asset-related data to optimize the value of assets throughout their lifecycle. Transit agencies need to collect detailed information on the maintenance of vehicles, the cause of any breakdown, and the results of the conducted inspection. Regardless of agency size, all transportation agencies should attempt to run an optimal maintenance program. Implementing a proper vehicle maintenance program can help transit organizations improve the quality of their service and significantly lower overall costs.

Asset Management Maintenance Strategies

Transit maintenance strategies can be classified into different strategies with different costs and level of asset availability (Figure 11).

Figure 11: Asset Maintenance Strategies

- **Reactive or Corrective Maintenance (CM):** The simplest maintenance strategy is reactive or corrective maintenance, which does not involve asset inspection or maintenance until failure occurs. Since this maintenance strategy is not preventative, making the decision to either fix or replace the failed component will take place after the breakdown. Considering that the damages caused by sudden failures are usually significant or even destructive, transit agencies that choose a corrective maintenance strategy may incur more costs at the end. Therefore, the more suitable strategy is for transit systems to employ a more appropriate maintenance method with a predictive or preventative approach.
- **Preventive Maintenance known as Scheduled/Planned or Time-Based Maintenance (TBM):** Using a time-based maintenance strategy helps transit agencies prevent or mitigate the consequences of a significant failure of assets, rather than repairing after failure occurs. In this strategy, there are fixed time intervals for performing inspections and certain maintenance tasks. Time intervals are either recommended by equipment manufacturers or determined based on the experience of the transit agency maintenance personnel.
- **Predictive or Condition-Based Maintenance (CBM):** Predictive maintenance (PdM) or condition-based maintenance strategies are designed to forecast upcoming equipment failure and avoid occurrence of failure by fulfilling required maintenance tasks. Since in this approach, corrective actions are performed only when needed, it promises cost savings over a time-based preventive maintenance strategy. An effective predicting failure technique should provide adequate warning time for maintenance tasks to be planned and executed. To evaluate the physical condition of assets, predictive maintenance uses non-destructive testing technologies such as vibration analysis, oil analysis, and operational performance.
- **Proactive Maintenance:** The goal of this strategy is not only to prevent significant failure, but also to improve equipment performance. Therefore, the process requires a deeper inspection for determining the source of a problem and fixing it.
- **Risk-Based Maintenance (RBM):** This strategy requires risk-based inspections to prioritize maintenance based on the risk probability of equipment failure and its associated consequences. In the RBM process, failures with the highest impact and frequency should be addressed first.
- **Total Productive Maintenance (TPM):** TPM is a holistic approach to equipment maintenance that integrates proactive and preventive maintenance strategies to maximize the overall operational efficiency of equipment.
- **Reliability-Centered Maintenance (RCM):** RCM focuses on the functionality of the system by optimizing the implementation of a combination of reactive, preventive, and predictive maintenance strategies. RCM is not only used to evaluate maintenance priorities, but is also used as a tool for ranking replacement activities.

Conducting Quality Assessments

Agencies need to perform quality checks to minimize inventory data issues such as mis-categorized data, inaccurate data, double counting of assets, and missing data. There are various methods for performing quality checks. When there is a conflict between logical and statistical tests, an on-site investigation may be required to clarify the issue.

STATE OF GOOD REPAIR MODELS & PRACTICES

Transit Economic Requirements Model (TERM Lite)

TERM is FTA's decision support tool for determining required capital needs. TERM assesses the SGR backlog, determines the level of annual investment to achieve SGR, evaluates the impacts of various future funding levels on capital performance, and prioritizes investment needs.

TERM is used for assessing the current physical condition of public transit assets and estimating the future national transit investment needs for asset rehabilitation and replacement. By using TERM, it is possible to forecast the next 20-year trend of reinvestment needs. According to the User Training Transit Economic Requirements Model Overview provided by FTA, TERM can simulate a 20-year scenario and predict asset maintenance, rehabilitation, and replacement costs over a 20-year period, based on the existence of the following:

- Current inventory status
- Yearly spending budget
- Prioritizing goals (such as safety, reliability, etc.)

Via TERM, FTA is able to estimate transit capital needs and develop reports (including semiannual reports to Congress known as "Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance" (C&P Report). In generating the C&P Report, using TERM allows FTA to evaluate four primary investment scenarios: maintain asset conditions, maintain performance, improve conditions, and improve performance.

In addition to C&P Reports, FTA uses TERM to develop other reports, including the National Surface Transportation Commission, the Rail Modernization Study, and the National State of Good Repair. TERM predicts capital investment needs through obtaining information from the NTD and other resources to specify the existing inventory of public transit assets and their age. In the TERM asset model, asset age is considered a proxy for determining its condition. TERM measures the condition of each asset on a 5-point scale. For each type of transit asset, there is a particular decay curve, which is used to predict the change in asset condition over time.

Using TERM, the yearly asset replacement needs are forecasted by identifying the assets whose conditions will fall below 2.5 on the 5-point scale. The asset maintenance costs and rehabilitation actions may be formatted to occur on a yearly basis and half/quarter life intervals, respectively.

TERM is capable of analyzing and assessing the future asset condition for different user-defined investment scenarios, and also developing estimates of their required capital to maintain the performance of the system. Users define scenarios based on specific requirements, including asset maintenance and replacement, budget limitations, and economic factors.

MBTA Capital Investment Program

One of the highest priorities for the Massachusetts Bay Transportation Authority (MBTA) is the continuous implementation of SGR. MBTA uses a Capital Investment Program (CIP) as an SGR approach, which relies on spending funds over a five-year period in a way that corresponds to the MBTA's operational targets within its fiscal capacity.

This analytical model allows estimating asset rehabilitation and replacement needs and prioritizing capital spending for transit infrastructure projects. Given a budget limit, the MBTA approach functions by evaluating asset rehabilitation and replacement projects based on certain features and then prioritizing them through an ongoing process that strives to balance capital needs across the entire range of MBTA transit services. In this regard, the approach focuses on three major attributes of each project: asset's age as a percentage of its useful life (which is considered as a proxy for service quality), operational impact (yes/no value), and cost-effectiveness. Next, considering the budget limit, the system simulates projects and prioritizes them through scoring and ranking by using a weighted scoring method, which is based on the user-defined weights for the three aforementioned factors. Since in each year the approach only simulates a selection of projects for analysis, the unfunded projects become candidates for the next year.

MBTA's SGR database is used to predict long-term and major needs for capital assets. MBTA engages in continuous collection and refinement of data, as well as integration with a computerized maintenance management system (CMMS). Recent activities that MBTA has performed to enhance its SGR database include:

- Converting from a PC-based to a web-based version (to provide direct access for field and maintenance personnel, and to facilitate the updating of asset data on a continuous basis).
- Revisiting asset structure and detail (to facilitate future NTD and MAP reporting, to better integrate with the CIP and to identify the optimal level of asset line item granularity).
- Incorporating condition and performance ratings (to comply with MAP-21 and to analyze the relationships between asset age, condition, and performance).
- Incorporating decay curves (to recognize that asset condition deteriorates at different rates over the useful life, and to forecast future SGR).

- Revise the asset prioritization methodology (to support future capital and maintenance decisions).

ALDOT Transit Asset Management and Prediction Model

The old maintenance management system of the Alabama Department of Transportation (ALDOT) was developed in 1970s. It had a reactive approach, which led to fixing problems after occurrence of equipment failure. Therefore, the system was incapable of scheduling future maintenance activities, predicting deterioration, estimating costs, and prioritizing replacements.

In 2005, the University Transportation Center for Alabama (UTCA) developed a linear regression model for predicting the future condition of ALDOT individual vehicles and its overall fleet quality. This model contains a database with approximately 40 data items (such as vehicle type, age, and condition) on each vehicle. Asset conditions are examined on a 5-point scale that considers the start of engine trouble, running condition, interior condition, air conditioning, wheelchair lift operation, exterior condition, and mileage.

The model considers age, the total mileage of the vehicle, annual mileage over unpaved roads, wheelchair accessibility of the vehicle, and the percentage of population over age 65 as independent variables. Considering the budget, the system uses information on current conditions and future predicted conditions to simulate replacement of vehicles over time. Replacements are prioritized based on asset condition if there is insufficient funding.

Caltrain

Caltrain is a California commuter rail line on the San Francisco Peninsula in the Santa Clara Valley. In 2006, Caltrain developed an SGR database to improve decision-making for prioritizing rehabilitation and replacement needs within its budget constraints. Caltrain's database determines an asset's SGR by managing asset information, rating asset conditions, and tracking work orders. This database enables the user to track asset-related information such as condition and maintenance activities.

Caltrain uses performance targets and performance measures to gauge the progress toward achieving its goals. Monitoring the progress toward goals and objectives occur both internally and through integration with reporting requirements. Caltrain's goals can be categorized as:

- Safety and Health
- Stewardship and Efficiency
- Sustainability, Livability and Economy
- System Performance
- Organizational Excellence

For each of these categories, Caltrain established specific strategic objectives, performance measures, and performance targets. For example, Caltrain's safety and health strategic objectives

include zero worker fatalities and promote community health through active transportation reduced-pollution in communities.

Metropolitan Transportation Commission (MTC)

MTC believes that to achieve SGR, all transit assets must be replaced at the end of their useful life. MTC prepares and updates the Regional Transportation Plan (RTP) for the San Francisco Bay area. MTC is responsible for receiving federal funds, prioritizing regional investment needs, and providing program funds to transit agencies. To quantify the transit assets being used by Bay area agencies, MTC started using the Regional Transit Capital Inventory (RTCI) in 2006. MTC uses this inventory system database to support the analysis of asset repair, rehabilitation, and replacement needs, as well as to estimate the required funding for the region.

RTCI as a comprehensive asset inventory contains information on over 80,000 assets, including:

- Revenue and Non-revenue Vehicles
- Fixed Guideways, Bridges, Tunnels
- Stations, Fare Collection Systems
- Administrative and Maintenance Facilities
- Equipment and Systems

RTCI asset inventory contains information on asset name, date of placing the asset in service, replacement and rehabilitation costs, and useful life of the asset. Currently, MTC updates RTCI data every four years. RTCI data were collected in 2008, and updated in 2011. In 2014, MTC started investing to improve the RTCI program in preparation for its upcoming data update cycle in 2015.

MTC uses the age of an asset as a proxy for its condition. In this regard, MTC assumes a fixed set of life for assets (in years) and then models the expected replacement cost as assets reach the end of their useful life.

Utah Transit Authority (UTA)

UTA provides public transportation throughout six metropolitan counties located in the Wasatch Front region of Utah. In 1970, UTA began operating buses and providing service for the public. Since that time, it has grown into a mid-sized multi-modal transit system, which operates fixed-route buses, express buses, ski buses, light rail lines, a streetcar line, and a commuter rail train.

The previous UTA Asset Management System (AMS) was only a database inventory of physical assets. It was inconsistent in terms of entering and storing the information, and also had limited details regarding asset attributes. After UTA recognized the need to improve its asset management system (AMS), it began using the SGR Pilot Program. The results show that the new AMS is user-friendly and versatile. It enables UTA to make better investment decisions and prioritize investments based on different factors, including asset condition, risk, and budget.

Washington Metropolitan Area Transit Authority (WMATA)

WMATA established an Infrastructure Renewal Program (IRP) to renovate its old facilities and replace the equipment that reached the end of its useful life. In 2008, a \$150 million annual fund for 10 years was authorized to be available to WMATA for addressing National Transportation Safety Board (NTSB) safety recommendations and SGR. NTSB identified WMATA's old rail cars as a contributing factor to the severity of passenger fatalities and injuries in a June 2009 Washington Metro train collision, which occurred between two southbound Red Line Washington Metro trains. Maryland, Virginia, and the District of Columbia also provided funds for implementation of WMATA improvements.

Based on WMATA's SGR strategy, rehabilitation of rail cars should be performed when the cars are 17 to 18 years old, and replacement takes place when they are 35 years old. WMATA considers 15 years as the useful life for its buses, provided that they are overhauled at mid-life.

NOTICE OF PROPOSED RULEMAKING

As the Transit Asset Management Rulemaking Process is still under the Comment Review period (see Figure 12), the Final Rule on Transit Asset Management has not been issued at the time of the publication of this report (June 2016). Therefore, this section attempts to present current information and the acceptable terminology (e.g., main asset categories), as the appropriate data collection methodology, performance measures, and reporting guidelines are solidified.

Figure 12: TAM Rulemaking Process

The NPRM suggests two categories for classifying the transit providers: Tier I and Tier II. Figure 13 shows the proposed two tiers that were included in the TAM NPRM Fact Sheet (FTA, 2015).

Tier I	Tier II
Operate > 100 vehicles in peak revenue service, or Operate rail fixed-guideway public transportation systems	Operate ≤ 100 vehicles in peak revenue service, and Do not operate rail fixed-guideway public transportation systems or Receive federal funds exclusively from §5310 or §5311 programs

Figure 13: TAM Classification of Transit Providers

The Fact Sheet also proposes the TAM Plan Elements that are required by each of the transit providers. As Tier I operates more complex systems, it has more requirements than Tier II agencies. The following are the nine TAM elements required by the Tier I agencies. Of these nine elements, only four are required by Tier II providers.

1. Inventory of Capital Assets
2. Condition Assessment
3. Decision Support Tools
4. Investment Prioritization
5. TAM and SGR Policy
6. Implementation Strategy
7. List of Key Annual Activities
8. Identification of Resources
9. Evaluation Plan

Tier I agencies are required to develop their own TAM plans. Tier II providers, on the other hand, may develop their own plans or participate in a Group Plan that can be sponsored by a State DOT or a recipient of FTA's Section 5307 or 5310 programs. Further, the transit providers must designate an Accountable Executive who will ensure that there will be enough resources to carry out the TAM Plan and the Transit Agency Safety Plan.

The performance measurements of asset performance should include the different asset classes within the four main asset categories: Rolling Stock (Revenue Vehicles), Facilities

Infrastructure, and Equipment. The proposed performance measures are as follows (FTA NPRM Fact Sheet, 2015):

- Rolling Stock (Revenue Vehicles): Percentage of revenue vehicles within a particular asset class that have either met or exceeded their useful life benchmark (ULB).
- Facilities – all buildings or structures: Percentage of facilities within an asset class, rated below 3 on the Transit Economic Requirements Model (TERM) scale (1=poor to 5=excellent).
- Infrastructure – rail fixed guideway track, signals, and systems: Percentage of track segments, signal, and systems with performance restrictions.
- Equipment (non-revenue vehicles): Percentage of vehicles that have met or exceeded their Useful Life Benchmark (ULB).

ULB is defined as the expected lifecycle of a capital asset or the acceptable period of use in service for a particular transit provider’s operating environment. Thus, ULB takes into account a transit provider’s unique operating environment such its geography, service frequency, or passenger loads.

Figure 14 provides some examples of the main four categories and classes as presented in the TAN NPRM in October 2015. Additional examples are presented in Appendix C (*Federal Register*, 80(189), 2015).

Category	Class
Rolling Stock	<ul style="list-style-type: none"> ▪ Railcars ▪ Buses ▪ Paratransit Vehicles ▪ Cutaways ▪ Cars and Vans ▪ Ferries
Facilities	<ul style="list-style-type: none"> ▪ Administration ▪ Maintenance ▪ Depots or Terminals ▪ Parking Garages
Infrastructure	<ul style="list-style-type: none"> ▪ Rail-Fixed Guideway ▪ Signal Systems ▪ Structures ▪ Catenary ▪ Mechanical Systems ▪ Electrical Systems ▪ IT Systems
Equipment	<ul style="list-style-type: none"> ▪ Construction ▪ Service Vehicles ▪ Maintenance

Figure 14: Examples of TAM Categories and Classes

Source: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/NPRM_website_508.pdf

Overall, the intent of the NPRM is to help transit providers achieve and maintain the nation’s public transportation assets in SGR. To maintain this condition, capital assets should be able to operate at a full level of performance. According to the NPRM (FTA, 2015), a capital asset is considered in a state of good repair when it complies with the following criteria:

- It is able to perform its designed function.
- It does not pose a known unacceptable safety risk.
- Its lifecycle investments must have been met or recovered.

Furthermore, the capital asset must meet all three criteria to be in a SGR. This means that an asset must be able to perform its designed function, it must not pose a known unacceptable safety risk, and its lifecycle investments must have been met or recovered.

WEB APPLICATION

As part of this project, a web application was developed to help transit agencies, specifically small- and medium-size agencies, with the development or use of an asset inventory software tool. The TAM software application was developed following available information and is organized based on the four main asset categories discussed in the NPRM section: Revenue Vehicles, Facilities, Infrastructure, and Equipment. Each category contains data collected by the research team from different sources. The research team attempted to capture the key elements that would satisfy the need for transit agencies to keep their assets under a state of good repair. At the time of the release of this tool, the software included data collection, database storage, and some basic reporting and data management capabilities. Although every attempt was made to include all possible data fields, and as this was the first attempt to develop such a tool, it is expected that future updates will be made to improve the TAM software if there is industry interest. Improvements can include additional data elements, specific reports needed by the agency internally and for external reporting, and more sophisticated data management tools for easy manipulation of the data that resides in the TAM database. Appendix D presents screenshots of the main database elements, and Appendix E presents the Graphical User Interface of the TAM web application.

NEXT STEPS

The most important development will be the release of the Final Rule of Transit Asset Management. This will guide future work in this area, which can ultimately lead to new developments. Past knowledge or developments may need to be modified accordingly to adjust to the expected FTA TAM Final Rule. Transit agencies will need to pay attention to what data they may be required to report. Additional information and publications may be appropriate to assist agencies with the proper investment to keep transit systems running under SGR.

Finally, as this is a relatively new field, it opens many opportunities for research, development of tools, methodologies, and other areas that can be used by agencies to efficiently prioritize investments and keep the capital assets in SGR, so that the delivery of transit services are reliable and with a minimum level of disruptions for the benefit of the general public.

REFERENCES

- Amekudzi, A., & Meyer, M. (2011). Best Practices in Selecting Performance Measures and Standards for Effective Asset Management. Final.
- AASHTO. (2006). Motion to Amend the Definition to Advocate the Principles of Transportation Asset Management. AASHTO Standing Committee on Highways.
- APTA. (2013). Capital Asset Inventory and Condition Assessment. Recommended Practice. APTA SGR-TAM-RP-002-13. APTA Standards Development Program. Working Group: Transit Asset Management. http://www.apta.com/gap/fedreg/Documents/Capital_Asset_Inventory_Assessment.pdf.
- APTA. (2013). Defining a Transit Asset Management Framework to Achieve a State of Good Repair. Recommended Practice. APTA SGR-TAM-RP-002-13. APTA Standards Development Program. Working Group: Transit Asset Management. <http://www.apta.com/gap/fedreg/Documents/Defining.a.transit.asset.management.framework.to.achieve.a.state.of.good.repair.pdf>
- APTA (2013). Creating a Transit Asset Management Program. Recommended Practice. APTA SGR-TAM-RP-002-13. APTA Standards Development Program. Working Group: Transit Asset Management. <http://www.apta.com/gap/fedreg/Documents/Creating.a.Transit.Asset.Management.Program.pdf>.
- Caltrain. CTAMS Final Report. (n.d.). www.fta.dot.gov/documents/Caltrain_CTAMS_Final_Report.pdf.
- Federal Register. (2015). Part 625–Examples of Asset Categories, Asset Classes, and Individual Assets. *Federal Register*, 80(189). Proposed Rules. Federal Transit Administration. US Department of Transportation. <https://www.gpo.gov/fdsys/pkg/FR-2015-09-30/pdf/2015-24491.pdf>.
- FHWA and AASHTO. (1996). Asset Management: Advancing the State of the Art into the 21st Century through Public-Private Dialogue. US Department of Transportation.
- FHWA. (1999). Asset Management Primer. Office of Asset Management, US Department of Transportation.
- FHWA. (2006). Asset Management Data Collection for Supporting Decision Processes. US Department of Transportation.
- FHWA. (2013). Performance-Based Planning and Programming Guidebook. US Department of Transportation.
- FHWA. (n.d.). Relationships between Asset Management and Travel Demand: Findings and Recommendations from Four State DOT Site Visits. US Department of Transportation. www.fhwa.dot.gov.

- FHWA. (2015). Asset Management. US Department of Transportation.
<http://www.fhwa.dot.gov/asset>.
- FTA. (2008). Transit State of Good Repair – Beginning The Dialogue. US Department of Transportation.
- FTA. (2010). National State of Good Repair Assessment. US Department of Transportation.
- FTA. (2010). Transit Asset Management Practices: A National and International Review. US Department of Transportation.
https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/TAM_A_National_and_International_Review_-_6.10_FINAL_0.pdf.
- FTA. (2012). Asset Management Guide: Focusing on the Management of Our Transit Investments. FTA Report No. 0027. US Department of Transportation.
- FTA. (2013). Defining State of Good Repair. US Department of Transportation.
<https://www.transit.dot.gov/regulations-and-guidance/asset-management/state-good-repair/sgr-white-paper>.
- FTA. (2013). Transit Asset Management (TAM) Pilot Program. Asset Inventory and Condition Assessment Guide. FTA-2011-004-TPM. Volume 1. US Department of Transportation.
- FTA. (2013). Defining State of Good Repair. White Paper. US Department of Transportation.
- FTA. (n.d.). Transit Asset Management Newsletter. State of Good Repair: Noteworthy Practices. US Department of Transportation.
- FTA. (2015). Transit Asset Management Notice of Proposed Rulemaking Fact Sheet. US Department of Transportation.
https://www.transit.dot.gov/sites/fta.dot.gov/files/TAMFactSheet_10_2_15.pdf.
- FTA. (2015). Transit Asset Management (TAM) Notice of Proposed Rulemaking (NPRM). US Department of Transportation.
https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/NPRM_website_508.pdf.
- FTA. (2016). TAM/NTD Guidance Crosswalk. US Department of Transportation.
http://www.fta.dot.gov/documents/TAM_NPRM_and_NTD_guidance_crosswalk.pdf.
- Flintsch, G. W., & Bryant, J. W. (2006). Asset Management Data Collection for Supporting Decision Processes. US Department of Transport, Federal Highway Administration, Washington, DC.
- Florida Department of Transportation. (2014). Best Practices in Evaluating Transit Performance. IPWEA–NAMS.AU. Condition Assessment and Asset Performance Guidelines. Preamble Document.
- Markow, M., & Racosky, J. (2001). Asset Management Implementation Plan and Tiered System Process. Colorado Department of Transportation Research Branch.
- National Cooperative Highway Research Program (NCHRP). (2006). Performance Measures and Targets for Transportation Asset Management. NCHRP Report 551. Transportation Research Board.

- NCHRP. (2010). Transportation Performance Management: Insight from Practitioners. NCHRP Report 660. Transportation Research Board.
- NCHRP. (2010). Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies. NCHRP Report 666. Transportation Research Board.
- Parsons Brinckerhoff, Inc. Asset Management Guide: Focusing on the Management of Our Transit Investments. Federal Transit Administration, US Department of Transportation.
- Perk, V., & Kamp, N. (2003). Handbook of Automated Data Collection Methods for the National Transit Database.
- Puig, Joaquim. (2011). Asset Optimization and Predictive Maintenance in Discrete Manufacturing Industry. Master's project, École Polytechnique Fédérale De Lausanne, Switzerland.
- Robert, W., Gurenich, D., & Hoffman, J. Asset Management Decision Support System Model. Technical.
- Schneider, J., Gaul, A., Neumann, C., Hografer, J., Wellssow, W., Schwan, M., et al. (2005). Asset Management Techniques.
- National Transit Database (NTD). (2014). Asset Inventory Module: FY 2014 Reporting Manual. Transportation Research Board (TRB). (2000). Performance Measures to Improve Transportation Systems and Agency Operations: Report of a Conference. Conference Proceedings 26. Washington, DC: National Academy Press.
- TCRP. (2003). A Guidebook for Developing a Transit Performance-Measurement System. TCRP Report 88. Transportation Research Board.
- TCRP. (2004). Performance-Based Measures in Transit Fund Allocation. TCRP Synthesis 56. Transportation Research Board.
- TCRP. (2011). Transit Asset Condition Reporting: A Synthesis of Transit Practice. National Academy of Sciences. TCRP Synthesis 92. Transportation Research Board.
- TCRP. (2012). State of Good Repair: Prioritizing the Rehabilitation and Replacement of Existing Capital Assets and Evaluating the Implications for Transit. TCRP Report 157. Transportation Research Board.
- Zimmerman, K., & Stivers, M. (2007). A Guide to Maintenance Condition Assessment Systems.

APPENDIX A: NTD Asset Inventory Module

Asset Inventory Module FY 2014 Reporting Manual NTD

NTD Asset Inventory Module web page:
<http://www.ntdprogram.gov/ntdprogram/assetInventory.htm>

The National Transit Database (NTD) Asset Inventory Module (AIM) is designed to collect basic information on assets and infrastructure from U.S. transit agencies. The collected data can assist the Federal Transit Administration (FTA) with future capital cost projections for the replacement and capital renewal activities of transit assets.

A pilot version of the AIM (Microsoft Excel spreadsheet) was created by the NTD to assist transit agencies with the asset data reporting. The Asset Inventory Module contains the following forms:

- Agency Identification (A-00)
- Administrative and Maintenance Facility Inventory (A-10)
- Passenger and Parking Facility Inventory (A-20)
- Rail Fixed Guideway Inventory (A-50)
- Track Inventory (A-55)
- Service Vehicle Inventory (A-60)
- Revenue Vehicle Inventory (A-70)
- Direct Entry Inventory (A-80)

As the NTD module is related to the State of Good Repair (SGR) project, this research considers this element to be one of the outputs of the proposed database system. Although at this point AIM is still considered a proof of concept, it contains the main elements that are considered by FTA in the State of Good Repair & Asset Management documents.

Agency Identification (A-00)

The A-00 form collects basic information about organizations filing the National Transit Database (NTD) reports. This is required for all transit agencies, including State recipients, Metropolitan Planning Organizations (MPOs), and regional planning commissions. Fields required in the A-00 Form:

Transit Agency Identification Information

- NTD Identification Number
- Agency Name and Acronym
- Mailing Address or P.O. Box

- City
- State
- ZIP Code

Person Reporting

- Name
- Title
- Department
- E-Mail Address
- Phone Number

Urbanized Area

- UZA1? – UZA10?
- Notes (optional)

Administrative and Maintenance Facility Inventory (A-10)

The A-10 form collects basic information on administrative and maintenance facilities used to supply transit service. Fields required in the A-10 Form:

- Facility Name
- Section of a Larger Facility
- Street Address
- City
- State
- ZIP Code
- Primary Mode
- Facility Type
- Year Built or Replaced (as new)
- Square Feet
- Percent Capital
- Responsibility
- Estimated Cost
- Year Dollars of Estimated Cost
- Notes (optional)

Passenger and Parking Facility Inventory (A-20)

The A-20 form collects basic information on passenger and passenger parking facilities used to supply transit service. Fields required in the A-20 Form:

- Facility Name
- Section of a Larger Facility

- Street Address
- City
- State
- ZIP Code
- Latitude
- Longitude
- Primary Mode
- Facility Type
- Year Built or Replaced (as new)
- Square Feet or
- Parking Space
- Unit
- Percent Capital
- Responsibility
- Estimated Cost
- Year Dollars of
- Estimated Cost
- Notes (optional)

Rail Fixed Guideway Inventory (A-50)

The A-50 form collects data on linear guideway assets and power and signal equipment found in or making up an agency's rail network. Fields required in the A-50 Form:

- Rail Mode Type
- Guideway Element
- Quantity – Linear Feet
- Quantity – Track Feet
- Avg. Expected Service Years
- Allocation Unit
- Year of Construction or Rehab: Pre-1920
- Year of Construction or Rehab: 1920-1929
- Year of Construction or Rehab: 1930-1939
- Year of Construction or Rehab: 1940-1949
- Year of Construction or Rehab: 1950-1959
- Year of Construction or Rehab: 1960-1969
- Year of Construction or Rehab: 1970-1979
- Year of Construction or Rehab: 1980-1989
- Year of Construction or Rehab: 1990-1999
- Year of Construction or Rehab: 2000-present

- Total Quantity
- Percent Capital Responsibility
- Notes (optional)

Track Inventory (A-55)

The A-55 form collects data on track assets in an agency's rail network. Fields required in the A-55 Form:

- Rail Mode Type
- Agency-Specific Curvature Threshold
- Track Element
- Quantity
- Units
- Avg. Expected Service Years
- Percent Capital Responsibility
- Notes (optional)

Service Vehicle Inventory (A-60)

The A-60 form collects data on different types of service vehicles used to indirectly deliver transit service, maintain revenue vehicles, and perform transit-oriented administrative activities. Fields required in the A-60 Form:

- Service Vehicle Fleet Name
- Type of Service Vehicle
- Number of Vehicles in Fleet
- Year of Manufacture
- Percent Capital Responsibility
- Estimated Cost
- Year Dollars of Estimated Cost
- Notes (optional)

Revenue Vehicle Inventory (A-70)

The A-70 form replaces the current A-30 Revenue Vehicle Inventory form in the Asset Module of the 2011 Reporting Manual. The A-70 form collects data on the revenue vehicle inventory at the end of the fiscal year and identifies the characteristics of the vehicles in the fleet. Fields required in the A-70 Form:

- RVI ID
- Number of Vehicles in Total Fleet
- Number of Active Vehicles in Fleet
- Number of Americans with
- Disabilities Act of 1990 (ADA) Accessible Vehicles

- Number of Emergency Contingency Vehicles
- Vehicle Type Code
- Funding Source
- Year of Manufacture
- Manufacturer Code
- Model Number
- Year of Last Renewal
- Type of Last Renewal
- Estimated Renewal Cost
- Year Dollars of Estimated Renewal Cost
- Estimated Replacement Cost
- Year Dollars of Estimated Replacement Cost
- Parts
- Warranty
- Fuel Type Code
- Vehicle Length
- Seating Capacity
- Standing Capacity
- Total Miles on Active Vehicles During Period
- Average Lifetime Miles per Active Vehicle
- Supports Another Mode
- Notes (optional)

Direct Entry Inventory (A-80)

Form A-80 is optional for all agencies. Agencies can choose to either enter data in the appropriate A-10 through A-70 forms or directly enter all data into the tables in the A-80 form. The following figure presents a diagram with the Asset Inventory Module Forms.

Passenger Facilities	
1.	Bus Transfer Center
2.	Elevated Fixed Guideway Station
3.	At-Grade Fixed Guideway Station
4.	Underground Fixed Guideway Station
5.	Simple At-Grade Platform Station
6.	Exclusive Grade-Separated Platform Station
7.	Surface Parking Lot
8.	Parking Structure
9.	Other

Primary Modes	
1.	RMM – Transit Rail Mode/Ferry
2.	RMM – Transit Rail Mode/Amtrak
3.	RMM – Transit Rail Mode/Airport
4.	RMM – Transit Rail Mode/Intercity Bus
5.	AG - Automated Guideway
6.	AR - Alaska Railroad
7.	CB - Commuter Bus
8.	CC - Cable Car
9.	CR - Commuter Rail
10.	DR - Demand Response
11.	FB - Ferry Boat
12.	HR - Heavy Rail
13.	IP - Inclined Plane
14.	JT – Jitney
15.	LR - Light Rail
16.	MB – Bus
17.	MG - Monorail/Automated Guideway
18.	PB – Publico
19.	RB - Bus Rapid Transit
20.	SR - Streetcar Rail
21.	TB – Trolleybus
22.	TR - Aerial Tramway
23.	VP - Vanpool
24.	YR - Hybrid Rail

Administrative and Maintenance Facilities	
1.	Maintenance Facility (Service and Inspection)
2.	Heavy Maintenance and Overhaul (Backshop)
3.	General Purpose Maintenance Facility/Depot
4.	Vehicle Washing Facility
5.	Vehicle Blow-Down Facility
6.	Vehicle Fueling Facility
7.	Vehicle Testing Facility
8.	Administrative Office / Sales Office
9.	Revenue Collection Facility
10.	Combined Administrative and Maintenance Facility
11.	Other

Vehicle Types	
1.	AB - Articulated bus
2.	AG - Automated guideway vehicle
3.	AO – Automobile
4.	BR - Over-the-road bus
5.	BU - Bus
6.	CC – Cable car
7.	CU – Cutaway bus
8.	DB - Double decked bus
9.	FB - Ferryboat
10.	HR - Heavy rail passenger car
11.	IP - Inclined plane vehicle
12.	LR - Light rail vehicle
13.	MO - Monorail vehicle
14.	RL - Commuter rail locomotive
15.	RP - Commuter rail passenger coach
16.	RS - Commuter rail, self-propelled passenger car
17.	SB - School bus
18.	SV - Sport Utility Vehicle
19.	TB - Trolleybus
20.	TR - Aerial tramway
21.	VN - Van
22.	VT - Vintage trolley/streetcar

Funding Sources	
1.	UA – Urbanized Area Formula Program
2.	OF – Other Federal funds
3.	NFPA - Non-Federal public funds
4.	NFPE - Non-Federal private fund

Vehicle Renewals	
1.	Mid-Life Power Train
2.	Mid-Life Overhaul
3.	Life-Extending Overhaul

Fuel Types	
1.	BD - Bio-diesel
2.	BF - Bunker fuel
3.	CN - Compressed natural gas (CNG)
4.	DF - Diesel fuel
5.	DU - Dual fuel
6.	EB - Electric battery
7.	EP - Electric propulsion
8.	ET - Ethanol
9.	GA - Gasoline
10.	GR - Grain additive
11.	HD - Hybrid diesel
12.	HG - Hybrid gasoline
13.	KE - Kerosene
14.	LN - Liquefied natural gas (LNG)
15.	LP - Liquefied petroleum gas (LPG)
16.	MT - Methanol
17.	OR - Other fuel (Describe)

Manufacturer Codes	
1.	AAI - Allen Ashley Inc.
2.	ABB - Asea Brown Boveri Ltd.
3.	ACF - American Car and Foundry Company
4.	AII - American Ikarus Inc.
5.	ALS - ALSTOM Transport
6.	AMI - Amrail Inc.
7.	ASK - AAI/Skoda
8.	BBB - Blue Bird Corporation
9.	BFC - Breda Transportation Inc.
10.	BIA - Bus Industries of America
11.	BOM - Bombardier Corporation
12.	BRA - Braun
13.	BUD - Budd Company
14.	BVC - Boeing Vertol Company
15.	CBC - Collins Bus Corporation (formerly Collins Industries Inc./COL)
16.	CBW - Carpenter Industries LLC (formerly Carpenter Manufacturing Inc.)
17.	Crown Coach Corporation
18.	CCC – Cable Car Concepts Inc.
19.	CCI - Chance Bus Inc. (formerly Chance Manufacturing Company/CHI)
20.	CEQ - Coach and Equipment Manufacturing Company
21.	CHA - Chance Manufacturing Company
22.	CMC - Champion Motor Coach Inc.
23.	CMD - Chevrolet Motor Division - GMC
24.	CVL - Canadian Vickers Ltd.
25.	DIA - Diamond Coach Corporation (formerly Coons Manufacturing)
26.	DMC - Dina/Motor Coach Industries (MCI)
27.	DTD - Dodge Division - Chrysler Corporation
28.	EBC - ElDorado Bus (EBC Inc.)
29.	EDN - ElDorado National (formerly El Dorado/EBC/National Coach/NCC)
30.	EII - Eagle Bus Manufacturing
31.	FIL - Flyer Industries Ltd (also known as New Flyer Industries)
32.	FLX - Flxible Corporation
33.	FRC - Freightliner Corporation
34.	FRD - Ford Motor Corporation
35.	Federal Coach
36.	GCC - Goshen Coach
37.	GEC - General Electric Corporation
38.	GIL - Gillig Corporation
39.	Girardin Corporation
40.	Glaval Bus
41.	GMC - General Motors Corporation
42.	GTC - Gomaco Trolley Company
43.	HIT - Hitachi
44.	HSC - Hawker Siddeley Canada
45.	INT - International

Manufacturer Codes	
46.	KAW - Kawasaki Rail Car Inc. (formerly Kawasaki Heavy Industries)
47.	MAF - Mafersa
48.	MBB - M.B.B.
49.	MCI - Motor Coach Industries International (DINA)
50.	MKI - American Passenger Rail Car Company (formerly MorrisonKnudsen)
51.	MPT - Motive Power Industries (formerly Boise Locomotive)
52.	NAB - North American Bus Industries Inc. (formerly Ikarus USA Inc./IKU)
53.	NEO - Neoplan - USA Corporation
54.	NFA - New Flyer of America
55.	NOV - NOVA Bus Corporation
56.	OBI - Orion Bus Industries Ltd. (formerly Ontario Bus Industries)
57.	Overland Custom Coach Inc.
58.	OTC - Oshkosh Truck Corporation
59.	PCI - Prevost Car Inc.
60.	PLY - Plymouth Division-Chrysler Corporation
61.	PST - Pullman-Standard
62.	PTC - Perley Thomas Car Company
63.	RHR - Rohr Corporation
64.	SDU - Siemens Mass Transit Division
65.	SFB - Societe Franco-Belge De Material
66.	SHI - Shepard Brothers Inc.
67.	SLC - St. Louis Car Company
68.	SOF - Soferval
69.	SPC - Startrans (Supreme Corporation)
70.	SPC - Supreme Corporation
71.	SPR - Spartan Motors Inc.
72.	STR - Starcraft
73.	SUM - Sumitomo Corporation
74.	SVM - Specialty Vehicle Manufacturing Corporation
75.	TBB - Thomas Built Buses
76.	TCC - Tokyo Car Company
77.	TEI - Trolley Enterprises Inc.
78.	TMC - Transportation Manufacturing Company
79.	TTR - Terra Transit
80.	TTT - Turtle Top
81.	UTD - UTDC Inc.
82.	VAN - Van Hool N.V.
83.	WAM - Westinghouse-Amrail
84.	ZZZ - Other (Describe)

APPENDIX B: TAM/NTD Guidance

This appendix clarifies the relationship between the proposed NTD guidance and the proposed TAM rule. FTA is combining new MAP-21 requirements from both the NTD statute (49 U.S.C. 5335) and the Transit Asset Management statute (49 U.S.C. 5326) in a single set of NTD reporting requirements.

- 49 U.S.C. 5335(a) – The NTD shall collect asset condition information..
- 49 U.S.C 5335(c) – The NTD may collect any asset inventory and condition assessment information from any grant recipient.
- 49 U.S.C. 5326(b)(3) – Each designated recipient must report on the condition of their system, and any change in condition from the last report.
- 49 U.S.C. 5326(c)(3)(B) – Designated recipients report annual performance targets for the next fiscal year.
- 49 U.S.C. 536(c)(3)(A) – Designated recipients report on progress towards meeting the current fiscal year’s performance targets.

It is important to note that it is possible for an agency to be considered Tier II under the TAM rule, but to also be an urban full reporter for the purposes of the NTD. The threshold for being a Tier I reporter is 101 vehicles, whereas the threshold for being an NTD full reporter is 31 vehicles. The table below identifies the proposed TAM rule requirements for inventory, condition assessments, and performance measures, as well as how they relate to proposed guidance on the NTD reporting requirements. Many of the NTD elements are listed as requirements for both full and reduced reporters. It is important to recognize that only those systems for which the element is applicable would need to report. For example, the guideway requirements would not be applicable to a bus, only a full reporter. Similarly, the requirements for section 5310 reporters would only apply if they own, operate, or manage the specific asset type in public transportation service.

Category	Class	Component of TAM Plan (if applicable)		Expected Reporting Requirements for NTD Asset Inventory Module (as applicable)	
		Tier I	Tier II/ Group	Urban Full Reporters	Urban Reduced, §5310 and §5311 Reporters
Inventory					
Rolling Stock	Revenue Vehicles	X	X	<p>All current vehicle information,</p> <ul style="list-style-type: none">• Everything at right• Primary funding source• Year of Rebuild• Manufacturer• Mode Name• Number of Active Vehicles• Standing Capacity• Total Miles on Active Vehicles• Avg. Lifetime Miles per Active Vehicle <p><u>Plus</u> the Useful Life Benchmark (ULB) for each fleet group. The NTD system would calculate annual performance based on the date of manufacture information entered into the vehicle inventory.</p> <p><u>Plus</u> the performance target for the next fiscal year for each vehicle type.</p>	<p>Limited data collection,*</p> <ul style="list-style-type: none">• Number of identical vehicles• Vehicle type (bus, car, cutaway, etc.)• Vehicle length• Seating capacity• Year of manufacture• ADA accessibility• Ownership <p><u>plus</u> the Useful Life Benchmark (ULB) for each fleet group. The NTD system would calculate annual performance based on the date of manufacture information entered into the vehicle inventory.</p> <p><u>Plus</u> the performance target for the next fiscal year for each vehicle type.</p> <p>*This is a new requirement for 5310 recipients</p>

Facilities	Passenger Stations and Parking	X	X	<p>Passenger and passenger parking facilities used in the provision of transit service, including facility name, street address, square footage and number of parking spaces, year built or substantially reconstructed, and primary mode.</p> <p>Plus: condition rating for each facility.</p> <p>Plus the performance target for the next fiscal year for the facility group.</p>
	Maintenance and Administrative	X	X	<p>Administrative and maintenance facilities used to supply transit service, including facility name, street address, square footage, year built or substantially reconstructed, and primary transit mode supported.</p> <p>Plus: condition rating for each facility.</p> <p>Plus the performance target for the next fiscal year for the facility group.</p>
Infrastructure	Track	X		<p>Track assets, including length and total number of track special work, reported as network totals by rail mode and operating agreement. The data includes expected service years and date of construction or major rehabilitation.</p> <p>Plus: Slow zones based on directional route miles of track.</p> <p>Plus: The performance target for the next fiscal year for each mode.</p>
	Guideway, Signals & Systems	X		<p>Linear guideway assets and power and signal equipment, including the length of specific types of guideway and corresponding equipment, reported as network totals by mode and operating agreement. The data includes quantity, expected service years, date of construction or major rehabilitation (within a 10 year window).</p>
Equipment	Nonrevenue/ Service Vehicles	X	X	<p>Service vehicles that support transit service delivery, maintain revenue vehicles, and perform administrative activities. The data includes quantity, expected service life, year of manufacture. The NTD system would calculate annual performance based on the manufacturer's age information that is entered into the vehicle inventory.</p> <p>Plus: The performance target for each service vehicle group for the next fiscal year.</p>

Condition Assessment			
Revenue Vehicles	x	x	The system would automatically calculate condition based on data included in the inventory.
Facilities	x	x	Facility condition on TERM Scale 1-5. Reported for each facility in the facility inventory form.
Infrastructure	x		The system would automatically calculate condition based on data included in the inventory.
Equipment	x	x	The system would automatically calculate condition based on data included in the inventory.

The proposed TAM performance measures would require the following targets to be reported to the NTD:

- **Rolling Stock:** Percentage of revenue vehicles within a particular asset class that have either met or exceeded their useful life benchmark (ULB). FTA is proposing that reporters submit *one target for each revenue vehicle classification*.
- **Facilities:** Percentage of facilities within an asset class, rated below 3 on the Transit Economic Requirements Model (TERM) scale (1=poor to 5=excellent). FTA is proposing that reporters be required to provide *an annual target for each facility type*.
- **Infrastructure:** Percentage of track segments, signal, and systems with performance restrictions. FTA is proposing that reporters submit *an annual target for each mode*.
- **Equipment:** Percentage of vehicles that have met or exceeded their ULB. FTA is proposing that reporters be required to provide *one target for the percentage of classification of non-revenue vehicle that have met or exceeded their useful life benchmark for each service vehicle category*.

APPENDIX C: Examples of Categories, Classes, and Individual Assets

ASSET CATEGORY		ASSET CLASS	INDIVIDUAL ASSET
	Equipment	Construction	Crane Prime Mover
		Maintenance	Vehicle Lift Track Geometry Car
		Service Vehicles	Tow Truck or wrecker Emergency Response Vehicle
	Rolling Stock	Buses	40 Foot Bus 60 Foot Bus
		Cutaways	
		Cars and Vans	
		Railcars	Light Rail Vehicle Locomotive Passenger Coach
		Paratransit Vehicles	Van Cutaway
		Ferries	Catamaran Docking
	Infrastructure	Signal Systems	Signal or Relay House Substation Interlockings
		Rail-Fixed Guideway	Track Segment Interlockings
		Catenary	
		Structures	Bridges Tunnels Elevated Structures
		Mechanical Systems	
		Electrical Systems	
		IT Systems	
	Facilities	Maintenance	
		Administration	
		Depots or Terminals	
		Parking Garages	

APPENDIX D: Database Elements

Revenue Vehicles	Facilities	Infrastructure	Equipment
Revenue Vehicles	Administrative and Maintenance Facility	Tracks	Service Vehicle
	Passenger and Parking Facility	Rail-Fixed Guideway	Construction
		Systems	Maintenance
		Catenary	Catenary
		Structures	ITS Systems

REVENUE VEHICLES

Revenue Vehicles
Asset ID:
Asset ID (manual):
Primary Mode:
Asset Name:
Model:
Serial Number:
Location Identifiers:
Purchasing Information:
Year of Manufacture:
Vendor:
Contract:
Price:
Manufacturer Code:
Date In-Service:
Year of Last Rehabilitation Activity:
Type of Last Rehabilitation Activity:
Estimated Rehabilitation Cost:
Year of Estimated Rehabilitation Cost:
Estimated Replacement Cost:
Year of Estimated Replacement Cost:
Parts:
Warranty:
Fuel Type Code:
Vehicle Length:
Standing Capacity:
Total Miles:
Average Lifetime Miles:
Unit Quantities:
Expected Useful Life:
Asset Criticality:
Active:
ADA Vehicle:
Funding Source:
Condition:
Notes:

FACILITIES

Administrative and Maintenance Facility	Passenger and Parking Facility
Asset ID:	Asset ID:
Asset ID (manual):	Asset ID (manual):
Primary Mode:	Primary Mode:
Facility Name:	Facility Name:
Section of a Larger Facility:	Section of a Larger Facility:
Street Address:	Street Address:
City:	City:
State:	State:
ZIP Code:	ZIP Code:
Latitude:	Latitude:
Longitude:	Longitude:
Facility Type:	Facility Type:
Year Built or Replaced:	Year Built or Replaced:
Size (Square Feet):	Size (Square Feet):
Percent Transit Agency Capital Responsibility:	Percent Transit Agency Capital Responsibility:
Estimated Cost:	Estimated Cost:
Year of Estimated Cost:	Year of Estimated Cost:
Funding Source:	Funding Source:
Condition:	Condition:
Notes:	Notes:

INFRASTRUCTURE

Tracks	Rail-Fixed Guideway	Systems	Catenary	Structures
Asset ID:	Asset ID:	Asset ID:	Asset ID:	Asset ID:
Asset ID (manual):	Asset ID (manual):	Asset ID (manual):	Asset ID (manual):	Asset ID (manual)
Rail Mode Type:	Primary Mode:	Rail Mode:	Mode:	Primary Mode:
Track Element:	Asset Name:	Type:	Overhead Device:	Type:
Linear Track:	Guideway Element:	Year Built or Replaced:	Quantity - Linear Feet:	Year Built or Replaced:
Track Special Work (Excluding Linear Assets):	Quantity - Linear Ft:	Cost:	Year Built or Replaced:	Cost:
Quantity:	Quantity - Track Ft:	Avg Expected Service Years:	Avg Expected Service Years:	Avg Expected Service Years:
Units:	Avg Expected Service Years:	% Transit Agency Capital Responsibility:	% Transit Agency Capital Responsibility:	% Transit Agency Capital Responsibility:
Avg Expected Service Years:	Avg Estimated Service Years:	Funding Source:	Funding Source:	Funding Source:
% Transit Agency Capital Responsibility:	Allocation Unit:	Condition:	Condition:	Condition:
Funding Source:	Year of Construction or Rehab:	Notes:	Notes:	Notes:
Condition:	% Transit Agency Capital Responsibility:			
	Funding Source:			
	Condition:			
	Notes:			

EQUIPMENT

Service Vehicle	Construction	Maintenance	ITS Systems
Asset ID:	Asset ID:	Asset ID:	Asset ID:
Asset ID (manual):	Asset ID (manual):	Asset ID (manual):	Alternative Asset ID:
Service Vehicle Name:	Primary Mode:	Primary Mode:	Primary Mode:
Model Number:	Type:	Type:	Asset Name:
Serial Number:	Year Built or Replaced:	Year Built or Replaced:	Vendor:
Type of Service Vehicle:	Cost:	Cost:	Cost:
Avg Expected Service Years:	Avg Expected Service Years:	Avg Expected Service Years:	Avg Expected Service Years:
% Transit Agency Capital Responsibility:	% Transit Agency Capital Responsibility:	% Transit Agency Capital Responsibility:	% Transit Agency Capital Responsibility:
Year of Manufacture:	Funding Source:	Funding Source:	Funding Source:
Estimated Cost:	Condition:	Condition:	Condition:
Year of Estimated Cost:	Notes:	Notes:	Notes:
Warranty:			
Active:			
Funding Source:			
Condition:			
Notes:			

APPENDIX E: Web Application Graphical User Interface

Asset Management

Data Management

Data Export