Transit Asset Management (TAM) Pilot Program

FTA-2011-004-TPM

Volume 1 – Asset Inventory and Condition Assessment Guide

CH2MHILL®

September 2013

TBG091712092129MKE

Table of Contents

Tables

Figures

1 Introduction

1.1 RTA and the Transit Service Boards

The Regional Transportation Authority of Northeastern Illinois (RTA) is the oversight, funding, and regional planning agency for the three transit operators (also known as Service Boards) that serve Northeastern Illinois:

- Chicago Transit Authority (CTA) –nation's second largest public transportation system. The CTA service area covers the City of Chicago and 40 surrounding communities. Through its bus and rail systems, it provides more than 80 percent of the public transit trips in the six-county Chicago metropolitan area (Cook, DuPage, Will, Lake, Kane, and McHenry counties) either with direct service or connecting service to Metra and Pace.
- Metra – commuter rail agency. Metra serves more than 100 communities in the six counties with 241 stations on 11 lines running from Chicago's downtown.
- Pace – suburban bus and regional paratransit. Pace is the suburban transit provider for the Chicago area. Pace serves riders with fixed bus routes, vanpools, and Dial-a-Ride programs covering 3,500 square miles spread over six counties and 284 municipalities. Pace is also the ADA paratransit provider for the region.

The RTA was created in 1974 by approval of a referendum by the residents of the six counties (Cook, DuPage, Will, Lake, Kane, and McHenry counties). The RTA is a special-purpose unit of local government and a municipal corporation of the State of Illinois. The three Service Boards - each led by a Board of Directors - individually handle their respective transit operations and fare responsibilities.

RTA Mission

The RTA will ensure financially sound, comprehensive, coordinated public transportation for the Northeastern Illinois region.

The RTA regional system is the third largest in the country, covers approximately 7,200 route miles, and provides more than two million daily rides. The RTA's combined assets include approximately 7,000 revenue vehicles, 380 rail stations, over 350 bus routes, and 60 maintenance facilities. With some of the nation's oldest transit assets, the RTA also has significant reinvestment needs to attain and maintain a state of good repair (SGR).

Table 1: Representative Service Board Resources and Transit Service Provided (2012)

	CTA Bus	CTA Rail	Metra	Pace
Revenue Vehicles	1,817	1,330	1,265	2,584
Other Vehicles	934		576	143
Fixed Guideway Route Miles	3.7	207.8	980.4	N/A
Annual Revenue Miles	52.4 million	65.2 million	47.41 million	35.1 million
Annual Revenue Hours	5.6 million	3.6 million	1.54 million	2.1 million
Annual Passenger Miles	725.0 million	1,541 million	1,768.8 million	256.3 million
Stations, Bus Stops and Transit Facilities	11,468 posted bus stops	145	269	9 transfer centers, 9 Park-n-rides, 18 boarding/ turnaround facilities

Source: 2012 Operations data from CTA, Metra, Pace

RTA has been involved in Transit Asset Management since 1987, when it began conducting system capital needs studies. Today, RTA is into its third generation Transit Asset Management effort, resulting in unprecedented knowledge of its current backlog, condition of assets, and ability to forecast future replacement and rehabilitation needs.

In 2006, the RTA, along with the CTA, Metra and Pace, and its partners for Transit, launched a strategic planning project coined "Moving Beyond Congestion" (MBC). Among other things, MBC allowed the RTA and the Service Boards to address critical questions about the condition and adequacy of the public transportation system, as well as the external factors, such as growing congestion. This strategic plan effectively launched the third generation of Transit Asset Management for the RTA and the Service Boards, several years before the Moving Ahead for Progress in the 21st Century (MAP-21) legislation came to fruition.

RTA's current strategic plan for 2012-2016 is called "the Way Forward". The strategic priority initiatives contained therein aim to focus on a state of good repair, reducing expenses, and increasing efficiencies.

1.2 TAM Description and FTA Grant

In 2011, the RTA received an $800,000 Transit Asset Management (TAM) Pilot Project grant from the Federal Transit Administration (FTA). This pilot project includes TAM improvements that build off existing RTA TAM processes already underway, namely the Capital Asset Condition Assessment, Capital Optimization Support Tool (COST), and management approaches already in use. The objectives of RTA's TAM grant include:

- Document RTA's existing policies; goals and objectives; performance targets and evaluation processes; and inventory/condition data collection, management, and reporting processes such that other local and regional operators can benefit from RTA's experience;
- Advance the TAM "state-of-the-art" capabilities in the areas of estimated capital investment needs and investment prioritization; and
- Develop asset-to-project groupings using the analytical foundation provided by RTA's existing project screening and prioritization process and FTA's existing Transit Economic Requirements Model (TERM) model as a foundation for tool development.

The TAM Pilot Project is roughly a 25 month process for RTA. The TAM deliverables are documented in two volumes, which include:

- Volume 1 – Asset Inventory and Condition Assessment Guide (this report)
- Volume 2 – Capital Optimization Support Tool

This document presents the first "how to" guide on developing an asset inventory and conducting condition assessments. The intent is that this document will be helpful to other operators or funding agencies conducting similar tasks. The supplementary work papers are contained in Volume 2.

1.3 MAP-21 and NTD Reporting Requirements

The 2012 legislation Federal Moving Ahead for Progress in the 21st Century Act (MAP-21) requires the FTA to establish a national transit asset management system that includes:

(1) A definition of state of good repair (SGR) with performance measures
(2) A requirement that grantees develop transit asset management plans
(3) Reporting requirements for asset inventory and condition assessments
(4) Analytical process or decision support tools
(5) Technical assistance on asset management for grantees

> "Grantees are now required to establish and use an asset management system to develop capital asset inventories and condition assessments and report on the condition of their system as a whole"
> **– Administrator Rogoff**

As of September 2013, the FTA has just issued the draft rulemaking concerning the legislation. The actual rulemaking is will be issued subsequent to the comment period.

The grantees will be expected to submit an annual report that outlines progress during the fiscal year towards the performance targets established for the past fiscal year and identifies performance targets for the next fiscal year. The grantees will have three months after the final rule to establish TAM performance targets in relation with the FTA measures.

In addition, MAP-21 establishes new National Transit Database (NTD) reporting requirements for grantees. It is anticipated that the grantees will have to provide data on operating and asset condition, replacement costs, and information on transit asset inventory and condition assessment. Because inventories, condition assessments, and decision support tools are explicitly cited in the legislation as new requirements, guidance documents such as this one and others funded by FTA take on new significance.

1.4 PAS 55 and ISO 55000

In addition to MAP-21, there are two other standards which may affect transit agency adoption and implementation of asset management systems. These are PAS 55 and ISO 55000.

- The Institute Asset Management (IAM) led the development of Publicly Available Specification (PAS) 55 in 2004. The standard contains a specification for the optimized management of physical infrastructure assets, as well as guidelines to apply the standard. The standard is applicable to a wide range of infrastructure, including water, power, manufacturing, road, air and rail transport systems.

- The International Standards Organization (ISO) has adopted PAS 55 as the basis for development of a new ISO 55000) series of international standards. The standards have an expected date of publication of 2014. When complete, the series will include three standards:

  - ISO 55000 provides an overview of asset management and the standard terms and definitions
  - ISO 55001 is the requirements specification for an integrated, effective management system for assets
  - ISO 55002 provides guidance for implementation of the system

1.5 Purpose from an Agency Perspective

For the purpose of this document, an agency is interpreted to be either a transit operating agency, or a regional transit funding agency. Findings and recommendations are applicable to both types of agencies.

Though the RTA is a regional funding agency, this document is applicable to individual transit agencies.

The RTA has been involved in transit asset management 25 years now. RTA's efforts are transparent and result in increasingly reliable levels of asset information.

Through the FTA TAM Pilot Project grant, the RTA has been able to significantly enhance several of its asset management processes, as well as document the practice for the benefit of others. The RTA created this document as the first of a two volume "how to" guide series to identify lessons learned and empirical experience. The RTA hopes that this condition assessment guide will help other agencies in two primary ways:

- By providing a set of asset inventory development foundational elements for agencies who might be embarking on the development of their asset management inventories for the first time, or wishing to update and refine their inventories; and

- By explaining the main approaches, trade-offs involved, issues/options and steps involved for agencies wanting to conduct asset condition assessments and sampling.

2 Asset Management in RTA Region

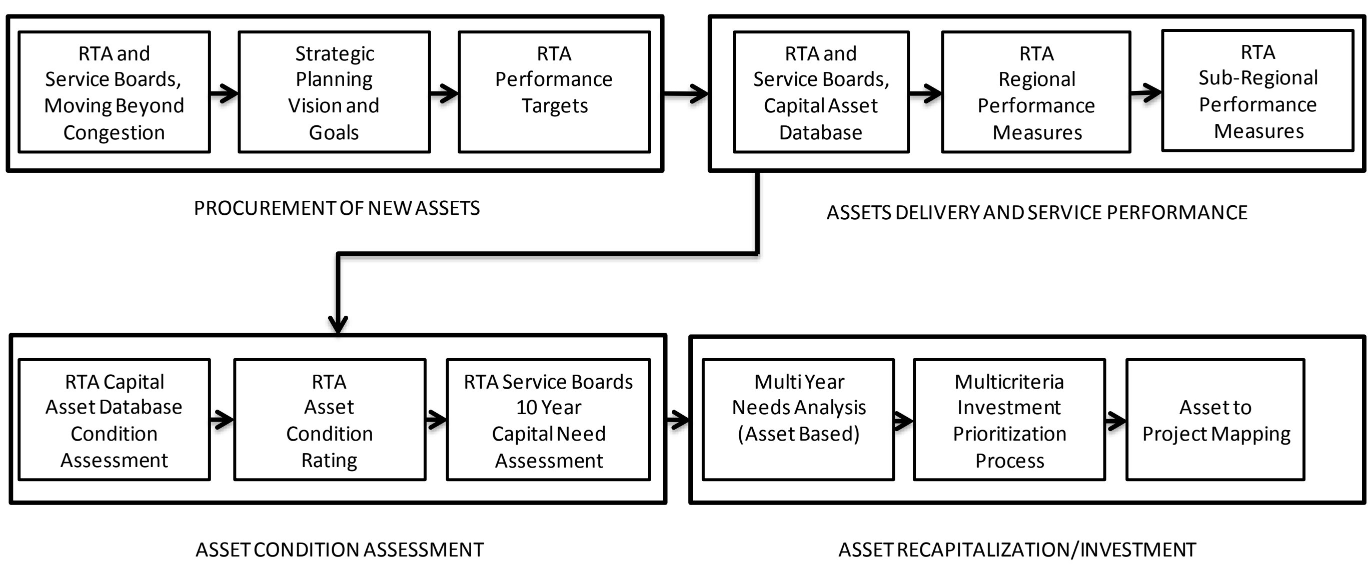
2.1 Transit Asset Management System

The Transit Asset Management (TAM) System in place at RTA today is a product of a significant evolution that includes, among others:

- Individual Service Board capital planning processes
- RTA Strategic Plan – Moving Beyond Congestion (2006)
- TAM-related State Legislation requirements (e.g., Public Act 95-0708, 2008)
- Joint efforts between RTA and the Service Boards over the past 25+ years and unprecedented levels of collaboration in the last 5 years

The drivers, programs and processes that guide RTA's Transit Asset Management System follow the typical transportation asset management cycle, from procuring new assets; to delivering assets and service performance; conducting condition assessments; and asset re-capitalization. The drivers and processes follow the asset lifecycle. They are illustrated in the boxes as illustrated in Figure 1 below.

Figure 1: RTA Transit Asset Management Drivers, Processes and Asset Lifecycle



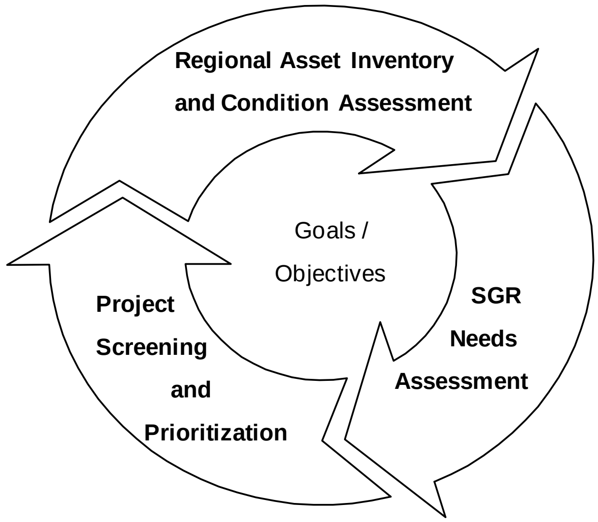
Narrowing this to TAM-specific activities that need to be pursued on an ongoing basis, RTA's TAM system is composed of the following three elements (Figure 2):

- An ongoing regional transit asset inventory and condition assessment program – that is, a thorough understanding (database) of the RTA's total asset base and characteristics, including condition.

- A State of Good Repair (SGR) needs assessment process based on the inventory – that is, a means to project detailed and total needs based on inventory data and condition information, dollar-wise and time-wise such that the system stays in a State of Good Repair.

- A project screening and prioritization capital development process, which uses the goals and objectives set in the RTA Strategic Plan to achieve optimum outcomes and links to an ongoing performance measurement program.

Figure 2: TAM Elements at RTA



Strengthening the nexus between each of these three elements is vitally important because each activity provides critical knowledge for the next. "Connecting the dots" spans the spectrum from tactical information (e.g., actual asset condition) all the way to strategic decision making. RTA has worked with the Service Boards to gradually adopt best practices not only to strengthen the quality of each of the elements, but as new tools and techniques become available, to connect these elements in a manner that supports the RTA Strategic Plan.

The RTA, in conjunction with the three Service Boards, is continuing to develop a more systematic and integrated approach to TAM, including concurrent implementation of its Capital Asset Condition Assessment program and customization of its Capital Optimization Support Tool. This includes greater emphasis on performance measures.

The following section provides a more detailed history of the evolution of Asset Management in the RTA region.

2.2 Evolution of Asset Management in the RTA Region

As mentioned in the previous chapter, RTA is currently in its third-generation TAM effort. This section retraces the history of asset management development at RTA.

2.2.1 2000's and Earlier: Capital Needs List

In 1987, the RTA completed a detailed examination of the transit system's capital needs list. This effort developed the first comprehensive inventory of capital assets and an age-based estimate of capital renewal requirements, known as the RTA Bedrock Investment Program (BIP). BIP was a spreadsheet-based software tool to estimate both deferred and future capital needs for the Service Boards. The results of this analysis focused on the first Strategic Plan and served as a basis for legislative initiatives to increase the level of capital funding. BIP pioneered the development of the asset inventory based needs analysis on which FTA's TERM was later founded.

In 1995, the RTA created the Transit Capital Asset Model (CAM) to (1) update the original asset inventory, (2) incorporate asset condition information from the extensive engineering assessments of CTA rail infrastructure, and (3) improve the model's utility for the RTA and the Service Boards' capital planning staff. This represented RTA's second generation Asset Management development. CAM estimated current and future capital renewal needs and supported evaluation of the impact of various funding levels and renewal strategies on system conditions over time. CAM was developed in tandem with FTA's Transit Economics Requirements Model (TERM) model, with many of the same capabilities.

In 2000, the RTA developed the Regional Transportation Asset Management System (RTAMS), a transportation information retrieval system. The system improved access to the region's enormous transportation data resources being gathered by the RTA, its Service Boards, and other regional transportation and planning agencies.

In July 2006, the RTA, along with the Service Boards and its Partners for Transit, launched Moving Beyond Congestion (MBC), a strategic planning initiative meant to raise awareness about the need to maintain, enhance, and expand transit service as well as to solicit input from key stakeholders and the general public. MBC provided the foundation for the subsequent funding and reform legislation enacted in 2008 and 2009. The legislation mandated that the RTA provide more effective financial oversight, regional planning, and coordination among the three operating Service Boards. In addition, the RTA is now required to prepare a Strategic Plan at least every five years consistent with the Chicago Metropolitan Agency for Planning's Comprehensive Plan. This process involves a multilayered approach to determine which capital projects become programmed in the five year Capital Plan and Annual Budgets. This consists of a screening process that groups potential projects into related types of investments (e.g., preservation, expansion, or enhancement); prioritizes projects based on customer impacts, mission criticality, ridership impacts, and benefit-cost analysis; and evaluates additional criteria, such as project readiness, to determine the actual programming.

Efforts to complete MBC Strategic Plan included the development of the RTA Performance Measures. It established performance standards and measurements regarding the adequacy, efficiency, and coordination of public transportation services in the region, and the implementation of the goals and objectives in the Strategic Plan. RTA is required to develop performance measures to inform the public about the extent to which the provision of public transportation in the metropolitan region meets the goals, objectives, and standards for the RTA, the Service Boards, and the broader community of stakeholders and to reflect the adequacy and efficiency of public transportation services. In July of 2008, the RTA Board adopted Ordinance No. 2008-46 endorsing the work done by the RTA and Service Board task force on the regional performance measures and directed the Executive Director to begin collecting data and to report to the Board and publish the results for the eventual inclusion in the future comprehensive amendment to the strategic plan.

2.2.2 2009: Baseline Assessment using Age-Based Quintiles

In 2008, the RTA initiated its third generation of Asset Management development – a condition assessment of the existing capital assets for each of the region's three Service Boards: CTA, Metra, and Pace. These three agencies are diverse transit systems representing large to very large, newer and old systems, and most importantly, all competing for regional dollars that would ultimately only partially fund backlogs. While the challenges were significant, the Service Boards worked well together to undertake and complete the assessment in a cost-effective and timely manner. Some features of the process are described in greater detail below but, in short, the process included the following steps:

- Established an Inventory Assessment Team
- Reviewed other agency procedures
- Defined/Categorized Assets (e.g.; Track & Structures, Signals/Communications/Fare Collection, Stations/Garages/Facilities, Rolling Stock)
- Determined useful life and establish asset age quintile of each asset
- Created asset inventory templates to include asset type, origination date, quantity, unit value/replacement cost and condition and populate the Inventory tables
- Observed/sampled specific assets to verify condition based on asset age
- Based on asset unit value/replacement cost, determined backlog and normal reinvestment over a given, agreed-upon period of ten years.

Initially, Service Boards collected data for each asset type, including description, location, quantity, age, replacement cost, and useful life. Condition was added based on age-based quintile calculations using a 5 to 1 scale (first, second, third and fourth quarters of useful life plus "past" useful life). In addition, the effort created a relational database for recording, maintaining, and reporting asset information.

Representatives from the Service Boards assisted in all aspects of this process including: the design and development of the inventory tables, the condition ratings system based on useful life and industry standards, the definition of "State of Good Repair (SGR)", the sampling plan and sampling data. Asset Information Teams were formed to design and develop the industry framework. Each Asset Information Team consisted of members representing the RTA, the Service Board and the consultant team. For discussion purposes at the Asset Information Team meetings, assets were grouped into five asset types:

- Track and Structures
- Electrical/Subway Equipment
- Signals/Communications/Fare Collection
- Stations/Garages/Facilities
- Rolling Stock

The effort provided the RTA with a plan for capital asset condition assessment and established administrative criteria for the capital replacement, rehabilitation, and maintenance of assets. In 2010, the RTA published the initial report on the capital asset condition assessment (referred to as the Baseline Assessment). The report summarized the results of the 18-month collaborative effort to assess the general condition of the region's capital assets as of December 31, 2009 and to determine valuation, backlog, and capital needs over 10 years. The initial 10-year capital needs assessment was based on cost components for backlog, normal replacement, and capital maintenance.

During the Baseline Assessment, the RTA and Service Boards determined that an asset's age could act as the primary "predictor" of an asset's condition. This approach reflected the best approach possible among the Service Boards while taking into consideration the limited resources of each Service Board and the level of effort required to undertake the overall assessment. While availability of in-depth information and data was unavailable for each asset for the Service Boards, sufficient data was collected, and satisfactory age estimates were established for nearly all assets.

During the process of compiling data for the age-based inventory tables, a number of asset groups were selected for an extremely limited on-site sampling effort. The sampling, representing less than 1% of each asset class, was meant to test the degree of consistency between asset age and the condition of assets in actual field conditions. For the most part, though not all cases, the results of the limited sampling did generally confirm the condition rating process based on asset age.

FTA's Transit Economic Requirements Model (TERM)

TERM is a national level transit capital investment needs analysis tool. The FTA developed TERM to assess both the size of the nation's state of good repair backlog and the level of investment required to address both the backlog and normal (ongoing) reinvestment needs. The FTA then reports those needs to Congress via the *Conditions and Performance Report*. The RTA benefits from TERM in several ways:

- Condition measures and the related asset curves used to assess RTA's regional transit asset conditions were developed for use in TERM.
- The hierarchy of asset types used to develop the inventory framework for the assessment of regional investments needs was derived from TERM.
- RTA's Capital Optimization Support Tool was initially developed as a modified and customized version of TERM. While COST continues to benefit from advances in TERM's design, the reverse is also true (TERM continues to benefit from development advances of COST).

While TERM is used by the FTA for a national level of analysis of SGR and 20-year projections of reinvestment needs, TERM Lite is a local version of TERM designed for transit agencies to forecast and prioritize local and regional capital needs.

2.2.3 2011: Repeatable Asset Condition Update Process

In 2011, the RTA started a 5-year effort to annually update the Baseline Assessment. The process used in the Capital Asset Condition Assessment Updates (referred to as the Condition Assessment Updates) closely aligns to that used by the FTA and other industry peers. As part of the conversion of the separate inventories, individual asset line items were assigned to the detailed asset type codes and related asset inventory hierarchy utilized by the FTA's TERM. Use of this TERM-based asset type mapping ensures that asset documentation and the assessment of the RTA and Service Board reinvestment needs is consistent with forthcoming FTA asset reporting requirements and emerging industry asset reporting standards.

Using FTA's TERM asset inventory hierarchy enables the RTA to apply the FTA's asset decay curves based on national data. The FTA has developed "generic" transit asset decay curves for major asset types using condition data collected from transit agencies nationwide. These curves predict asset physical condition as a function of age, maintenance history, and other factors on a common 5 to 1 rating scale. Sources for this information can be found at http://www.fhwa.dot.gov/policy/2002cpr/appc.htm.

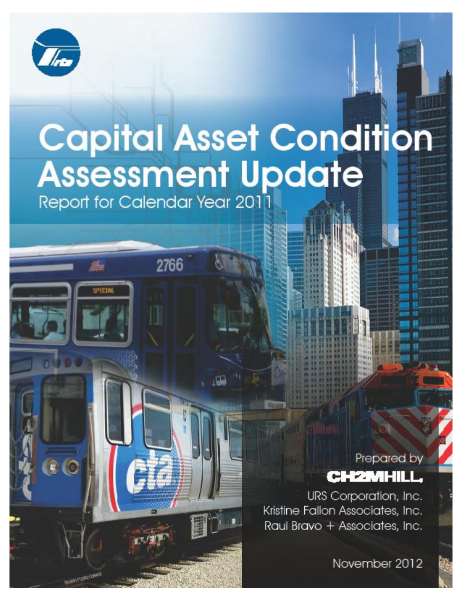
The decay curve approach to estimate asset condition represents a shift from the prior approach used in the Baseline Assessment, which relied purely on age-based useful life quintiles (i.e., first quintile for first quarter of asset life, second quintile for second quarter of asset life, and so forth up to fifth quintile for assets exceeding their life). Using the decay curve approach, asset condition is estimated on an empirically derived continuum of physical condition, as opposed to age, to help develop a regional distribution of asset conditions and prioritize asset replacement.

Similar to the Baseline Assessment, on-site samplings of actual transit asset conditions were completed to assess the region's transit assets as a part of this Condition Assessment Update. The objective of these condition assessments (still ongoing) is to both validate and eventually recalibrate FTA's decay curves to better reflect the asset deterioration characteristics of transit assets in the Chicago region. By recalibrating the curves to reflect the local operating environment, the RTA can improve the accuracy of its condition assessments.

The Update assessment process features a continuation of the close partnership between the RTA and the three Service Boards. An Asset Management Committee was formed at the beginning of the Update largely made up of the same members that had participated in the Baseline Assessments. Each Service Board assigns participation; generally the cadre of participants represents capital planning, finance, and operations. The Committee generally meets each month either at the RTA offices or at the Service Board offices to discuss ongoing issues, the results of current research topics, and the status of current Update and needs modeling efforts.

Meanwhile, RTA, working with the Service Boards, developed the current strategic plan for 2012-2016 called "the Way Forward". The strategic priority initiatives contained therein aim to focus on a state of good repair, reducing expenses, and increasing efficiencies. Transit Asset Management supports all five key strategic priorities, which are:

- Strategic capital investments
- Economies of scale
- Maximize use of the system
- Enhanced customer experience
- Coordinated government affairs, marketing and outreach



The RTA has completed its 2012 Capital Asset Condition Assessment Update report. The document is intended to serve as RTA's annual snapshot of conditions and needs, an annual repeatable process.

2.3 RTA's Capital Optimization Support Tool

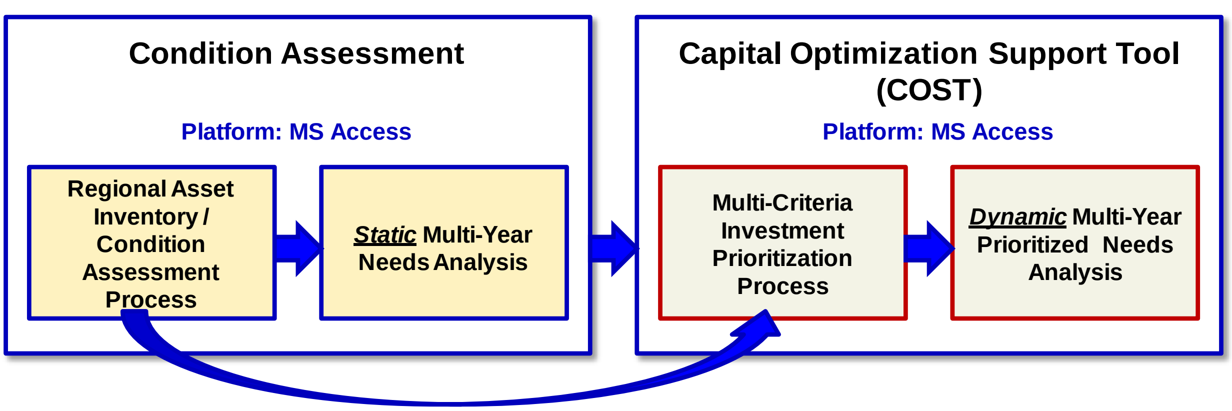
The RTA's new Capital Optimization Support Tool (COST) provides the RTA and the Service Boards an improved ability to both assess the region's capital reinvestment needs and then prioritize those needs subject to the region's long-term strategic objectives. In April 2011, the RTA and the Service Boards initiated development of COST. This decision support tool uses asset inventory data collected through the Condition Assessment Update process to assess and prioritize transit capital investment needs subject to regional funding capacity and long-term strategic objectives.

COST provides a unique perspective and understanding – particularly as they relate to long-term reinvestment needs – that other types of analyses cannot. For example, detailed onsite engineering condition assessments provide an excellent understanding of reinvestment needs and asset conditions as they exist today and how those conditions will impact near term reinvestment actions (e.g., as outlined in a capital improvement plan). However, condition assessments only provide a snapshot of needs and conditions as they exist at a specific point in time (today) and do so only for those assets included in the assessment. In contrast, COST is specifically designed to assess reinvestment needs and project asset conditions for all capital assets, and it does so over an extended time horizon of ten, twenty years or longer.

While currently focused solely on the assessment of regional reinvestment needs (i.e., preservation of the existing stock of transit assets), moving forward, COST will help the region identify an optimal balance between replacing aging infrastructure (maintain); improving the throughput, reliability, and safety of existing services (enhance); and adding new capacity to improve system performance (expand) – all within the confines of limited financial resources. At a more detailed level, COST will assist the RTA and the region to establish priorities within each of these types of needs (e.g., prioritizing between different asset replacement projects).

COST is able to assess the region's capital reinvestment needs by importing asset inventory and condition assessment data collected during the Condition Assessment Updates. The relationship between COST and the Condition Assessment data collection processes is illustrated in Figure 3. At the start of the Condition Assessment Process the three Service Boards each submit data tables (MS Excel based) to a centralized data warehouse. These datasheets are then uploaded to the Regional Asset Inventory Database (MS Access based), where the data are reviewed and validated. The validated data are then exported to COST. More detail on RTA's experience COST is available in the Capital Optimization Support Tool "How To" Guide, another document of this series.

Figure 3: Relationship between the Asset Condition Assessment and COST Processes



3 "How To" Guide To Build and Update an Asset Inventory

3.1 Uses of an Inventory

Asset inventories are critical for transit agencies in measuring SGR and forecasting reinvestment needs. With the recent Federal MAP-21 legislation, asset inventories are required for recipients of Federal funding support.

In practice, asset inventories mean different things to different users of the information within transit agencies. It is critical to appreciate this reality when building or refining an asset inventory. Four perspectives are presented.

From an accounting perspective, an asset inventory, registry, or ledger represents the official record of a business's current assets, including property owned. Typically, the financial accounting system would record a description of the asset, the purchase value, year of acquisition, number of units, and in-service status. Agencies must also comply with regulatory standards, such as GASB 34. Financial accounting systems also contain assumptions regarding depreciation. Often the financial accounting inventory level of detail is high-level and may not lend itself well to TAM as defined in this report. For instance, with new construction, an entire extension with multiple assets could be identified as a single record.

From a maintenance perspective, assets are what need to be maintained or replaced. The level of information varies significantly from asset to asset, depending on replacement practices (i.e., whether an asset is replaced at the component, assembly, or sub-assembly level) and other asset data. Asset data may require less granularity if handled by an outside contractor. Maintenance employees' main tools include information contained on a work order, often accessible through a computerized maintenance management system. A detailed asset inventory, though not a day-to-day tool, is nonetheless a useful reference for maintenance personnel, particularly if integrated with the work order system.

From a capital planning perspective, the asset inventory represents the universe of the assets to be managed over time regardless of "owner". Capital budgets are typically one and two year budgets, while capital plans typically span five or more years. Capital planning is interested in knowing when assets need to be replaced or rehabilitated, and how much investment will be required each year. Capital planning is also interested in knowing how asset replacement needs are to be converted into specific projects. More robust inventories and condition assessments help better plan capital reinvestment needs over an extended time horizon, including estimating and smoothing out spikes in the reinvestment program.

From a risk management perspective, the asset inventory is of interest to identify potential risks to public safety and reliability caused by overdue maintenance and capital replacement. Asset managers sometimes develop risk registers for this purpose. Lately, attention is being placed on mitigating global climate change impacts by flagging assets in susceptible areas.

An asset inventory is a living register. Every year, as new assets are purchased and brought into revenue service, or as ageing assets are retired, the inventory will change and should be updated accordingly.

Governmental Accounting Standards Board 34 (GASB 34)

GASB 34, issued in 1999, established new financial reporting standards for state, local, and special-purpose governments, such as transit agencies. Related to asset management, GASB 34 changed the way that state and local governments offer financial information to the public by requiring governments to use accrual accounting and report the value of their capital assets, including depreciation, in their annual reports. Accrual accounting measures not just current assets and liabilities but also long-term assets and liabilities (such as capital assets, including infrastructure, and general obligation debt). It also reports all revenues and all costs of providing services each year, not just those received or paid in the current year or soon after year-end.

Source: http://www.gasb.org/st/summary/gstsm34.html

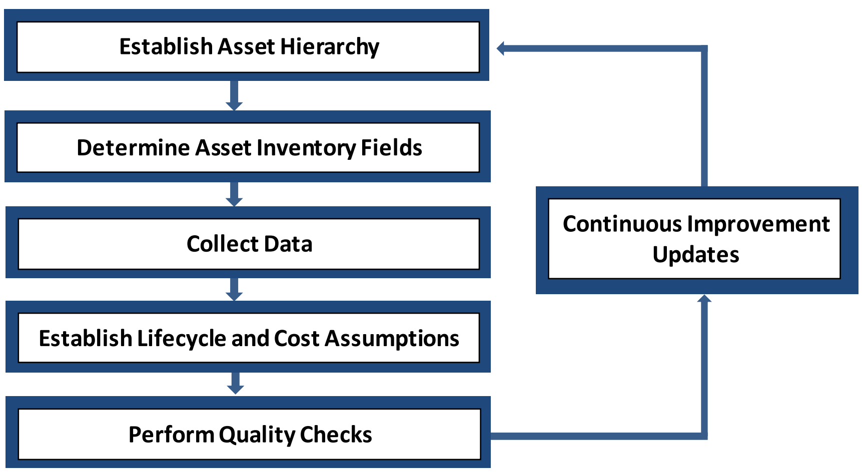
3.2 Inventory Development

The foundation of the condition assessment process is a detailed asset inventory that documents the transit assets. Establishing the inventory database structure is important in order to ensure data collection consistency. In developing an inventory, it is critical to assess the objective of the inventory, its structure or hierarchy, the level of disaggregation needed, the condition rating scale and definitions, and compliance with regulatory (e.g. MAP-21 and GASB 34) and regional reporting requirements. Participation of staff from various departments and/or operators in the development process of the asset inventory improves consistency and leverages knowledge to inform the inventory framework.

As part of the Baseline Assessment, the RTA and its Service Boards established a comprehensive Regional Asset Inventory Database representing all asset categories of public transportation capital assets. It provided a forum for representatives from the Service Boards to assist in all aspects of the process including the design and development of the inventory tables, the condition ratings system based on useful life and industry standards, the definition of SGR, condition rating process, a sampling plan, and sampling data. The Condition Assessment Update maintained this inventory framework with some improvements.

The inventory development process can be summarized by a half dozen key steps summarized in Figure 4, below. Each is further detailed in this section.

Figure 4: Asset Inventory Development Steps



3.3 Asset Hierarchy

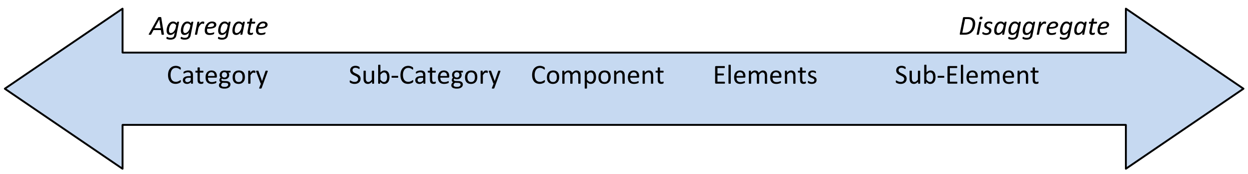
RTA's asset inventory is in fact three asset inventories, one for each Service Board. Each uses a hierarchical asset inventory structure that grouped all of the regions' transit assets into five categories and related sub-categories, as appropriate and selected by the Service Board. These structures were chosen to be consistent with FTA's practice. The first two levels of that structure are presented in Table 2.

Table 2: Example of Asset Inventory Hierarchy

Category	Sub-Category
Facilities	Buildings
	Equipment
	Storage Yard
Guideway Elements	Track Structures
	Trackwork
Stations	Bus
	Rail

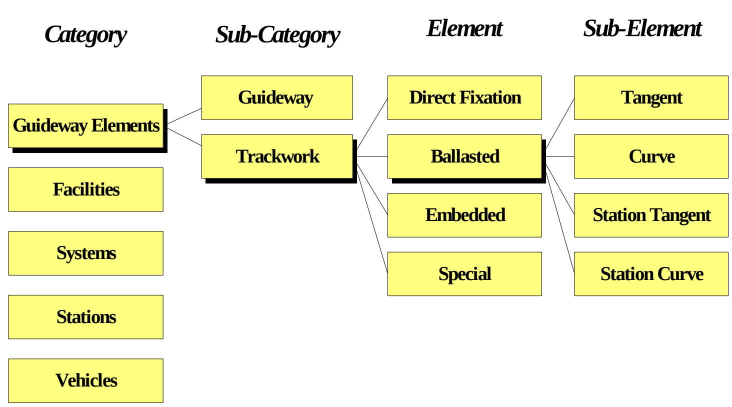
Category	Sub-Category
Systems	Communications
	Traction Power
	ITS & Security
	Revenue Collection
	Train Control
	Utilities
Vehicles	Revenue Vehicles
	Non-Revenue Vehicles

Ideally, the inventory hierarchy will be consistent with the Enterprise Asset Management's hierarchy. This way, the information can be aggregated and disaggregated to suit the purpose.



It is important to note that there can be several overlapping inventory structures; the key if there are multiple structures is there be a crossover to the data can be aggregated and disaggregated for planning and reporting needs. In the case of RTA, there are essentially two sets of inventory structures: the one maintained by the Service Boards, and the one which the Capital Optimization Support Tool (COST), which is close to FTA's TERM Lite structure. Each Service Board structure was mapped to the COST structure so that capital reinvestment needs can be readily estimated. An example of the COST/TERM four level asset inventory is presented below in Figure 5.

Figure 5: Four Level TERM Asset Inventory



Using sub-categories, components, elements and sub-elements enables rolling up and grouping assets into higher level categories, while at the same time allowing for the inventorying of individual assets and their components. This ability to aggregate and disaggregate asset data is important since components may be in different condition and have different life cycle needs. Recording asset data down to the element level enables an agency to track the condition of its assets at the sub-category, component, and element level. This disaggregation also makes on-site sampling more straightforward.

Determining the correct level of disaggregation depends on the level of detail needed. Using the inventory for reporting would not require the same level of detail as would be required for using the inventory for capital and maintenance planning. Since different components of an asset may have different useful lives and could require intermediate replacement, capital and maintenance planning requires a more robust inventory with disaggregated data.

Over time, the inventory structure will evolve as more detailed information becomes available, and the process become more sophisticated. The hierarchical structure should be able to accommodate these changes.

Establishing the asset inventory hierarchy structure lays the foundation to document detailed transit assets. FTA's hierarchy defines an asset by category, sub-category, element, and sub-element. For each unique asset, FTA assigns a five-digit detailed type code, as illustrated in Table 3. Many transit agencies have followed FTA's lead and adopted FTA's inventory structure or a similar "parent-child" structure. To enable integration between an inventory and TERM, it is recommended that an inventory includes a field that maps an inventory asset back to a TERM code. Note that an agency may itemize an asset that is not included in the TERM asset classifications.

What is the "Right" Level of Detail for an Asset Inventory?

This is a common challenge. There are trade-offs involved in the level of detail selected and the level of effort to both produce the initial inventory and then to maintain it over time.

The level of detail should be commensurate with the decision support need requirements. By selecting a flexible hierarchical structure, an agency can start with a higher level inventory and gradually add granularity as data availability and needs arise.

One example with RTA was facilities, where initially facilities were reported at the highest level (i.e., the entire maintenance facility); then components were introduced.

Table 3: Example of FTA TERM Classifications for Bus Maintenance Facilities

Type	Category	Sub-Category	Element	Sub-Element
21200	Facilities	Buildings	Maintenance	-
21210	Facilities	Buildings	Maintenance	Bus
21211	Facilities	Buildings	Maintenance	Bus Stratum 1 < 200 Vehicles
21212	Facilities	Buildings	Maintenance	Bus Stratum 1 200 to 300 Vehicles
21213	Facilities	Buildings	Maintenance	Bus Stratum 1 > 300 Vehicles
21214	Facilities	Buildings	Maintenance	Bus Stratum 2 < 200 Vehicles
21215	Facilities	Buildings	Maintenance	Bus Stratum 2 200 to 300 Vehicles
21216	Facilities	Buildings	Maintenance	Bus Stratum 3 < 200 Vehicles
21217	Facilities	Buildings	Maintenance	Bus Stratum 3 200 to 300 Vehicles
21218	Facilities	Buildings	Maintenance	Bus Stratum 4 < 200 Vehicles
21219	Facilities	Buildings	Maintenance	Bus Stratum 4 200 to 300 Vehicles

A complete set of FTA's TERM asset classification structure is located at www.fta.dot.gov/documents/Thursday_PM_-_Gates_-_TERM_Light.pdf

Overcoming Challenges in Inventory Hierarchies – Case Study

The RTA has had to overcome challenges in reconciling the inventory hierarchy structures developed by individual Service Boards with the inventory structure used in the Capital Optimization Support Tool (COST).

When the Service Boards developed their Baseline Inventory as part of the Baseline Assessment, they adopted a two-tier inventory structure as follows (see CTA example below):

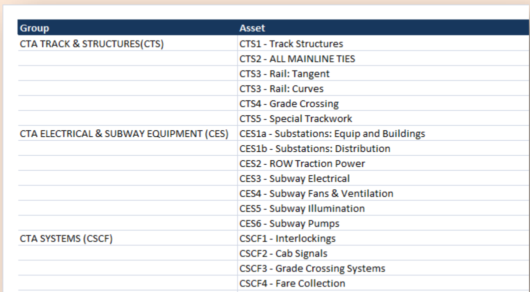
Group	Asset
CTA TRACK & STRUCTURES(CTS)	CTS1 - Track Structures
	CTS2 - ALL MAINLINE TIES
	CTS3 - Rail: Tangent
	CTS3 - Rail: Curves
	CTS4 - Grade Crossing
	CTS5 - Special Trackwork
CTA ELECTRICAL & SUBWAY EQUIPMENT (CES)	CES1a - Substations: Equip and Buildings
	CES1b - Substations: Distribution
	CES2 - ROW Traction Power
	CES3 - Subway Electrical
	CES4 - Subway Fans & Ventilation
	CES5 - Subway Illumination
	CES6 - Subway Pumps
CTA SYSTEMS (CSCF)	CSCF1 - Interlockings
	CSCF2 - Cab Signals
	CSCF3 - Grade Crossing Systems
	CSCF4 - Fare Collection
	CSCF5 - Radio Systems
	CSCF6 - GPS Bus
	CSCF7 - CCTV Station
	CSCF8 - Cable Plant
	CSCF10 - Fiber Optic Systems
	CSCF11a - Station SCADA Systems
	CSCF11 b- Substation SCADA RTUs
	CSCF12a - Public Address Systems Audio
	CSCF12b - Public Address Systems VMS
CTA STATIONS, GARAGES, FACILITIES (CFS)	CFS1a CTA Stations
	CFS1b CTA Station Parking
	CFS2 Bus Passenger Facilities
	CFS3a - Bus and Rail Maintenance Facilities: Bus Garages
	CFS3b - Bus and Rail Maintenance Facilities: Other Major Facilit

With update efforts, Service Boards wished to retain their original "RTA asset type" designation (i.e., "CTS1 - Track Structures"). This structure is not exactly the same as the four level COST model structure, which has caused confusion and apparent errors in reconciling the two.

Overcoming Challenges in Inventory Hierarchies – Case Study Continued

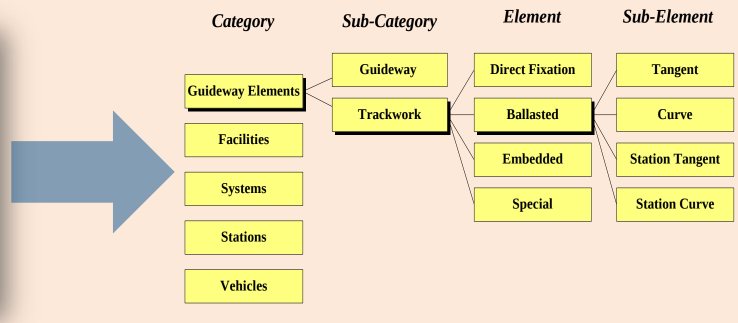
In order for COST to work, all assets must be assigned a TERM asset type, otherwise the model would not be able to recognize the asset and include it in the projections.

Two Level "RTA" Hierarchy



Group	Asset
CTA TRACK & STRUCTURES(CTS)	CTS1 - Track Structures
	CTS2 - ALL MAINLINE TIES
	CTS3 - Rail: Tangent
	CTS3 - Rail: Curves
	CTS4 - Grade Crossing
	CTS5 - Special Trackwork
CTA ELECTRICAL & SUBWAY EQUIPMENT (CES)	CES1a - Substations: Equip and Buildings
	CES1b - Substations: Distribution
	CES2 - ROW Traction Power
	CES3 - Subway Electrical
	CES4 - Subway Fans & Ventilation
	CES5 - Subway Illumination
	CES6 - Subway Pumps
CTA SYSTEMS (CSCF)	CSCF1 - Interlockings
	CSCF2 - Cab Signals
	CSCF3 - Grade Crossing Systems
	CSCF4 - Fare Collection

Four Level TERM Hierarchy



The asset type assignment determines how COST will:

- Assign prioritization scores
- Rehab the asset (including number and cost of rehabs)
- Permit asset replacement (or not)
- Apply soft-cost and contingency factors
- Map assets to projects.

In the case of RTA, mixing the two asset structures has led to some confusion, where multiple RTA asset types can belong to the same TERM category or sub-category, and conversely, multiple TERM elements and sub-elements can belong to the same RTA asset type.

This issue can easily occur for individual transit agencies, where the Enterprise Asset Management structure is not fully aligned with the structure of the capital asset prioritization tool. The best solution is first to appreciate the differences, then to harmonize the two, and providing ample documentation. Harmonizing two different structures is not very hard to do. The three options are:

(1) Alter the COST type listing by making it more region specific

(2) Apply TERM/FTA codes to the main structure

(3) A combination of the first two options.

3.4 Asset Inventory Fields

Establishing the inventory framework requires identifying the needed inventory fields. Each agency will have different needs and requirements and, therefore, must develop its own inventory fields. Critical fields, such as record identification number, name, description, quantity, useful life, replacement cost, and location identifiers, enable the tracking and inventory of assets. Note that location may require the use of multiple fields as the way to identify an asset's location varies by type. For example, signs may use a line and a milepost; whereas, a maintenance building may have a postal address.

Depending on the use of the inventory, other fields can store additional information, such as usage, maintenance regimen, serial number, and manufacturer. These additional fields are helpful for capital planning and projections for both age-based quintile and asset decay curve approaches. Appendix B lists sample fields in RTA's database. While the list is extensive, not all fields were initially populated. Over time, it is anticipated that more fields will be filled in as well as added as more data becomes available.

Sample Asset Inventory Fields

The RTA's Asset Inventory Database has over 40 fields. Critical fields include:

- Record identification number
- Name
- Description
- Quantity
- Useful life
- Replacement cost
- Location identifiers

Depending on an agency's needs, additional optional fields may include:

- Usage
- Maintenance regimen
- Serial number
- Manufacturer

Appendix B lists fields used by RTA in its Condition Assessment Update.

Several agencies are grappling with integrating GIS information with their asset inventories. GIS can be helpful to integrate track drawings; aerials and other location specific information. Tradeoffs include set-up and maintenance costs.

The asset inventory should also be designed to retain historical data. The design of the RTA's inventory includes a data field to track the update status ("add" for new assets, "delete" for retirements, and "modify" for updates/changes) and enable the database to retain current and past asset data.

3.5 Data Collection

Once the fields of the inventory are established, population of the inventory can begin. Completing an inventory requires compiling data from various resources. In many cases, existing data will be fragmented between different existing systems and resources. Reconciling these resources can sometimes be difficult. An agency may prefer to start anew and link the new inventory back to its financial accounting system, for instance, a posteriori.

When developing a plan for an inventory, the departments and roles of their staff should be established at the onset. Depending on staffing availability, inventories may be compiled by interns, engineers, field staff, or consultants.

3.5.1 Resources

An enterprise asset management (EAM) system, if available and populated, provides the best starting point to develop a list of assets. However, smaller agencies are less likely to have an EAM system. In its absence, a maintenance management system, financial accounting system, or asset ledger can provide information for the inventory but not to the same level of detail as from an EAM system.

3.5.2 Populating the Inventory

EAM, financial accounting, and maintenance management systems can help populate the initial inventory database. The usefulness of these management systems depends on their purpose and completeness. For example, financial accounting systems record the number of units purchased, but they may not track installation date, location, or the number of units in operation. The industry is rife with examples of onsite surveys revealing surprises when it comes to checking the official record of assets.

In the absence of complete data, an agency needs to rely more on input from staff and on-site inventories. Asset managers/owners can provide specific information for given asset categories or sub-categories that they manage and maintain. They also may have useful supporting documentation of assets. Examples include MMS data for Vehicles; facilities maintenance spreadsheets for Facilities; maintenance contract databases for elevators/escalators, and so forth.

In the worst case, an on-site inventory may be required. For surveying in the field, smaller agencies may inventory their assets by recording the inventory on a clipboard and entering the data manually into Excel. Agencies with more sophisticated information technology (IT) systems may use a laptop or tablet to record assets that allows them to import these entries directly into the inventory database.

Populating and improving an inventory requires time and effort. Over time, the inventory will gradually become more complete and detailed with updates. See Section 3.8: Continuous Improvements and Section 3.9: Inventory Update Schedule, for additional discussion.

3.5.3 Life Cycle and Cost Assumptions

Regional and national data can help define assumptions for useful life and develop rehabilitation, replacement, soft, and contingency costs in order to populate data fields in an inventory. FTA has invested heavily in developing national estimates based on empirical information as part of TERM. Since local factors influence useful life and costs, an agency should modify these assumptions to be compatible with its local experience and operating environment.

3.5.3.1 Useful Life

Useful life is one of the biggest drivers of capital reinvestment. A useful life value must be attached for all assets in the inventory.

Assets may deteriorate more or less rapidly depending on the operating environment, weather, as well as maintenance history. Adjusting useful life and the number of rehabilitations to reflect the local operating environment and actual maintenance performed will improve the accuracy of forecasting reinvestment needs.

RTA used the TERM life cycle assumptions as a baseline in developing regional assumptions. Through consensus building sessions with the three Service Boards, RTA modified the useful life assumptions based on regional experience (e.g., adjusting the useful life of maintenance facility to 60 years). Appendix C lists useful life and number of rehabilitations per life cycle for each of the three Service Boards.

3.5.3.2 Replacement Costs

Determining replacement costs is challenging because prices vary geographically and over time. Procurement history for an agency can serve as a data point in determining asset replacement costs. By documenting the year of validity for a replacement cost, an agency can apply inflation to determine how much the replacement is expected to cost at the time of expenditure.

In the case of RTA, the replacement costs were primarily Service Board driven.

The current state-of-the-practice separates replacement costs from soft and contingency costs. By excluding soft and contingency costs, an agency can use their own like replacement costs or use FTA's database of standard replacement costs for the vast majority of assets in TERM. Agencies can then apply standardized soft and contingency costs applicable to the local environment to the TERM replacement costs. For example, urban areas may have higher soft and contingency costs. Costs also vary by type of asset. Typically, infrastructure components have higher soft and contingency rates than for rolling stock (vehicles) and equipment.

Soft and Contingency Cost Estimating Resources

Soft Costs:

- *Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects*[1] describes soft costs and provides a new methodology to estimate soft costs based on historical projects.

Contingency Costs:

- *Cost Contingencies, Development Basis, and Project Application*[2] present various cost and schedule contingency approaches that have been applied successfully to major transit projects and other public infrastructure projects.

[1]Transit Cooperative Research Program Report 138, Transportation Research Board, 2010

[2]Transportation Research Record: Journal of the Transportation Research Board, Transportation Research Board of the National Academies, Issue 2111, Pages 109-124, 2009

Based on regional experience and peer review, RTA established soft and contingency rates for the region, as listed in Table 4.

Table 4: Definitions of Soft and Contingency Costs for the RTA

Soft Cost Definition	• The majority of soft costs are expended in the planning, engineering, and project management efforts. These services include in-house agency staff, government related support staff, and occasionally consultants. Project start-up expenses are also included in this category. Project financing cost and "other" expenses (reconciliation and unaccountable costs) comprise the full range of project development capital costs (FTA definition).
Soft Cost Factors Applied	• Rail and Bus Infrastructure Components: Additional 22.7% of total base cost including miscellaneous costs related to development of passenger services. • Rail and Bus Rolling Stock and Equipment: Additional 15% of total base cost including miscellaneous costs related to development of passenger services.
Contingency Cost Definition	• Contingency costs are budgeted for unforeseen emergencies or design shortfalls typically identified after a project commences. The contingency is included in the budget so the project can proceed with minimal interruption for changes or cost overruns.
Contingency Cost Factors Applied	• Rail and Bus Infrastructure Components: Additional 20% of total base cost including miscellaneous costs related to development of passenger services. • Rail and Bus Rolling Stock and Equipment: Additional 15% of total base cost including miscellaneous costs related to development of passenger services.

Soft and Contingency Cost Conclusions

RTA and the Service Boards have conducted research regarding soft and contingency costs as part of an ongoing effort to continuously improve the accuracy of capital need estimates. The following conclusions are offered:

- "The devil is in the details" in seeking to establish reliable and standardized soft and contingency assumptions for transit capital assets; academic research on this topic is in its infancy.
- Several cost estimating resources are identified in the prior text box.
- Based on the research conducted, there is a wide range of soft costs reports (7 to 22 percent of replacement value), as well as contingency costs (11 to 32 percent). Reasons include local conditions; cost of doing business; impact of commodity price swings such as steel and cement; and other factors.
- It is helpful to examine peer soft and contingency costs; however the recommended approach is to base the development of asset class soft and contingency costs on a survey of local empirical data, and update those over time.

3.6 Quality Checks

Several steps can be taken to improve data accuracy, comprehensiveness, and consistency of an inventory. A series of logical and statistical checks can identify different kinds of issues with accuracy, consistency, quality, and gaps in asset entries in order to expose problematic data. Table 5 lists a few quality validation approaches. The goal of these checks is to examine both factual and structural issues with the inventory database (i.e., identify data issues and any problems with the database structure itself). These approaches primarily rely on data sorting, visual inspection of the data, input from asset managers/owners, and comparison with other data sources. Based on the results of logical and statistical checks, an asset manager/owner for a specific asset category or sub-category can provide valuable input and help identify any missing assets or inconsistent values/attributes. Follow-up on-site surveys may be needed to help supplement and verify inventory data.

Table 5: Inventory Quality Validation Approaches

Validation Approach	Steps
Basic Validation	– Sort data to identify key missing attributes for each asset; validate consistency of each asset's basic attributes; and verify each asset's description with asset category used in the asset inventory category structure. – Approach includes checking the consistency of the unit measurement with the asset quantity, class, and unit costs as well as reviewing assets line-by-line to ensure that assets were classified correctly and were not placed under the wrong classification. For instance, making sure that the replacement cost is for a unit and not for the entire system (fare collection, radios).
Trickledown Comparisons	– Examine each asset profile to ensure cost and quantity subtotals are reasonable/realistic and that key sub-categories, components, or elements are not missing; verify that asset totals match totals for related categories with logical/expected proportions (e.g., catenary lines and railway track should occur in roughly equal lengths). – Approach is most likely to identify unreported assets. A high proportion of total replacement costs in one category may indicate an overestimation of replacement costs in that category or an underreporting of assets and/or replacement costs in other categories.
Expected Assets	– Identify gaps in assets and/or miscategorizations of vehicles, stations, and guideways by checking that the inventory is in basic agreement with National Transit Database (NTD) data. – Approach uses a checklist to verify the inventory against NTD data at an entry-by-entry basis. – NTD collects data on the number and types of revenue vehicles, facilities, and stations, and on the number of elevators and escalators at stations whose primary purpose is to provide passenger accessibility to stations. NTD also collects data on transit way mileage including miles of track (at grad, elevated on structure or fill, open cut, and subway), and number of grade crossings.
Outlier Analysis	– Check for inconsistent inputs, such as costs, quantities, and useful life that do not align with industry standards, other data, or operations. – Approach sorts assets first by cost and focuses on higher value items and assets without replacement costs since these will have an amplified effect on the total expected capital investment needs. Subsequent reviews can sort assets by quantities and useful life to identify additional outliers.

Validation Approach	Steps
Modal Tests (Only Applicable to Agencies with Multiple Operators)	– Cross tabulate asset quantities and replacement costs to compare asset profiles and distributions for similar operators to identify unusual categories and distributions of quantities and replacement cost totals; miscategorizations of assets; and unusual ratios, asset totals, and asset replacement cost subtotals. – Approach can use ratios of annual operating expenses to total capital replacement costs and total capital replacement costs per service hour or passenger to help identify outlier values. – Approach generally summarizes asset categories down to the element level to highlight whether operators created their own classifications or did not use existing asset classifications.

The quality checks listed above will likely identify a few inventory data issues. Table 6 lists causes of five primary types of data issues and recommendations to avoid or resolve them.

Table 6: Inventory Data Issues

Data Issue	Description/Cause/Recommendation
Ambiguous Data	– **Description:** Insufficient data available to classify an asset and/or its attributes properly. – **Cause:** Ambiguous data can arise for several reasons. Staff may provide inconsistent information because they reported an asset under the wrong classification. This may be caused by staff having a different interpretation of the asset classification definition. It may also be unclear what information or units should be entered into certain fields. – **Recommendation:** The reporting form used to develop the inventory should be as detailed as possible and a guide should provide the detailed instructions necessary to complete the inventory reporting forms and define asset classifications.
Miscategorized Data	– **Description:** This primarily to "new assets" that are added to an existing inventory. The issue occurs when the new asset is introduced under a new asset class different than an existing one. – **Cause:** In most cases, miscategorization arises when staff populating/updating the inventory do not fully understand the asset classification system. One example that occurred for RTA was with the RTA asset classification. RTA class 21401 is Bus Terminals (under Facilities). RTA class 42051 is Station Code (Under Stations). In this example, a decision was made to classify passenger facing facilities as "Stations" as guiding principle. The correct classification code was therefore 42051. – **Recommendation:** Instruction on how to classify assets and update the inventory should be as detailed as possible and anticipate this type of issue.

Data Issue	Description/Cause/Recommendation
Inaccurate Data	– **Description:** Inventory data incorrectly reported; units for inventory data do not agree (e.g. units for an asset do not agree with costs). – **Cause:** Inaccurate data is caused less by the reporting process than by input errors or issues with the primary data sources. These issues often pertain to unusual reported costs and will most likely require follow up. – **Recommendation:** Providing precise instructions and definitions can address confusion or misunderstanding that can lead to inaccurate data. In addition, providing additional documentation and descriptions of the asset in the notes and encouraging staff to report and document the unit costs increases the information available to help resolve issues and can improve the accuracy of reported asset costs.
Missing Data	– **Description:** Assets not included in the inventory; blank entries. – **Cause:** Assets are not included in the inventory because they are not reported or do not appear in resources used to generate the inventory. Smaller agencies sometimes report a narrower range of assets in their inventory because they are shared with other levels of government, or services are contracted. – **Recommendation:** Missing data is a difficult issue to address, but not all missing data is critical. The structure of the asset reporting worksheet should get staff to examine the capital asset holdings comprehensively. A data validation process that compares asset profiles helps identify and respond to missing data.
Double Counting of Assets	– **Description:** Redundant assets in the inventory database; double cost counting. – **Cause:** Double counting stems from staff's lack of understanding of individual standard asset classifications and inconsistencies between unit costs and quantities. Double counting of assets may occur if staff classifies an asset under multiple categories, creating multiple database entries for the same asset. Double counting of costs can arise when asset definitions are not sufficiently clear and when the asset cost basis is unclear (e.g., the replacement cost of an entire system is inputted as a unit cost). – **Recommendation:** These pitfalls underscore the value of encouraging staff to report additional asset descriptions in the asset description and notes. Redundant entries can be hard to prevent and usually will not be detected without using a data validation process, but once identified, they can just be deleted. Having unique or project-based asset identification numbers to tie assets back to project, accounting, or other databases can also facilitate the identification of redundant assets.
Inconsistent Inventory Data Across Operators (Only Applicable to Agencies with Multiple Operators)	– **Description:** Different data for identical or similar assets in the inventory. – **Cause:** Different operators may have different assumptions (e.g., replacement costs or useful life) for a wide variety of reasons (e.g., historic, policy, or recent practices). – **Recommendation:** It depends on the situation, but generally, it is recommended to seek consistency across operators. Group discussions can help facilitate consensus.

3.7 Data Sharing

The distribution of information depends on the purpose of the inventory. Preparation of an inventory may be required under external requirements and regulations. Under MAP-21, transit agencies that receive federal support must create an asset management system and report condition of their assets in their inventory.

Meanwhile, local, regional, or state governments may also require agencies to provide an inventory and condition assessment of their assets. In the case of the RTA, each of the three Service Boards must submit their inventories as part of the regional planning and funding process.

Inventory data may also be used for various internal activities. These activities may include capital planning, preparation of grant applications, operations planning, and IT integration with EAM, financial, and maintenance systems. Establishing a system for data sharing internally is not only important in populating the inventory but also distributing the results for maximum agency benefit.

In the Chicago region the RTA set up a project SharePoint site to be able to have a common platform for sharing asset inventory (and condition data) with each of the Service Boards. In addition to having the latest inventories posted, the RTA also publishes annual updates upon request.

3.8 Continuous Improvements

Continual maintenance and updates of the inventory is essential to ensure the reliability of the data and forecasts. With each update, new information will become available. There will be opportunities for refinements to the database and process. New data tables for new or unreported assets will be created. Newly installed or unreported assets will be added to the inventory. Previously empty fields will be filled with data points. New fields for the data tables may be inserted. Understanding this fluidity is important in designing the flexibility of the inventory framework.

Through experience, the inventory framework will evolve and expand. It is important to incorporate flexibility into the inventory to accommodate these changes. After the Baseline Assessment, the RTA and Service Boards offered suggestions to improve and expand the inventory framework for the Condition Assessment Update, such as:

- Using a data dictionary to provide consistent interpretation/application of terms in the inventory tables (see Appendix B)
- Adding a level of disaggregation where needed or where supported by data
- Adding several new fields including "level of usage" and "maintenance regimen."

Over time, the level of detail available will continue to increase. In the Chicago example, for the 2011 Condition Assessment Update, the Service Boards submitted data tables for asset information that were not available in 2009 Baseline Assessment. The Update also disaggregated some assets to provide more detail. Overall, for the 2011 Condition Assessment Update, the Service Boards reported over 14,500 assets, a 26% increase from 2009 Baseline Assessment. Table 7 summarizes the inventory statistics for the Baseline Assessment and the Condition Assessment Update and shows the difference between the two reports.

Table 7: Inventory Statistics for RTA

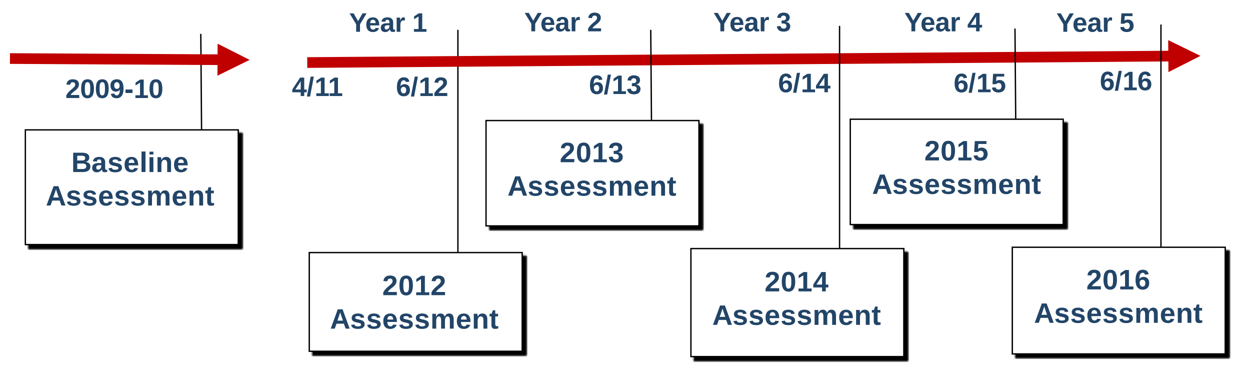
	2010 Baseline Assessment	**2012 Condition Assessment Update**	**Difference**
Data Tables	80	121	51%
Individual Assets Reported	11,574	14,556	26%
Total Data Points	671,292	855,210	27%

3.9 Inventory Update Schedule

Developing a schedule for updates ensures that forecasts are based on up-to-date information on current assets as well as new or overhauled assets. Since an inventory provides a snapshot of an agency's assets in time, inventory updates are necessary to provide up-to-date information. Over time, new assets will be placed into revenue service. Major overhauls will be conducted. Older assets will be retired. The inventory should not just add new assets and remove retired assets. It should capture historical data by retaining retired assets to assist with the further calibration of forecasts. Scheduled updates also help an agency comply with regulatory requirements. For example, MAP-21 requires a grantee to provide an annual report on its performance towards reaching its Asset Management Plan as well as asset condition information for the National Transit Database.

An agency conducting condition assessments as part of the inventory update should incorporate a condition sampling plan. Identifying sampling needs enables an agency to budget for data collection and helps ensure that with time an agency will have a statistically significant sample. The RTA has made it a policy decision and priority to update the inventory annually, as shown in Figure 6, by providing annual funding for Condition Assessment Updates. In addition to meeting the FTA's requirements to provide an inventory and report asset condition annually, the RTA's approach will enable RTA to have an up-to-date understanding of its asset needs for capital planning. In addition, since the Condition Assessment Updates include on-site sampling of assets, over time, the RTA's database will become more complete, improving accuracy of the inventory and projections.

Figure 6: RTA Example of Annual Updates Following Baseline Assessment



Currently, the RTA is on a cycle to produce draft assessments in April for the previous calendar year (e.g., April 2013 for the Calendar Year ending December 31, 2012). It's been the RTA's experience that finalizing these reports takes a few more months to incorporate all of the outstanding comments. The goal is that as the process becomes more standardized, the assessment update can be completed more quickly.

4 "How To Guide to" Conduct a Condition Assessment

4.1 FTA Condition Assessment Philosophy

FTA established the most commonly used condition rating process as part of its TERM documentation for condition assessments. The FTA's five-level condition rating process (Table 8) defines condition ratings for each level and a methodology for estimating the condition of individual assets based on asset type, age, and other factors. Working on a scale from 1 (worn) through 5 (excellent), rating values are the primary means by which TERM evaluates an asset's current and future rehabilitation and replacement needs. FTA defines a 2.5 or higher as the rating at which an asset is in SGR. By adopting the FTA's five point condition rating levels, an agency can ensure compatibility of its condition assessment with MAP-21 and FTA's information requests as well as with FTA's asset decay curves used in TERM Lite. Consistency of an agency's assessment rating system with FTA's condition rating levels becomes especially important when an agency plans to use TERM Lite to forecast its capital reinvestment needs based on an asset's life cycle.

Building on the TERM asset conditions, the RTA developed base asset descriptions for its Baseline Assessment and Condition Assessment Update. With some exceptions, the RTA and the Service Boards have largely adopted FTA's five point condition rating scale, thus ensuring consistency with FTA and compliance with MAP-21 condition assessment requirements. For the original Baseline Assessment, the RTA utilized a five-level, age-based quintile condition rating system comparable to that used by FTA. Since the RTA has adopted FTA's decay curve condition estimation approach, RTA is now using the FTA's five-level condition rating levels.

Table 8: Condition Rating Levels

Condition	RTA Definition (2009-10)	Condition	RTA Definition (2011-present)
Excellent 5	▸ Asset is in the first quarter of its useful life	Excellent 4.8 to 5.0	▸ New asset ▸ No visible defects
Good 4	▸ Asset in the first half of its useful life	Good 4.0 to 4.7	▸ Asset showing minimal signs of wear ▸ Some (slightly) defective or deteriorated component(s)
Adequate 3	▸ Asset has not exceeded three quarters of its life	Adequate 3.0 to 3.9	▸ Asset has reached its mid-life (condition 3.5) ▸ Some moderately defective or deteriorated component(s)
Marginal 2	▸ Asset is in the last quarter of its life	Marginal 2.0 to 2.9	▸ Asset reaching or just past the end of its useful life (typically reached between condition 2.75 and 2.5) ▸ Increasing number of defective or deteriorated component(s) and increasing maintenance needs
Past its Useful Life 1	▸ Asset has exceeded its useful life and is not in SGR. These assets are considered to backlog and have not been replaced or rehabilitated due to a lack of funding	Worn 1.0 to 1.9	▸ Asset is past its useful life and should be prioritized for repair or replacement

4.2 Approaches to Condition Assessment

There are three approaches to measuring asset condition: (1) straight age-based, linear condition projection; (2) decay curves condition estimation; and (3) physical site visits via sampling or other methods. Each approach is briefly described in Table 9. As part of the Condition Assessment Update, the RTA transitioned from an age-based quintile approach to an asset condition decay curve approach that is supplemented by sampling observations of assets to assist in validating condition estimates.

Table 9: Condition Approaches and Application

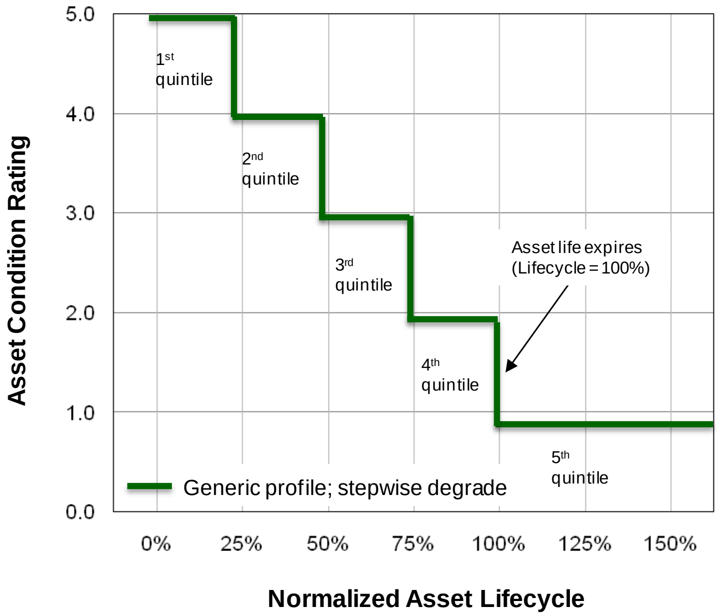
Condition Approaches	Methodology	RTA Experience
1. Age Quintiles	Asset useful life divided into five quintiles	Basis for condition used during Baseline Assessment
2. Asset Condition Decay Curves	Estimated asset condition based on asset type specific decay curve	FTA-developed curves used to estimate asset conditions for Condition Assessment Update
3. Sampling Observations	Physical observation by condition experts, then rated by using a scale	Process initiated. Will be used in future to validate/recalibrate FTA decay curves

4.2.1 Age-Based Quintiles

In the absence of more detailed information and resources, an asset's age can act as the primary "predictor" of an asset's condition. According FTA's October 2008 report, Transit State of Good Repair: Beginning the Dialogue, "physical asset condition assessment is the best way to measure SGR for individual assets and on an agency-wide basis. Asset age is a second best proxy."

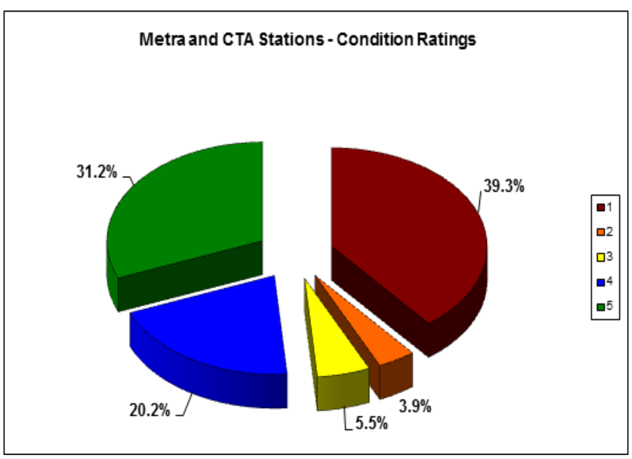
For the Baseline Assessment, the RTA utilized a five point, age-based quintile condition rating system as illustrated in Figure 7 (i.e., first quintile for first quarter of asset life, second quintile for second quarter of asset life, and so forth up to fifth quintile for assets exceeding their life). This approach reflected the best approach possible among the Service Boards at that time, while taking into consideration the limited resources of each Service Board and the level of effort required for the overall assessment. While in-depth information and data was not available for each asset for the Service Boards, sufficient data was collected and satisfactory age estimates were established for nearly all assets.

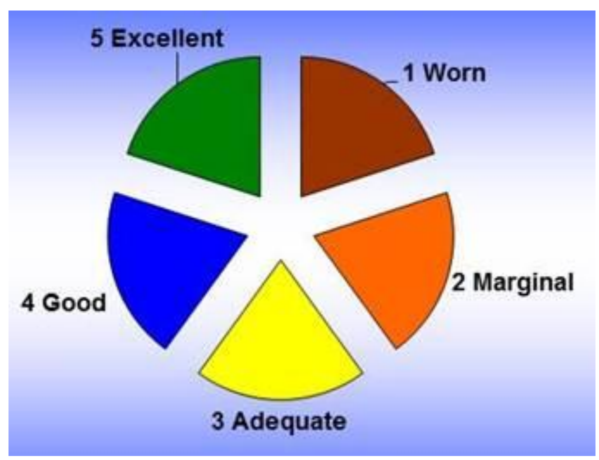
Figure 7: Age-Based Condition Rating Scale
(Stepwise condition rating based on remaining useful life)



For consistency with FTA's five point condition rating scale, RTA's asset condition ratings were broken into five categories on a 1-to-5 scale with 1 representing an asset "past its useful life" and 5 representing a relatively new asset in "excellent" condition. For the purposes of the Baseline Assessment, the SGR was defined as a condition rating of 3, or "adequate with no backlog." In effect, anything rated 3 or higher is in a SGR. Anything rated lower than 3 begins to take on "marginal" aspects and is in its last quarter of the asset's useful life. Figure 8 below illustrates the capture and graphical representation of condition rating data.

Figure 8: Example of Age-Based Quintiles Condition Output



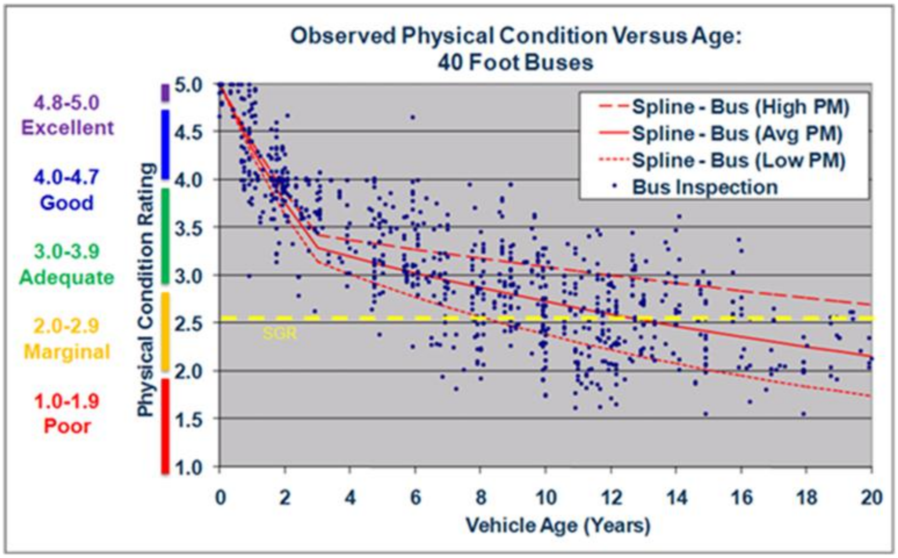


4.2.2 Decay Curves

Decay curves based on on-site asset condition samplings can also be used to predict an asset's condition. The FTA has developed generic transit asset decay curves for major asset types using condition data collected from transit agencies nationwide. These curves predict asset physical condition as a function of age, maintenance history, and other factors on a common 5-to-1 rating scale. Figure 9 illustrates a typical decay curve for a 40-foot bus based on nationwide empirical data. The "best fit" curves in red (there are three curves based on the level of preventive maintenance) predict the expected physical deterioration of a 40-foot bus over time.

The decay curve exhibits a steep decline in the first three to four years of bus life, followed by a long period of slower gradual decline. Note that for an average preventative maintenance regimen, the best fit spline intersects a standard 12 year bus life at a physical condition rating of 2.6. It takes an additional 1.5 years – 13.5 year bus life – for the bus to reach a condition rating of 2.5.

Figure 9: Asset Decay Curve Example

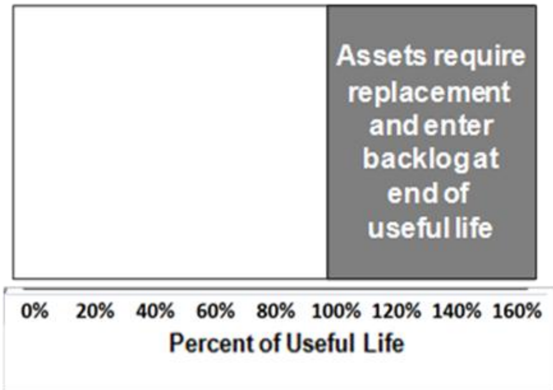


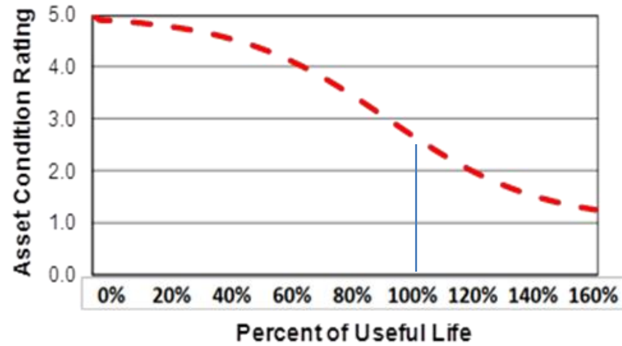
The decay curve approach to estimate asset condition represents a shift from the prior approach utilized by the RTA, which relied purely on age-based useful life quintiles. Using the decay curve approach, asset condition is estimated on an empirically derived continuum of physical condition, as opposed to age. There are several advantages to using decay curves:

- Provide more accurate predictions and distributions instead of using a life cycle proxy;
- Provide an asset class-specific rating prediction;
- Are consistent with on-site (field) observation condition rating criteria definitions; and
- Have no impact on asset backlog and investment needs estimates.

This ability to predict asset condition and distributions on a continuum enables an agency to make more informed capital planning decisions and prioritize reinvestments needs. As shown in Figure 10, when an asset exceeds its useful life in the age quintile approach (shown on the left side of the figure), it is no longer considered in SGR and is due for replacement, entering the backlog. Similarly, for the asset decay curve approach (shown on the right), once an asset reaches 100% of its useful life, it is added to the backlog as illustrated by the blue asterisk. However, since the decay curve approach provides a continuum of physical condition, an agency can prioritize the order of asset replacements based on asset condition.

Figure 10: Replacement Needs versus Asset Conditions





4.2.3 Sampling Observations

On-site sampling tests the degree of consistency between predicted condition and the actual condition of an asset. Sampling requires physical observations by condition assessor of assets that are then rated by using a scale. Sampling is valuable for both age-based quintile and decay curve approaches.

The RTA conducted on-site sampling for both the Baseline Assessment and the 2011 Condition Assessment Update. For the most part, though not all cases, the results of the limited sampling confirmed the condition rating process used. Sampling is addressed in detail in the next section of the report.

4.3 SGR Monitoring and Performance Measures

At the time of this writing, there are various definitions and opinions of State of Good Repair (SGR) but no single, industry-wide accepted definition. In fact, the FTA has been in the process of facilitating a dialogue with the industry to help develop a single definition.

The drive to both define SGR and quantify SGR needs is unlikely to go away soon. Condition assessments can help an agency monitor SGR and comply with regulatory requirements. The RTA and the Service Boards established their own definition of SGR for the purpose of its Condition Assessment Updates. Under the RTA's definition, *assets are in SGR if they are replaced once they reach useful life; all rehabs are performed; and capital maintenance is up to date. Note this definition does not tie directly to the physical condition of the asset; it is a based on up-to-date maintenance practices and capital replacement intervals.*

In regards to this definition, two performance measures can help an agency monitor SGR related to condition assessments: condition rating and remaining years of useful life. Both of these measures have been defined in great detail in this "how to" guide. Beyond these measures, there are a number of other performance measures that can help an agency manage SGR. Examples include:

- Regional backlog projections (per year)
- Required funding to attain specific investment targets
- Percent of replaceable assets exceeding useful life
- SGR Backlog ratio
- Current and projected asset age distribution (i.e., showing the percent of useful life consumed)

Clearly there are multiple measures to document an agency's status with respect to asset management and State of Good Repair.

The RTA first reported regional performance measures in 2009 with the release of the 2007 Regional Report Card, which aggregates performance data from CTA, Metra, and Pace to describe system-wide performance. In late 2010, the RTA enhanced its performance measurement program by publishing its first Sub-Regional Performance Measures Report, which describes performance at the Service Board and mode levels. The data for the RTA performance measure reports come mostly from the National Transit Database, with several elements reported by each Service Board, and are updated annually. RTA has also refined the Regional and Sub-Regional reports so that they track comparative measures for RTA versus regional and sub-regional peer agencies. RTA intends to integrate SGR measures into the report over time.

In 2013, the RTA has developed definitions as well a performance measure for State of Good Repair.

Asset Level SGR Definition

An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

Mode, Service Board, or Regional Level (Aggregate) SGR Definition

A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.

In order to measure SGR, RTA further developed a performance measure called "Percent of Assets in SGR".
Definition of the Measure: The degree of attainment of SGR for a group of assets is evaluated as the total level of reinvestment required to replace all assets that exceed their useful life and address all outstanding rehabilitation and annual capital maintenance needs divided by the total replacement value of those assets.

Measurement of SGR applies to the aggregate level (e.g., asset class) and would not normally be calculated on an asset level. The RTA SGR measure is financially weighted (i.e., it is weighted by replacement value). RTA formally began presenting this measure to the RTA Board in September, 2013. Both RTA system-wide and Service Board performance measure results were presented.

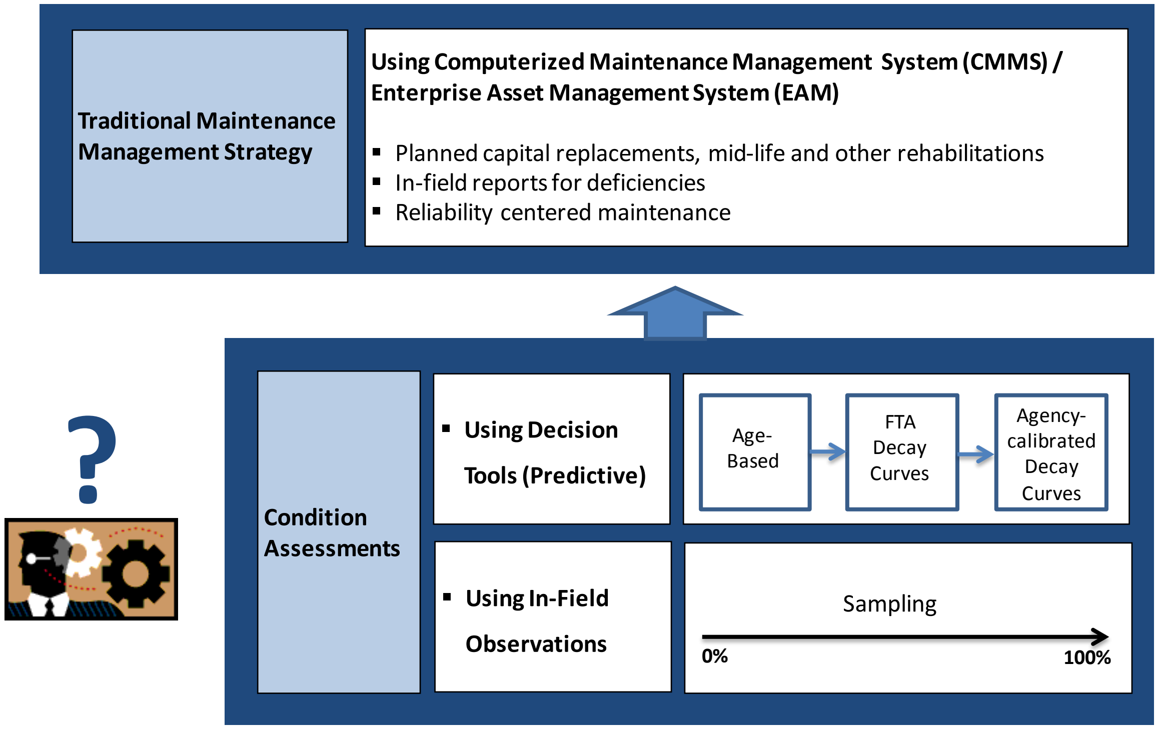
4.4 Recommendations for Given Situation

The suitable condition assessment approach depends on the agency's policy objectives as part of a broader capital planning and strategic maintenance program, its prior experience with surveys and condition assessments and other factors. An agency must also take into consideration regulatory requirements in developing its condition assessment approach (e.g., MAP-21 requires agencies to report on asset condition in addition to creating an asset management system).

There are several approaches possible to predict asset condition as discussed in this chapter. An agency must decide for itself which approach is most appropriate given its needs and resources. The more sophisticated approaches can use robust analytical tools integrated with the agency's Enterprise Asset Management (EAM) system, with additional on-site observation for validation and refinement.

Figure 11 below summarizes the main choices available for condition assessments. All condition assessment work is considered complementary to the primary maintenance management strategy.

Figure 11: Condition Assessment Approaches in Support of Overall Maintenance Strategy

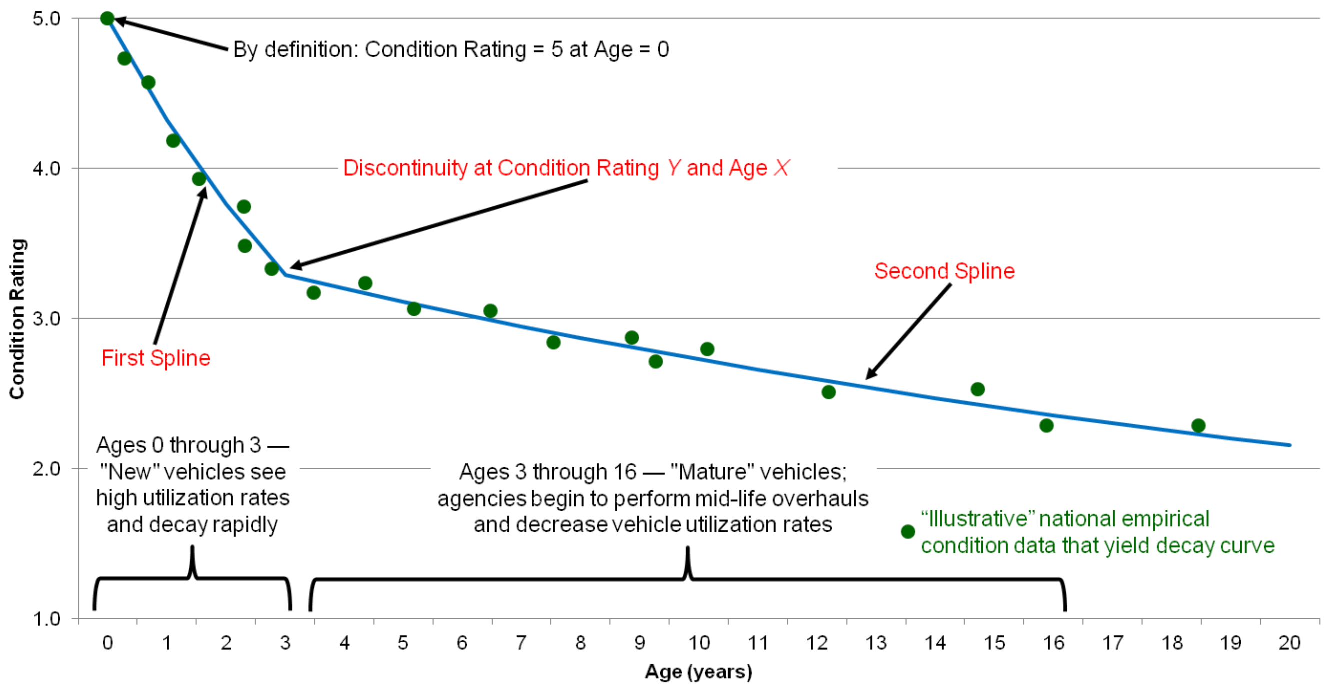


4.5 Decay Curve Calibration Process

Decay curves are regressions based on national field condition data sets collected. While the shape of a decay curve will vary based on the empirical data, a typical decay curve is a "spline model" that has four major defining features: start point, first spline, discontinuity point, and second spline, as shown in Figure 12 for a 40 foot motor bus. The shape of the curve makes sense, instinctively, as one compares one's experience maintaining a personal vehicle.

By definition, it is assumed that when an asset is brand new, the condition rating equals a five out of five. Empirical asset condition data is then used to determine the other three features and create a best fit decay curve. For motor buses, the slope of the first spline is greater than that for the second spline since "new" vehicles typically have higher utilization rates and decay more rapidly. The discontinuity point is the point at which the asset rate of deterioration changes. Using the decay curve, an agency can predict the condition of an asset based on its asset age.

Figure 12: Decay Curve for Motor Bus (40 ft)



The typical condition decay curve has the form:

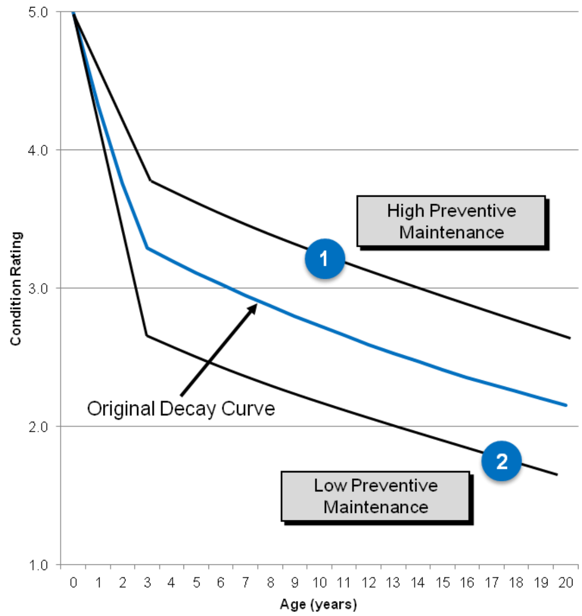
$$Condition = 1 + 4e^{(\beta_0 + \beta_1 Dum_1 + \beta_2 Dum_2 + Age(\alpha_0 Age + \alpha_1 Dum_1 + \alpha_2 Dum_2 + \lambda Maintenane\ Cost))}$$

where,

- Condition = Condition Rating (y-axis)
- Age = Asset's age (x-axis)
- β, α and λ are parameters determined by the regression fit
- The Dum (dummies) parameters are used to create different slope and intercept values for different periods in the asset's lifecycle
  - Creates the "discontinuity" in the decay curve
  - It's all linear inside the parentheses above "e"
  - So for example, Dum1 is only in effect from age 0 to 5 (so this time period has its own slope and intercept values) and Dum2 is in effect from age 5 on.
- Maintenance Cost is a parameter designed to capture maintenance investments which help delay condition rating degradation

The discontinuity point and slope of the splines may change based on preventive maintenance and other factors that influence condition. For example, assets owned by an agency with a robust preventive maintenance program will deteriorate more slowly, shifting the decay curve up and to the right, as shown in Figure 13.

Figure 13: Impact of Preventive Maintenance on Asset Decay Curve



The FTA has developed "national" decay curves that are based on national empirical data, mainly from 2000 to 2002. Since the decay curves are based on the experience of a broad sample of U.S. transit agencies, the curves are not necessarily the most representative of the local physical and operating environment (e.g., the harsh northern environment in Chicago). Local condition observations for assets can help recalibrate the decay curves by supplementing the national data. However, the local sample must be sufficient in size to influence the decay curves. The size of the necessary sample also depends on the asset since the number of samples in FTA's national database varies by asset, as demonstrated in Table 10.

Table 10: Number of Data Points for a Given Asset Type

Asset Type	Number of Data Points
Bus Maintenance Facility	23
Bus Maintenance Facility	42
Buses	846
Rail Cars	100
Rail Stations	94

Source: FTA

As TAM matures, further guidance will become available with regard to best practices to recalibrate national asset decay curves for individual transit agencies. In the meantime, sampling asset conditions will increase an agency and its staff's awareness and sensitivity to asset condition. Furthermore, on an asset-by-asset basis, an agency can compare actual sampled condition to the projected condition to identify reasons for inconsistency.

The RTA plans to use the on-site condition sampling data to validate and recalibrate the decay curves adopted from FTA when the sampling size is sufficiently large enough. On-site condition assessments performed each year will help the RTA better represent the asset decay and life expectancy experiences of its Service Boards. It is estimated that the RTA's sample size will be sufficiently large to recalibrate some decay curves by late 2013. At that point, the RTA condition assessment results (assessed condition ratings for individual assets) will be compared to the FTA decay relationships (using statistical and graphical representations) and the decay curves will be recalibrated as appropriate to improve condition rating predictive accuracy.

5 “How to Guide to” Conduct Sampling of Assets

5.1 What Is Sampling And Why Is It Meaningful?

On-site sampling of actual transit asset conditions enables an agency to validate and refine the asset inventory data, but more importantly support the agency’s capital planning and maintenance management strategy. If the agency does not have or does not use decision support tools to predict or project asset condition, then on-site sampling and reporting is the only manner to report actual asset condition. With decision support tools in place and in regular use, sampling provides a valuable source of information to validate and refine condition data, informs important capital replacement timing decisions and provides a snapshot in time.

Objectives of Sampling

- Validate asset detail in the inventory.
- Determine a defensible asset condition rating, based on a standard scale.
- Use field observations as input to recalibrate decay curve to account for local conditions.
- Identify complex assets that need to be disaggregated into components and elements in future updates.

The RTA and its Service Boards conducted on-site sampling ranging from 1 percent to 70 percent of assets (depending on asset type) during the first two years of the condition update efforts. The sampling was conducted as a team effort with RTA, Service Board, and consultant staff working side by side. Figure 14 shows example assets sampled by the RTA.

Figure 14: On-Site Sampling - Examples

Rail Car

Maintenance Facility

Roof

Revenue Bus

Station Signage

Grade Crossing

It should be noted that on-site sampling, while performed by knowledgeable staff, usually engineers or architects with many years of experience, is *not* intended to address legal or regulatory requirements. For this reason, the staff involved are referred to as condition assessors, not inspectors.

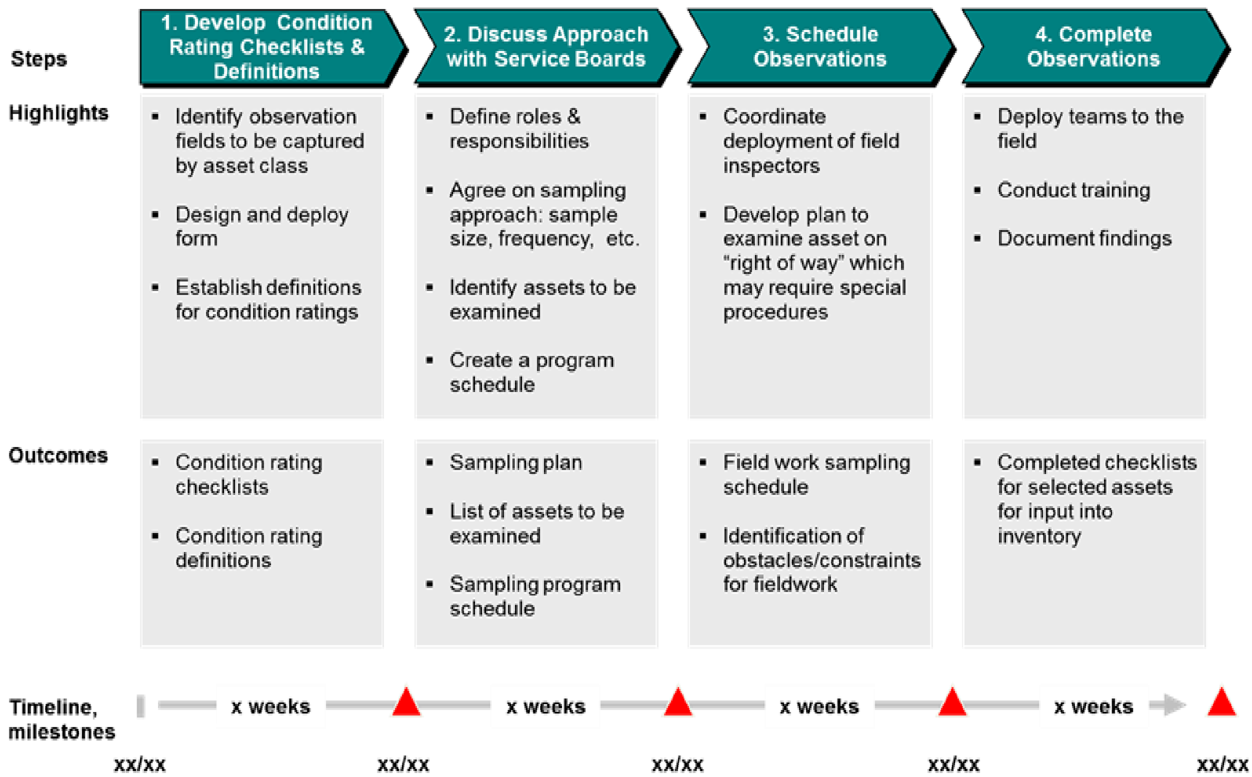
5.2 Setting Up a Sampling Plan

A sampling plan should provide statistically reliable results while cost effectively assessing asset condition through on-site observations. The plan should balance the constraints of fieldwork and weigh the sampling towards higher-value assets while ensuring an even sampling of the different asset categories.

Following the baseline assessment which tended to focus on assets nearing the end of their useful lives, the RTA and the Service Boards decided against a "worst first" approach to sampling, opting instead for a balanced selection of assets regardless of condition.

To ensure consistency and reliable results, several items of the sampling plan need to be finalized, before deploying condition assessors to the field to observe the assets. Figure 15 provides an overview of various steps used by the RTA to conduct sampling.

Figure 15: Asset Sampling Delivery Process



Step 1 entails developing the condition rating checklists and definitions to support the asset inventory. Condition checklists for each asset include required observation fields. Established condition rating definitions for each component and element of an asset sub-category can be used to define the condition scores and improve consistency across multiple condition assessors.

Step 2 requires developing a detailed sampling plan and schedule. If multiple transit operators are involved, the size, objectives, and resources of the various agencies should be considered in developing a sampling plan. Planned projects can also influence the development of a list of assets to be examined. As an example, the CTA's effort to replace its fare collection equipment with a new open system architecture system was considered in determining which assets were to be examined. Additionally, the agency should determine the strategy regarding taking photos (e.g. document only assets below a particular condition threshold or document a representative set of conditions).

Step 3 involves scheduling condition assessors for field examinations. Special attention needs to be paid to safety (i.e., safety related training) and insurance requirements, such as for right-of-way rail observations. This step also identifies any obstacles to inspecting specific assets that must be resolved before conducting the on-site assessments.

Step 4 represents the actual deployment of resources to the field to observe and document asset conditions. Teams should have the expertise necessary to quickly gather required asset data. Assigning a team to complete assessments for similar asset categories improves consistency across an asset category or sub-category. The knowledge of agency staff – in the case of the RTA project, Service Board personnel responsible for operating and maintaining the assets – was essential in successful completion of the overall sampling effort.

5.3 Condition Assessment Criteria and Tools

In regard to data collection approaches, condition assessors may use more simple methods (e.g., documenting condition using a clipboard, paper, and pen) or more sophisticated IT solutions (e.g., entering condition onto laptops or tablets, such that information can be imported directly into the inventory).

Several tools can be used to assist condition assessors in conducting a condition assessment. Establishing an asset registry, checklist, and rating definitions along with providing training can help ensure that the appropriate assets are inventoried at the correct level of detail and that the condition ratings are consistent across condition assessors.

5.3.1 Condition Rating Checklists

Condition rating checklists identify the required information for the assessors to collect. They represent a straightforward input sheet. The RTA developed condition rating checklists for the selected sample of assets. Checklist data can be collected manually or via the use of tablets.

A sample checklist for bus garages, shown in Table 11, identifies the asset classes (sub-category) and their components and elements for evaluation. The level of detail on the forms corresponds to the specific component condition level definitions developed by the FTA for development of its asset decay curves, which are based on on-site asset conditions of a sample of U.S. transit properties.

5.3.2 Condition Rating Definitions

Establishing precise definitions for rating assets improves consistency and enables condition assessors to more accurately classify condition. Condition assessors must have an effective understanding of what these condition ratings imply before attempting to apply these ratings in the field.

As discussed in Section 4.1: FTA Condition Assessment Philosophy, the RTA developed its condition assessment rating structure and definitions based to a large extent on TERM documentation for condition assessments. The base asset descriptions are based on a five-level condition rating process with a scale from 1 (worn) through 5 (excellent). However, the RTA tailored the rating definitions slightly to increase the applicability to the Chicago transit region. Furthermore, the actual asset condition rating descriptions used in the underlying condition inspections vary across assets. These differences reflect the application of the base descriptions to the specific design, technology, and decay characteristics of the various assets. Rating definitions were also developed for assets not included in TERM definitions and for components of disaggregated assets. Table 12 defines the condition ratings for a bus maintenance facility garage roof.

Table 11: Sample Condition Rating Checklist

BUS MAINTENANCE FACILITY (BUS GARAGE) ASSESSMENT FORM

Facility Name: Facility Capacity (# of Buses):			Date: / /
Age: Yrs.	Gross Area: Sq. Ft.	Date of last Facility Renovation:	Assessed by:

ASSET CONDITION RATINGS: 1 = WORN, 2 = MARGINAL, 3 = FAIR, 4 = GOOD, 5 = EXCELLENT

ASSET CLASS	COMMENT	LAST RENOV.	PHOTO	CONDITION
Site (sidewalks, landscaping/grounds, fences, roadways/driveways, lighting)				1 2 3 4 5
Building (exterior - walls, windows, stairs, doors, interior - flooring, walls, ceiling, stairs)				1 2 3 4 5
Roof (roofing system, gutters/drains, skylight)				1 2 3 4 5
Heat/Ventilation (capacity/reliability, ventilation/air conditioning)				1 2 3 4 5
Mechanical/Plumbing Systems (floor drains, plumbing fixtures, fire protection system)				1 2 3 4 5
Electrical System (wiring, panels, convenience outlets and switches)				1 2 3 4 5
Industrial /Wastewater Treatment System (sand; interception; oil/water separation, water treatment equipment)				1 2 3 4 5
Building Equipment (elevators, air compressors/sump pumps/ejectors)				1 2 3 4 5
Cranes				1 2 3 4 5
Hoists				1 2 3 4 5
Lifts				1 2 3 4 5
Storage Areas				1 2 3 4 5
Buswasher				1 2 3 4 5
Other				1 2 3 4 5

ACTIVITIES PERFORMED AT THIS FACILITY:

☐ Preventive Maintenance	☐ Normal Running Repairs	☐ Engine Re-Builds	☐ Road Call Repairs
☐ Transmission Replacement	☐ Normal Body Work	☐ Component Re-builds	
☐ Normal Running Repairs	☐ Heavy Body Work	☐ Normal Bus Servicing	

Table 12: Sample Condition Rating Definitions

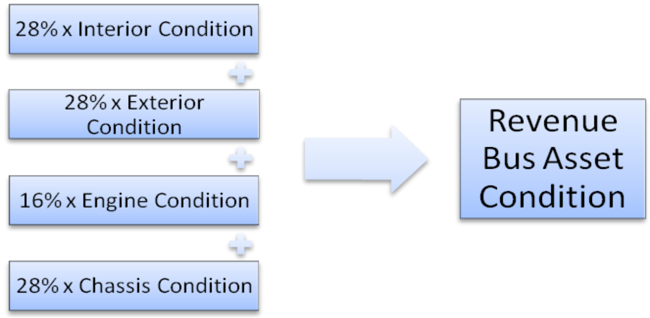
Facilities: Bus Maintenance Facilities (Garages)

Component	Element	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
Roof	Summary	Significant deterioration; over 30 years old; leaks, patches and broken parts; poor drainage	Signs of deterioration; over 20 years old; minor leaks; drainage problems; strong consideration for replacement	Minor signs of deterioration; 1-20 years old; no leaks; drainage functional	No signs of wear or deterioration; 5-10 years old	New; under warranty; rehabilitated or renovated
	Roofing System	Significant deterioration; several roof leaks, numerous patches; over 39 years old; rotting roof deck	Signs of deterioration; minor leaks; water ponding; greater than 20 years old	Minor signs of deterioration; no leaks; 10-20 years old; minor repairs	No signs or wear or deterioration; 5-10 years old	New; under warranty; rehabilitated or renovated
	Gutters, Drain System	Gutters missing in part, leaking, defective or broken supports, incorrect pitch; roof drainage system not functioning as designed	Some gutters and drains not functioning	Gutters and drains functional; only minor defects	All gutters and drains in good condition and good working order	New; under warranty; rehabilitated or renovated
	Skylights	Leaking; cloudy glazing; boarded over	Minor leaks, thermally inefficient	No water leaks	No water or air leaks; thermally efficient	New; under warranty

5.3.3 Composite Scoring

Using the scores of individual components and elements, the on-site condition data can be aggregated into a single, overall condition score for an asset. Since the condition assessments were conducted at the component level, and the inventory data in many cases were aggregated at the asset sub-category level, RTA developed weighting factors to calculate an aggregated asset-level condition based on the percent value of each component/element. For example, the replacement cost for a revenue bus’s components were used to calculate the weighting factors for the interior, the exterior, engine compartment, and chassis components of the bus. These same percentages would then be applied to the individual component/element condition scores to derive a single aggregated asset condition score, as shown in Figure 16. The RTA used this approach for all major assets with disaggregated components/elements.

Figure 16: Asset Composite Scoring Process



5.4 Executing the Sampling Site Visits

The policies and procedures for executing the sampling work should be established by each agency. They will vary based on an agency's asset modes (e.g., bus, heavy rail) and resources.

The on-site sampling schedule developed in Step 3 of Figure 12 will provide an overview of the on-site inspections. However, additional coordination will be necessary based on required assessor qualifications and staffing availability. If a contractor team is conducting the assessment work, coordination is needed between the contractor team and agency staff.

During the initial sampling visits, clarification questions will likely arise about how to classify the condition of an asset. On-site team training for the first day provides an opportunity to address questions and improve consistency across how condition assessors administer the ratings.

RTA found that for the level of detail required in the condition assessments, one condition assessor staff person was sufficient for all asset types. The degree to which the assessor needed to be accompanied on site varied widely. For park-and-rides, stations, and some structures, one contractor staff could survey the facility without agency staff oversight. In some cases, to minimize the agency staff time, combined visits were scheduled (e.g., vehicles and maintenance facilities).

5.5 Integration of Sampling Data into Inventory

The last step in sampling is importing the condition rating sampling data into the inventory database. Sampled condition ratings require a different field than the projected condition rating fields for assets, which is based on age or on decay curves if available. The date of sampling (month-day-year) should be captured as well. The process to import the data varies based on the IT capabilities of an agency and can range from manual data entry to importing of data recorded on laptops or tablets.

Agencies need to determine for themselves how to utilize the condition rating data collected. Logical next steps and potential uses of the information include:

- Adding to the inventory for Operations, populating CMMS/EAM
- Preparing condition rating reports by asset class; presenting to management
- Integrating into condition rating database to calibrate decay curves, if applicable
- Updating condition projections and capital replacement program
- Supporting ad-hoc requests
- Using as input for project prioritization.

Appendix A: Glossary and Abbreviations

ACM	Annual Capital Maintenance – Ongoing minor capital investments as required to maintain a state of good repair over the next 10-year period.
Asset Decay Curves	FTA has developed "generic" transit asset decay curves for major asset types using data collected from transit agencies nationwide. An asset decay curve joins age with physical condition so the curve itself becomes the predictor of the asset's physical condition.
Asset Types	Categories of assets making up each Service Board asset inventory. The Capital Decision Prioritization Support Tool uses five main categories of assets: Guideway; Stations; Facilities; Systems and Vehicles.
Backlog	Deferred investments in asset rehabilitation, replacement, and annual capital maintenance.
Condition Rating Levels	Rating levels established by RTA and the Service Boards for purposes of categorizing physical condition of assets. The five levels are: excellent, good, adequate, fair, and worn.
Contingency Costs	Contingency costs are budgeted for unforeseen emergencies or design shortfalls typically identified after a project commences. The contingency is included in the budget to minimize interruptions due to changes or cost overruns.
Capital Optimization Support Tool / COST	Capital Optimization Support Tool - Decision support tool developed by RTA with support from the Service Boards to assess and prioritize transit capital investment needs within the parameters of regional funding and the region's long-term strategic objectives.
Facilities	The Facilities category includes all assets related to maintenance and administrative facilities (but excluding systems within the facilities). Facilities represent one of five main COST asset types.
FTA	Federal Transit Administration
Guideway	Guideway includes all assets related to the guideway including track, track or Bus Rapid Transit (BRT) guideway, and associated structures. Guideway is one of five main COST asset types.
MAP-21	Moving Ahead for Progress in the 21st Century, the 2012 Transportation Legislation bill
Normal Reinvestment	Normal replacement, plus scheduled rehabilitation work and Annual Capital Maintenance
Normal Replacement	Ongoing replacement of existing assets as they reach the end of their expected useful life. Normal replacement does not include deferred replacement needs, only those needs for assets that will reach the end of their useful life over the next ten year period.
Rehabilitation	Ongoing rehabilitation needs for existing assets. Rehabilitation does not include deferred rehabilitation needs, only those rehabilitation activities that will arise over the next ten year period as required to maintain a state of good repair.
RTA	Regional Transportation Authority of Northeastern Illinois

SGR	State of Good Repair – Federally-led, collaborative initiative to comprehensively articulate the problem, to define a commonly adopted definition of "state of good repair", and to identify strategies, technical assistance briefs, peer to peer exchanges, and best practices aimed at achieving such a state industry-wide (FTA, Transit State of Good Repair, Beginning the Dialogue, October 2008). For the RTA's Condition Assessment Updates, SGR is used primarily as a major assumption for determining capital needs – that is, assets are replaced once they reach useful life, all rehabs are performed and capital maintenance is up to date.
Stations	Stations represent customer facing facilities, and include assets such as passenger stations, transfer terminals, and park and rides. Station assets exclude systems assets already accounted for under Systems. Stations represent one of five main COST asset types.
Soft Costs	The majority of soft costs are expended in the planning, engineering, and project management efforts. These services include in-house agency staff, government related support staff, and the occasionally consultants. Project start-up expenses are also included in this category. Project financing cost and "other" expenses (reconciliation and unaccountable costs) comprise the full range of project development capital costs (FTA definition).
Systems	Systems include all infrastructure support categories, such as communications, train control, traction power, and fare collection systems. Systems represent one of five main COST asset types.
TAM	Transit Asset Management
TERM	Transit Economics Requirements Model – FTA-led program, which is FTA's capital needs analysis tool. TERM Lite represents a local/regional version of TERM.
Useful Life	Expected life of a particular asset (e.g., 12 years for a transit bus). Expected useful lives for individual assets are driven by several factors, including historical performance, manufacturer recommendations, and policy.
Unconstrained Needs	Financially unconstrained. Unconstrained needs scenarios are typically the first run to establish total asset management needs in order to fully measure the combination of upcoming needs as well as any existing backlog.
Vehicles	Vehicles include both revenue vehicles and non-revenue vehicles. Vehicles represent one of five main COST asset types.

Appendix B: Sample Data Field Definitions

The data field definitions on the pages that follow are examples of typical fields collected in building an asset inventory. The table provides suggested unites, as well as examples and potential values.

For additional information, please contact Mr. John Goodworth, Division Manager, RTA, goodworthj@rtachicago.org

FIELD NAME	DEFINITION	UNITS	EXAMPLE	POSSIBLE VALUES
Record ID	Internal unique database record ID number, automatically assigned by Access	-	-	-
Update Status	Please indicate the type of change for any revision you make to the existing data. The choices are "add" (for new assets), "delete" (for retirements) or "modify" (for updates/changes). Please note that assets acquired between January 1 2010 and December 31, 2011 are considered New Assets so the choice "add" should be identified.	N/A	add	add, delete, modify: old, modify: new
Service Board	The Service Board reporting on the asset.	N/A	PACE	CTA, METRA, PACE
FTA Asset Type Code	Mapping to the FTA TERM Asset Structure	N/A	10210	5 Digit Numeric
SB Asset Number	The asset identification number the Service Board uses to track the asset. This field could correspond to the Service Board Financial Accounting asset number, or some other internal reference number.	N/A	722ACG1678	Alphanumeric
Quantity	The number of assets included in this record (row).	Each	1	Integer, minimum of 1
Area	The number of square feet in a parking lot, station platform, maintenance facility, yard or bus turn-around.	Square Feet	1425	Integer
Line	The overall route designation.	N/A	Blue; 82; UP-N	Rail line or route number
Branch	The designation for a part of a line.	N/A	Douglas	Text
Start	The distance measurement for the start of a linear asset, such as a milepost or surveying distance for a rail line.	Milepost or feet	11.29; 42+04	Decimal number or stationing number
End	The distance measurement for the end of a linear asset, such as a milepost or surveying distance for a rail line.	Milepost or feet	11.29; 42+04	Decimal number or stationing number
Length	The difference between the End and Start measurements, in whole feet.	Feet	423	Integer
Track Number	The operator's designation for the rail track associated with the asset at a location, where there is more than one track and the track number is needed to identify the asset in question.	N/A	2	Integer, minimum of 1
Location Name	The name of the asset location, such as a station, garage, storage facility or maintenance facility.	N/A	Noyes	Text
Location Address	The street address, city and zip of the asset location.	N/A	837 Noyes, Evanston 60201	Alphanumeric
Design Life	The number of years the asset can be expected to be used before wearing out and needing to be replaced (sometimes also referred to as "useful life").	Years	20	Integer, minimum of 1
In Service Year	The year the asset was purchased and/or put into service.	4-Digit Year Number	1944; 2003	Four-digit year number

FIELD NAME	DEFINITION	UNITS	EXAMPLE	POSSIBLE VALUES
Remaining Life	The difference between the design life and the number of years since the asset was put into service (this is automatically calculated, unless it is overridden with a different value due to rehab activity). Field has already been updated for 2012.	Years	12	Calculated integer = Design Life - (CurrentYear - InServiceYear)
Usage	A qualitative assessment of the usage level of the asset, such as the traffic level or impact placed on a rail line. Heavily used assets are expected to decay more rapidly than lightly used assets.	N/A	Heavy	Light, Medium, Heavy
Maintenance Regimen	A qualitative assessment of the amount of maintenance the asset typically performed on the asset. A low maintenance regime means no to minimal maintenance; a medium maintenance regime means standard preventive maintenance activities were performed on the asset; a high maintenance regime means the Service Board performed "above and beyond" normally expected preventive maintenance on the asset.	N/A	High	Low, Medium, High
Year Major Renovation	The year in which the last major renovation, rehab or overhaul of the asset took place.	N/A	2008	Four-digit year number
Number of Rehabs per Life	The number of renovations, rehabs or major overhauls the asset requires in order to achieve its full design life (many assets have 1 major overhaul during its life; many systems assets are simply replaced when they reach the end of their useful life).	N/A	1	Integer
Rehabilitation Cost	The cost of the rehabilitation (of thousands of dollars) of an individual item in the asset row, in $2011.	Thousands of Dollars	15	Dollars, in thousands (000's)
Mode	Mode most corresponding to the assets TERM designation (Bus, Rail, Paratransit. Specific definitions are: MB (motor bus); HR (heavy rail); CR (Commuter Rail); DR (Demand Response); VP (Vanpool); SY (systemwide asset, covering multiple modes)	N/A	HR	MB, HR, CR, DR, VP, SY
Serial Number	The manufacturer-assigned serial number or VIN for the asset item.	N/A	RCI290196	Alphanumeric
Manufacturer	The name of the company that made the item.	N/A	Ford	Text
Model	The manufacturer-assigned model name of the asset item.	N/A	Crown Victoria	Text
Description	A short description of the asset, to help identify what differentiates it from other items in the same category.	N/A	Nordco Spike Driver w/Gauger	Text
Owner	The owner of the asset, which is generally the service board. Other owners can be a corporation (e.g., BNSF owns track that Metra uses or a real estate company owns the land for a bus turn-around) or by a municipality (such as a station or parking lot).	N/A	METRA, Riverside Plaza Inc.	Text
Design Headway	The system design headway for a cab signal, in seconds.	Seconds	90	Integer
Reverse Signals	Whether or not the cab signal system has reverse signals.	N/A	Y	Y, N
Track Type	Whether the track is straight (tangent) or curved (curved).	N/A	tangent	tangent, curved

FIELD NAME	DEFINITION	UNITS	EXAMPLE	POSSIBLE VALUES
Number Of Spans	The number of spans of a bridge or track support structure that are included in the single asset.	N/A	3	Integer
Number Of Tracks	The number of tracks that are included in the single asset.	N/A	4	Integer
Number of Tie Replacement	Estimate of number of ties that need to be replaced each year (Metra field only)	N/A	1200	Integer
Number of Grade Crossings to Rehab	The number of grade crossings that are scheduled to be rehabilitated during the year in question.	N/A	10	Integer
Bus Length	The length of the model of bus, in feet.	Feet	49	Integer
Replacement Cost Each	The replacement cost (in thousands of dollars) of an individual item in the asset row, in $2011.	Thousands of Dollars	29.5	Dollars, in thousands (000's)
Replacement Cost Total	The replacement cost (in thousands of dollars) of all items in an asset row where the quantity is greater than 1, in $2011.	Thousands of Dollars	295	Dollars, in thousands (000's)
Annual Capital Maintenance Cost	The cost associated with keeping an asset in a state of good repair, annualized, and in $2011. Capital maintenance costs are typically significant and anticipated and are associated with keeping the asset in service for the full term of its useful life. Capital maintenance costs are characterized by replacement or rehabilitation of asset components, but not replacement of the entire asset. Examples of typical capital maintenance costs are bus overhauls (CTA, Pace), rail car overhauls (CTA, Metra), structure component replacement such as flange angles, foundations or connection angles (CTA, Metra).	Thousands of Dollars	30	Dollars, in thousands (000's)
Condition Rating (Age Based)	Age-based condition rating for the asset(s), based on 2009 Baseline Assessment and updated to December 2011. 5: Excellent; 4: Good; 3: Adequate; 2: Marginal; 1: Past Its Useful Life.	N/A	3	1, 2, 3, 4, 5
Condition Rating (Decay Curve)	Decay-curve condition rating based on TERM Decay curves for each asset.			
Soft Cost %	The majority of soft costs are expended in the planning, engineering, and project management efforts. These services include in-house agency staff, government related support staff, and the use of consultants for particular tasks. Project start-up and initiation expenses are also included in this cost category. Project financing cost and an "other" expense line item, which includes any reconciliations and unaccountable costs, comprise the full range of project development capital costs. (Federal Transit Administration definition)	N/A	12.5	Decimal percent, to 1 decimal place
Contingency %	These costs are budgeted for unforeseen emergencies or design shortfalls typically identified after a project commences. The contingency is included in the budget so the project can proceed with minimal interruption for changes or cost overruns	N/A	20.0	Decimal percent, to 1 decimal place

FIELD NAME	DEFINITION	UNITS	EXAMPLE	POSSIBLE VALUES
Comments	Any additional comments needed to describe the asset or clarify its condition rating.	N/A	All of these fare boxes will need to be replaced in 4 years when a new fare card system is introduced.	Text

Appendix C: Major Useful Life Assumptions

Useful Life Assumptions, CTA

RTAAssetType	Code	Category	Sub-Category	Element	Sub-Element	UsefulLife	Rehabs
Track Structures	10112	Guideway Elements	Guideway	At Grade Ballast	HR	80	0
Track Structures	10322	Guideway Elements	Guideway	Elevated Structure	Steel Viaducts HR	80	0
Track Structures	10402	Guideway Elements	Guideway	Elevated Fill	HR	80	0
Track Structures	10512	Guideway Elements	Guideway	Underground	Tunnel HR	80	0
Track Structures	10602	Guideway Elements	Guideway	Retained Cut	HR	80	0
Rail	11000	Guideway Elements	Trackwork	-	-	30	0
Rail	11101	Guideway Elements	Trackwork	Direct Fixation	Tangent	40	0
Rail	11102	Guideway Elements	Trackwork	Direct Fixation	Curve	25	0
Rail	11201	Guideway Elements	Trackwork	Ballasted	Tangent	40	0
Rail	11202	Guideway Elements	Trackwork	Ballasted	Curve	25	0
Grade Crossings	11303	Guideway Elements	Trackwork	Embedded	At-Grade Crossings	20	0
Special Trackwork	11400	Guideway Elements	Trackwork	Special	-	40	0
Bus Turnaround	13201	Guideway Elements	Bus Guideway	Turnaround	CTA	20	5
Other Major Facilities	21100	Facilities	Buildings	Administration	-	60	1
Railcar Maint Shops	21152	Facilities	Buildings	Administration	CTA Admin Building - 2 floor	60	5
Other Major Facilities	21251	Facilities	Buildings	Maintenance	CTA -- Interior Bus	60	5
Bus Garages	21251	Facilities	Buildings	Maintenance	CTA -- Interior Bus	60	5
Other Major Facilities	21254	Facilities	Buildings	Maintenance	CTA -- Rail	60	5
Railcar Maint Shops	21254	Facilities	Buildings	Maintenance	CTA -- Rail	60	5
Other Major Facilities	21255	Facilities	Buildings	Maintenance	CTA -- Warehouse	60	5
Yard	22212	Facilities	Storage Yard	Rail	HR	50	1
Work Equipment Misc	23300	Facilities	Equipment	Maintenance	-	20	0
Other Major Facilities	25000	Facilities	Central Control	-	-	60	1
Cab Signals	31102	Systems	Train Control	Wayside Train Control	HR	25	0
Grade Crossings	31402	Systems	Train Control	Roadway Crossings	HR	25	0
Interlockings	31500	Systems	Train Control	Interlockings	-	40	0
Substations	32202	Systems	Electrification	Substations	HR	30	0
SCADA RTUs	32210	Systems	Electrification	Substations	SCADA RTUs	7	0
ROW Traction Power	32400	Systems	Electrification	Contact Rail	Contact Rail/Chairs/Anchor/Incline	20	0
ROW Traction Power	32400	Systems	Electrification	Contact Rail	Contact Rail/Chairs/Anchor/Incline	25	0
Substation Distribution	32501	Systems	Electrification	Power Cable	Substations	30	0
Subway Electrical Serv	32600	Systems	Electrification	Building	Electrical Systems	25	0
Cable Plant Fiber	33101	Systems	Communications	Cable	-	20	0
Fiber Optic BB	33102	Systems	Communications	Cable	Nodes	10	0
Public Address Audio	33200	Systems	Communications	PA Systems	-	10	0
Bus Rail Radio Systems	33700	Systems	Communications	Base Radio Stations	-	15	0
SCCTV Cameras	33900	Systems	Security/Surv Equipment		-	15	0
CCTV Stations	33900	Systems	Security/Surv Equipment		-	5	0
Vault Operations	34002	Systems	Central Revenue Collection	-	HR	10	0
Subway Illumination	36101	Systems	Utilities	Lighting	Subway	20	0
Subway Pumps	36204	Systems	Utilities	Sump Pumps	Subway	30	0
Subway Fans - no updates	36302	Systems	Utilities	Fan Plants	Subway	25	0
GPS OnBoard Bus	37004	Systems	ITS	GPS	-	10	0
Stations	41051	Stations	Rail	CTA	At-Grade	60	5
Stations	41052	Stations	Rail	CTA	At-Grade Median	60	5
Stations	41053	Stations	Rail	CTA	Elevated	60	5
Stations	41054	Stations	Rail	CTA	Subway	60	5
Station Parking	41601	Stations	Rail	Parking	Garage	20	5
Station Parking	41602	Stations	Rail	Parking	Lot	20	1
Public Address VMS	41901	Stations	Rail	Signage & Graphics	Electronic	10	0
Rail Revenue Cars	51601	Vehicles	Revenue Vehicles	Heavy Rail	HR	25	3
Buses	51903	Vehicles	Revenue Vehicles	Motor Bus	BA	12	1
NonRevenue Vehicles	53001	Vehicles	Non-Revenue Vehicles	Car	-	5	0
Work Trucks	53002	Vehicles	Non-Revenue Vehicles	Truck	-	10	0
NonRevenue Vehicles	53002	Vehicles	Non-Revenue Vehicles	Truck	-	5	0
Work Equipment Trailers	53003	Vehicles	Non-Revenue Vehicles	Special	-	15	0
RailborneWork Equipment	53003	Vehicles	Non-Revenue Vehicles	Special	-	20	0

Useful Life Assumptions, Metra

RTAAssetType	Code	Category	Sub-Category	Element	Sub-Element	UsefulLife	Rehabs
Rail Bridges NCS	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges - MD-N	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges-MD-Main	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges-MD-W	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges -SWS	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_UP-W	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_UP-NW	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_UP-N	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_RI	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_ME	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_HC	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail Bridges_BNSF	10330	Guideway Elements	Guideway	Elevated Structure	Bridge	80	0
Rail	11200	Guideway Elements	Trackwork	Ballasted	-	70	0
Grade Crossing Track	11303	Guideway Elements	Trackwork	Embedded	At-Grade Crossings	12	0
Special Trackwork	11400	Guideway Elements	Trackwork	Special	-	70	0
Ties	11601	Guideway Elements	Trackwork	Ties	Wood	28	0
Ties	11601	Guideway Elements	Trackwork	Ties	Wood	32	0
Maint & Yard Facilities	21154	Facilities	Buildings	Administration	Metra Admin Building - 15 floor	60	5
Maint & Yard Facilities	21257	Facilities	Buildings	Maintenance	Metra -- Rail	60	5
Work Equipment	23311	Facilities	Equipment	Maintenance	Rail CR	10	0
Work Equipment	23311	Facilities	Equipment	Maintenance	Rail CR	20	0
Maint & Yard Facilities	23403	Facilities	Equipment	Maintenance	Train Washer	60	0
Maint & Yard Facilities	25000	Facilities	Central Control	-	-	60	1
BNSF Signals	31111	Systems	Train Control	Wayside Train Control	Signals & Train Stops CR	40	0
Metra Signals	31111	Systems	Train Control	Wayside Train Control	Signals & Train Stops CR	40	0
UP Signals	31111	Systems	Train Control	Wayside Train Control	Signals & Train Stops CR	40	0
CN (NCS) Signals	31111	Systems	Train Control	Wayside Train Control	Signals & Train Stops CR	40	0
CN (HC) Signals	31111	Systems	Train Control	Wayside Train Control	Signals & Train Stops CR	40	0
BNSF Grade Xing Signal	31401	Systems	Train Control	Roadway Crossings	CR	40	0
CN(NCS) Grade Xing Sig	31401	Systems	Train Control	Roadway Crossings	CR	40	0
CN (HC) Grade Xing Sig	31401	Systems	Train Control	Roadway Crossings	CR	40	0
Metra Grade Xing Sig	31401	Systems	Train Control	Roadway Crossings	CR	40	0
UP Grade Xing Signals	31401	Systems	Train Control	Roadway Crossings	CR	40	0
BNSF Interlockings	31500	Systems	Train Control	Interlockings	-	40	0
UP Interlockings	31500	Systems	Train Control	Interlockings	-	40	0
CN Interlockings	31500	Systems	Train Control	Interlockings	-	40	0
CN (NCS) Interlockings	31500	Systems	Train Control	Interlockings	-	40	0
Metra Interlockings	31500	Systems	Train Control	Interlockings	-	40	0
Substations	32201	Systems	Electrification	Substations	CR	30	0
Traction Power	32501	Systems	Electrification	Power Cable	Substations	40	0
Catenary & Strct	32700	Systems	Electrification	Overhead Catenary	-	40	0
Catenary & Strct	32706	Systems	Electrification	Overhead Catenary	Poles and Foundation	80	0
Cable Plant	33101	Systems	Communications	Cable	-	20	0
Fiber Optic BB Net	33102	Systems	Communications	Cable	Nodes	10	0
Public Address Systems	33200	Systems	Communications	PA Systems	-	10	0
Telephone Systems	33400	Systems	Communications	PBX	-	10	0
Telephone Systems	33401	Systems	Communications	Phone System	-	10	0
Wireless Telephones	33401	Systems	Communications	Phone System	-	5	0
Radio Systems	33500	Systems	Communications	Radio	-	15	0
Radio Systems	33700	Systems	Communications	Base Radio Stations	-	15	0
Microwave	33701	Systems	Communications	Base Radio Stations	-	15	0
Radio Systems	33800	Systems	Communications	Mobile Radios	-	15	0
CCTV Vending	33900	Systems	Security/Surv Equipment		-	10	0
CCTV Homeland Security	33900	Systems	Security/Surv Equipment		-	10	0
Fare Collection	34001	Systems	Central Revenue Collection	-	CR	40	0
Fare Collection	34001	Systems	Central Revenue Collection	-	CR	20	0
Fare Collection	34001	Systems	Central Revenue Collection	-	CR	7	0
Fare Collection	35001	Systems	Revenue Collection	CR	Other Fare Equipment	40	0
Fare Collection	35001	Systems	Revenue Collection	CR	Universal Fare Card	15	0
Fare Collection	35111	Systems	Revenue Collection	In-Station	System CR	10	0
Fare Collection	35115	Systems	Revenue Collection	In-Station	TVMs	15	0
Fare Collection	35201	Systems	Revenue Collection	On-Vehicle	Fareboxes	10	0
Train Stations	41056	Stations	Rail	Metra	At-Grade w Building	60	5
Train Stations	41059	Stations	Rail	Metra	Downtown Terminal	60	5
Station Parking	41601	Stations	Rail	Parking	Garage	60	5
Station Parking	41602	Stations	Rail	Parking	Lot	20	1
Locomotives	51301	Vehicles	Revenue Vehicles	Commuter Rail	RL	30	1
Coaches	51302	Vehicles	Revenue Vehicles	Commuter Rail	RP	50	1
EMUs	51303	Vehicles	Revenue Vehicles	Commuter Rail	RS	35	1
EMUs	51303	Vehicles	Revenue Vehicles	Commuter Rail	RS	50	1
NonRevenue Vehicles	53000	Vehicles	Non-Revenue Vehicles	Work vehicles	-	10	0
NonRevenue Vehicles	53000	Vehicles	Non-Revenue Vehicles	Autos and vans	-	5	0

Useful Life Assumptions, Pace

RTAAssetType	Code	Category	Sub-Category	Element	Sub-Element	UsefulLife	Rehabs
Garages - Site Work	21153	Facilities	Buildings	Administration	Pace Admin Building - 2 floor	60	5
ADA Facilities	21153	Facilities	Buildings	Administration	Pace Admin Building - 2 floor	50	5
ADA Facilities	21258	Facilities	Buildings	Maintenance	Pace -- Bus - Small	50	5
Garages - Site Work	21258	Facilities	Buildings	Maintenance	Pace -- Bus - Small	60	5
Infrastructure Support	21258	Facilities	Buildings	Maintenance	Pace -- Bus - Small	20	5
Garages - Site Work	21259	Facilities	Buildings	Maintenance	Pace -- Bus - Large	60	5
Radio Systems City	33500	Systems	Communications	Radio	-	20	0
Radio Systems Buses	33500	Systems	Communications	Radio	-	10	0
Radio Systems Sub Para	33500	Systems	Communications	Radio	-	10	0
CTS	33900	Systems	Security/Surv Equipment		-	4	0
Suburb Event Recorders	33900	Systems	Security/Surv Equipment		-	5	0
Suburb Road Recorders	33900	Systems	Security/Surv Equipment		-	5	0
Paratransit Event Rec	33900	Systems	Security/Surv Equipment		-	20	0
Vanpool Drivecam	33901	Systems	Security/Surv Equipment	Bus On-Board Video	-	20	0
Fare Collection	34000	Systems	Central Revenue Collection	-	-	5	0
Fare Collection Paratransit	35201	Systems	Revenue Collection	On-Vehicle	Fareboxes	7	0
Fare Collection	35201	Systems	Revenue Collection	On-Vehicle	Fareboxes	5	0
ITS IBS Systems	37000	Systems	ITS	-	-	12	0
AVL Systems	37002	Systems	ITS	AVL	-	2	0
AVL Systems	37002	Systems	ITS	AVL	-	5	0
ADA Call Center-other	37003	Systems	ITS	CAD	-	20	0
Bus Terminal	42051	Stations	Motor Bus	-	Pace Bus Terminal	15	1
ADA Pass Facilities	42052	Stations	Motor Bus	-	Pace Bus Park & Ride	10	1
Bus Pass Pavement	42052	Stations	Motor Bus	-	Pace Bus Park & Ride	10	1
Paratransit	51407	Vehicles	Revenue Vehicles	Demand Response	VN	4	0
ADA Rolling Stock	51407	Vehicles	Revenue Vehicles	Demand Response	VN	4	0
Suburb Rolling Stock	51903	Vehicles	Revenue Vehicles	Motor Bus	BA	12	1
Suburb Rolling Stock	51906	Vehicles	Revenue Vehicles	Motor Bus	BD	12	0
Suburb Rolling Stock	51912	Vehicles	Revenue Vehicles	Motor Bus	OTR	12	0
Vanpool	52302	Vehicles	Revenue Vehicles	Vanpool	VN	4	0
ADA Rolling Stock	52501	Vehicles	Revenue Vehicles	Rural	AO	4	0
ADA Rolling Stock	52520	Vehicles	Revenue Vehicles	Rural	-	4	0
Non-Revenue Vehicles	53000	Vehicles	Non-Revenue Vehicles	Autos and vans	-	5	0
Non-Revenue Vehicles	53000	Vehicles	Non-Revenue Vehicles	Small Trucks	-	7	0
Non-Revenue Vehicles	53000	Vehicles	Non-Revenue Vehicles	Work vehicles	-	10	0

Appendix D: Condition Rating Definitions

In order to have a consistent scoring approach, the RTA developed condition rating for all major asset types. The table on the following pages illustrates the condition rating definitions applicable to heavy rail vehicles. When assessors conduct field visits, there is a consistent definition for each condition (1 through 5).

For additional information, please contact Mr. John Goodworth, Division Manager, RTA, goodworthj@rtachicago.org

Vehicles, Heavy Rail Vehicles

Component	Element	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
Car Assembly	Summary	Major damage; Structural or safety concerns	Deteriorating reliability; structure OK, frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
	Car Body	Body panels damaged; roof leaks; paint peeling; attachments, floors and walls damaged; structural concerns	Scratches and dents; paint yellowing; seats patched or dirty; floors, walls and structure generally OK	Light scratches, minor dents & chips; seating worn	Preventative maintenance	New; performance acceptable
	Doors	Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
	Electric	Wiring corroded or insulation deteriorated beyond repair; converters, lighting or current collectors severely deteriorated, unreliable and unserviceable	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
Truck Assembly	Summary	Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
	Couplers	Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs		New; performance acceptable
	Trucks	Poor reliability; safety concerns; excessive wear; structural deficiencies	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
Propulsion / Control	Summary	Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
	Propulsion	Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
	ATC (if used)	Poor reliability; safety concerns; obsolete	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
Air & Brakes		Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
HVAC		Poor reliability	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable
ATC/PTC		Poor reliability; safety concerns	Deteriorating reliability; frequent or major repairs	Minor repairs	Preventative maintenance	New; performance acceptable

Vehicles, Motor Bus Vehicles

Equipment	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
Interior	Parts broken or missing, not functional.	Visible leakage, switches or hinges frozen, non-critical parts broken or loose	Corroded or dirty but repairable with cleaning, painting or adjusting	Clean and mechanically sound but age apparent	Like new condition, clean and tight
Exterior	Heavy corrosion or damage, holes evident, access doors loose, parts worn beyond reasonable service limits	Corrosion evident, hinges or latches frozen, major cosmetic damage, some non-critical parts broken	Minor corrosion or scrapes present but could be repaired with cleaning priming and painting, minor cosmetic damage, parts heavily worn but serviceable	Condition generally good, may need painting	Like new condition, clean and tight
Engine Compartment	Heavy corrosion, holes evident, major leaks, parts broken or missing, not functioning	Corrosion and cracking evident, heavy leakage, some mountings broken, damaged cables and belts, heavy wear, broken or missing parts	Minor corrosion or cracking present but repairable, minor leakage, worn cables and belts.	Generally clean, mechanically sound, wear visible, minimal leakage	Like new condition, clean and tight
Chassis / Under-structure	Heavy corrosion, holes and cracking, massive leaks, parts broken or missing, not functioning	Corrosion and cracking evident, heavy leakage, some mountings broken, damaged hoses, heavy wear, broken or missing parts	Minor corrosion or cracking present but repairable, minor leakage, worn hoses and bushings, some components require adjustment	Generally clean, mechanically sound, visible wear, minimal leakage	Like new condition, clean and tight

Appendix E: Assessment Forms

The RTA developed assessment forms for all major asset types. The example that follows is for a CTA rail car. Note RTA developed separate assessment forms for CTA and Metra rail cars, due to the differences in the fleets.

For additional information, please contact Mr. John Goodworth, Division Manager, RTA, goodworthj@rtachicago.org

REVENUE VEHICLE (CTA RAIL CAR) ASSESSMENT FORM

Vehicle Identification – Fleet: Vehicle Identification – Vehicle Number:	Date: / / 2013
	Assessed by: Accompanied by:
Vehicle Age: Yrs	Mid-Life Overhaul: :

ASSET CONDITION RATINGS: 1 = WORN, 2 = MARGINAL, 3 = FAIR, 4 = GOOD, 5 = EXCELLENT

RAIL CAR	*COMMENTS*	LAST REHAB.	PHOTO	CONDITION
Car Body Assembly – Summary				1 2 3 4 5
Car Body Exterior				1 2 3 4 5
Door Panels				1 2 3 4 5
Interior (floor, seats, interior panels)				1 2 3 4 5
Vehicle Systems – Summary				1 2 3 4 5
Couplers				1 2 3 4 5
Trucks				1 2 3 4 5
Propulsion / Control				1 2 3 4 5
Auxiliary Electrical System				1 2 3 4 5
ATC				1 2 3 4 5
Operator's Cab				1 2 3 4 5
HVAC				1 2 3 4 5
Door Operators				1 2 3 4 5
PA/Communications/Run Signs				1 2 3 4 5
Other				1 2 3 4 5

Transit Asset Management (TAM) Pilot Program

FTA-2011-004-TPM

Volume 2 – Capital Optimization Support Tool

CH2MHILL®

September 2013

TBG091712092129MKE

This is Volume 2 for the Regional Transportation Authority (RTA)'s Transit Asset Management (TAM) Pilot Project grant from the Federal Transit Administration (FTA). Volume 2 consists of three separate reports included herein, as follows:

- Part 1 – RTA Capital Optimization Support Tool (COST) Model "How To" Guide
- Part 2 – Multi-Criteria Investment Prioritization Process "How To" Guide
- Part 3 – Asset to Project Mapping "How To" Guide

Each report has its own table of contents. Volume 1: Asset Inventory and Condition Assessment Guide is a separate deliverable.

Volume 2, Part 1

RTA COST Model "How To" Guide

Pilot Product #4: Capital Prioritization Decision Support Tool

Prepared for

Regional Transportation Authority

Regional Transportation Authority of Northeastern Illinois

September 2013

CH2MHILL®

Table of Contents

1. Introduction

1.1 FTA TAM Grant

In 2011, the Regional Transportation Authority of Northeastern Illinois (RTA) received an $800,000 Transit Asset Management (TAM) Pilot Project grant from the Federal Transit Administration (FTA). This pilot project includes TAM improvements that build off existing RTA TAM processes already in progress, namely the Capital Asset Condition Assessment, Capital Decision Prioritization Support Tool (now called the Capital Optimization Support Tool, COST or "the Tool"), and management approaches already in use. The objectives of RTA's TAM grant include:

- Document RTA's existing policies; goals and objectives; performance targets and evaluation processes; and inventory/condition data collection, management, and reporting processes such that other local and regional operators can benefit from RTA's experience
- Advance the TAM "state-of-the-art" capabilities in the areas of estimated capital investment needs and investment prioritization
- Develop asset-to-project groupings using the analytical foundation provided by RTA's existing project screening and prioritization process and FTA's Transit Economic Requirements Model (TERM) model as a foundation for tool development.

The TAM Pilot Project is an 18 month process for RTA, which is documented in two volumes and the four work papers:

- Volume 1: Asset Inventory and Condition Assessment Guide
- Volume 2: Part 1 – RTA COST Model "How To" Guide, Pilot Product #4: Capital Prioritization Decision Support Tool
- Volume 2: Part 2 – Multi-Criteria Investment Prioritization Process "How To" Guide, Pilot Product #2: Multi-Criteria Investment Prioritization Process
- Volume 2: Part 3 – Asset to Project Mapping "How To" Guide, Pilot Product #3: Asset-to-Capital Project Numbering Convention.

This document presents the "how to" guide on development and application of RTA's COST. This document is intended to be helpful to other operators or funding agencies developing and applying similar decision support tools.

1.2 RTA's Capital Decision Prioritization Support Tool

This "How to" Guide provides a detailed description of RTA's COST, focusing on the required steps to populate, run, and maintain the Tool.

Overview of Tool: As background, RTA's COST is an MS Access based analysis model (based on FTA's TERM Lite Model) designed to perform the following analyses for RTA and its three Service Boards; the Chicago Transit Authority (CTA), Metra and Pace:

1. Assess current size of state of good repair (SGR) backlog.
2. Assess (estimate) current asset conditions.
3. Conduct assessment of 20-year unconstrained capital reinvestment needs.
4. Assess the impact of constrained reinvestment on:
    a. SGR backlog

    b. Asset Conditions
    c. Proportion of assets in SGR
5. Prioritize reinvestment (rehab and replacement) needs based on five investment criteria (asset condition, number of riders impacted and impact of investments on each of the following: reliability, safety, and O&M costs). Includes the prioritization of reinvestment needs for expansion assets assumed to be acquired during the period of analysis.
6. Prioritize investment in expansion/enhancement assets (as proposed by RTA and its Service Boards) based on investment cost per rider impacted.
7. Assess the impact of expansion/enhancement investments on:
    a. SGR backlog
    b. Asset Conditions
    c. Proportion of assets in SGR.

COST's ability to assess the impact of constrained funding on the RTA region's future SGR backlog and asset conditions is dependent on its ability to prioritize between multiple SGR investment alternatives (i.e., given that funding is insufficient to address all needs, what needs should we address first?). Development of a reliable SGR prioritization routine was therefore critical to providing COST with the ability to conduct meaningful analyses of the expected impacts of constrained funding on the future SGR backlog and future asset conditions. Much of the prioritization capability developed by RTA for COST has already been adopted and incorporated into FTA's TERM Lite model. Similarly, the Tool's ability to select between expansion and enhancement investments when funding is limited required development of a prioritization process for these investment types.

In addition to supporting "what-if" analysis of the potential future impacts of constrained funding, COST's ability to prioritize reinvestment needs was also intended to help support the identification and prioritization of actual reinvestment projects. Specifically, RTA and its Service Boards can use the tool as an independent and objective review of the list of SGR investment projects identified by Service Board staff through more traditional engineering and project selection processes. In this role, COST (and its prioritization routine) acts as an "alternative perspective", potentially identifying reinvestment opportunities and prioritizations that RTA may not have otherwise considered.

Document Overview: The intention of this Guide is to instruct users on the steps required to fully utilize RTA's COST, including the steps required to populate the tool with data, develop and run "what-if" scenarios and access and export output data. Specifically, this Guide considers each of the following:

Chapter 2: Background on RTA's Capital Optimization Support Tool
Chapter 3: Opening, Saving and Existing COST
Chapter 4: Populating and Maintaining the Tool
Chapter 5: Building Analysis Scenarios
Chapter 6: Running the Model
Chapter 7: Working with Output.

1.3 Definition of Terms

Following are definitions of key terms as used by this Guide:

- Needs Analysis: In the context of COST, needs analysis refers to the process of determining the level of investment required to attain specific investment objectives and also with how those investment dollars are allocated to different uses (e.g., between various asset types). In general, needs analysis falls into two broad categories:

  - *Unconstrained needs:* The level of investment required to address all outstanding and future needs, irrespective of actual or expected funding availability.
  - *Constrained Needs:* As the name suggests, under constrained needs analysis, there is insufficient funding to address all needs. This analysis shows the level of investment required to attain more realistic investment objectives (e.g., maintain the size of the current investment backlog, or eliminate the backlog over 20 years).

- <u>Reinvestment in Existing Assets (SGR) vs. Investment in New Expansion or Enhancement Assets:</u> COST is designed to assess and prioritize investment needs for both existing and expansion assets. In general, these investment types fall into the following categories:
  - *Reinvestment in Existing Assets:* Refers to SGR (i.e., rehab and replace) investments in assets that are currently in service (i.e., *existing* assets).
  - *Investment in expansion assets:* Refers to the planned/proposed future purchase of new assets that either: (i) expand existing service capacity (e.g., fleet expansion), (ii) adds a new service (e.g., New Starts) or (iii) enhance existing service (e.g., new technologies such as real-time arrival information).

- <u>Scenario Analysis:</u> In the context of COST, scenario analysis refers to the process of identifying specific investment objectives and then assessing the investment needs associated with attaining that scenario. Examples include:
  - Maintain historic funding levels
  - Maintain the current backlog
  - Eliminate the backlog over a set time period (e.g., 20 years).

- <u>Prioritization:</u> For this Guide, prioritization is the process of identifying a preferred or optimal order for reinvestment events. Implicit in this statement is the assumption that:
  - *Funding is insufficient to address all needs.* Hence prioritization is required to determine which assets should be addressed first (and which assets have needs that may not be addressed)
  - *Investment needs can be ranked.* In other words, there are good analytic or other bases on which to rank investment needs – from highest to lowest—to determine in which outstanding needs are most effectively addressed (and potentially leaving some needs unaddressed).

- <u>Asset Condition and Decay:</u> Asset condition refers here to the estimated physical condition of a transit asset. Specifically, COST includes a set of embedded asset decay curves that predict the current and future physical condition of a transit asset based on its type, age and other factors (e.g., use and maintenance history). COST uses these condition relationships to prioritize reinvestment needs (in part) based each asset's predicted physical condition (both currently and in the future). COST also uses these same asset decay curves to generate current and future distributions of asset conditions.

The following definitions for State of Good Repair (SGR) separate the asset level from aggregate level.

- <u>Asset Level SGR:</u> An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

<u>Mode, Service Board, or Regional Level (Aggregate) SGR</u>: A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.

2. Background – RTA's Capital Optimization Support Tool

This chapter provides background on RTA's capital planning processes including

- RTA's asset management practices: past and present
- COST Overview
- COST Development and Relation to TERM Lite.

2.1 RTA's Asset Management Practices: Past and Present

The Regional Transportation Authority (RTA) is responsible for planning, funding and oversight of all public transportation in Northeastern Illinois. As such, the RTA allocates funding to three Service Boards: CTA, Metra commuter rail and Pace suburban bus. The RTA network serves the third largest US transit market, with nine million in population and two million daily rides. The RTA's combined assets include approximately 7,000 revenue vehicles, 380 rail stations, over 350 bus routes, and 60 maintenance facilities. With some of the nation's oldest transit assets the RTA also has significant reinvestment needs, including an estimated $24.6 billion over the next ten years to attain and maintain a SGR, which is more than three times higher than the projected funding during the same time period.

Asset Management at RTA: RTA's current TAM system consists of:

1. an ongoing regional transit asset inventory/condition assessment program
2. an SGR needs assessment process founded on that inventory
3. a project screening and prioritized capital plan development process, that begins with the goals and objectives set in the Strategic Plan and links to an ongoing performance measurement program.

These latter tools moved the RTA beyond the preexisting Transit Capital Asset Model (CAM) to a more integrated prioritization based routine compatible with FTA's TERM model.

RTA's TAM History: In 1987, the RTA completed a detailed examination of the transit system's capital needs as part of the studies which led to the RTA's first Strategic Plan. This effort developed the first comprehensive inventory of capital assets and an age-based estimate of capital renewal requirements, known as the RTA Bedrock Investment Program (BIP). The BIP was a spreadsheet-based software tool used to estimate both deferred and future capital needs for the Service Boards. The results of this analysis focused the first Strategic Plan and served as a basis for legislative initiatives to increase the level of capital funding. The BIP pioneered the development of the asset inventory based needs analysis, on which FTA's TERM was later founded.

The RTA created CAM in 1995 to:

- update the original asset inventory
- incorporate asset condition information from the extensive engineering assessments of CTA rail infrastructure
- improve the model's utility for the RTA and the Service Board capital planning staff.

CAM estimated current and future capital renewal needs and supported evaluation of the impact of various funding levels and renewal strategies on system conditions over time. CAM was a second generation asset needs analysis tool developed in tandem with FTA's TERM model (with many of the same capabilities).

The Regional Transportation Asset Management System (RTAMS) is a transportation information retrieval system developed by the RTA. The system's goal is to improve access to the region's enormous transportation data resources being gathered by the RTA, its Service Boards and other regional transportation and planning agencies. RTAMS has followed an evolutionary development path since the initial pilot project proposal was presented to the RTA Board in August 2000.

After successful completion of the pilot, RTAMS has been used by RTA staff since the summer of 2001 with incremental improvements to the system deployed each year. Each increment added new content, enhanced usability and improved functionality. Improvements have been driven by user feedback and the addition of content partners. Developmental highlights included:

- site redesign and external access to CTA, Metra, and Pace in the fall of 2002
- transformation from an interactive mapping application to a full Web site giving access to other transportation and planning agencies and municipal officials in 2003
- addition of planning studies and the Illinois State Toll Highway Authority as a content partner in 2004
- performance and capacity improvements and website launched to the general public in 2005.

RTAMS is now a live interactive web-site.

Strategic Plan – Moving Beyond Congestion (MBC): In July of 2006, the RTA, along with CTA, Metra, and Pace, and its Partners for Transit (business, government, civic and religious organizations that have joined the RTA in their commitment to transit and the MBC initiative) launched MBC, a strategic planning project meant to raise awareness about the need to maintain, enhance and expand transit service, and to solicit input from key stakeholders and the general public. The Authority's strategic plan included the further goals of enhancing coordination, integrating information, and improving system access and ease of use. One of the purposes of the Strategic Plan was to provide a long-range plan to guide the region in achieving a world-class public transportation system which is the keystone to growing business opportunities, a thriving job market, clean air and livable communities over the coming decades. Furthermore, the Strategic Plan allowed the RTA and the Service Boards to address critical questions about the condition and adequacy of the public transportation system, as well as the external forces and factors, such as growing traffic congestion.

TAM Related Legislation Requirements: The strategic planning work provided the foundation for the subsequent funding and Illinois reform legislation enacted in January 2008 as P.A. 95-0708. The legislation mandates the RTA to provide more effective financial oversight, regional planning, and coordination among the three operating Service Boards. In enhancing the role of the RTA, the legislation makes the Strategic Plan the cornerstone of all the RTA planning, financial and oversight activities going forward.

2.2 RTA's Capital Optimization Support Tool

In April 2011, RTA initiated development of the Capital Decision Prioritization Support Tool (now Capital Cost Optimization Tool or COST). COST is an MS Access based database and model that houses a comprehensive inventory of all major capital assets owned and operated by RTA's three Service Boards. COST also includes asset type specific life expectancies and life cycle reinvestment rules used to allow the tool to asses or predict each of the following:

- Current size of SGR backlog
- 20-year unconstrained capital reinvestment needs
- The impact of constrained reinvestment on:
    - SGR backlog

  - Asset Conditions
  - Proportion of assets in SGR
- Prioritize reinvestment (rehab and replacement) needs
- Prioritize proposed expansion and enhancement investments
- Assess the impact of expansion/enhancement investments on:
  - SGR backlog
  - Asset Conditions
  - Proportion of assets in SGR.

Need for SGR Investment Prioritization: COST's ability to assess the impact of constrained funding on the RTA region's future SGR backlog and asset conditions is dependent on its ability to prioritize between multiple SGR investments (i.e., rehab and replacement of *existing* assets). More specifically, when funding is not sufficient to address all SGR investment needs (i.e., funding is constrained), then the Tool requires rules to determine which needs are addressed and which needs will enter the SGR backlog. The prioritization rules allow the Tool to rank SGR investment needs from highest to lowest priority. For each year of a constrained model run then, COST reorders investment needs from highest to lowest priority and then invests in these needs from highest to lowest until the available funding capacity for that year is exhausted. This process is repeated for each year of COST's 20-year forecast period.

Need for Expansion/Enhancement Investment Prioritization: Similarly, COST also requires the ability to prioritize between investments in additional assets, including those that either expand service capacity/add new services (*expansion* investments) or those that enhance the quality of existing services (*enhancement* investments). As with the SGR reinvestment prioritization, the expansion/enhancement investment prioritization ranks these investments from highest to lowest, based on cost and number of riders that benefit, and then invests in these needs until the available funding capacity is exhausted.

Prioritization - SGR Backlog Management: As described to this point, COST's prioritization routine is used as a means to allocate funding between competing needs for the primary purpose of assessing the impact of alternative reinvestment priorities on the size and composition of the region's SGR backlog and long-term reinvestment needs. As different reinvestment priorities will lead to some asset needs being addressed and others entering the SGR backlog, adjusting these priorities and their weights allow an analyst to use COST to examine the desirability of alternative investment prioritization weights with respect to the SGR backlog. COST can then help identify a preferred mix of investment priorities that can be used to guide actual reinvestment priorities within the region.

Prioritization - Capital Programming: COST's prioritization capabilities can also provide a more direct input to the region's investment prioritization process. Specifically, RTA and the Service Boards can compare COST's selected reinvestment priorities, for specific asset types and locations, with the reinvestment priorities identified through more traditional engineering and project planning methods (e.g., as documented in the CIP and capital budgets). In this role, COST provides an independent, objective and alternative review of the region's reinvestment plans. This comparison can then be used to help further refine and prioritize those plans, potentially leading to improved investment decisions.

COST and The Multi-Criteria SGR Investment Prioritization Process: RTA's objective in developing the multi-criteria prioritization process for SGR investments was to equip COST with the two types of prioritization capabilities described above, i.e.:

- Analyze the impact of alternative reinvestment priorities on future SGR backlog needs and
- Support the prioritization of actual reinvestment actions (through comparison of Tool investment selections with engineering based project selections)

Hence, all of the prioritization development actions described in this Guide and in more detail in the Multi-Criteria Investment Prioritization Process "How To" Guide have been conducted with the purpose of providing RTA's COST with these two capabilities.

For each year of a 20-year model run, COST first identifies which of the region's assets require some reinvestment action (e.g., rehab or replacement) to attain SGR. Next, the Tool assigns prioritization scores to each of these assets and the tool will reinvest in the highest scoring assets until the expected amount of reinvestment funding for that year are exhausted. Using this prioritization, COST then determines for each year, what assets undergo reinvestment actions, what assets enter the SGR backlog, and what projects the funded investment actions imply.

A higher level conceptual overview of COST's SGR reinvestment needs and prioritization analysis is found in Figure 2-1. This representation emphasizes the Tool's reliance on the asset inventory data obtained from RTA's annual asset inventory and condition assessment update process. Figure 2-1 also highlights the simulation process used for each year of the 20-year period of analysis to:

1. assess needs for each analysis year
2. score and rank all potential investment actions and
3. undertake the highest ranked investment actions subject to expected funding capacity.

These prioritized annual needs are then used to help develop a 10-year regional investment plan.

Figure 2-1: COST – SGR Needs Forecasting and Prioritization Tool Combined

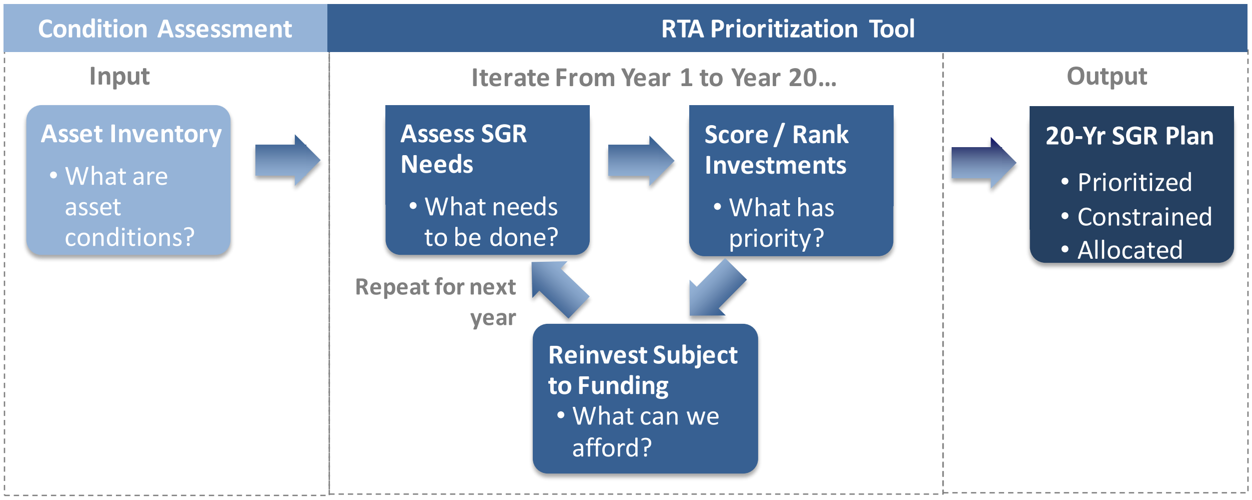


Figure 2-2 provides an overview of the five investment criteria used to score and rank all potential SGR reinvestment actions – including asset condition, number of riders impacted, and the contribution of reinvestment actions to each of service reliability, rider and agency staff safety and security, and finally O&M cost reduction. The weight placed on each criterion is variable within COST and hence can be varied to reflect agency policies or to conduct sensitivity analyses. The process used to score each SGR reinvestment criterion is highlighted in Figure 2-3 (refer to the "How to" Guide for Multi-Criteria Prioritization for a more in-depth explanation).

Figure 2-2: COST – SGR Investment Prioritization Criteria and Scoring

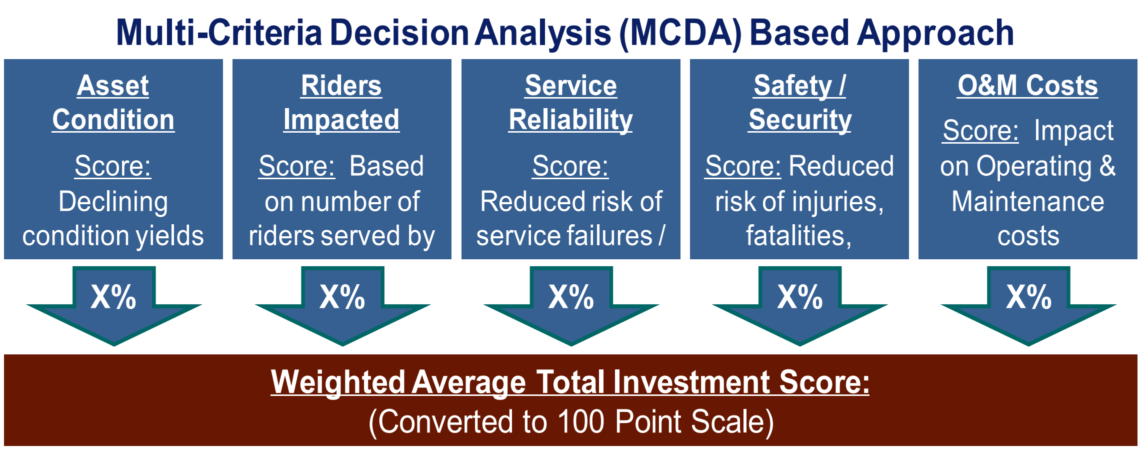
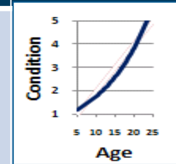
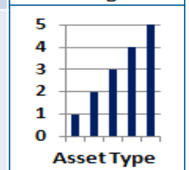
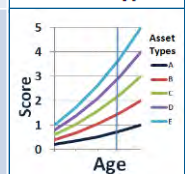
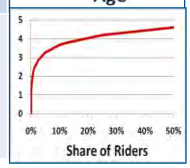


Figure 2-3: Approach to Scoring by SGR Investment Criterion

Criterion	Approach	Dynamic or Static?	Illustration
Condition	• Decay curve based condition estimate – Age based 1 to 5 scale	• Dynamic	
O&M Cost Impact	• Fixed score by asset type	• Static	
Reliability and Safety/ Security	• Combination of: – Fixed score by asset type – Dynamic score by asset age	• Mixed	
Riders Impacted	• Logarithmic score based on share of total agency riders impacted – Scale ensures all assets obtain score	• NA	

Scoring is "dynamic" throughout the 20-year period covered by each model run for some criteria. Specifically, COST assesses each asset's condition at the start of each analysis year (including the start or "backlog year"). This evaluation is then used to score and rank potential SGR investments with respect to asset condition, reliability and safety/security (with scoring for reliability and safety/security driven in part by condition). Due to this constant re-evaluation, the scoring for all assets is constantly changing (i.e., is "dynamic") throughout the 20-years of each model run.

Expansion/Enhancement Asset Acquisition Prioritization: At the time of writing, the process used to prioritize the initial acquisition of expansion and enhancement assets is significantly simpler than that used to prioritize reinvestment actions for either existing assets or expansion/enhancement assets (following their acquisition). Specifically, the acquisition of expansion and enhancement investments (identified as "Expansion" assets in the asset inventory) is based on a single investment criterion, "Riders impacted per dollar invested" (i.e., number of riders benefiting from the expansion/enhancement investment divided by the investment cost). The higher the value of this ratio, the higher the asset's prioritization score. Note that unlike the prioritization scores for reinvestment actions, the acquisition prioritization scores for expansion/enhancement investments are not confined to a set scoring range of 1 to 100.

Note that the single "Riders impacted per dollar invested" investment criterion only applies to the acquisition of expansion/enhancement assets. Following their acquisition, reinvestment needs for expansion/enhancement investments are prioritized using the same five-criteria scoring and compete for the same investment funds as "existing" assets.

Finally, it is important to emphasize that the acquisition of new assets and reinvestment in existing assets are prioritized entirely separately from one-another and also utilize different budget amounts. Expansion asset acquisition is funded from a different budget than asset reinvestments – and these budgets cannot be shared within COST.

COST Output: RTA's COST provides output results in three different formats. These include:

- Reports: Printable MS Word or PDF reports on current and future reinvestment needs, the SGR backlog, asset conditions and other SGR measures (users can also access the query data underlying each report)
- Excel Exports: Charted analysis results exported to Excel (for use in presentations, reports and further analyses)
- Raw Data: Detailed, asset level investment needs, SGR backlog and condition analysis. Provides users with access to the detailed data behind the output reports and Excel exports

Figures 2-4 and 2-5 below provide examples of the analyses generated by COST. Figure 2-4 presents a sample forecast showing the impact of constrained investment expenditures on the future SGR backlog, asset conditions and percent of assets exceeding their useful life. Figure 2-5 provides examples of both (1) average prioritization investment scores by asset type and (2) detailed, raw investment scores for individual transit assets.

Figure 2-4: COST Projects Future Investment Needs, Backlog and Asset Conditions

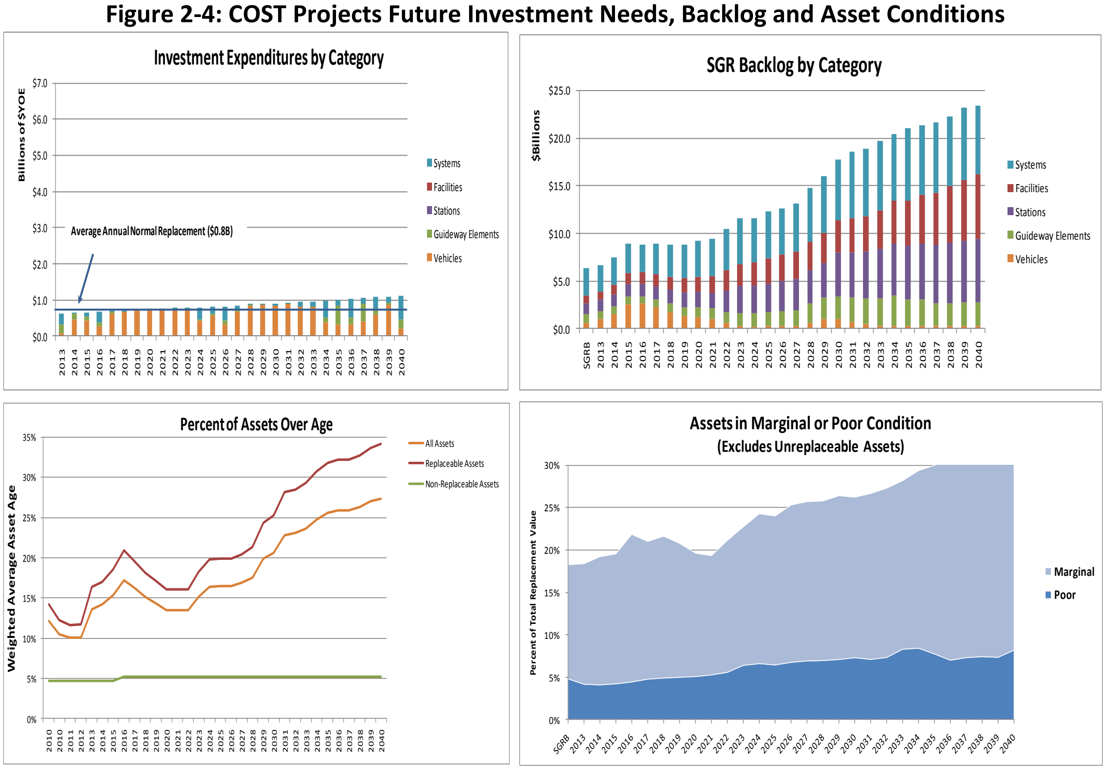
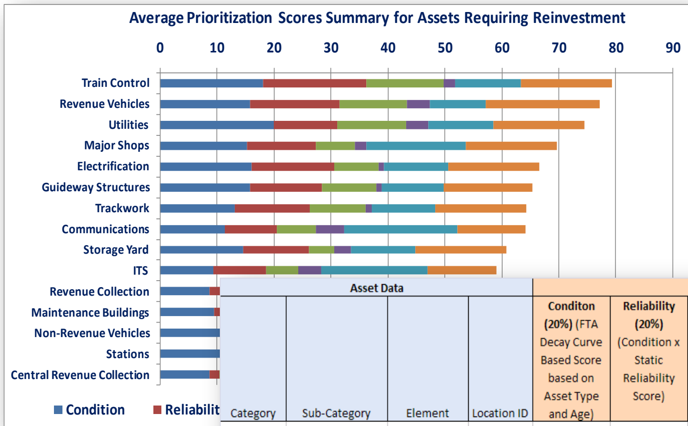


Figure 2-5: SGR Investment Prioritization Scoring – Grouped by Asset Type and by Individual Asset



Asset Data				Prioritization Score						
Category	Sub-Category	Element	Location ID	**Conditon (20%)** (FTA Decay Curve Based Score based on Asset Type and Age)	**Reliability (20%)** (Condition x Static Reliability Score)	**Safety & Security (20%)** (Condition x Static Safety Score)	**Security (5%)** (Static Security Score Only)	**Impacted Riders (20%)** (Logarithmic Score based on Share of Total SB Riderhip)	**O&M Cost Impact (20%)** (Static Reliability Score Only)	**Total Score (100%)** (weighted sum of scores in coulmns J to O times 20)
Facilities	Major Shops	Bus	67983	3.06	2.45	1.84	2	4.36	4	63.00
Facilities	Storage Yard	Rail	96550	3.79	3.04	1.52	3	3.00	4	62.89
Guideway	Trackwork	Direct Fixation	69362	3.79	3.79	3.79	1	1.05	4	62.84
Systems	Electrification	Substations	83117	3.14	2.51	1.88	1	4.36	4	62.66
Guideway	Guideway	Elevated Structu	95422	3.82	3.05	3.05	1	2.04	4	61.77
Facilities	Storage Yard	Bus	69631	3.35	2.68	1.34	3	3.62	4	61.66
Guideway	Trackwork	Ties	34853	3.60	3.60	3.60	1	1.05	4	60.80
Guideway	Trackwork	Direct Fixation	14253	2.88	2.88	2.88	1	2.99	4	60.63
Systems	Electrification	Contact Rail	83655	3.38	3.38	2.03	1	2.56	4	60.42
Systems	Train Control	Interlockings	88773	2.80	2.80	2.80	2	2.61	4	59.27
Guideway	Trackwork	Embedded	44226	2.89	2.89	2.89	1	2.61	4	59.25
Systems	Train Control	Roadway Crossi	25409	2.47	2.47	2.47	2	3.49	4	59.13
Systems	ITS	GPS	98564	2.33	2.33	1.87	4	4.68	3	59.00
Systems	Utilities	Fan Plants	68472	3.03	1.82	2.43	4	2.99	4	58.66

2.3 COST Development and TERM Lite

Prior to initiating development of COST, the RTA identified and evaluated alternative approaches to assessing and prioritizing the region's capital reinvestment needs. Following this evaluation, the RTA, working in concert with the region's three Service Boards, selected FTA's TERM as the starting point for development of the Capital Decision Prioritization Support Tool (now COST). Specifically, RTA and the Service Boards made the decision to build COST using the existing TERM framework as a starting point. As development proceeded, TERM would be adapted or "customized" as needed to meet RTA's specific needs. In particular, TERM's pre-existing investment benefit-cost analysis was removed and a multi-criteria investment prioritization routine substituted in its place. Many of RTA's Tool development actions have focused on the development, implementation, testing and improvement of this prioritization capability.

As with all other aspects of RTA's regional condition assessment process and related efforts, RTA and the Service Boards have worked closely and cooperatively to ensure the design, development and implementation of COST that best addresses the needs of the region. Moreover, it is RTA's hope and intention that the completed Tool is of value to other potential industry users.

3. "How to" Guide to Opening, Saving and Sharing COST

This chapter provides background on how to open COST and how MS Access saves work while the Tool is open. This chapter also discusses how to maintain the MS Access file (separate from maintaining the records within it) and how to save copies of COST (for version control, scenario control and file sharing). The chapter starts with consideration of the computer requirements to run COST.

3.1 Computer Requirements (MS Access)

RTA's COST was designed to run using MS Access 2007. Given the presence of differing versions of MS Access as used by RTA and Service Board staff, the MS Access 2007 version of the Tool can also been run using MS Access 2010 (32 bit version) and special, 2003 versions have also been developed as required.

Therefore, to run COST, users must have a PC laptop or desktop loaded with MS Access 2007 or later (32 bit version). Use of MS Access 2003 is not recommended but RTA will accommodate RTA or Service Board users that require an MS Access 2003 version of the Tool. Note that COST may experience slow run times on PCs with smaller RAM.

3.2 3.2 Primer on Saving Access Data Records and Files

Saving Records: As just noted, COST is based in MS Access. Therefore all Tool data, including asset inventory records and model input parameters, are stored in data tables. It is important for new users not familiar with MS Access (or other database software packages) to note that Access saves all changes to asset records as soon as the user leaves that asset record. Hence, unlike MS Excel, where the user can make changes to an existing file and then choose not to save those changes (e.g., when exiting the file), MS Access will save all changes as they are made and these changes cannot then be "undone". Concerned users are therefore advised to save "Read-Only" copies of COST to ensure prior record and parameter settings can be retrieved if needed.

Saving Copies of the Tool: The entire COST model– including all data tables, forms, reports, code and queries – is stored in a single MS Access file. Moreover, the tool is only designed to maintain the output for a single analysis scenario. Given these properties, the user should be advised that:

- Users can make as many copies of the tool as desired
- Users should save/archive copies of prior Tool runs/scenarios they may want to retain for future analysis/reference
- A good Tool scenario/version naming system is *highly recommended.*

3.3 Compact and Repair (Damaged and Growing Files)

COST is designed to run a "compact and repair" routine whenever the user exits MS Access after using the Tool. This routine eliminates temporary data files that can accumulate as users run different scenarios using the tool. The presence of these temporary data files manifests itself in the form of an increasing file size for the Tool (with the file size increasing each time the Tool is run).

The user may want to run the MS Access "compact and repair" utility (or just close and reopen the file) if they suspect the file size is becoming very large or the Tool does not appear to be performing properly (as can happen when the file becomes too large or damaged). To run the utility, click the MS Office symbol in the upper left-hand corner and select "Manage" from the drop down menu and then "Compact and Repair Database".

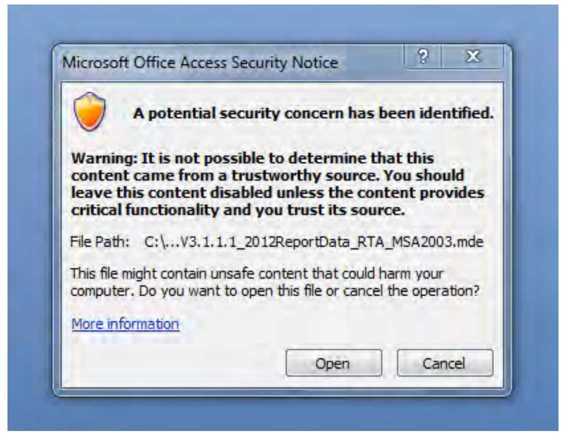
3.4 Sharing Files

Users can share MS Access files as they do any other file type. Given that MS Access files can easily exceed e-mail attachment size limits, users may need to "Zip" the file prior to e-mailing (note: MS Access files tend to compress to roughly 25 percent of their un-compressed size).

4. "How to" Guide to Navigate COST

This chapter provides a brief overview of how to navigate COST's Main Menu and data input forms. It begins with a description of how to open COST. Note that this chapter does not provide descriptions of how to develop or run scenarios – it is solely focused on how to find your way around the Tool.

4.1 Opening the Tool



COST file is opened like any other file for a PC application. Just, locate the file name for the version of the Tool you want to open and double click the file name. Note that the user needs to click the "Open" button on the "Microsoft Office Access Security Notice" for the Tool to open properly. Other considerations include the following:

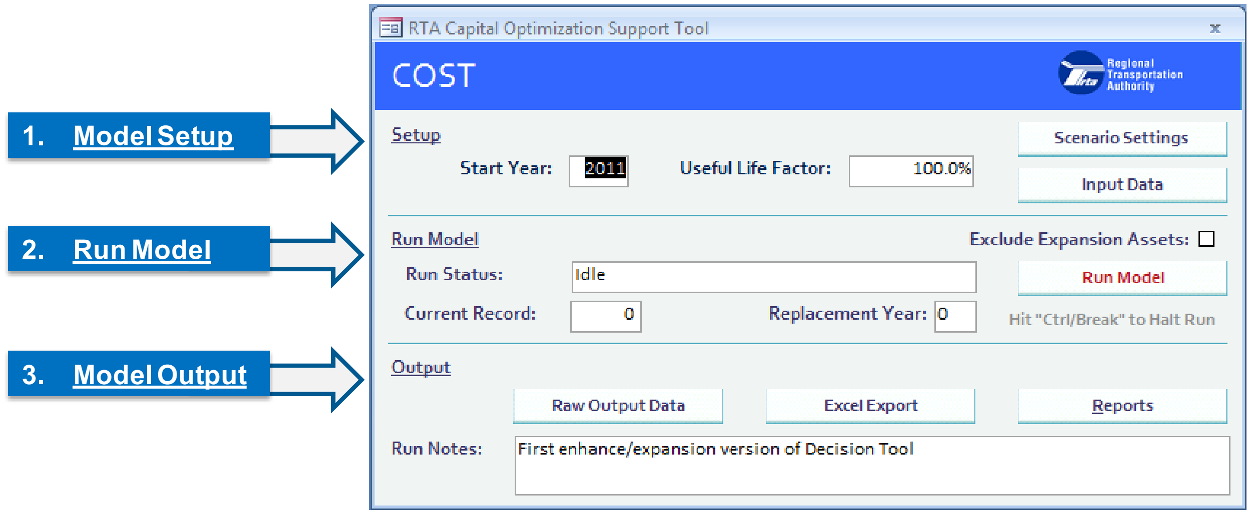
- Zipped Files: If stored in a Zip file, extract COST before opening it. Zip files are read only and the Tool will need read/write capability, so it must be saved to a folder outside of the Zip folder before use.
- Server Files: If stored in a server, copy COST to your desktop/lap top before opening it. COST needs to make significant use of RAM capacity and movement of the file data back and forth between the server and your PC will result in poor run times.

4.2 Main Menu

COST's Main Menu is the starting point for inputting data, setting up Tool analysis scenarios, running scenarios, and reviewing and analyzing scenario results. As illustrated in Figure 4-1 below, the Main Menu is segmented into three key functional areas:

- Model Setup: The upper-third of the menu provides access to all the settings and data required to develop analysis scenarios and run the Tool. This includes access to COST's prioritization settings, budget constraints, asset inventory data, asset life cycle cost assumptions, ridership by location data and cost inflation settings.
- Run Model: The middle-third of the menu provides display information on the status of the model when completing a 20-year run. It is also the location of the "Run Model" button, which activates an actual model run.
- Model Output: The bottom-third of the menu provides access to all output results for a completed model run. This includes several pre-defined analysis reports (on prioritized investment needs and SGR backlog and condition forecasts), an export to Excel of pre-defined charts of output results and finally a detailed, and an asset level query of all analysis results.

Figure 4-1: COST – Main Menu



4.3 Input Forms

Clicking on the Scenario Settings and Input Data buttons found in the Setup section of the Main Menu provides access to two sets of data input forms. These forms allow the user to define analysis scenarios and revise the Tools asset inventory data, life cycle cost assumptions and other parameters. Specifically, these forms include the following.

- **Scenario Settings:** The primary forms used to set up analysis scenarios. Input forms include:
  - <u>Prioritization Criteria Settings:</u> Parameters to control the weights placed on each of the Tool's five reinvestment criteria. This form also allows users to directly adjust the scoring for the O&M cost impact, reliability and safety/security criteria.
  - <u>Expenditure (Budget) Constraints:</u> Independently controls the level of funding available for:
    - *Existing Assets:* Reinvestment in existing assets (includes rehabilitation and replacement of expansion assets)
    - *Expansion Assets:* Acquisition of expansion assets – including assets for new services and new assets that enhance quality of existing services

- **Input Data:** Forms used to update Tool input data including:
  - <u>Asset Inventory Records</u>: including existing and proposed future asset acquisitions
  - <u>Life Cycle Cost profiles</u>: timing and cost of asset rehabs and replacement by asset type
  - <u>Ridership by location</u>: used for prioritization scoring
  - <u>Inflation rate</u>: for reinvestment costs forecast in projection years

Figure 4-2: COST – Scenario Settings Forms

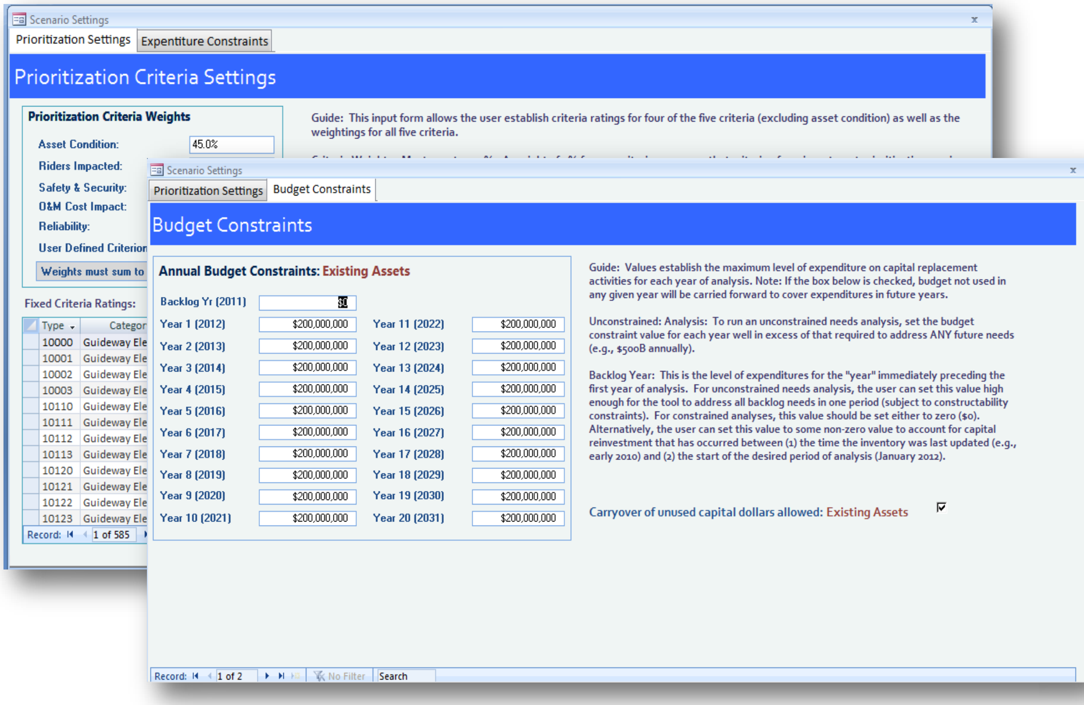
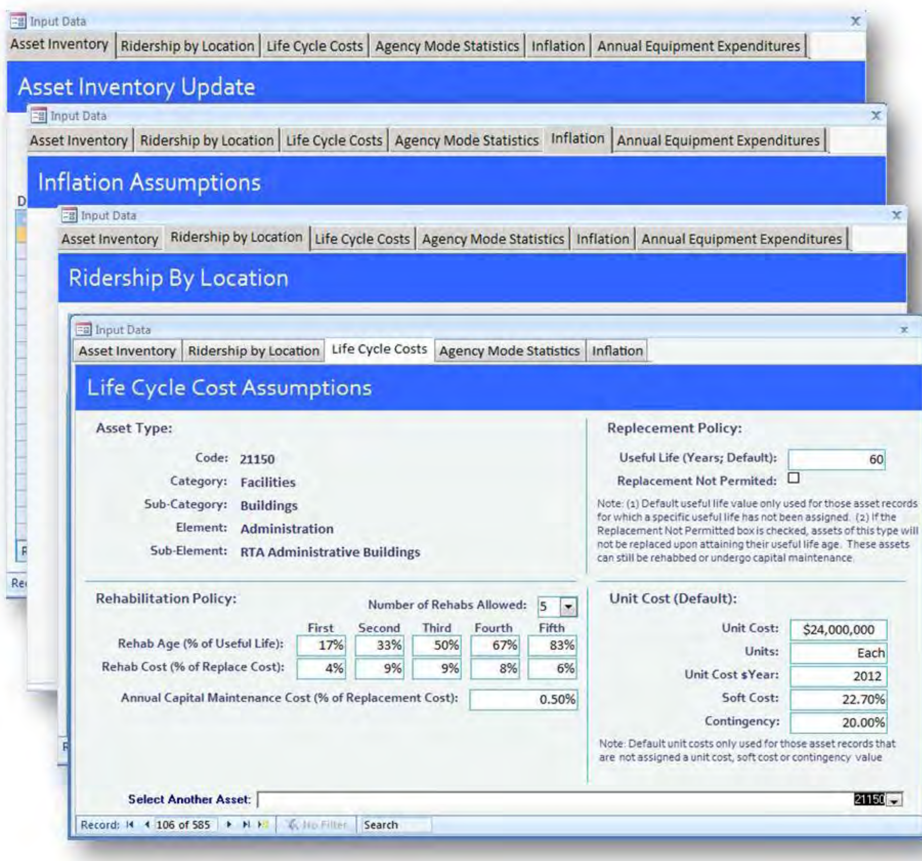


Figure 4-3: COST – Data Input Forms



4.4 Tool Output

As noted the Tool output is accessed through the buttons located on the bottom third of COST's Main Menu. The Tool provides three different types of output:

- Reports: Twelve different predefined and formatted reports relating to prioritized needs, SGR backlog, and condition forecasts. Users can either access the reports themselves or the data underlying the reports (for further analysis in MS Excel or another environment).
- Excel Export: COST can export pre-defined charts and graphs of current and expected future values for investment needs, the SGR backlog and asset conditions to MS Excel – allowing users to copy and paste these charts and graphs into reports and/or presentations
- Raw Output Data: A query presenting the detailed output results at the asset level (including current and expected future values for investment needs, the SGR backlog and asset conditions). The raw output data is the data source used to populate the Reports and Excel Export charts. COST will export the complete, unprocessed output results to a table that can be copied to Excel for further analysis.

Figure 4-4: COST – Printing Reports

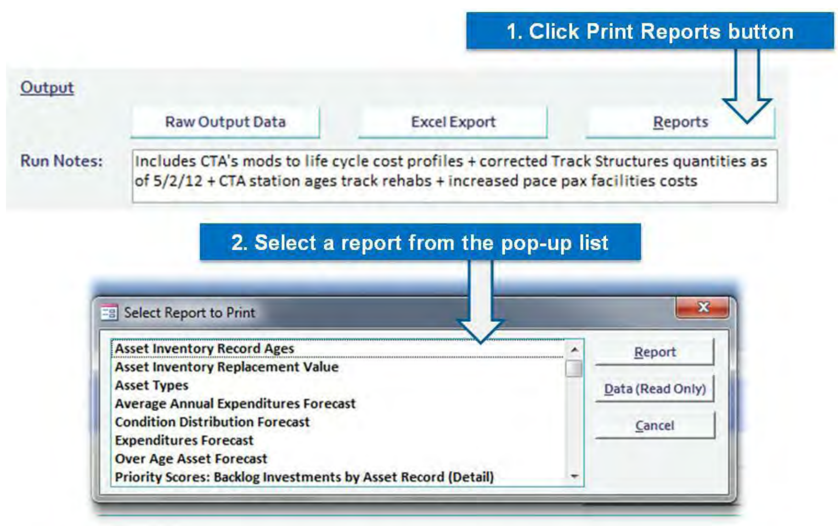
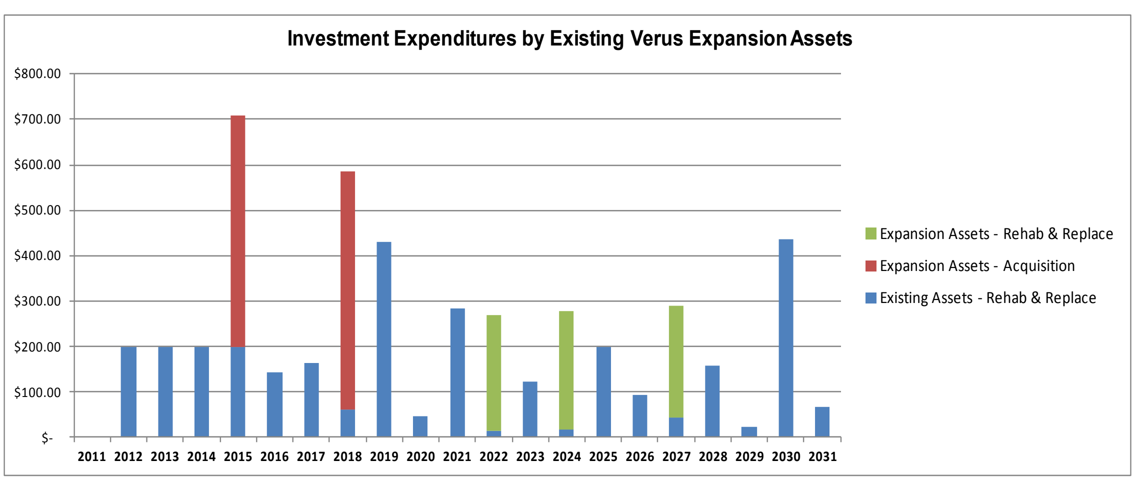


Figure 4-5: COST – Excel Export Example



5. "How to" Guide to Populate and Maintain COST

This chapter describes the steps required to populate COST with asset inventory data and also how to set-up, adjust and/or maintain all other model input parameters (excluding those for defining scenarios, which are coved in the next section). The focus in this section is on the data input forms accessed by the Input Data button located in the upper right of the Main Menu.

5.1 Loading and Modifying Asset Inventory Records

Overview

This section describes the steps required to enter asset inventory data into COST and then how to adjust and maintain the data once entered. Note that the data entry description provided here is different than that actually followed by RTA (where inventory data are imported into the tool from a regional asset inventory database using an MS Access based import method). Much of the actual asset data entry description that follows is intended to support potential Tool users other than RTA and its Service Boards.

Tool Asset Inventory Data Table and Fields

All asset inventory data – including records for both *existing* transit assets (i.e., those currently in service) and expansion assets (i.e., proposed or planned asset acquisitions) – are maintained within a single data table in RTA's COST (tbl06AssetInventory). To populate this table, the user should first develop an Excel workbook (or database data table) that lists all assets to be entered into the Tool in a format (including data types) that is consistent with the format of COST's asset inventory data table. Once complete, these predefined data records can then simply be copied and pasted (or imported) into the Asset Inventory table. A complete listing of COST's asset inventory table fields is presented below in Figure 5-1. It is important to note that many of the fields (more than half) are solely for documentation purposes and are not required fields for the Tool to operate.

Figure 5-1: COST – Inventory Data Fields

Field Name	Description	Required Field?	Notes	Data Type
Asset ID	Unique Asset ID	No		Integer
Agency ID Code	Agency ID Code	Yes	Non RTA agencies can use "9999"	Integer
Transit System	Agency Name	Yes		Text
LocID	Ridership Location Code	Yes	User can define	Integer
Line	Rail line or bus garage/division name	Yes		Text
Branch	Rail branch	YesNo	Reference field	Text
Location_Address	Address of asset location	No	Reference field	Text
AssetName	Name of Asset	No	Reference field	Text
Station_Start	Starting milepost marker for guideway assets	No	Reference field	Integer
Station_End	Ending milepost marker for guideway assets	No	Reference field	Integer
TypeDesc	Asset description field	No	Reference field	Text
Comments	Asset comment	No	Reference field	Text
Mode Code	NTD mode code	Yes	CR, HR, LR, MB, DR	Text

Field Name	Description	Required Field?	Notes	Data Type
RTAAssetType	RTA specified asset type name	Recommended	Non RTA agencies can use there own asset type names	Text
Asset Type Code	TERM Asset Type Code	Yes		Integer
Category	TERM Asset Category	Yes		Text
Sub-Category	TERM Asset Sub-category	Yes		Text
Element	TERM Asset Element	Yes		Text
Sub-Element	TERM Asset Sub-element	Yes		Text
Quantity	Unit quantity	Yes		Double
Units	Type of units (e.g., each, sq feet, miles, spaces)	Recommended		Text
Date Built	Date asset was built / entered service life	Yes		Integer
Rehabed	Has asset been rehabbed: False or True	Yes		True/False
CostYr	Dollar year replacement costs are denominated in	Yes	e.g., $2012	Integer
Agency_SoftCost	Assumed soft-cost factor	Yes	Will be added to replacement cost	Percent
Contingency	Assumed contingency cost factor	Yes	Will be added to replacement cost	Percent
Unit Replacement Cost	Unit replacement cost denominated in "CostYr" dollars	Yes		Dollar
Current Dollars Total Cost	Total replacement cost denominated in "CostYr" dollars	Yes		Dollar
Total Replacement Cost	Total replacement cost denominated in model start year dollars	No	Tool will autopulated this when model is run	Dollar
Override	When checked, Tool will prioritize asset for immediate replacement, regardless of asset age	Recommended	Default value is "False"	True/False
Condition Rating	Observed, actual condition rating for asset	No		Double
Data Date	Date the asset record was last updated	Recommended		Integer
Data Source	Source of asset data	Recommended		Text
Agency_UsefulLife	Expected useful life of asset	Highly Recommended	Tool will utilize default value if not populated	Integer
Notes	Additional details on asset (type, history, special considerations)	No		Text
DelayReplaceAge	Allows user to specify an asset replacement age that differs from Useful life	No	Useful for forced scheduling of asset replacement (e.g., based on planned procurement)	Integer
Existing_Expansion	Identifies whether asset currently exists or is a proposed expansion asset	Yes		Text
ExpansionProject_Name	Name of Expansion project -- all project assets must have the same name	No	Recommended for expansion projects	Text
SoureRecID	Unique Asset ID from underlying RTA regional asset inventory	No		Integer
Asset	Optional asset description field	No		Text
UpdateStatus	Update status of asset record	No		Text
SBAssetNumber	Service Board Unique asset ID (RTA Specific)	No		Integer
Length	Asset length	No		Integer
TrackNumber	Number of tracks on rail segment	No		Integer
LocationName	Location name	No		Text
Area	Service region / area	No		Integer
YearMajorRenovation	Year of last major asset rehab	Recommended		Integer
MaintenanceRegime	Relative level of annual asset maintenance	Recommended	High, medium low	Text

Field Name	Description	Required Field?	Notes	Data Type
NumberOfRehabs	Number of past rehabs	Recommended		Integer
Usage	Relative level of annual asset use	Recommended	High, medium low	Text
RemainingLife	Estimated remaining asset useful life	Recommended		Integer
SerialNumber	Asset serial number	No		Text
Manufacturer	Asset manufacturer	No		Text
Model	Asset model	No		Text
Description	Asset description	No		Text
BudgetGroup	Asset budget group (RTA specific identifier)	No		Text
Owner	Asset owner	No		Text
DesignHeadway	Asset / corridor design headway	No		Integer
ReverseSignals	Reverse Signals?	No	Yes/no; Signal specific	Yes/no
TrackType	Type of track	No	Track specific	Text
NumberOfSpans	Number of bridge spans	No	Bridge specific	Integer
NumberOfTracks	Number of tracks	No	Track specific	Integer
TieReplacement	Tie replacement assumptions	No	Tie specific	Text
GradeCrossingRehabNumber	Number of past rehabs for grade crossings	No	Grade crossing specific	Integer
BusLength	Length of bus	No	Bus specific	Integer
ConditionRatingCurve	Decay curve used for Condition Rating	No		Text
ConditionRatingSampling	Sampled asset condition	No		Integer
SourceFileName	Source of asset data	No		Integer
SourceFileWorkSheet	Source of asset data: worksheet name	No		Text
SourceFileRow	Source of asset data: worksheet row	No		Integer
RehabCost	Cost to rehab asset	No		Dollar
CapitalMaintenanceCost	Cost for annual capital maintenance	No		Dollar
SamplingYear	Year asset condition was sampled	No		Integer
Data Status	Update status of asset record	No		Text

Asset Type Codes

A key field to populate in COST is the "Asset Type Code". This code is used to assign individual asset records to specific asset types, including specific life cycle cost assumptions for each asset type. The listing of asset types is founded on the asset types developed by FTA for TERM but asset types can be added, deleted, or modified by the user. These asset type codes correspond to a hierarchy which groups assets into five key categories – guideway, facilities, systems, stations and vehicles – and a detailed breakout of sub-categories, elements and sub-elements. The full listing of asset types used by COST (subject to change) is provided in Appendix B.

Ridership Location Codes

In addition to assigning asset type codes to each asset record, the user must assign a "Ridership Location" code to each asset record (LocID). This must be done for ALL asset types regardless of whether that asset actually serves riders or not. However, in contrast to the Asset Types codes, which are pre-defined (though alterable), the user must set-up and maintain the ridership by location table, including assignment of asset location codes, and then make the correct assignment of those ridership location codes to each asset identified in COST's Asset Inventory. A more complete description of the purpose, development and maintenance of the ridership by location codes and related table is provided below in the section titled "Ridership by Location Table and Codes".

Asset Costs, Quantities and Useful Life

COST includes a number of fields related to asset cost. The user must carefully consider how best to populate those fields given their available data.

<u>Unit Costs:</u> Users should enter a unit cost value for all asset records (in the "Unit Replacement Cost" field, i.e., cost for "like replacement" of an item) as well as a related quantity value (in the "Quantity" field for the number of units). If the user fails to enter a unit cost value, the Tool will locate a default unit cost pre-populated in the Tool. It is not recommended that users take advantage of these pre-populated costs but rather that they enter their own unit costs that reflect their agency's specific experience. Regardless, the user must enter a value in the quantity field (which the tool will use to estimate a total replacement cost – with no adjustment for soft-costs and contingencies as of yet).

<u>Current Dollars Total Cost and Total Replacement Cost:</u> The user can choose to leave this un-populated and COST will then use the unit cost and quantity values to populate these two fields. The "Current Dollars Total Cost" field contains the total cost of assets in that record expressed in "CostYr" dollars (i.e., whatever year value is stored in the CostYr field for that asset record). In contrast, "Total Replacement Cost" is the same asset value but now expressed in the dollars as of the "Start Year" entered on COST's Main Menu. Once again, the user does not need to worry about populating either of these fields. COST will populate these fields each time the Tool is run.

<u>Soft-Costs and Contingencies:</u> The "Agency_SoftCost" field allows the user to add a soft-cost amount to each asset's replacement value. Note that this amount is added "over-and-above" the amount recorded in the unit cost/total cost fields. If the user does <u>not</u> want any soft-costs added to the unit cost values (e.g., if soft-costs are already embedded in the unit cost value), just enter 0% into this field. Similarly, users can also enter a percent amount for cost contingencies in the "Contingency" field (again, just enter 0% if no contingency amount is desired).

<u>Cost Year:</u> Finally, the user must enter a value into the "CostYr" field to designate the year in which the unit costs are denominated. For example, if the unit costs for a vehicle type were based on actual procurement costs for that type in 2011, enter "2011" into the CostYr field.

Override Field

COST's "override" field is intended to provide a means of ensuring that problem assets are highly prioritized for replacement by COST's prioritization routine. Specifically, checking this box for any asset will ensure that this asset obtains a very high prioritization score for replacement (likely in the first period of the analysis – assuming sufficient funds are available). Note that COST will simulate the replacement of any asset for which this box is checked in the inventory table, regardless of the asset's age. The intention is to provide a means of ensuring "accelerated retirement" for problem assets, including those that need to be replaced well before they have attained their expected useful life (e.g., a bus damaged in an accident or a facility destroyed in a fire).

Copying and Pasting from Excel

Experienced COST users will become familiar with the Tool's "Asset Inventory Update" form, which is accessed via the "Input Data" button on the Tool's Main Menu. While this <u>form</u> does provide a potential means of entering asset inventory data into the tool, it is recommended that users enter data directly into the Tool's asset inventory <u>table</u> (to help ensure all desired fields are fully populated). As this initial data population step requires working "outside" of COST's graphical user interface, it is recommended that this activity be performed by staff familiar with MS Access or similar database products.

<u>Copying Asset Data from a Spreadsheet:</u> The following easy steps assume the user has pre-populated the asset inventory information into a spreadsheet and that this data will then be copied (or imported) into COST. The steps are:

1. Open the Excel file containing the pre-populated asset inventory data, then
2. Highlight all of the populated asset records (do NOT highlight any rows with column/field names) and then
3. Click Excel's copy icon (or "Ctrl-C" or right click and select "Copy"). This action will place all of the asset record data in Excel onto your computer's clip board.

<u>Pasting Data into the Tool:</u> Next:

4. Open COST and then hit the "F11" key on your keyboard. This action will provide access to COST's underlying tables, queries and forms.
5. Locate the "tbl06AssetInventory" table and open it (double click). If this table already has data in it and you want to delete that data, simply highlight the records you wish to delete and hit the "Delete" key on your keyboard.
6. You are now ready to paste data into the Tool. To do this, locate the last record in the tbl06AssetInventory table, (if there is no data in the table this will be the only record), which is empty and is marked on the left with a "∗" symbol. Now, highlight this blank record by clicking on the "∗" symbol.
7. Finally, right click and select "paste" from the menu above (or hit "Ctrl-V") to paste the data from your clip board into the inventory table.

The table is now populated with the asset records developed in Excel and ready for use.

<u>Potential Problems:</u> Users will experience error messages when pasting from Excel to the tbl06AssetInventory table if some field values are not of the proper type (e.g., the user tried to copy text into a numeric field). To help prevent this from happening, the user may wish to first enter a small number of test records to ensure all data types are correct before entering the full data set. Similarly, the user may still want to enter data into the tbl06AssetInventory table in "batches" (i.e., 100 records at a time) if data entry and data type errors continue to be of issue. This practice is helpful in identifying any specific asset records that suffer from data type issues.

5.2 Existing vs. Expansion Assets

COST is designed to prioritize and invest in both existing assets (i.e., assets already in service) and planned asset expansions and enhancements. The expansion and enhancement assets include prioritization for both the initial asset acquisition (funded using an independent expansion/enhancement asset budget) and for SGR reinvestments following their acquisition (prioritized and funded using the same prioritization process and budget constraint as used for existing assets).

For COST to be able to distinguish between and properly analyze *existing* assets vs. *expansion* assets, the user must properly populate the following fields:

- Existing_Expansion: Enter "Existing" for assets that have already been acquired and which currently support transit service. Alternatively, existing assets will all have a date built value that is less than or equal to today's year. Enter "Expansion" for planned investments in new, expansion or enhancement assets (such as additional fleet vehicles, assets associated with new expansion services such as New Starts procurement or for new technologies). Note expansion assets refer to future planned or programmed acquisitions that expand the transit agency's asset holdings.

- ExpansionProject_Name: Intended for expansion investments, enter the name of the expansion project (if there is one). This allows users to track and group multiple expansion assets associated with a single project.

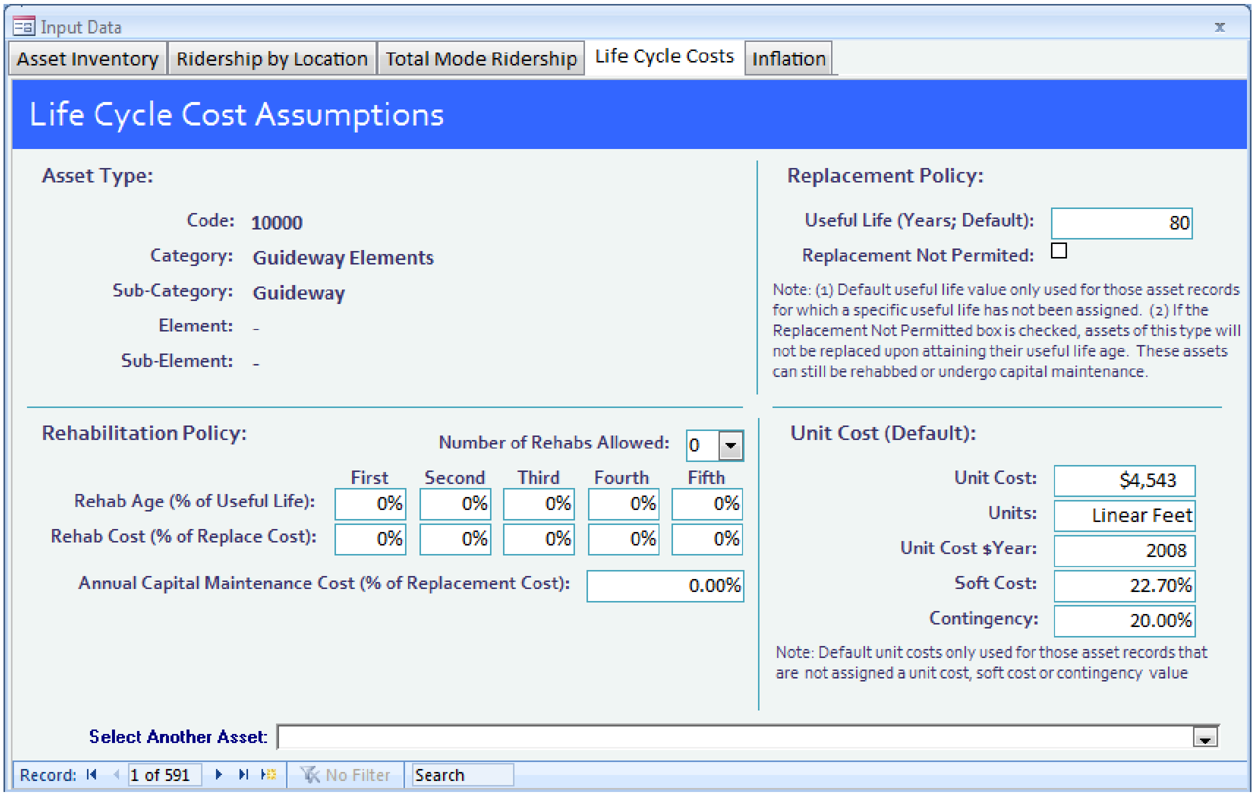
- Date Built: The "Date Built" values for *expansion* projects must exceed the value of the "Start Year" entered by the user on COST's Main Menu (Setup section). Date built values that are less than the Start Year value will lead to calculation errors when the Tool processes expansion asset records.

Beyond these three fields, there is no difference between expansion and existing assets in how the inventory table data fields should be populated. Note, however, that the user must still populate ridership records for expansion assets in the Ridership By Location table (or select existing ridership locations) – see the discussion of the Ridership By Location table as it relates to expansion assets below.

5.3 Defining Life-Cycle Cost Profiles

COST provides a great deal of flexibility in defining the life-cycle cost profiles of all asset types recognized by the tool. Specifically, the life-cycle cost profile determines the cost and timing of all asset reinvestment events – including asset rehabilitation, replacement and an additional expenditure type known as "annual capital maintenance" seen in Figure 5-2.

Figure 5-2: COST – Life Cycle Cost Assumptions Form



To enter or modify the asset life cycle cost profile for an individual asset type, go to COST's Main Menu, click the Input Data button and select the "Life Cycle Costs" tab (Figure 5-2). Next, locate the asset type you wish to modify by clicking the drop-down box at the base of this form, scrolling through the list of asset types and selecting the desired type. The data presented in this form defines the cost and timing of life-cycle events including asset rehabilitation, replacement and annual capital maintenance. Note that values on the right-hand side of the form – including asset useful life, unit costs, soft-costs and contingencies are all default values. Hence as long as the user populates the related fields in the inventory records (i.e., for useful life, unit costs, soft-costs and contingencies) these default values will never be used. If the user keeps the related fields in the asset inventory fields unpopulated, then COST will use these default values.

In contrast, the values stored in the fields in the lower-left panel of this form are not default values and will apply to all assets of that type. To understand and potentially modify these values note the following:

Number of Rehabs Allowed: This setting determines the number of rehabs the tool will "perform" for each asset type over a full asset life-cycle. The user can choose any number from zero (0) to five (5) rehabs per asset.

Rehab Age: This setting determines the timing of each rehab as a percent of the asset's useful life (the Tool will ultimately round this value to a specific age). For example, if an asset is given a useful life of 20 years, and the user enters a value of "50%" for one of these rehabs, the tool will assume all assets of this type and useful life will require a rehab at 10 years of age (20 x 0.50).

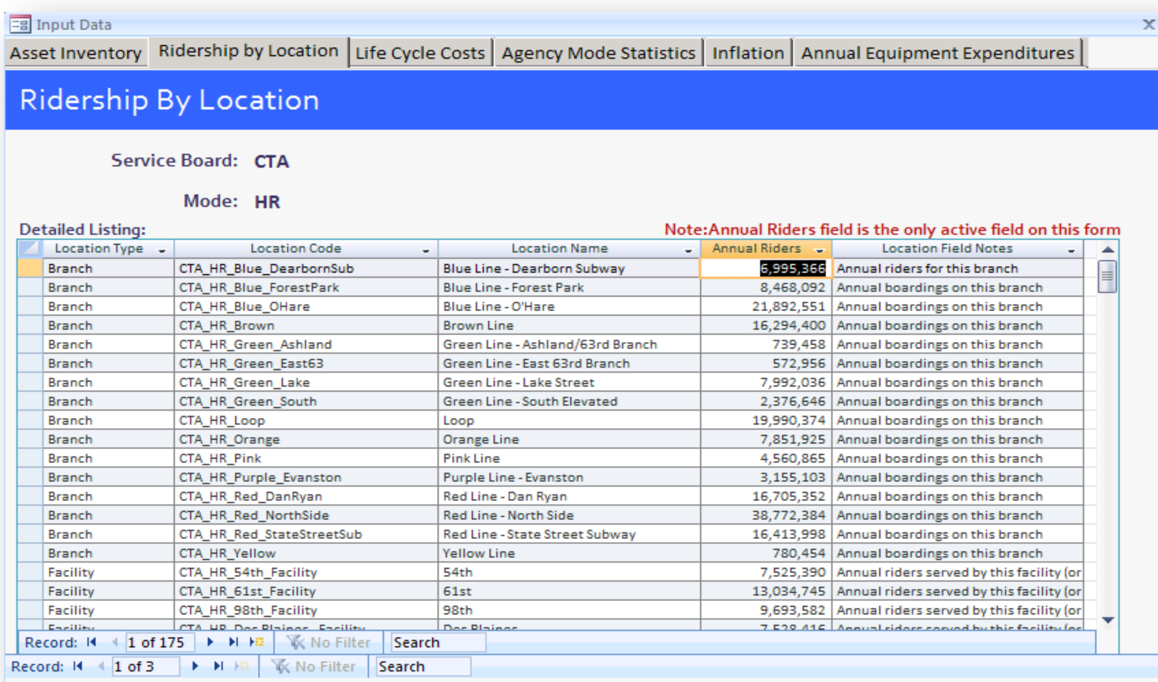
Rehab Cost: Similarly, this setting determines the cost of each rehab as a percent of the asset's replacement value. For example, if an asset is given a replacement value of $100,000 and the user enters a value of "25%" for the cost of a rehab, the tool will assume all assets of this type and replacement cost will require a rehab of value $25,000 ($100,000 x 0.25).

Annual Capital Maintenance: Finally, an annual capital maintenance setting greater than zero allows the user to ensure that a small amount of reinvestment occurs for assets of that type every year of the 20-year analysis period. Hence, if the value of an asset is $100,000 and the user enters a value of "0.25%" for annual capital maintenance COST will assume all assets of this type and replacement cost will require an annual investment amount of $250 ($100,000 x 0.0025). Annual capital maintenance is intended to help address reinvestment needs that are small on average but recurring in nature.

5.4 Ridership by Location Table and Codes

The last key data table for the user to populate is the Ridership by Location table (tbl20LocationRidership). The ultimate purpose of this table is support investment prioritization based on the number of riders served by an asset – *including expansion assets*. In principle, investment prioritization should favor reinvestment in assets that serve large numbers of riders over assets serving fewer riders. All else being equal the former will tend to generate greater investment benefits. The Ridership by Location table supports this prioritization by developing a list of potential asset locations (e.g., station names or route segments) and location codes, and then assigning annual ridership levels to those locations (note that vehicle fleets are treated as a "location"). Records in the asset inventory are then assigned a location code (LocID) from the Ridership by Location table, thus linking individual assets to numbers of riders served by that asset. For special guidance on how to complete the Ridership by Location table for expansion assets, please refer to the end of this section.

Figure 5-3: COST – Ridership by Location Form


Input Data

Asset Inventory | Ridership by Location | Life Cycle Costs | Agency Mode Statistics | Inflation | Annual Equipment Expenditures

Ridership By Location

Service Board: CTA

Mode: HR

Detailed Listing:

Note:Annual Riders field is the only active field on this form

Location Type	Location Code	Location Name	Annual Riders	Location Field Notes
Branch	CTA_HR_Blue_DearbornSub	Blue Line - Dearborn Subway	6,995,366	Annual riders for this branch
Branch	CTA_HR_Blue_ForestPark	Blue Line - Forest Park	8,468,092	Annual boardings on this branch
Branch	CTA_HR_Blue_OHare	Blue Line - O'Hare	21,892,551	Annual boardings on this branch
Branch	CTA_HR_Brown	Brown Line	16,294,400	Annual boardings on this branch
Branch	CTA_HR_Green_Ashland	Green Line - Ashland/63rd Branch	739,458	Annual boardings on this branch
Branch	CTA_HR_Green_East63	Green Line - East 63rd Branch	572,956	Annual boardings on this branch
Branch	CTA_HR_Green_Lake	Green Line - Lake Street	7,992,036	Annual boardings on this branch
Branch	CTA_HR_Green_South	Green Line - South Elevated	2,376,646	Annual boardings on this branch
Branch	CTA_HR_Loop	Loop	19,990,374	Annual boardings on this branch
Branch	CTA_HR_Orange	Orange Line	7,851,925	Annual boardings on this branch
Branch	CTA_HR_Pink	Pink Line	4,560,865	Annual boardings on this branch
Branch	CTA_HR_Purple_Evanston	Purple Line - Evanston	3,155,103	Annual boardings on this branch
Branch	CTA_HR_Red_DanRyan	Red Line - Dan Ryan	16,705,352	Annual boardings on this branch
Branch	CTA_HR_Red_NorthSide	Red Line - North Side	38,772,384	Annual boardings on this branch
Branch	CTA_HR_Red_StateStreetSub	Red Line - State Street Subway	16,413,998	Annual boardings on this branch
Branch	CTA_HR_Yellow	Yellow Line	780,454	Annual boardings on this branch
Facility	CTA_HR_54th_Facility	54th	7,525,390	Annual riders served by this facility (or
Facility	CTA_HR_61st_Facility	61st	13,034,745	Annual riders served by this facility (or
Facility	CTA_HR_98th_Facility	98th	9,693,582	Annual riders served by this facility (or

Record: 1 of 175 No Filter Search

Record: 1 of 3 No Filter Search

While users can enter and revise ridership by location in the "Ridership by Location" form (accessed via the Input Data button on COST's Main Manu) first time users for an agency adopting RTA's COST will need to directly populate the underlying tbl20LocationRidership table. To do so, hit the "F11" key on your keyboard, then locate and open the tbl20LocationRidership table. The user next needs to develop a listing of asset locations and corresponding location IDs, codes and descriptive data. There is no standard for doing this and each agency must develop a listing that best suits their agency and available data. Here are a few guidelines:

- All assets MUST be assigned an asset location ID (LocID) – so work out a listing of locations such that all assets can be assigned a location (and annual ridership level). Options include location by:
  - Rail line or branch
  - Station/passenger facility
  - Bus division/depot/maintenance facility/service area
  - Vehicle fleet
  - Mode (best for assets that serve an entire mode)
  - System (best for assets that serve all agency modes)

- All locations will need to be assigned an annual ridership level – so the list of asset locations must be designed around the available data on annual of ridership by location (e.g., by station or rail line).

Figure 5-4: COST – Ridership by Location Table Data Fields

Field Name	Description	Required Field?	Notes	Data Type
LocID	Unique Location ID	Yes		Integer
LocCode	Alternate Location ID	No	Used by RTA to generate list of locations -- Can be the project name for expansion projects	Text
UnlinkedTrips	Number of annual unlinked trips	Yes		Integer
AgencyID	Transit agency NTD ID	No		Integer
ServiceBoard	Name of transit agency	No		Text
Mode	Mode type	No	FTA model codes	Text
LocType	Branch, station, facility, vehicle	No	Background info	Text
LocName	Location name	No	Can be the project name for expansion projects	Text
LocNotes	Notes on location	No	Can be the project name for expansion projects	Text
DataDate	Date table was last updated	No		Year

Once the user has completed development and population of the Ridership by Location table, it is **critical** that each record in the asset inventory table (tbl06AssetInventory) be assigned one of the location ID values (LocID). *This value is required to link these two tables together and any missing values will result in assets be excluded from ALL tool needs and prioritization calculations.*

Special Guidance for Expansion Assets: As with existing assets, *all expansion assets must be assigned to a valid Location ID from the Ridership by Location table (tbl20LocationRidership). Otherwise the needs for these assets will not be captured in the tool's output*. Moreover, given that expansion assets are prioritized based on the number of riders served by the expansion/enhancement asset divided by the investment cost (i.e., riders per dollar invested or number of impacted riders/investment cost), it is equally important that the number of impacted riders be assigned as accurately as possible. For this reason, it is highly recommended that users create a new Ridership by Location table record (in the Ridership by Location form) if an expansion asset does not correspond to a pre-existing ridership location already included in the Ridership by Location table.

To add a new ridership location record for an expansion asset (or group of expansion assets from the same project) the user should:

1. Open the Ridership By Location tab found on the Input Data Form (accessed via the Main Menu).
2. Locate the agency and mode name corresponding to a new asset (e.g., expansion buses would be added to the Motor Bus mode).
3. Populate the (New) record located at the bottom of the displayed table (marked with a "∗"):
    a. MS Access will auto populate the Location ID (LocID) field (take note of this auto-generated number)
    b. Enter location type as "Expansion"
    c. Enter the expansion project name in the Location Code, Location Name and Location Field Notes fields.
    d. Enter the number of annual riders expected to be impacted by the expansion investment in the Annual Riders field.
4. Note the value of the auto-generated number in the LocID field and assign this value to all of the associated expansion asset records in the Asset Inventory. You can do this in the Asset Inventory Update tab. Example: Support the auto-generated LocID value for an expansion asset project is "999". The user should note this value, go to the Asset Inventory Update tab and locate all of the expansion project asset records, and then assign "999" to the Location ID field for each of the expansion asset records for that project.

6. "How to" Guide to Build Analysis Scenarios

This chapter describes how to develop and enter analysis scenarios into RTA's COST. Types of scenarios include:

- Unconstrained needs: Level of investment to address all outstanding and future needs assuming funding is unlimited
- Constrained Needs:
  - Impact of continuing to reinvest at current/recent rates
  - Impact of increases or decreases to current/recent reinvestment rates
  - Level of investment to attain specific investment targets (e.g., maintain backlog, eliminate backlog in 10, 15, or 20 years…)
- Alternative priorities - Impact of changes to investment priorities on:
  - Composition of expenditures
  - Composition of backlog
  - Size of backlog
- Forced early retirement of problem assets ("Override")
- Impact of asset expansion on the backlog and reinvestment needs

6.1 Budget Constraints

Most analysis scenarios are designed to assess the 20-year investment needs and/or investment impacts associated with specific a dollar level or rate of reinvestment. These scenarios can be grouped into two types:

Unconstrained: An "unconstrained" needs analysis assumes that funding is unlimited now and in all future years. This analysis scenario is then used to assesses the level of investment needed to address all outstanding reinvestment needs (i.e., eliminate any existing SGR backlog) as well as all future needs over the 20-year period of model analysis. This analysis scenario will also demonstrate the impact of eliminating the backlog and addressing all reinvestment needs – including the impact on asset conditions and the share of assets exceeding their useful life. Note that COST's prioritization routine is irrelevant to the unconstrained needs scenario – given that funding is unlimited, there is no need to prioritize how it is spent.

Constrained: In contrast, a "constrained" needs analysis assumes that funding is limited over the 20-year period of analysis – such that funding is insufficient to address all outstanding and future needs. Whereas there is only one "outcome" (i.e., set of future needs and condition impacts) under the unconstrained scenario, there are essentially an infinite number of potential "constrained needs" scenarios – each reflecting a different level of funding and investment prioritization.

Two Budget Constraints

The current version of COST utilizes two separate budget constraints.

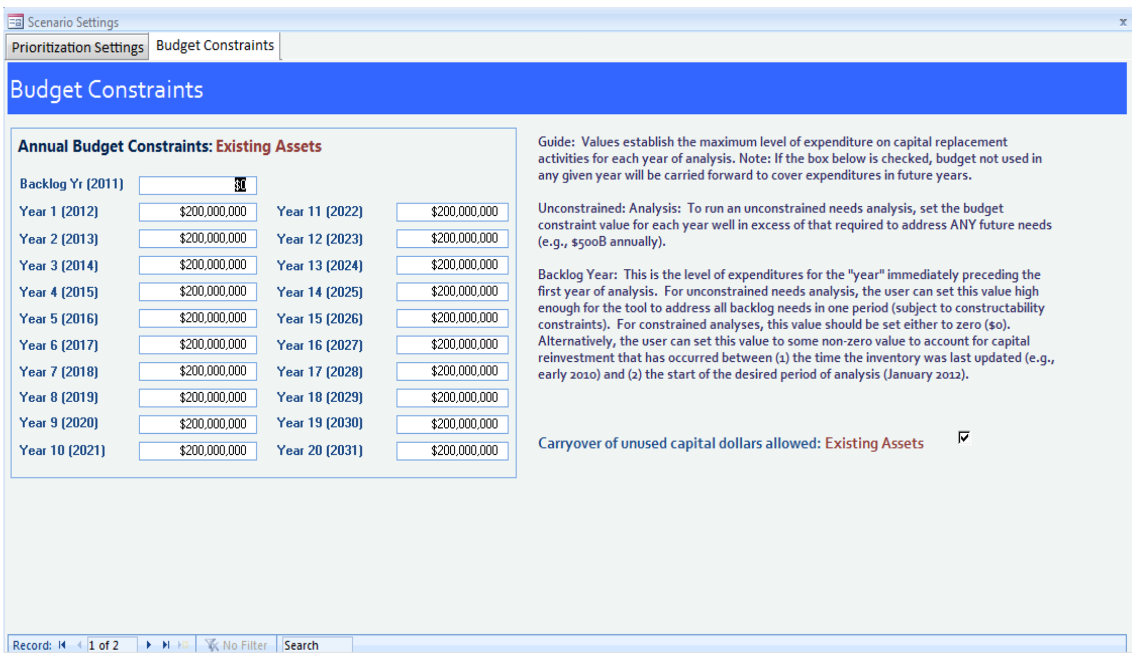
- Expansion Assets Budget: The Expansion Assets budget constraint represents funds that can only be used for the acquisition of expansion assets or new enhancement assets (but not enhancements to existing assets). These funds cannot be used for reinvestment actions, including the rehab/replacement of expansion assets following their acquisition.

- Existing Assets Budget: The Existing Assets budget constraint represents funds that can only be used for the rehab and replacement of assets existing at the start of model run and for expansion and enhancement assets following their acquisition. These funds cannot be used for expansion asset acquisition.

Entering Budget Constraints

COST allows users to easily enter and alter 20-year funding level profiles for analysis scenarios (with separate budgets for existing and expansion assets as noted above). To enter a funding level profile, first click the "Scenario Settings" button on the Tool's "Main Menu" and then select the "Budget Constraint" tab (see Figure 6-1). Use the record selector buttons at the bottom of the form (or the "Page Down" and "Page Up" keys) to scroll between the Existing Asset and Expansion Assets budget input forms.

Figure 6-1: COST – Budget Constraint Form



Next, enter an annual level of investment dollars for both the Existing Assets and Expansion Assets budgets for each year for the 20-year analysis period and also for the "backlog" year (see below). No Expansion assets budget amount is required if your inventory has no expansion assets. The entered amounts now set annual limits on the level of reinvestment for each forecast year – the Tool cannot reinvest more in any given year than is entered for that year (unless there are "carry over" funds – see below). The following notes will help users determine what amounts to enter:

<u>Financially Unconstrained Model Runs:</u> To run the Tool unconstrained, enter very high funding amounts (i.e, $500B) for each projection year. This will ensure that the level of funding is more than enough to address all outstanding reinvestment needs in all years of the projection period.

- For unconstrained runs, the prioritization scores are calculated but are irrelevant (as all needs are addressed)

<u>Constrained Run Scenarios:</u> Setting the constraint to lower levels (low enough that all needs are not addressed in each projection year) allows the user to assess the impacts of alternative funding availability on investment priorities, the SGR backlog and future asset conditions. Examples of constrained funding scenarios include the level of funding to:

- Eliminate backlog over a fixed time period (e.g., 10-years)
- Maintain current SGR backlog
- Maintain the historical annual reinvestment rate

To identify the annual level of funding required to attain specific investment targets (e.g., maintain the current SGR backlog), the user will need to enter and test multiple values until they identify an average annual funding level (or pattern of expenditures – funding does not have to be at the same level in all future years) that reasonably attains the desired target. Given that reinvestment needs are inherently "lumpy", multiple solutions may be possible.

<u>Setting the Expenditure Amount for Backlog Year (Year 0):</u> The expenditure constraint value for year 0 (backlog year) should be set to zero ($0) for most constrained reinvestment scenarios

- Otherwise, this reinvestment will reduce backlog needs
- Users may want to enter some amount for the backlog year (year 0) to capture reinvestment actions that occurred between (1) the time the asset data were collected and (2) the start of year 1 analysis (but the tool, not the user will determine how these funds were invested in year 0)

Carryover of Unused Funds

For some (typically higher funding level) constrained needs scenarios, it is possible that the level of investment funds for some years will be more than that required to address all outstanding needs up to that point – thus leaving some investment funds for that year "unspent". The user has two options of how to address these unspent funding amounts. The first is to just assume that all funding dollars must be spent in that year and hence are "use or lose" dollars for that year.

The second option is to assume that unused dollars can be "carried over" and applied to needs in a future time period. If the user wants unused funds to be applied to future time periods, then the "Carryover of unused capital allowed" box on the Budget Constraint form must be checked (Figure 6-2). If funds are assumed to be devoted to non-reinvestment uses if not used, then the "Carryover of unused capital allowed" box should remain unchecked. <u>*Note that the Existing Asset budget and the Expansion Asset budgets have their own, independent "Carryover of unused capital allowed" checkboxes – so you must (un)check both if that is your intended outcome*</u>*.*

Figure 6-2: COST – Budget Constraint Form "Carryover" Checkbox

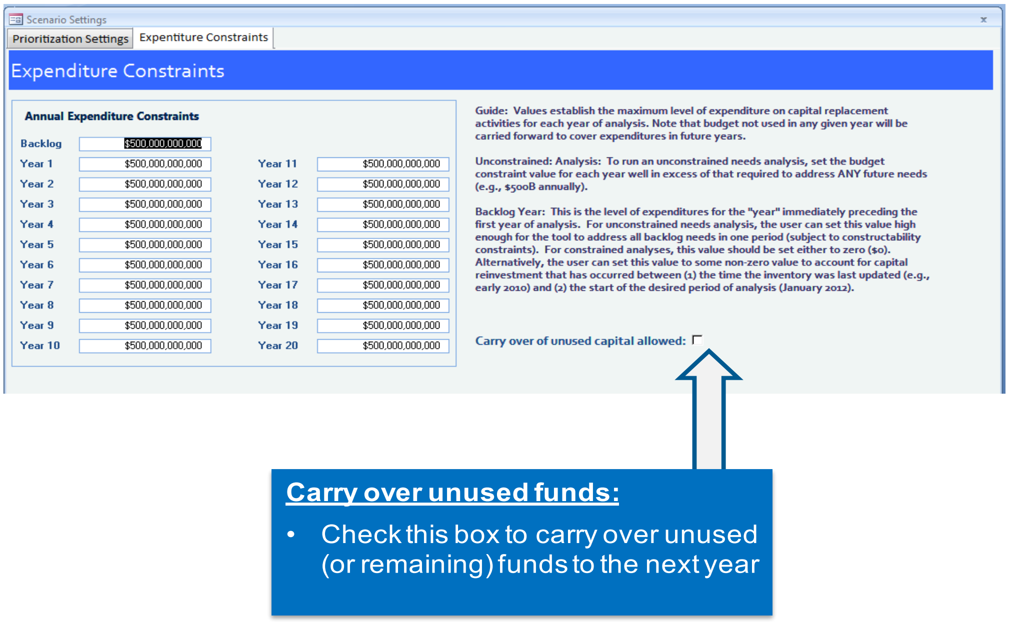


Figure 6-3 below provides examples of several types of constrained and unconstrained funding scenarios that can be developed using COST's Budget Constraint form.

Figure 6-3: COST – SGR (Existing Asset) Budget Constraint Funding Scenarios

Scenario	Purpose / Value	How to Define
Maintain Current Spending	• What is the impact on the SGR backlog and prioritization of continuing to reinvest at the current (historical) rate?	• Enter $0 for year 0 • For years 1 to 20 enter avg. level of Service Board reinvestment for past 5 to 10 years • Can adjust for inflation
Maintain Backlog	• What level of investment will maintain the current size of the backlog (either in dollar terms or as a percent of all asset holdings)?	• User must enter test values for years 1 to 20 (enter same value for each year) and run the model multiple times until value of backlog in year 20 = value in year 0.
SGR in 20 Years	• What level of annual reinvestment is required to eliminate the SGR backlog in 20 years?	• User must enter test values for years 1 to 20 (e.g., enter same value for each year) and run the model multiple times until value of SGR backlog = $0 in year 20.
Un-constrained	• What would avg. annual reinvestment be if there was no backlog? • Investment must be higher than this to reduce the backlog	• Enter a very high level of investment (e.g., $500B) for years 0 (backlog year) through year 20
"Planned" or "Budgeted"	• Enter year by year funding amounts that are both (1) financially sustainable and (2) correspond with timing of known major reinvestment needs • Output will show impact of plan on future SGR backlog and help prioritize needs	

6.2 Inflation

COST allows the user to inflate investment needs across all 20-years of the projection period using a single inflation rate. The inflation rate cannot be controlled by asset type or projection year. To enter an inflation rate, first click the "Input Data" button on the Tool's "Main Menu" and then select the "Inflation" tab (see Figure 6-4). The user now has the following options:

Inflation Assumption:

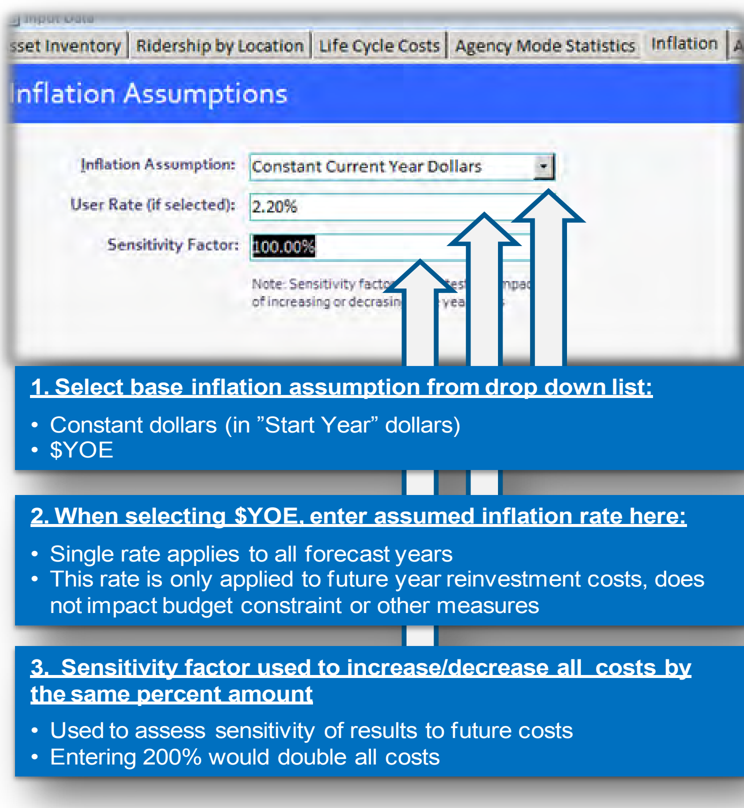
- **Constant year dollars**: Denominated in "start year" dollars – based on start year value entered on the Main Menu (select "Constant Current Year Dollars" from drop down menu)
- **Year of Expenditure:** $YOE with annual inflation rate determined by the User Rate entered in the form (select "Year of Expenditure Dollars" from drop down menu)

User Rate: User input inflation rate to apply to all forecast years

Sensitivity Factor: "Sensitivity factor" that can be used to increase (decrease) the cost of all assets by the same percent amount (e.g., entering 110% will increase all costs, in all periods, by 10%).

If the user wishes to control the inflation rate by asset type or projection year it is advised that this be done outside of the model. Specifically, run the analysis with 0% inflation, export the relevant needs output to Excel (see Chapter 8) and then inflate all costs as desired (starting from the start year dollars).

Figure 6-4: COST – Inflation Form



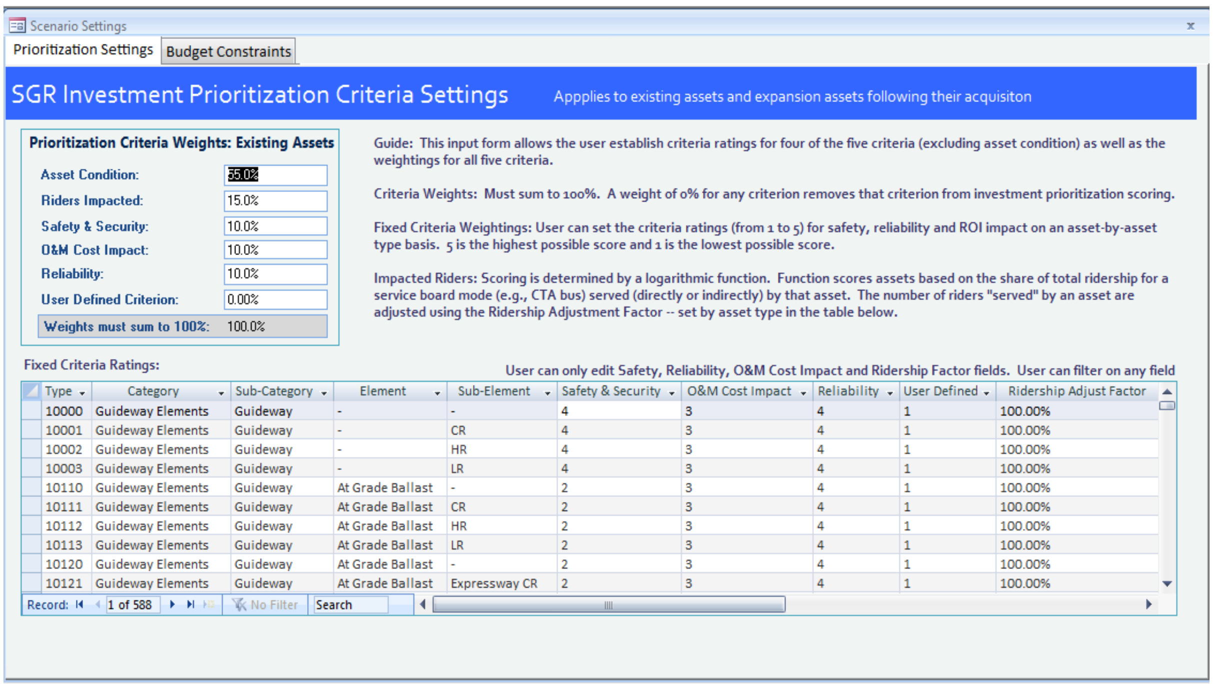
6.3 Prioritization Adjustments: Calibration and Scenario Analysis (SGR Investments)

The next option for scenario development is to adjust COST's SGR investment prioritization settings. While the SGR prioritization settings (including criteria weights and scoring) may more properly be considered a tool calibration issue (i.e., the prioritization settings to best match the organization's strategic objectives and priorities), varying these settings provides valuable information on the impact of changes in priorities on the composition of asset expenditures, mix of assets in the backlog and even the size of the backlog. Following is a description of how to adjust the prioritization settings. It is then up to the user to determine how best to (1) calibrate these settings to set up a preferred "baseline" (representing the agency's priorities and also providing a point of comparison for other settings) and then (2) to modify these settings to assess the impact on needs and the backlog.

SGR Investment Prioritization Overview

COST's SGR investment prioritization routine impacts the order in which the Tool addresses reinvestment needs when the level of available funding is constrained. Specifically, COST scores each investment option against the five different investment criteria. These individual criteria scores are then summed to a total score, with differing user-defined weights applied to each criterion. COST then uses these total scores to (1) rank each investment needs in each investment period and then to (2) address the highest ranked needs in each investment period until no reinvestment funds remain in that period. As the prioritization impacts the order in which assets are replaced it therefore also impacts what needs get added to the backlog and can also impact the size of the backlog itself.

Figure 6-5: COST – SGR Investment Prioritization Criteria Settings Form


Scenario Settings

Prioritization Settings | Budget Constraints

SGR Investment Prioritization Criteria Settings — Appplies to existing assets and expansion assets following their acquisiton

Prioritization Criteria Weights: Existing Assets

Asset Condition:	55.0%
Riders Impacted:	15.0%
Safety & Security:	10.0%
O&M Cost Impact:	10.0%
Reliability:	10.0%
User Defined Criterion:	0.00%
Weights must sum to 100%:	100.0%

Guide: This input form allows the user establish criteria ratings for four of the five criteria (excluding asset condition) as well as the weightings for all five criteria.

Criteria Weights: Must sum to 100%. A weight of 0% for any criterion removes that criterion from investment prioritization scoring.

Fixed Criteria Weightings: User can set the criteria ratings (from 1 to 5) for safety, reliability and ROI impact on an asset-by-asset type basis. 5 is the highest possible score and 1 is the lowest possible score.

Impacted Riders: Scoring is determined by a logarithmic function. Function scores assets based on the share of total ridership for a service board mode (e.g., CTA bus) served (directly or indirectly) by that asset. The number of riders "served" by an asset are adjusted using the Ridership Adjustment Factor -- set by asset type in the table below.

Fixed Criteria Ratings:

User can only edit Safety, Reliability, O&M Cost Impact and Ridership Factor fields. User can filter on any field

Type	Category	Sub-Category	Element	Sub-Element	Safety & Security	O&M Cost Impact	Reliability	User Defined	Ridership Adjust Factor
10000	Guideway Elements	Guideway	-	-	4	3	4	1	100.00%
10001	Guideway Elements	Guideway	-	CR	4	3	4	1	100.00%
10002	Guideway Elements	Guideway	-	HR	4	3	4	1	100.00%
10003	Guideway Elements	Guideway	-	LR	4	3	4	1	100.00%
10110	Guideway Elements	Guideway	At Grade Ballast	-	2	3	4	1	100.00%
10111	Guideway Elements	Guideway	At Grade Ballast	CR	2	3	4	1	100.00%
10112	Guideway Elements	Guideway	At Grade Ballast	HR	2	3	4	1	100.00%
10113	Guideway Elements	Guideway	At Grade Ballast	LR	2	3	4	1	100.00%
10120	Guideway Elements	Guideway	At Grade Ballast	-	2	3	4	1	100.00%
10121	Guideway Elements	Guideway	At Grade Ballast	Expressway CR	2	3	4	1	100.00%

Record: 1 of 588 No Filter Search

Adjusting the SGR Investment Prioritization Settings

Users have two options to adjust SGR investment prioritization settings: the criteria weights and the fixed prioritization scores for some asset types (see Figure 6-5). It is recommended that users keep the fixed scoring consistent (once established) and only vary the scoring weights for purposes of scenario development.

> <u>Prioritization Criteria Weights:</u> Altering the prioritization score weights is straightforward. From the Tool's Main Menu, click the "Scenario Settings" button and select the "Prioritization Settings" tab. The prioritization criteria weights are found in the upper left-hand corner of the form. To alter these weights, the user merely needs to adjust the percent weight values to obtain the desired balance across all criteria while ensuring these values total to 100%. Obviously, increasing the weight placed on any criterion will increase that criterion's influence

on the overall prioritization scores. While each criteria represents a different outcome (e.g., more reliable vs. more safe service) it should be noted that there tends to be a high correlation between asset reliability, safety and O&M cost impact scores. For this reason, it is typically best to utilize scoring weights that place a high emphasis on asset condition and then with lesser amounts on asset reliability, safety and O&M cost impacts – this will help ensure a more balanced mix of reinvestment actions over a 20-year analysis period.

Fixed Scoring: The lower panel of the Prioritization Criteria Settings Form allows the user to determine how each asset type is scored with respect to the asset reliability, safety and O&M cost impact criteria. Specifically, it is intended that the user assign an integer value, from 1 to 5, to each asset type identified in this table (and for each of the asset reliability, safety and O&M cost impact criterion). For example, for the reliability criterion, the user should assign a value of 1 if reinvesting in an asset type has very little or no impact on service reliability. In contrast, the user should assign a 5 if reinvestment in an asset type can potentially generate significant improvements in service reliability. The same should be done for asset reliability, safety and O&M cost impacts. Each of these criterion is also scored as the product of its fixed score, as just described, and its asset condition score (which increases from 1 at early asset age to 5 for very old assets). Hence, the true score for the reliability, safety and security impact criterion is a mix of the fixed scoring and asset condition.

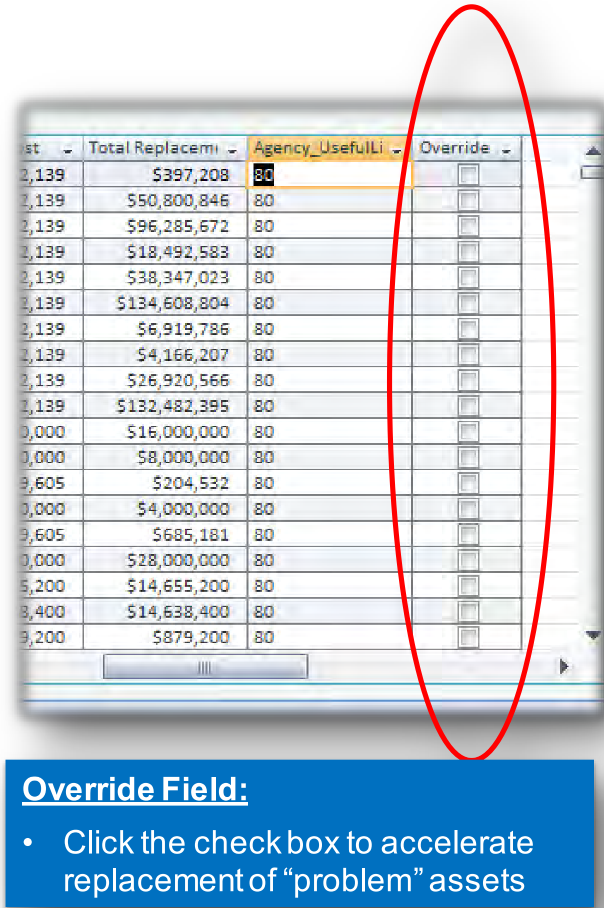
Note: It is preferable that the fixed scoring be calibrated once, based on input from a mix of agency representatives, and only altered infrequently.

6.4 Investment "Override"

COST's "Override" function provides a quick and easy way to force the replacement of problem assets – regardless of whether that asset has attained its full expected useful life or not. Specifically, when used this function alters the age of the "overridden" asset to 300% (three times) its expected useful life. By doing so, the prioritization routine "believes" the asset to be extremely old and hence assigns high prioritization scores for asset condition, reliability, safety and O&M cost impact. This in turn assures that the asset receives high priority for replacement (but does not absolutely guarantee replacement if the asset type is subject to low static scoring). The Override function should only be used for highly problematic assets. Examples include vehicles damaged in accidents or a station damaged in a fire or otherwise no longer fit for service.

To use the Override function, the user must first locate the record of the asset to be "overridden" in the inventory. One option is to access the Asset Inventory tab of the "Input Data" form (button located on the Main Menu). From the Asset Inventory tab, locate the agency and mode responsible for the asset (using the record selectors at the base of the form). Once the agency and mode are selected, scroll through the field names in the form table and apply filters to help narrow the number of records displayed. Finally, once the record has been identified, scroll through the field names until you have found the "Override" field. Now just check the "Override" field check box for those assets.

Figure 6-6: COST – Asset Inventory Form – Override Field



6.5 Including Expansion and Enhancement Assets

Including expansion and enhancement investments in a model run requires completion of the following steps:

1. Add Expansion/Enhancement Records to Asset Inventory: Ensure that you have added expansion asset records to the asset inventory and that each new asset record has a corresponding Ridership by Location record entered into the Ridership by Location table (see Chapter 5 for detailed explanations on how to do so.
2. Add Budget Amounts to Expansion Asset Budget Table: Add or modify the available Expansion Asset budget amount as described above in Chapter 6.
3. Uncheck the "Exclude Expansion Assets" check box located on COST's Main Menu

Then run the COST model as usual. Note that the addition of a significant level of expansion and enhancement asset investment – especially expansion assets with useful lives shorter than 20 years – can lead to significant changes in the size of the projected SGR backlog. Pre-existing assets must now compete with expansion assets for the same limited capital reinvestment funding over 20 years.

6.6 Applications of COST

RTA's COST tool is designed to carry out a range of analyses related to assessing current reinvestment needs and the expected condition and SGR backlog impacts of various rates of future capital reinvestment. This section provides sample applications of COST, focused on RTA's own intended uses of the tool.

Standard Model Run Scenarios

For most model analyses, RTA users alter the level funding available to COST to assess the impact of those variations in funding on future asset conditions, on the size of the future backlog and on other related metrics. Based on prior experience, these runs represent variations of the analysis scenarios outlined below in Figure 6-7. These scenarios are comparable to those used by FTA and other agencies when conducing SGR needs analysis.

Figure 6-7: Standard Model Run Scenarios

Scenario	Purpose / Value	How to Define
Maintain Current Spending	• What is the impact on the SGR backlog and prioritization of continuing to reinvest at the current (historical) rate?	• Enter $0 for year 0 • For years 1 to 20 enter avg. level of Service Board reinvestment for past 5 to 10 years • Can adjust for inflation
Maintain Backlog	• What level of investment will maintain the current size of the backlog (either in dollar terms or as a percent of all asset holdings)?	• User must enter test values for years 1 to 20 (enter same value for each year) and run the model multiple times until value of backlog in year 20 = value in year 0.
SGR in 20 Years	• What level of annual reinvestment is required to eliminate the SGR backlog in 20 years?	• User must enter test values for years 1 to 20 (e.g., enter same value for each year) and run the model multiple times until value of SGR backlog = $0 in year 20.
Un-constrained	• What would avg. annual reinvestment be if there was no backlog? • Investment must be higher than this to reduce the backlog	• Enter a very high level of investment (e.g., $500B) for years 0 (backlog year) through year 20
"Planned" or "Budgeted"	• Enter year by year funding amounts that are both (1) financially sustainable and (2) correspond with timing of known major reinvestment needs • Output will show impact of plan on future SGR backlog and help prioritize needs	

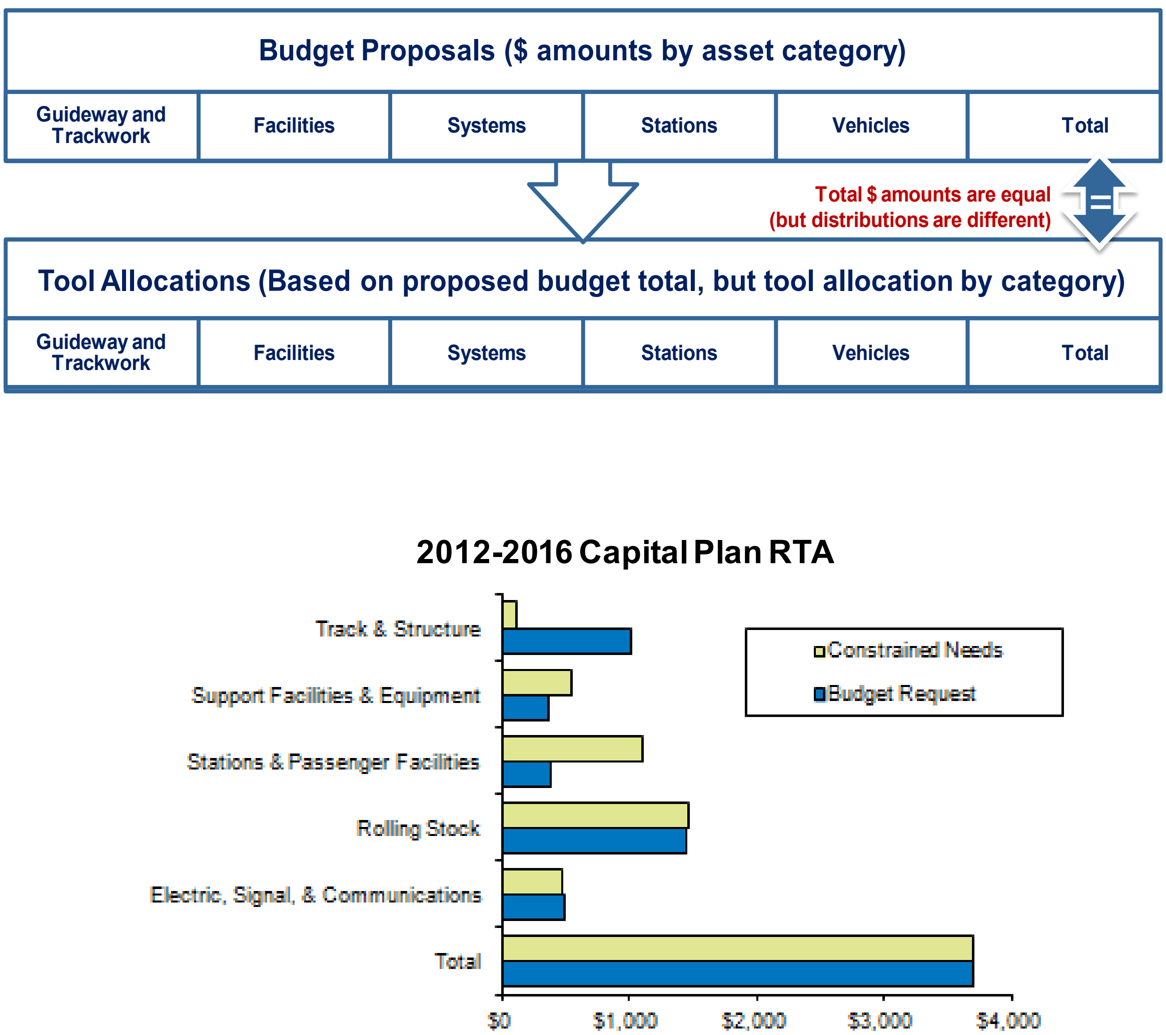
Budget Related Applications of COST

An additional and for RTA primary application of COST is the review of the annual capital budgets submitted to RTA by its Service Boards. As noted above, RTA is responsible for funding and oversight of all public transportation in Northeastern Illinois. Hence, each year RTA's three Service Boards submit their capital plans for the following year, which RTA must then reviews and approve. Within this process, RTA uses COST's prioritization capability to take an "independent look" at the Service Boards capital budget proposals to help assure that the mix of investments in the proposed capital budgets is consistent with the region's preferred mix of investment priorities (as determined by COST's prioritization scoring). Differences between the Service Board and COST generated investments priorities are used to help determine whether to (1) reconsider the Service Board's proposed investment decisions and/or (2) reconsider and potentially recalibrate and improve COST's investment prioritization.

A conceptual overview of the approach to comparing budget proposals with COST's prioritization of needs, along with an example, is presented below in Figure 6-8. In general, the steps used to compare budget proposals with COST's prioritized needs are to:

1. Group budget proposal investment amounts by asset category
2. Run COST financially constrained using the same total budget amount as is assumed in the regional investment budgets – then group the Tool's resulting prioritized needs into the same five asset categories
3. Given the same total budget amount, compare the allocation of budget amounts by asset categories as specified in the budget proposals with that determined by COST's prioritization process. How closely aligned are the budgeted and Tool prioritized needs?
4. Understand and address differences between the budget proposal and COST allocations. Did COST identify any specific needs not included in the budget proposals? Alternatively, were there needs the Tool was not aware of but should have been (implying the need for a Tool or data improvement).

Figure 6-8: General Approach to Budget Proposal and COST Prioritization Comparisons



6.7 Summary – How to Define a Scenario

Finally, Figures 6-9 and 6-10 below provide a summary of the options available to users to define analysis scenarios. Note that some of these options were not specifically addressed in the preceding chapter, such as changing the useful life of an asset (e.g., changing the life of a bus from 12 to 15 years) to assess the impact on overall needs.

Figure 6-9: How to Define a Scenario - Frequently Used Scenario Controls

Scenario Control (Location)	Description & Use	Example Uses
	Frequently Used Scenario Controls	
Expenditure Constraints (Scenario Settings Form)	• User controls level of expenditures for projection years 0 through 20 • Used to assess impact of varying rates of reinvestment on conditions, prioritization and the SGR backlog	• Sample scenarios include: – Unconstrained needs – Maintain current spending – Level of funding to attain SGR
Prioritization Settings (Scenario Settings Form)	• *While typically held fixed*, user can change investment scoring to assess impact on priority rankings, composition of reinvestment activities, and SGR backlog	• User can alter: – Criteria weights (simple adjustment) – Fixed criteria scoring (detailed change)
Inflation (Input Data Form)	• Sets assumed rate of inflation for analysis period from year 0 to 20 – same rate applied across all years • "Sensitivity" factor allows user to simultaneously adjust all projection costs up or down by the same set amount (default value is 100%)	• User can select: – Current year dollars – in Start Year dollars as input on Main Menu – Year of Expenditure – based on user entered rate

Figure 6-10: How to Define a Scenario – Less Frequently Used Scenario Controls

Scenario Control (Location)	Description & Use	Example Uses
<u>Less</u> Frequently Used Scenario Controls (these controls used more to define investment policies)		
Asset Useful Life (Asset Inventory Update Tab: Input Data Form)	• User can alter the useful life values of individual assets • Extending asset useful lives will lower long-term needs as assets require less frequent replacement	• e.g., change the useful life of "twelve year) buses to 14 years
Override (Asset Inventory Update Tab: Input Data Form)	• Clicking the override box for any asset will automatically assign an effective age of 1.5 times the asset's expected useful life (regardless of actual age) • Control used to accelerate replacement of problem assets	• Use of this feature does not ensure a highest possible prioritization score • Rather, ensures a high age based score for that specific asset's type and location (i.e., assets of other types and locations may still score higher)
Life Cycle Costs (Input Data Form)	• User can alter number, timing and cost of rehabs • Also controls cost of annual capital maintenance	• User can assess impact on needs of increasing/reducing number and/or cost of rehabs (note: will not impact condition measures)
Useful Life Factor (Main Menu)	• When set to values other than 100%, assets will be kept in service longer or shorter than their expected useful lives • This single factor allies to all assets	• Note: Useful life values are not altered (hence, if factor is set to 110%, assets will be kept in service until 110% of their expected useful life but will be overage one they exceed 100% of useful life)

7. "How to" Guide to Run COST

This chapter provides a brief description of how to run RTA's COST model as well as how to save copies of scenarios for future reference and distribution.

7.1 Running the Model

To run COST just go to the Main Menu and click the "Run Model" button after setting up any relevant scenario parameters (Figure 7-1). Clicking this button will bring up a warning asking the user if they wish to continue with this action – as doing so will erase any previous analysis results in the model. If the user clicks "yes", the Tool will proceed with the model run. As the Tool proceeds through the run, it will display the status of the model run at all times including (1) the actions the model is performing, (2) the forecast year it is performing those actions for and (3) the current record count. Note that the Tool passes through all records multiple times to complete a run (Figure 7-2). The time to complete a full run is dependent on the number of asset records in the inventory and the speed of the computer. For most datasets of up to 4,000 records or more it should not take more than a few minutes for the model to run, even on a slower machine.

Figure 7-1: Main Menu – Running COST

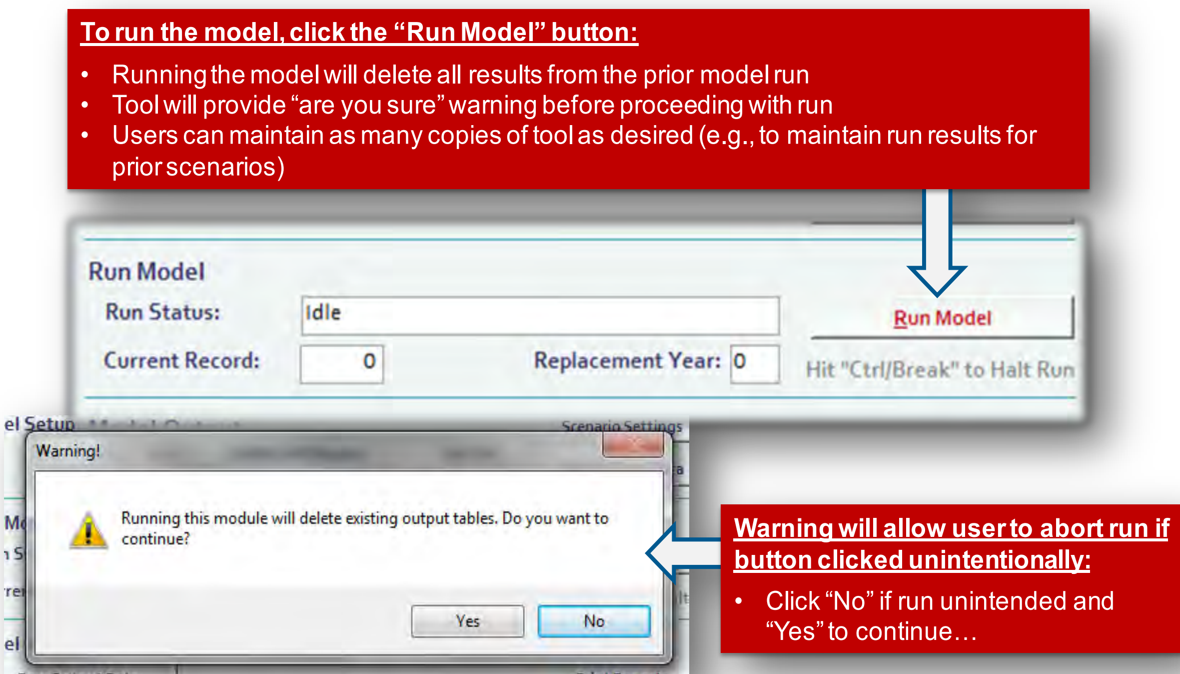
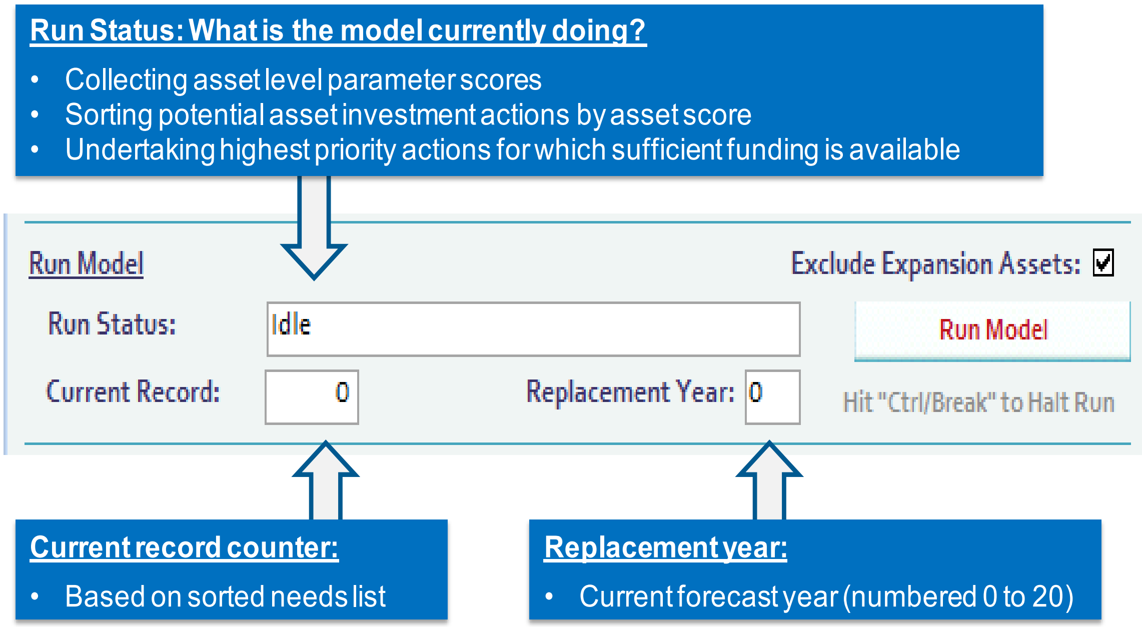


Figure 7-2: Running COST – Run Model Display



Should the user encounter unexpected problems during the model run (particularly after the model has been run many times in a row), it may be worthwhile to close and open the Tool and then use the "compact and repair utility". MS Access files tend to increase in size over time, particularly during analysis, if the compact and repair utility is not run on occasion. Therefore, it is recommended that the user run the compact and repair utility after every three to five model runs to ensure the file size remains manageable and to maintain optimal run performance.

7.2 Saving Scenarios

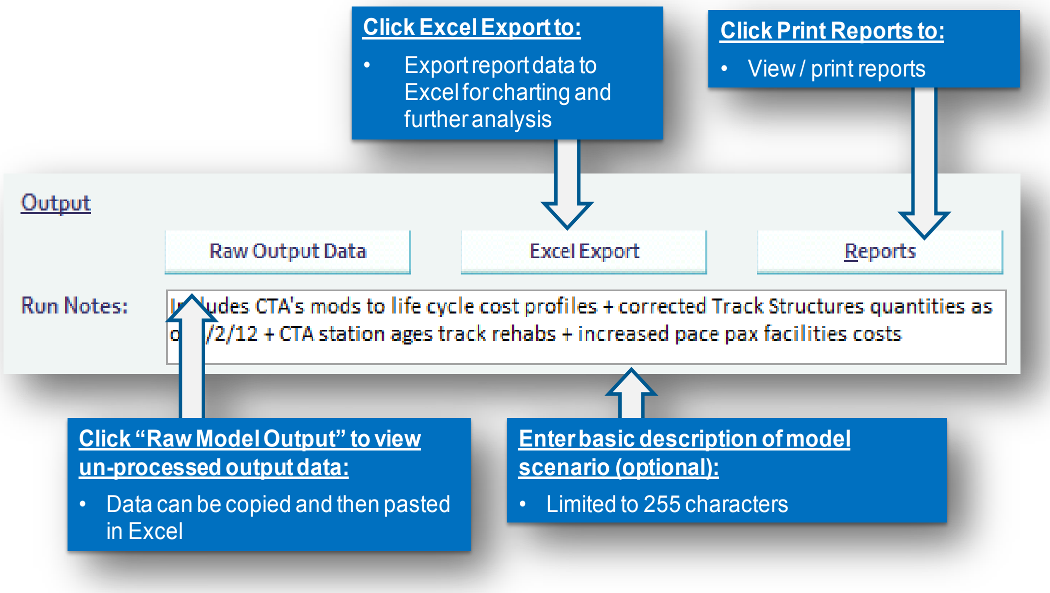
COST is only designed to house the output results for one analysis scenario at a time. Therefore, should the user want to save the results of a specific scenario, the user should save a copy of the model with the desired scenario run, and then create another copy (copies) of the Tool for other scenarios.

It is helpful to note here that MS Access files, including COST file, can typically be zipped to a fraction of their normal size. This property can be very helpful both to (1) save storage space when storing multiple copies of the Tool and (2) zip and e-mail copies of COST to other co-workers. (Note that COST will likely become too large to e-mail unzipped when fully populated with both input and output data.)

8. "How to" Guide to Work with Output

As noted in Chapter 4.5, COST provides three options for obtaining output data once a model run is complete. This chapter describes each of these output options, which are all accessed from the bottom section of the Tool's Main Menu (Figure 8-1).

Figure 8-1: Model Concept – How does the Tool's Needs Analysis Work?



8.1 Reports

At the time of writing, COST generates twelve (12) different reports (see Figure 8-2). Most reports present analysis of current and projected future values for the following:

- Prioritized expenditures
- SGR Backlog
- Asset Conditions
- Percent of assets exceeding their useful life
- Year-by-year investment prioritization scores by asset type

In addition, the Tool also generates some informational reports that document when the asset records were last updated, assumed replacement values (default values only, not asset specific values) and a listing of all asset types recognized by COST.

It is important to note that (1) all reports can be converted to pdf format and then saved, printed or e-mailed to others and (2) the Tool allows the user to generate a table containing the data behind each report and then copy and paste that data into Excel to support further analysis.

Figure 8-2: Model Output – Sample Report

SGR Backlog Forecast: 2010 - 2030

20-Jul-11

Summary Report

By Asset Category

	Annual Expenditures ($M)																				
Mode / Asset Category	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Heavy Rail																					
Facilities	$230.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Guideway Elements	$1,640.8	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Stations	$2,756.7	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Systems	$1,067.6	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Vehicles	$2,185.8	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Total: Heavy Rail	$7,880.9	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Motor Bus																					
Facilities	$863.3	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Systems	$36.5	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Vehicles	$276.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Total: Motor Bus	$1,176.2	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Systemwide Assets																					
Facilities	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Systems	$100.3	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Vehicles	$33.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Total: Systemwide Assets	$133.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Grand Total:	$9,190.6	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Wednesday, July 20, 2011

Page 1 of 1

Reports are accessed by clicking the "Reports" button found on the lower panel of the Main Menu (Figure 8-3). Clicking this button will open a pop-up form listing all of the reports. Scroll through and then select your desired report by clicking on its name (see report listing in Figure 8-4). At this point the user can either (1) click the "Report" button on the pop-up form – this action will open the report for viewing or (2) click the "Data (Read Only)" button to view the data underlying the selected report. If the "Report" button is selected the user now has the option to either view/print the report as is or to export the report to PDF (in Print Preview mode, click "PDF" in the Data section of the MS Access Menu) or MS Word format.

Figure 8-3: Model Output – Accessing the Reports

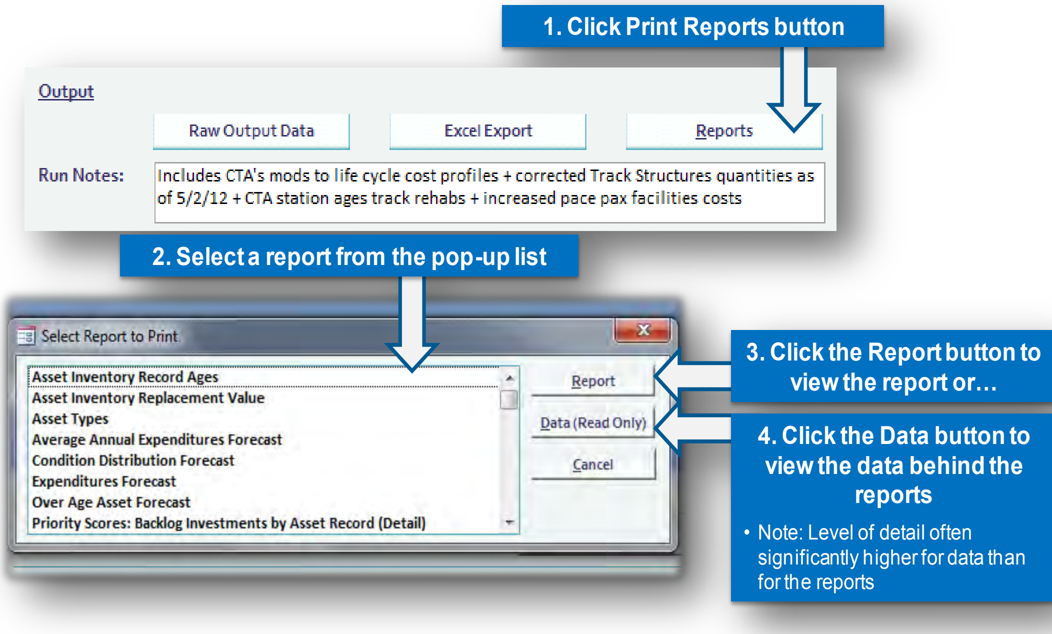
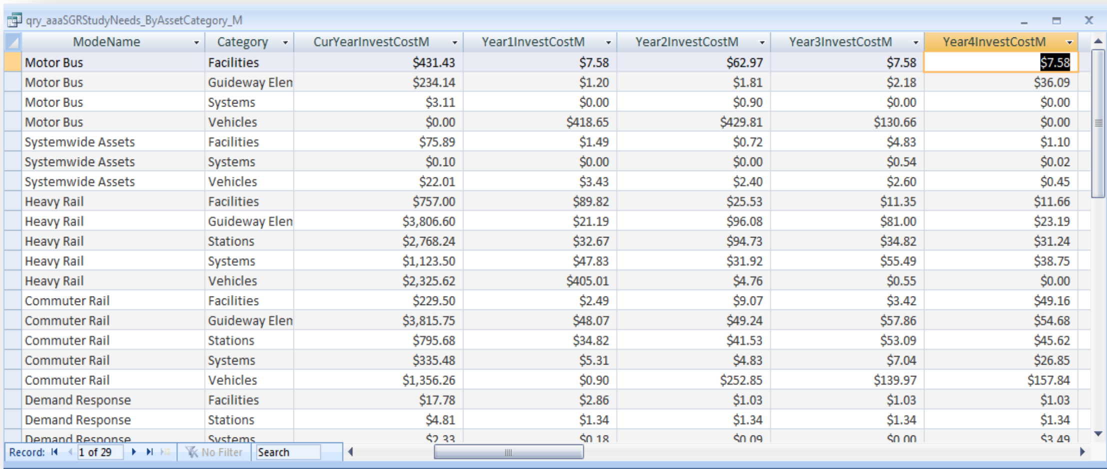


Figure 8-4: Model Output – Description of Tool Reports

Report	Type	Content
Asset Inventory Record Ages	• Input Data	• Analysis of the age of the tools' asset records
Asset Inventory Replacement Value	• Inventory	• Total replacement value of all • Grouped by mode and asset category
Asset Types	• Input Data	• Asset types recognized by the database • Data tab provides detail on asset life-cycle cost assumptions
Average Annual Expenditures Forecast	• Needs forecast	• Average annual level of dollar investment needs over 20-years of model run (based on scenario inputs)
Condition Distribution Forecast	• Condition	• Forecast of percent of assets in excellent, good, fair, marginal and poor condition
Expenditures Forecast	• Needs forecast	• Forecast of prioritized annual investment needs (based on scenario inputs)
Over Age Asset Forecast	• Condition	• Forecast of percent of assets that exceed their useful life (based on scenario inputs)
Priority Scores: Backlog Investments by Asset Record (Detail)	• Prioritization scores	• Record level prioritization scores for investments to reduce current backlog (year 0)
Priority Scores: Backlog Investments by Asset Type by Location	• Prioritization scores	• Prioritization scores for investments to reduce current backlog (year 0) grouped by asset type and location
Priority Scores: Backlog Investment by Asset Type (Base 100)	• Prioritization scores	• Prioritization scores for investments to reduce current backlog (year 0) grouped only by asset type
Priority Scores: Summary Scores By Asset Type for Next 10 Years	• Prioritization scores	• Prioritization scores grouped only by asset type for projection years 0 to 20
SGR Backlog Forecast	• Backlog	• Projection of SGR backlog for years 0 through 20 (based on scenario inputs)

Copying Report Data to Excel: As noted above, the user has the option of viewing the data used to populate each report and can also copy and paste that data into Excel. First, click the Reports button on the Main Menu and then selecte the desired report and click the "Data (Read Only)" button. This action will run a query to display the data behind the selected report, which will appear as a table (see Figure8-5). To copy this data to Excel, click the upper-left hand corner of this table (or highlight all table rows) and then click the copy icon on the MS Access menu (or hit "Ctrl-C"). Next, open a new Excel worksheet and click the "Paste" icon on the menu (or "Ctrl-V").

Figure 8-5: Model Output – Accessing Reports Data



ModeName	Category	CurYearInvestCostM	Year1InvestCostM	Year2InvestCostM	Year3InvestCostM	Year4InvestCostM
Motor Bus	Facilities	$431.43	$7.58	$62.97	$7.58	$7.58
Motor Bus	Guideway Elen	$234.14	$1.20	$1.81	$2.18	$36.09
Motor Bus	Systems	$3.11	$0.00	$0.90	$0.00	$0.00
Motor Bus	Vehicles	$0.00	$418.65	$429.81	$130.66	$0.00
Systemwide Assets	Facilities	$75.89	$1.49	$0.72	$4.83	$1.10
Systemwide Assets	Systems	$0.10	$0.00	$0.00	$0.54	$0.02
Systemwide Assets	Vehicles	$22.01	$3.43	$2.40	$2.60	$0.45
Heavy Rail	Facilities	$757.00	$89.82	$25.53	$11.35	$11.66
Heavy Rail	Guideway Elen	$3,806.60	$21.19	$96.08	$81.00	$23.19
Heavy Rail	Stations	$2,768.24	$32.67	$94.73	$34.82	$31.24
Heavy Rail	Systems	$1,123.50	$47.83	$31.92	$55.49	$38.75
Heavy Rail	Vehicles	$2,325.62	$405.01	$4.76	$0.55	$0.00
Commuter Rail	Facilities	$229.50	$2.49	$9.07	$3.42	$49.16
Commuter Rail	Guideway Elen	$3,815.75	$48.07	$49.24	$57.86	$54.68
Commuter Rail	Stations	$795.68	$34.82	$41.53	$53.09	$45.62
Commuter Rail	Systems	$335.48	$5.31	$4.83	$7.04	$26.85
Commuter Rail	Vehicles	$1,356.26	$0.90	$252.85	$139.97	$157.84
Demand Response	Facilities	$17.78	$2.86	$1.03	$1.03	$1.03
Demand Response	Stations	$4.81	$1.34	$1.34	$1.34	$1.34
Demand Response	Systems	$2.33	$0.18	$0.09	$0.00	$3.49

8.2 Excel Export

COST also allows the user to export scenario analyses directly to Excel as a set of pre-defined Excel charts (one-chart per worksheet). COST currently exports 7 different charts to Excel similar to the content included in the reports above.

Sample Excel export charts are presented below in Figure 8-7. To access the Excel Export charts, first click the "Excel Export" button at the bottom of the Main Menu (Figure 8-6). This action will launch a macro that will take roughly a minute to run. When complete, the macro will have opened a new Excel file (called "Book 1") that includes multiple worksheets, each showing a different output chart. These charts can then be modified and saved as desired. Charts can also be copied to a report or presentation.

Figure 8-6: Model Output – Accessing Excel Exports

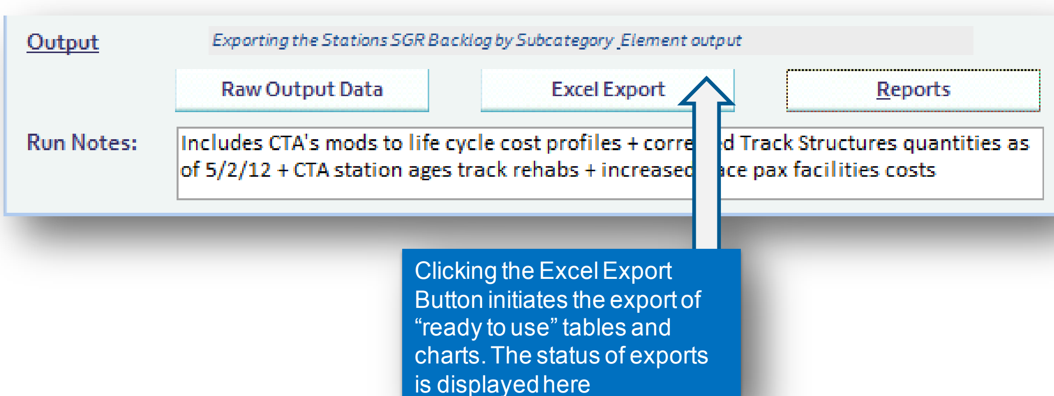
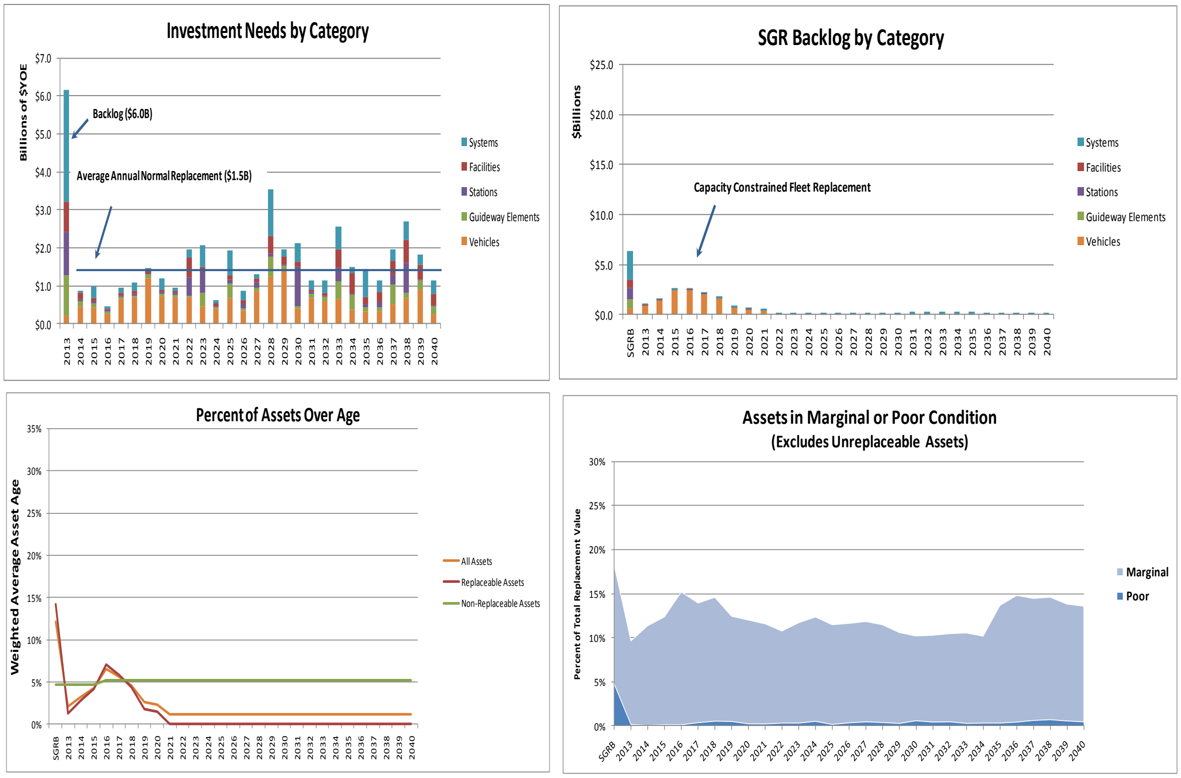


Figure 8-7: Model Output – Sample Excel Exports



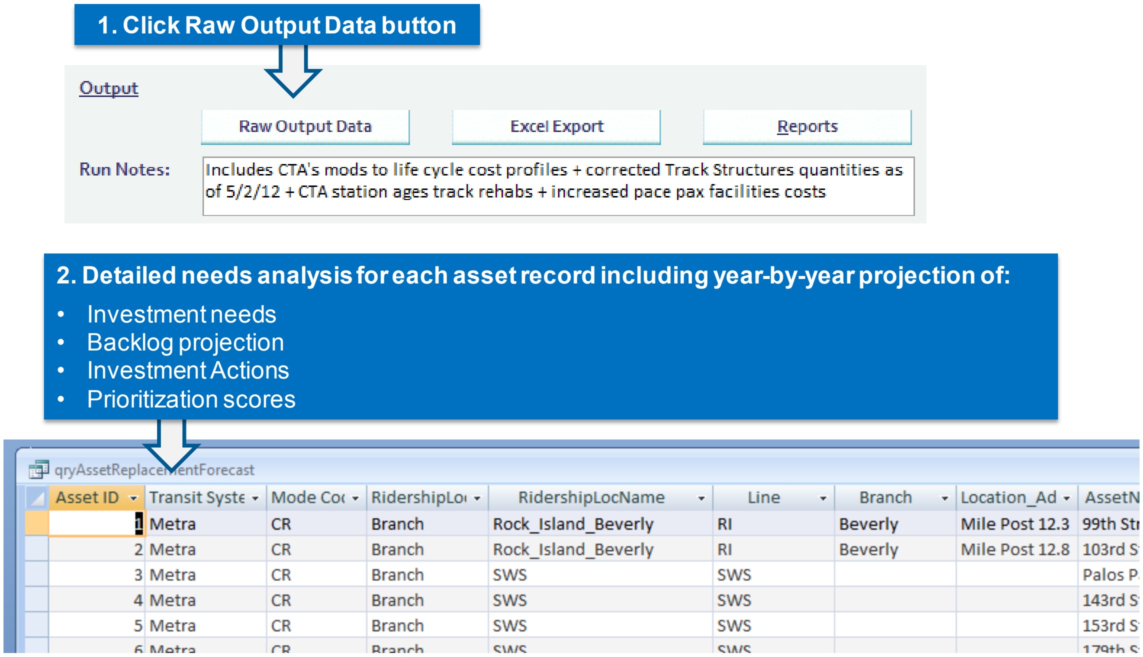
8.3 Detailed Run Results

Finally, COST also provides direct access to a complete listing of all model run output results, in a single table. Specifically, this table provides a comprehensive listing of all analysis results for each individual asset record identified in the Tool's Asset Inventory table and for each of the 20-years of analysis. Hence, for each asset, this output table lists the following for all 20-years of analysis:

- Prioritized investment needs
- SGR backlog
- Asset age
- Asset condition
- Prioritization score
- Investment action (including no action for years with no investment needs)

To access the data, just click the "Raw Output Data" button at the bottom of the Main Menu (Figure 8-8). Note that this output table is the source of data for all of the summary Reports and Excel Export charts described above.

Figure 8-8: Model Output – Accessing Raw Output Data



Appendix A: Glossary and Abbreviations

- Prioritization: For this guide, prioritization is the process of identifying a preferred or optimal order in which reinvestment events should occur. Implicit in this statement is the assumption that:
    - *Funding is insufficient to address all needs.* Hence prioritization is required to determine which assets should be addressed first (and which assets have needs that may not be addressed).
    - *Investment needs can be ranked.* In other words, there are good analytic or other bases on which to ranked investment needs – from highest to lowest—to determine in which outstanding needs are most effectively addressed (and potentially leaving some needs unaddressed).

- Prioritization Criteria: Prioritization criteria provide the basis for determining the priority of individual investments. In general, investments are made with the expectation that the completed investment will yield improvements to one or more aspects of agency operations (e.g., improvements to reliability, efficiency, safety, rider comfort or other characteristic). Within a prioritization routine, the most desirable or important of these types of investment outcomes are referred to as "investment criteria". Investments that perform best with respect to these criteria (i.e., tend to be provide the best mix of desired outcomes) are assigned the highest priority. Investments that perform poorly may receive a low priority ranking.

- Prioritization Criteria Scores: From the viewpoint of this guide (and RTA's COST), prioritization criteria should be quantifiable so investments can be assigned a numeric score reflecting their potential contribution to the desired outcome associated with that criterion (e.g., contribution to SGR). Note that numeric criteria scores facilitate objective comparisons between investment options. Given that different criteria may naturally be associated with specific unit quantities (e.g., condition rating for SGR and dollar values for impacts to operating costs), these score need to be converted to a common basis if the intention is to generate a multi-criteria prioritization score.

- Multi-Criteria Investment Prioritization (criteria weighting): Multi-criteria investment prioritization refers to the process of evaluating and prioritizing investment options based on each investment's performance against a mix of multiple investment criteria. In the context of this guide and RTA's COST, multi-criteria investment prioritization implies the (1) all criteria are individual scored on a common scale (e.g., running from 1 to 5) and (2) these criteria scores are combined into a weighted average score, with the weight placed on each criterion reflecting the relative importance of that criterion.

- Needs Analysis: In the context of COST, needs analysis refers to the process of determining the level of investment required to attain specific investment objectives and also with how those investment dollars are allocated to different uses (e.g., between various asset types). In general, needs analysis falls into two broad categories:
    - *Unconstrained needs:* The level of investment required to address all outstanding and future needs, irrespective of actual or expected funding availability
    - *Constrained Needs:* The level of investment required to attain more realistic investment objectives (e.g., maintain the size of the current investment backlog, or eliminate the backlog over 20 years). As the name suggests, under constrained needs analysis, there is insufficient funding to address all needs.

- Reinvestment in Existing Assets (SGR) vs. Investment in New Expansion or Enhancement Assets: COST is designed to assess and prioritize investment needs for both existing and expansion assets. In general, these investment types falls into the following categories:
  - *Reinvestment in Existing Assets:* Refers to SGR (i.e., rehab and replace) investments in assets that are currently in service (i.e., *existing* assets).
  - *Investment in expansion assets:* Refers to the planned/proposed future purchase of new assets that either: (i) expand existing service capacity (e.g., fleet expansion), (ii) adds a new service (e.g., New Starts) or (iii) enhances existing service (e.g., new technologies such as real-time arrival information).

- Scenario Analysis: In the context of COST, scenario analysis refers to the process of identifying specific investment objectives and then assessing the investment needs associated with attaining that scenario. Examples include:
  - Maintain historic funding levels
  - Maintain the current backlog
  - Eliminate the backlog over a set time period (e.g., 20 years).

- Asset Condition and Decay: Asset condition refers here to the estimated physical condition of a transit asset. Specifically, COST includes a set of embedded asset decay curves that predict the current and future physical condition of a transit asset based on its type, age and other factors (e.g. , use and maintenance history). COST uses these condition relationships to prioritize reinvestment needs (in part) based each asset's predicted physical condition (both currently and into the future depending on needs and funding availability). COST also uses these same asset decay curves to generate current and future distributions of asset conditions.

The following definitions for State of Good Repair (SGR) separate the asset level from aggregate level.

- Asset Level SGR: An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

- Mode, Service Board, or Regional Level (Aggregate) SGR: A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.

Appendix B: Asset Types in COST

Type	Category	Sub-Category	Element	Sub-Element
10000	Guideway Elements	Guideway	-	-
10110	Guideway Elements	Guideway	At Grade Exclusive	-
10120	Guideway Elements	Guideway	At Grade Exclusive	Expressway
10200	Guideway Elements	Guideway	At Grade-In-Street	-
10205	Guideway Elements	Guideway	At Grade-In-Street	Ductbank
10206	Guideway Elements	Guideway	At Grade-In-Street	Manhole
10210	Guideway Elements	Guideway	At Grade-In-Street	Grade Crossing
10211	Guideway Elements	Guideway	At Grade-In-Street	Grade Crossing - Panelled
10212	Guideway Elements	Guideway	At Grade-In-Street	Grade Crossing - Embedded
10310	Guideway Elements	Guideway	Elevated Structure	-
10320	Guideway Elements	Guideway	Elevated Structure	Steel Viaducts
10330	Guideway Elements	Guideway	Elevated Structure	Bridge
10340	Guideway Elements	Guideway	Elevated Structure	Foot Walk
10400	Guideway Elements	Guideway	Elevated Fill	-
10500	Guideway Elements	Guideway	Underground	-
10510	Guideway Elements	Guideway	Underground	Tunnel
10515	Guideway Elements	Guideway	Underground	Tube
10520	Guideway Elements	Guideway	Underground	Cut & Cover
10550	Guideway Elements	Guideway	Underground	Foot Walk
10600	Guideway Elements	Guideway	Retained Cut	-
10601	Guideway Elements	Guideway	Retained Cut	Box Culvert
11000	Guideway Elements	Trackwork	-	-
11110	Guideway Elements	Trackwork	Direct Fixation	-
11111	Guideway Elements	Trackwork	Direct Fixation	Tangent
11112	Guideway Elements	Trackwork	Direct Fixation	Curve
11113	Guideway Elements	Trackwork	Direct Fixation	Guarded
11114	Guideway Elements	Trackwork	Direct Fixation	Platform
11151	Guideway Elements	Trackwork	Open Deck	Tangent
11152	Guideway Elements	Trackwork	Open Deck	Curve
11153	Guideway Elements	Trackwork	Open Deck	Guarded
11154	Guideway Elements	Trackwork	Open Deck	Platform
11200	Guideway Elements	Trackwork	Ballasted	-
11210	Guideway Elements	Trackwork	Ballasted	Tangent
11211	Guideway Elements	Trackwork	Ballasted	Tangent - Concrete Tie
11212	Guideway Elements	Trackwork	Ballasted	Tangent - Wood Tie
11220	Guideway Elements	Trackwork	Ballasted	Curve
11221	Guideway Elements	Trackwork	Ballasted	Curve - Concrete Tie
11222	Guideway Elements	Trackwork	Ballasted	Curve - Wood Tie
11230	Guideway Elements	Trackwork	Ballasted	Guarded
11240	Guideway Elements	Trackwork	Ballasted	Platform
11300	Guideway Elements	Trackwork	Embedded	-
11310	Guideway Elements	Trackwork	Embedded	Tangent
11320	Guideway Elements	Trackwork	Embedded	Curve
11330	Guideway Elements	Trackwork	Embedded	At-Grade Crossings
11400	Guideway Elements	Trackwork	Special	-
11401	Guideway Elements	Trackwork	Special	Diamond Crossover
11402	Guideway Elements	Trackwork	Special	Diamond Crossover -- Direct Fixation
11403	Guideway Elements	Trackwork	Special	Diamond Crossover -- Ballasted
11404	Guideway Elements	Trackwork	Special	Single Crossover

Type	Category	Sub-Category	Element	Sub-Element
11405	Guideway Elements	Trackwork	Special	Single Crossover -- Direct Fixation
11406	Guideway Elements	Trackwork	Special	Single Crossover --Ballasted
11407	Guideway Elements	Trackwork	Special	Turnout
11408	Guideway Elements	Trackwork	Special	Turnout -- Direct Fixation
11409	Guideway Elements	Trackwork	Special	Turnout -- Ballasted
11410	Guideway Elements	Trackwork	Special	Turntable
11500	Guideway Elements	Trackwork	Yard	-
11600	Guideway Elements	Trackwork	Ties	-
11601	Guideway Elements	Trackwork	Ties	Wood
11602	Guideway Elements	Trackwork	Ties	Concrete
12000	Guideway Elements	Special Structures	-	-
12100	Guideway Elements	Special Structures	Fencing	-
12200	Guideway Elements	Special Structures	Retaining Walls	-
13000	Guideway Elements	Bus Guideway	-	-
13100	Guideway Elements	Bus Guideway	At Grade	-
13200	Guideway Elements	Bus Guideway	Turnaround	-
13201	Guideway Elements	Bus Guideway	Turnaround	CTA
13300	Guideway Elements	Bus Guideway	Elevated Fill	-
13400	Guideway Elements	Bus Guideway	Elevated Structure	-
13450	Guideway Elements	Bus Guideway	Elevated Structure	Bridges
13500	Guideway Elements	Bus Guideway	Subway	-
20000	Facilities	-	-	-
21000	Facilities	Buildings	-	-
21100	Facilities	Buildings	Administration	-
21101	Facilities	Buildings	Administration	Large Administration Buildings
21200	Facilities	Buildings	Maintenance	-
21210	Facilities	Buildings	Maintenance	Bus
21211	Facilities	Buildings	Maintenance	CTA -- Interior Bus
21212	Facilities	Buildings	Maintenance	CTA -- Exterior Bus
21215	Facilities	Buildings	Maintenance	Pace -- Bus - Small
21216	Facilities	Buildings	Maintenance	Pace -- Bus - Large
21220	Facilities	Buildings	Maintenance	Rail
21221	Facilities	Buildings	Maintenance	CTA -- Rail
21225	Facilities	Buildings	Maintenance	Metra -- Rail
21230	Facilities	Buildings	Maintenance	Utility building
21231	Facilities	Buildings	Maintenance	CTA -- Warehouse
21240	Facilities	Buildings	Heavy Maintenance	-
21241	Facilities	Buildings	Heavy Maintenance	Rail
21242	Facilities	Buildings	Heavy Maintenance	Bus
21250	Facilities	Storage Yard	-	-
21251	Facilities	Storage Yard	Rail	-
21252	Facilities	Storage Yard	Bus	Park
21260	Facilities	Buildings	Bus Turnaround Facility	-
21500	Facilities	Buildings	Building Components	-
21501	Facilities	Buildings	Building Components	Electrical
21502	Facilities	Buildings	Building Components	Fire Alarm
21503	Facilities	Buildings	Building Components	Plumbing
21504	Facilities	Buildings	Building Components	Drainage
21505	Facilities	Buildings	Building Components	HVAC
21506	Facilities	Buildings	Building Components	Boiler
21507	Facilities	Buildings	Building Components	Roof
21508	Facilities	Buildings	Building Components	Exterior

Type	Category	Sub-Category	Element	Sub-Element
21509	Facilities	Buildings	Building Components	Access and Parking
21510	Facilities	Buildings	Building Components	Elevators and Conveying Systems
21511	Facilities	Buildings	Building Components	Built-in Equipment and Specialties
21512	Facilities	Buildings	Building Components	Generators
21513	Facilities	Buildings	Building Components	Interior
21514	Facilities	Buildings	Building Components	Fencing
21515	Facilities	Buildings	Building Components	Other
22211	Facilities	Buildings	Administration	CTA Admin Building - 15 floor
22212	Facilities	Buildings	Administration	CTA Admin Building - 2 floor
22221	Facilities	Buildings	Administration	Metra Admin Building - 15 floor
22231	Facilities	Buildings	Administration	Pace Admin Building - 2 floor
23000	Facilities	Equipment	-	-
23100	Facilities	Equipment	Office	-
23101	Facilities	Equipment	Office	Software
23102	Facilities	Equipment	Office	Hardware -- computers, printers, copiers
23200	Facilities	Equipment	Office	Furniture
23400	Facilities	Equipment	Maintenance	-
23420	Facilities	Equipment	Maintenance	Pollution Treatment
23421	Facilities	Equipment	Maintenance	Bus Washer
23422	Facilities	Equipment	Maintenance	Train Washer
23423	Facilities	Equipment	Maintenance	Vehicle Paint booth
23424	Facilities	Equipment	Maintenance	Fuel Island
23425	Facilities	Equipment	Maintenance	Fuel Tank
23426	Facilities	Equipment	Maintenance	Dynamometers
23427	Facilities	Equipment	Maintenance	Lifts - Portable
23428	Facilities	Equipment	Maintenance	Lifts - Fixed
23429	Facilities	Equipment	Maintenance	Lifts - Fixed: In Floor
23430	Facilities	Equipment	Maintenance	Lifts - Fixed: Parallelogram
23431	Facilities	Equipment	Maintenance	Wheel truing machines
23432	Facilities	Equipment	Maintenance	Wheel presses
23433	Facilities	Equipment	Maintenance	Turntables, Truck
23434	Facilities	Equipment	Maintenance	Brake Lathe
23435	Facilities	Equipment	Maintenance	Air Compressor
23436	Facilities	Equipment	Maintenance	Cart
23437	Facilities	Equipment	Maintenance	Hoist
23438	Facilities	Equipment	Maintenance	Scrubber, Sprayer
23439	Facilities	Equipment	Maintenance	Misc Equip
25000	Facilities	Central Control	Building Only	-
30000	Systems	-	-	-
31000	Systems	Train Control	-	-
31200	Systems	Train Control	Wayside Train Control	-
31201	Systems	Train Control	Wayside Train Control	Automatic Transfer Panel
31202	Systems	Train Control	Wayside Train Control	Battery Equip
31203	Systems	Train Control	Wayside Train Control	Bonds
31204	Systems	Train Control	Wayside Train Control	Control Panel (local)
31205	Systems	Train Control	Wayside Train Control	Intrusion Detection Warning System
31206	Systems	Train Control	Wayside Train Control	Logical Controller
31207	Systems	Train Control	Wayside Train Control	Marker Coil
31208	Systems	Train Control	Wayside Train Control	Power Supplies

Type	Category	Sub-Category	Element	Sub-Element
31209	Systems	Train Control	Wayside Train Control	Power Supplies-UPS
31210	Systems	Train Control	Wayside Train Control	Receiver
31211	Systems	Train Control	Wayside Train Control	Relays
31212	Systems	Train Control	Wayside Train Control	Relay Cabinet
31213	Systems	Train Control	Wayside Train Control	Relay House (Bungalow)
31214	Systems	Train Control	Wayside Train Control	Repeater Signal
31215	Systems	Train Control	Wayside Train Control	RTU
31216	Systems	Train Control	Wayside Train Control	Signals
31217	Systems	Train Control	Wayside Train Control	Signal Bridge
31218	Systems	Train Control	Wayside Train Control	STAP (Station Processor)
31219	Systems	Train Control	Wayside Train Control	TPSS Feeds
31220	Systems	Train Control	Wayside Train Control	Track Circuit
31221	Systems	Train Control	Wayside Train Control	Train Control Cable
31222	Systems	Train Control	Wayside Train Control	Train Stop
31223	Systems	Train Control	Wayside Train Control	Programmed Station Stop System
31224	Systems	Train Control	Wayside Train Control	Other
31300	Systems	Train Control	Centralized Train Control	-
31301	Systems	Train Control	Centralized Train Control	Control Room (central)
31302	Systems	Train Control	Centralized Train Control	Logical Controller
31303	Systems	Train Control	Centralized Train Control	Power Supplies
31304	Systems	Train Control	Centralized Train Control	Receiver
31400	Systems	Train Control	Roadway Crossings	-
31411	Systems	Train Control	Roadway Crossings	Crossing Gate Arm
31412	Systems	Train Control	Roadway Traffic Signals	-
31500	Systems	Train Control	Commuunications	-
31501	Systems	Train Control	Commuunications	Data Transmission Unit
31502	Systems	Train Control	Commuunications	Train Wayside Comm
31503	Systems	Train Control	Commuunications	Transmitter
31700	Systems	Train Control	Onboard Train Control (cab signaling)	
31701	Systems	Train Control	Onboard Train Control (cab signaling)	Onboard Compter Systems
31702	Systems	Train Control	Onboard Train Control (cab signaling)	Receiver
31800	Systems	Train Control	Interlocking	-
31801	Systems	Train Control	Interlocking	Switch Machine
31802	Systems	Train Control	Interlocking	Switch Machine - Manual Ballasted
31803	Systems	Train Control	Interlocking	Switch Machine - Motorized Ballasted
31804	Systems	Train Control	Interlocking	Switch Machine - Manual Embedded
31805	Systems	Train Control	Interlocking	Switch Machine - Motorized Embedded
31806	Systems	Train Control	Interlocking	Switch Heaters
32000	Systems	Electrification	-	-
32200	Systems	Electrification	Substations	-

Type	Category	Sub-Category	Element	Sub-Element
32204	Systems	Electrification	Substations	AC Switchgear
32205	Systems	Electrification	Substations	DC Switchgear
32206	Systems	Electrification	Substations	Rectifier
32207	Systems	Electrification	Substations	Building
32208	Systems	Electrification	Substations	Battery
32209	Systems	Electrification	Substations	Charger
32210	Systems	Electrification	Substations	SCADA RTUs
32211	Systems	Electrification	Substations	Transformer
32212	Systems	Electrification	Substations	Generator
32213	Systems	Electrification	Substations	High Tension Towers
32214	Systems	Electrification	Substations	Building Electrical
32215	Systems	Electrification	Substations	Fire Alarm
32216	Systems	Electrification	Substations	Plumbing
32217	Systems	Electrification	Substations	Drainage
32218	Systems	Electrification	Substations	HVAC
32219	Systems	Electrification	Substations	Roof
32220	Systems	Electrification	Substations	Exterior
32221	Systems	Electrification	Substations	Access
32222	Systems	Electrification	Substations	Elevators and Conveying Systems
32223	Systems	Electrification	Substations	Built-in Equipment and Specialties
32300	Systems	Electrification	Breaker House	-
32400	Systems	Electrification	Contact Rail	Contact Rail, Chairs, Anchor and Incline
32404	Systems	Electrification	Contact Rail	Protection Boards
32405	Systems	Electrification	Contact Rail	3rd Rail Disconnect Switches
32406	Systems	Electrification	Contact Rail	Short Tie Extension Brackets
32407	Systems	Electrification	Contact Rail	Reactors
32408	Systems	Electrification	Contact Rail	Heaters
32700	Systems	Electrification	Overhead Catenary	-
32701	Systems	Electrification	Overhead Catenary	Trolley Wire
32702	Systems	Electrification	Overhead Catenary	Decorative Street lighting
32703	Systems	Electrification	Overhead Catenary	Ductbank
32704	Systems	Electrification	Overhead Catenary	Feed Span (+ and -)
32705	Systems	Electrification	Overhead Catenary	Manhole
32706	Systems	Electrification	Overhead Catenary	Poles and Foundation
32707	Systems	Electrification	Overhead Catenary	Pulleys
32708	Systems	Electrification	Overhead Catenary	Pole Grounding
32709	Systems	Electrification	Overhead Catenary	Tangent Span
32800	Systems	Electrification	Power Cable	-
32801	Systems	Electrification	Power Cable	Substation feed
32802	Systems	Electrification	Power Cable	Contact Rail feed
32902	Systems	Electrification	Bridge	Electrical System
32903	Systems	Electrification	Signal Load	-
32904	Systems	Electrification	C-Case	-
33000	Systems	Communications	-	-
33100	Systems	Communications	Cable Transmission System (CTS)	-
33101	Systems	Communications	Cable Transmission System (CTS)	Fiber Optic Cable Transmission System (FOCS)
33102	Systems	Communications	Cable Transmission System (CTS)	Cable
33103	Systems	Communications	Cable Transmission	Nodes

Type	Category	Sub-Category	Element	Sub-Element
			System (CTS)	
33104	Systems	Communications	Cable Transmission System (CTS)	MIS/IT/Network Systems
33200	Systems	Communications	Passenger Communications Systems	-
33201	Systems	Communications	Passenger Communications Systems	Public Address (PA)
33202	Systems	Communications	Passenger Communications Systems	Transit Passenger Information Systems (TPIS)
33203	Systems	Communications	Passenger Communications Systems	Variable Message Signs (VMS)
33204	Systems	Communications	Passenger Communications Systems	On-board vehicle
33205	Systems	Communications	Passenger Communications Systems	Station Passenger Emergency (Blue Light) Phones
33300	Systems	Communications	Safety and Security	-
33301	Systems	Communications	Safety and Security	On-Vehicle Video Systems
33302	Systems	Communications	Safety and Security	Emergency Location System
33303	Systems	Communications	Safety and Security	Emergency Management Panel (EMP)
33304	Systems	Communications	Safety and Security	Fire & Emergency Management System (F&EM)
33305	Systems	Communications	Safety and Security	Fire Management Panel
33306	Systems	Communications	Safety and Security	Gas Monitoring System
33307	Systems	Communications	Safety and Security	Gas fire suppression system
33308	Systems	Communications	Safety and Security	Intrusion Detection System (IDS)
33309	Systems	Communications	Safety and Security	Seismic Monitoring System
33310	Systems	Communications	Safety and Security	CCTV
33311	Systems	Communications	Safety and Security	CCTV -- Fixed
33312	Systems	Communications	Safety and Security	CCTV -- On-board vehicle
33400	Systems	Communications	Phone System	-
33401	Systems	Communications	Phone System	Private Branch Exchange (PBX)
33402	Systems	Communications	Phone System	Telephones
33403	Systems	Communications	Phone System	Fax
33500	Systems	Communications	Radio	-
33501	Systems	Communications	Radio	Bus Radio
33502	Systems	Communications	Radio	Base Radio Stations
33503	Systems	Communications	Radio	Radio Antenna
33504	Systems	Communications	Radio	Mobile Radios
33505	Systems	Communications	Radio	Mobile Radios, Handpack
33506	Systems	Communications	Radio	Transmitter
33800	Systems	Communications	SCADA	-
33801	Systems	Communications	SCADA	Programmable Logic Controller (PLC)
33802	Systems	Communications	SCADA	RTU
33803	Systems	Communications	SCADA	Rectifier
33804	Systems	Communications	SCADA	AIM

Type	Category	Sub-Category	Element	Sub-Element
33805	Systems	Communications	SCADA	ATC
33806	Systems	Communications	SCADA	IDS
33807	Systems	Communications	SCADA	TRACS
33810	Systems	Communications	SCADA	Other
33850	Systems	Communications	Communications Huts	Hut
33851	Systems	Communications	Communications Huts	Room
34000	Systems	Central Revenue Collection	-	-
34100	Systems	Central Revenue Collection	Coin Counters	-
34104	Systems	Central Revenue Collection	Bill Counters	-
34105	Systems	Central Revenue Collection	Vault	-
35000	Systems	Revenue Collection	-	-
35100	Systems	Revenue Collection	In-Station	-
35104	Systems	Revenue Collection	In-Station	Turnstiles
35110	Systems	Revenue Collection	In-Station	System
35115	Systems	Revenue Collection	In-Station	TVMs
35116	Systems	Revenue Collection	In-Station	Encoding Machine
35117	Systems	Revenue Collection	In-Station	Parking Meters
35118	Systems	Revenue Collection	In-Station	Change Machines
35120	Systems	Revenue Collection	In-Station	Fare Control System
35130	Systems	Revenue Collection	In-Station	Passenger Counters
35200	Systems	Revenue Collection	On-Vehicle	-
35201	Systems	Revenue Collection	On-Vehicle	Fareboxes
36000	Systems	Utilities	-	-
36100	Systems	Utilities	Lighting	-
36101	Systems	Utilities	Lighting	Subway
36102	Systems	Utilities	Lighting	Yard
36200	Systems	Utilities	Drainage	-
36201	Systems	Utilities	Drainage	Subway
36202	Systems	Utilities	Pump Rooms	Subway
36203	Systems	Utilities	Deep Wells	Subway
36204	Systems	Utilities	Sump Pumps	Subway
36205	Systems	Utilities	Sump Pump Discharge Pipes	Subway
36206	Systems	Utilities	Fire Protection Plumbing	Subway
36301	Systems	Utilities	Ventilation - Fans	Subway
36302	Systems	Utilities	Ventilation - Control Systems	Subway

Type	Category	Sub-Category	Element	Sub-Element
36303	Systems	Utilities	Compressed Air Pipes	Subway
36304	Systems	Utilities	Air Conditioning/HVAC	Subway
36400	Systems	Utilities	Emergency Exits	Subway
36401	Systems	Utilities	Emergency Exits	Tunnel Handrail
37000	Systems	ITS	-	-
37001	Systems	ITS	APC	-
37002	Systems	ITS	AVL	-
37003	Systems	ITS	CAD	-
37004	Systems	ITS	GPS	-
40000	Stations	-	-	-
40051	Stations	Rail	CTA	At-Grade
40052	Stations	Rail	CTA	At-Grade Median
40053	Stations	Rail	CTA	Elevated
40054	Stations	Rail	CTA	Subway
40056	Stations	Rail	Metra	At-Grade w Building
40057	Stations	Rail	Metra	At-Grade w Historic Building
40058	Stations	Rail	Metra	At-Grade w Shelter
40059	Stations	Rail	Metra	Downtown Terminal
40060	Stations	Motor Bus	-	RTA Bus Passenger Facility
40061	Stations	Motor Bus	-	Pace Bus Terminal
40062	Stations	Motor Bus	-	Pace Bus Park & Ride
41010	Stations	At-Grade	-	-
41011	Stations	At-Grade	Motor Bus	-
41020	Stations	Elevated	-	-
41021	Stations	Elevated	Motor Bus	-
41030	Stations	Subway	-	-
41031	Stations	Subway	Motor Bus	-
41040	Stations	Transit Center	-	-
41050	Stations	Shelter	Motor Bus	-
41060	Stations	Ferry Terminal	-	-
44000	Stations	Building	-	-
44100	Stations	Building	At-Grade	-
44200	Stations	Building	Elevated	-
44300	Stations	Building	Subway	-
44400	Stations	Building	Components	-
44411	Stations	Building	Components	Building Electrical
44412	Stations	Building	Components	Lighting
44413	Stations	Building	Components	Fire Alarm
44414	Stations	Building	Components	Plumbing
44415	Stations	Building	Components	Drainage
44416	Stations	Building	Components	HVAC
44417	Stations	Building	Components	Roof
44418	Stations	Building	Components	Exterior
44419	Stations	Building	Components	Station Attendant Booth
44420	Stations	Building	Components	Interior
44421	Stations	Building	Components	Emergency backup system: UPS
44422	Stations	Building	Components	Emergency backup system: Generator
44423	Stations	Building	Components	Other
45000	Stations	Platform	-	-
45400	Stations	Platform	-	-
45410	Stations	Platform	Surface	-
45411	Stations	Platform	Surface	Concrete, asphalt, tile

Type	Category	Sub-Category	Element	Sub-Element
45412	Stations	Platform	Surface	Wood
45413	Stations	Platform	Ferry Dock	-
45420	Stations	Platform	Shelters	-
45430	Stations	Platform	Canopy	-
45440	Stations	Platform	Signage & Graphics	-
45441	Stations	Platform	Signage & Graphics	Electronic
45442	Stations	Platform	Signage & Graphics	Static
45450	Stations	Platform	Lighting	-
46000	Stations	Access	-	-
46100	Stations	Access	Roadway	-
46110	Stations	Access	Roadway	Auto
46120	Stations	Access	Roadway	Bus
46200	Stations	Access	Parking	-
46210	Stations	Access	Parking	Garage
46220	Stations	Access	Parking	Lot
46230	Stations	Access	Parking & Equipment	-
46300	Stations	Access	Pedestrian	-
46310	Stations	Access	Pedestrian	Elevators
46320	Stations	Access	Pedestrian	Escalators
46330	Stations	Access	Pedestrian	Pedestrian bridge
46340	Stations	Access	Pedestrian	Pedestrian tunnel
46350	Stations	Access	Pedestrian	Bike Lockers
50000	Vehicles	-	-	-
51000	Vehicles	Revenue Vehicles	-	-
55000	Vehicles	Revenue Vehicles	Bus	-
55100	Vehicles	Revenue Vehicles	Bus	Articulated bus
55110	Vehicles	Revenue Vehicles	Bus	Articulated bus -- CNG
55120	Vehicles	Revenue Vehicles	Bus	Articulated bus -- Diesel
55130	Vehicles	Revenue Vehicles	Bus	Articulated bus -- Hybrid
55200	Vehicles	Revenue Vehicles	Bus	Large Bus (40 ft)
55210	Vehicles	Revenue Vehicles	Bus	Large Bus (40 ft) -- CNG
55220	Vehicles	Revenue Vehicles	Bus	Large Bus (40 ft) -- Diesel
55230	Vehicles	Revenue Vehicles	Bus	Large Bus (40 ft) -- Hybrid
55300	Vehicles	Revenue Vehicles	Bus	Medium Bus (35 ft)
55310	Vehicles	Revenue Vehicles	Bus	Medium Bus (35 ft) -- CNG
55320	Vehicles	Revenue Vehicles	Bus	Medium Bus (35 ft) -- Diesel
55330	Vehicles	Revenue Vehicles	Bus	Medium Bus (35 ft) -- Hybrid
55400	Vehicles	Revenue Vehicles	Bus	Small Bus (<30 ft)
55410	Vehicles	Revenue Vehicles	Bus	Small Bus (<30 ft) -- CNG
55420	Vehicles	Revenue Vehicles	Bus	Small Bus (<30 ft) -- Diesel
55430	Vehicles	Revenue Vehicles	Bus	Small Bus (<30 ft) -- Hybrid
55500	Vehicles	Revenue Vehicles	Bus	Over-the-Road Coach
55700	Vehicles	Revenue Vehicles	Bus	School bus
55800	Vehicles	Revenue Vehicles	Bus	Trolleybus
55900	Vehicles	Revenue Vehicles	Bus	Double Decker bus
56100	Vehicles	Revenue Vehicles	Rail	AGT
56200	Vehicles	Revenue Vehicles	Rail	Cable Car
56300	Vehicles	Revenue Vehicles	Rail	Commuter Rail
56310	Vehicles	Revenue Vehicles	Rail	Commuter Rail: Locomotive
56320	Vehicles	Revenue Vehicles	Rail	Commuter Rail: Passenger Coaches
56330	Vehicles	Revenue Vehicles	Rail	Commuter Rail: Self-Propelled Coaches
56400	Vehicles	Revenue Vehicles	Rail	Heavy Rail

Type	Category	Sub-Category	Element	Sub-Element
56500	Vehicles	Revenue Vehicles	Rail	Light Rail
56510	Vehicles	Revenue Vehicles	Rail	Light Rail -- LRV
56520	Vehicles	Revenue Vehicles	Rail	Light Rail -- Historic Streetcar
56530	Vehicles	Revenue Vehicles	Rail	Light Rail -- Monorail
57000	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	-
57100	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Automobile
57200	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Heavy Duty (22 passengers or more)
57300	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Super Medium-Duty (22-pass)
57400	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Medium-Duty (14-pass)
57500	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Light-Duty (12-pass)
57600	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Mini-Van
57700	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Van
57810	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Taxicab sedan
57820	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Taxicab station wagon
57830	Vehicles	Revenue Vehicles	Small bus, paratransit, vans and autos	Taxicab van
58000	Vehicles	Revenue Vehicles	Other	-
58100	Vehicles	Revenue Vehicles	Other	Aerial Tramway
58200	Vehicles	Revenue Vehicles	Other	Ferry Boat
58300	Vehicles	Revenue Vehicles	Other	Inclined Plane
58400	Vehicles	Revenue Vehicles	Other	Jitney
59000	Vehicles	Non-Revenue Vehicles	-	-
59100	Vehicles	Non-Revenue Vehicles	Car	-
59200	Vehicles	Non-Revenue Vehicles	Truck	-
59300	Vehicles	Non-Revenue Vehicles	Special	-
59400	Vehicles	Non-Revenue Vehicles	Locomotive, Switch	-

Volume 2, Part 2

Criteria Investment Prioritization Process "How To" Guide

Pilot Product #2: Multi-Criteria Investment Prioritization Process

Prepared for

Regional Transportation Authority of Northeastern Illinois

September 2013

CH2MHILL®

Table of Contents

1. Introduction

1.1 RTA and Its Transit Service Boards

The Regional Transportation Authority of Northeastern Illinois (RTA) is the oversight, funding, and regional planning agency for the three transit operators (also known as Service Boards) that serve Northeastern Illinois:

- Chicago Transit Authority (CTA) – the nation's second largest public transportation system. The CTA service area covers the City of Chicago and 40 surrounding communities. Through its bus and rail systems, it provides more than 80 percent of public transit trips in the six-county Chicago metropolitan area (Cook, DuPage, Will, Lake, Kane, and McHenry counties) either with direct service or connecting service to Metra and Pace.
- Metra – commuter rail agency. Metra serves more than 100 communities in the six counties with 241 stations on 11 lines running from Chicago's downtown.
- Pace – suburban bus and regional paratransit. Pace is the suburban transit provider for the Chicago area. Pace serves riders with fixed bus routes, vanpools, and Dial-a-Ride programs covering 3,500 square miles spread over six counties and 284 municipalities. Pace is also the ADA paratransit provider for the region.

The RTA was created in 1974 through approval of a referendum by the residents of the six counties (Cook, DuPage, Will, Lake, Kane, and McHenry counties). The RTA is a special-purpose unit of local government and a municipal corporation of the State of Illinois. The three Service Boards - each led by a Board of Directors - individually handle their respective transit operations and fare responsibilities.

The RTA regional system is the third largest in the country, covers approximately 7,200 route miles, and provides more than two million daily rides. The RTA's combined assets include approximately 7,000 revenue vehicles, 380 rail stations, over 350 bus routes, and 60 maintenance facilities. With some of the nation's oldest transit assets, the RTA also has significant reinvestment needs to attain and maintain a state of good repair (SGR).

Table 1: Representative Service Board Resources and Transit Service Provided (2012)

	CTA Bus	CTA Rail	Metra	Pace
Revenue Vehicles	1,817	1,330	1,265	2,584
Other Vehicles	934		576	143
Fixed Guideway Route Miles	3.7	207.8	980.4	N/A
Annual Revenue Miles	52.4 million	65.2 million	47.41 million	35.1 million
Annual Revenue Hours	5.6 million	3.6 million	1.54 million	2.1 million
Annual Passenger Miles	725.0 million	1,541 million	1,768.8 million	256.3 million
Stations, Bus Stops and Transit Facilities	11,468 posted bus stops	145	269	9 transfer centers,
				9 Park-n-rides, 18 boarding/ turnaround facilities

Source: 2012 Operations data from CTA, Metra, Pace

1.2 FTA TAM Grant

In 2011, the RTA received an $800,000 Transit Asset Management (TAM) Pilot Project grant from the Federal Transit Administration (FTA). This pilot project includes TAM improvements that build off existing RTA TAM processes already in progress, namely the Capital Asset Condition Assessment, Capital Decision Prioritization Support Tool (now called the Capital Optimization Support Tool, COST), and management approaches already in use. The objectives of RTA's TAM grant include:

- Document RTA's existing policies; goals and objectives; performance targets and evaluation processes; and inventory/condition data collection, management, and reporting processes such that other local and regional operators can benefit from RTA's experience;
- Advance the TAM "state-of-the-art" capabilities in the areas of estimated capital investment needs and investment prioritization; and
- Develop asset-to-project groupings using the analytical foundation provided by RTA's existing project screening and prioritization process and FTA's Transit Economic Requirements Model (TERM) model.

The TAM Pilot Project is an 18 month process for RTA, which is documented in two volumes and the four work papers:

- Volume 1: Asset Inventory and Condition Assessment Guide
- Volume 2: Part 1 – RTA COST Model "How To" Guide, Pilot Product #4: Capital Prioritization Decision Support Tool
- Volume 2: Part 2 – Multi-Criteria Investment Prioritization Process "How To" Guide, Pilot Product #2: Multi-Criteria Investment Prioritization Process
- Volume 2: Part 3 – Asset to Project Mapping "How To" Guide, Pilot Product #3: Asset-to-Capital Project Numbering Convention.

This document presents the second "how to" Guide on development and application of automated, multi-criteria investment prioritization processes. This document is intended to be helpful to other operators or funding agencies developing and applying similar multi-criteria investment prioritization processes.

1.3 RTA's Multi-Criteria Prioritization Process

This "How to" Guide provides a detailed description of the steps taken by RTA to develop the investment prioritization routine used by RTA's Capital Optimization Support Tool (COST). As background, RTA's COST is an MS Access based tool (based on FTA's TERM Lite Model) designed to perform the following analyses for RTA and its three Service Boards:

1. Assess current size of SGR backlog.
2. Assess (estimate) current asset conditions.
3. Conduct assessment of 20-year unconstrained capital reinvestment needs.
4. Assess the impact of constrained reinvestment on:
    a. SGR backlog
    b. Asset Conditions
    c. Proportion of assets in SGR
5. Prioritize reinvestment (rehab and replacement) needs based on five investment criteria (asset condition, number of riders impacted and impact of investments on each of the following: reliability, safety, and O&M costs). Includes the prioritization of reinvestment needs for expansion assets assumed to be acquired during the period of analysis.

6. Prioritize investment in expansion/enhancement assets (as proposed by RTA and its Service Boards) based on investment cost per rider impacted.
7. Assess the impact of expansion/ enhancement investments on:
    a. SGR backlog
    b. Asset Conditions
    c. Proportion of assets in SGR.

COST's ability to assess the impact of constrained funding on the RTA region's future SGR backlog and asset conditions is dependent on its ability to prioritize between multiple SGR investment alternatives (i.e., given that funding is insufficient to address all needs, what needs should be addressed first?). Development of a reliable prioritization routine was therefore critical to providing COST with the ability to conduct meaningful analyses of the expected impacts of constrained funding. Note that much of the prioritization capability developed by RTA for COST has already been adopted and incorporated into FTA's TERM Lite model.

In addition to supporting "what-if" analysis of the potential future impacts of constrained funding, COST's ability to prioritize reinvestment needs was also intended to help support the identification and prioritization of actual reinvestment projects. Specifically, RTA and its Service Boards can therefore use the tool as an independent, objective review of the list of SGR investment projects identified by Service Board staff through traditional engineering processes. In this role, COST (and its prioritization routine) acts as a "devil's advocate", potentially identifying investment opportunities and prioritizations that RTA may not have otherwise considered.

<u>Approaches to Prioritization:</u> This Guide is meant to provide value to other transit operators and funding agencies seeking to develop or refine their own prioritization processes. To this end it is helpful to first be aware of the many approaches that can be taken to prioritization (and their related purposes) and the multi-criteria process developed by RTA represents a specific approach and purpose. It is important that all of the approaches to prioritization presented below are complementary to one another (as they all address different aspects of prioritization):

- <u>Analysis Tool-Based Prioritization:</u> RTA's COST falls into this general category. COST is an automated process that assesses the current and future reinvestment needs for an inventory of transit assets. The prioritization "routine" is therefore also fully automated and hence requires clear rules for prioritizing needs based on information recorded in thousands of asset records. This type of prioritization is best suited for (1) mid- to long-term "what if" analyses and (2) mid- to high-level evaluations of actual reinvestment plans (i.e., have actual plans identified all needs and might these needs be prioritized differently).

- <u>Facilitated, "Pair wise comparison" Prioritization:</u> Briefly, in this approach agency staff work together to establish which prioritization factors (criteria) are most important to the agency and how those factors should be weighted (note that this is actually also part of the development steps for COST's prioritization routine). This approach then assigns prioritization scores to proposed investment projects (i.e., how well does each project support each of the identified criteria?) and assigns each project a priority ranking, from highest to lowest, based on the prioritization score. Note that this approach is typically based on actual, identified projects (as opposed to COST which works with an inventory of assets). Some industry observers suggest that this approach is best applied after the projects have been well developed for the sake of reliably scoring against the selected prioritization criteria, and have already been identified for inclusion in the Capital Improvement Program. Here prioritization helps determine the ordering of these projects and to determine which projects will "just need to wait" when funding is limited.

- Detailed Project Review Process: Under this approach, traditional engineering processes are used to identify reinvestment needs and then an intensive analysis of each project is conducted to assess:
  - How does this project contribute to agency SGR/ service performance?
  - What is the Net Present Value?
  - What is the impact on agency capital and Operations and Maintenance (O&M) costs?
  - Acquisition, operation, maintenance and disposal requirements?
  - Detailed assessment of contribution to agency prioritization criteria/strategic or TAM goals?

  In contrast to the first two approaches, this analysis is very detailed for some projects (less so for less expensive, smaller projects). The results of this analysis can help feed the first two approaches.

Once again, these three approaches are all considered to be mutually supportive of one another.

Document Overview: The intention of this Guide is to provide a detailed review of the specific process used by RTA to develop the prioritization routine utilized in RTA's COST. Specifically, this Guide considers each of the following:

Chapter 2: RTA's Capital Planning Process
Chapter 3: Identification of Preferred investment criteria
Chapter 4: Development of measures to score each criterion
Chapter 5: Aggregating Criteria into a Single Prioritization Score

1.4 Definition of Terms

The following are definitions of key terms used in this Guide:

- Prioritization: For this Guide, prioritization is the process of identifying a preferred or optimal order for reinvestment events. Implicit in this statement is the assumption that:
  - *Funding is insufficient to address all needs.* Hence prioritization is required to determine which assets should be addressed first (and which assets may not be addressed).
  - *Investment needs can be ranked.* In other words, there are good analytic or other bases that can be used to rank investment needs – from highest to lowest—to determine which outstanding needs are most effectively addressed.

- Prioritization Criteria: Prioritization criteria provide the basis for determining the priority of individual investments. In general, investments are made with the expectation that the completed investment will yield improvements to one or more aspects of agency operations (e.g., improvements to reliability, efficiency, safety, rider comfort or other characteristic). Within a prioritization routine, the most desirable or important of these types of investment outcomes are referred to as "investment criteria". Investments that perform best with respect to these criteria (i.e., tend to be provide the best mix of desired outcomes) are assigned the highest priority. Investments that perform poorly may receive a low priority ranking.

- Prioritization Criteria Scores: For the purposes of this Guide, prioritization criteria should be quantifiable so investments can be assigned a numeric score that reflects their potential contribution to the desired outcome associated with that criterion (e.g., contribution to SGR). Note that numeric criteria scores facilitate objective comparisons between investment options. Given that different criteria may naturally be associated with specific unit quantities (e.g., condition rating for SGR and dollar values for operating costs), these score need to be converted to a common basis if the intention is to generate a multi-criteria prioritization score.

- Multi-Criteria Investment Prioritization (criteria weighting): Multi-criteria investment prioritization refers to the process of evaluating and prioritizing investment options based on each investment's performance against a mix of investment criteria. In the context of this Guide and RTA's COST, multi-criteria investment prioritization implies that (1) all criteria are individually scored on a common scale (e.g., running from 1 to 5) and (2) these criteria scores are combined into a weighted average score, with the weight placed on each criterion reflecting its relative importance.

The following definitions for State of Good Repair (SGR) separate the asset level from aggregate level.

- Asset Level SGR: An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

- Mode, Service Board, or Regional Level (Aggregate) SGR: A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.

- Reinvestment in existing assets versus Investment in New Expansion or Enhancement Assets: COST is designed to assess and prioritize investment needs for both existing and expansion assets. In general, these investment types fall into the following categories:
    - *Reinvestment in Existing Assets:* Refers to rehabilitation and replacement or SGR investments in assets that are currently in service
    - *Investment in expansion assets:* Refers to the planned/proposed future purchase of new assets that either: (i) expand existing service capacity (e.g., fleet expansion), (ii) adds a new service (e.g., New Starts) or (iii) enhances existing service (e.g., new technologies such as real-time arrival information).

  The prioritization criteria discussed in this Guide generally refer to reinvestment choices, as the capability to prioritize new acquisitions, or expansion assets, is being developed in COST though not as part of the TAM grant itself.

2. Background – RTA Capital Planning and Prioritization Process

This chapter provides background on RTA's capital planning and prioritization processes including:

- Overview of regional capital budget development processes
- RTA's preexisting prioritization processes
- RTA's COST
- Overview of COST's prioritization process

2.1 RTA's Capital Plan Development Process

In 2006, the RTA, along with the Service Boards developed a Strategic Plan to raise awareness of the need to maintain, enhance and expand transit service in the region. The Authority's Strategic Plan included further goals of enhancing coordination, integrating information, and improving system access and ease of use. One of the purposes of the Strategic Plan was to provide a long-range plan to guide the region in achieving a world-class public transportation system that is the keystone to growing business opportunities, a thriving job market, clean air and livable communities over the coming decades. This work provided the foundation for the subsequent funding and reform legislation enacted in January 2008 as P.A. 95-0708. The legislation mandates the RTA to provide more effective financial oversight, regional planning, and coordination among the three operating Service Boards. In enhancing the role of the RTA, the legislation makes the Strategic Plan the cornerstone of all RTA planning, financial and oversight activities. The update to the Strategic Plan established a capital evaluation process for budget development; and established 10-year financial plan requirements and how they guide decision making. To deliver the financial portion of the plan, the RTA created the Capital Program Oversight Prioritization Process Task Force, with the participation of the three Service Boards.

In July of 2008, the RTA Board adopted Ordinance No. 2008-46 endorsing the work done by the RTA and the Service Boards Capital Program Oversight Prioritization Process Task Force and adopting the processes developed on an interim basis for capital evaluation in the 2009 budget development (see pages 7-3 and 7-4). This process, which became a permanent requirement of budget development, employs a multi-layered configuration to determine which capital projects become programmed in the five-year capital plan and annual budgets. This consists of a screening process that groups potential projects into related types of investments (e.g., preservation, expansion or enhancement) followed by a prioritization process that scores each proposed investment based on its customer impacts, mission criticality, ridership impacts and a benefit-cost test, and finally a programming process that overlays another set of criteria, such as project readiness, to determine the actual programming of the prioritized projects.

2.2 Role of Prioritization in RTA Capital Planning Process

In 2010 the RTA engaged in the development of the Capital Optimization Support Tool (COST) and completed the Asset Condition Assessment (new Transit Asset Management Initiatives) to report the region's capital backlog and 10-year capital needs. Subsequently the RTA updated the report in 2012 and is currently working on the 2013 update report. The RTA will incorporate the new TAM initiatives in a holistic manner that will utilize reports from COST that use quality data and well defined objectives and criteria for the update of capital planning and annual budgeting processes. This will help to transparently collaborate in the determination of budgetary needs resulting in the optimal allocation and subsequent greater straightforwardness in the obtaining of funding for required projects to obtain and maintain a SGR.

Currently, the RTA collects data from the Service Boards regarding potential capital projects to be included in the RTA's Capital Program. The RTA requests the Service Boards to provide certain information for each individual proposed project to be included in the Capital Program.

The proposed projects should fall into one of three categories: maintenance, enhancement and expansion. The project scope should include a complete description of the project including all significant elements; project justification including specific goal and purpose, quantifiable impacts on operating and cost or service reliability as well as ridership increases and State of Good Repair (SGR) progress. The Service Boards should include in the Capital Program a general discussion regarding SGR achievement for major system components within each Asset Category.

The RTA requires the Service Boards to use COST to assist them in this analysis. The Service Boards provide a parallel comparative analysis component report from COST to justify the proposed capital project.

2.3 RTA's COST

In April 2011, RTA initiated development of the Capital Decision Prioritization Support Tool (now COST). COST is an MS Access based database and model that houses a comprehensive inventory of all major capital assets owned and operated by RTA's three Service Boards: CTA, Metra and Pace. COST also includes asset type specific life expectancies and life cycle reinvestment rules which are used to allow the tool to assess or predict each of the following:

- Current size of SGR backlog
- 20-year unconstrained capital reinvestment needs
- The impact of constrained reinvestment on:
    - SGR backlog
    - Asset Conditions
    - Proportion of assets in SGR.

<u>Need for Prioritization:</u> COST's ability to assess the impact of constrained funding on the RTA region's future SGR backlog and asset conditions is dependent on its ability to prioritize between multiple investments. More specifically, when funding is not sufficient to address all investment needs (i.e., funding is constrained), then the Tool requires rules to determine which needs are addressed and which needs will enter the backlog. The prioritization rules allow the Tool to rank investment needs from highest to lowest priority. For each year of constrained funding then, COST reorders investment needs from highest to lowest priority and then invests in these needs from highest to lowest until the available funding capacity for that year is exhausted. This process is repeated for each year of COST's 20-year forecast period.

<u>Prioritization - Backlog Management:</u> As described to this point, COST's prioritization routine is used as a means to allocate funding between competing needs for the purpose of assessing the impact of alternative reinvestment priorities on the size and composition of the region's SGR backlog. As different reinvestment priorities will lead to some asset needs being address and others entering the SGR backlog, adjusting these priorities and their weights allow an analyst to use COST to examine the desirability of alternative investment prioritization weights with respect to the SGR backlog. COST can then help identify a preferred mix of priorities that can be used to guide actual reinvestment priorities within the region.

Prioritization - Capital Programming: Note however that COST's prioritization capabilities can also provide a more direct input to the region's investment prioritization process. Specifically, RTA and the Service Boards can compare COST's selected reinvestment priorities, for specific asset types and locations, with the reinvestment priorities identified through traditional engineering methods (e.g., as documented in the CIP and capital budgets). In this role, COST provides an independent, objective and alternative review of the region's engineering-based reinvestment plans. This comparison can help further refine and prioritize those plans, potentially leading to improved investment decisions.

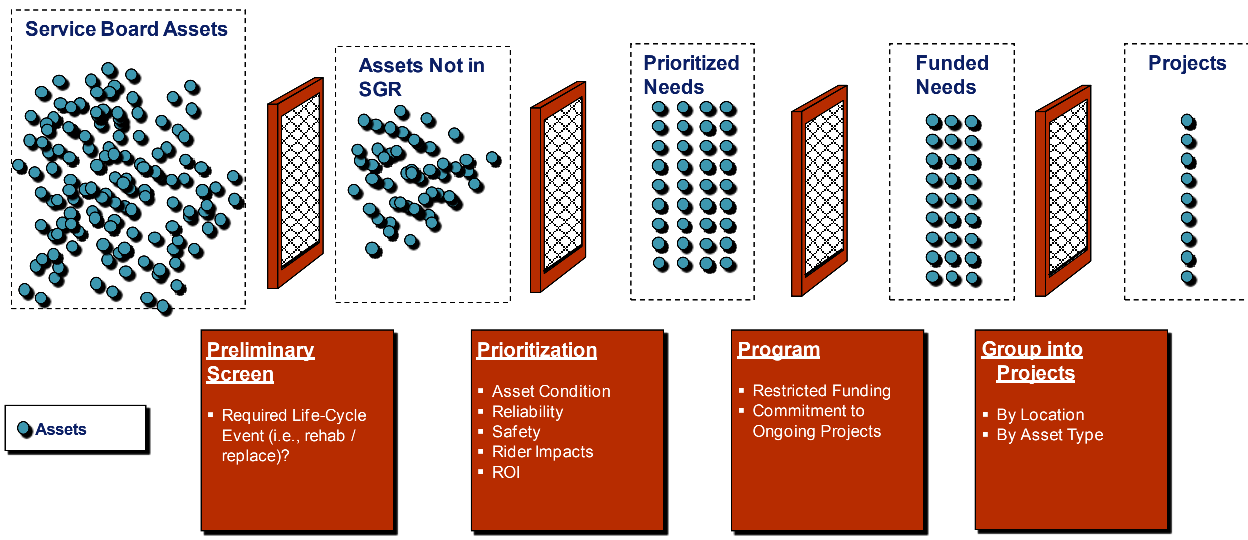
COST and the TAM Multi-Criteria Investment Prioritization Process: RTA's objective in developing the multi-criteria investment prioritization process was to equip COST with the two types of prioritization capabilities described above:

- Ability to analyze the impact of alternative investment priorities on future backlog needs and
- Support the prioritization of actual investments (through comparison for COST investment selections with engineering-based project selections)

Hence, all of the prioritization development actions described in this Guide have been conducted with the purpose of providing RTA's COST with these two capabilities.

A conceptual representation of the role of prioritization within RTA's COST is depicted below in Figure 2-1 with example prioritization criteria.

Figure 2-1: Role of Prioritization within RTA's COST



For each year of a 20-year model run, COST first identifies which of the region's assets require some reinvestment action (e.g., rehab or replacement) to attain SGR. Next, the Tool assigns prioritization scores to each of these assets and will reinvest in the highest scoring assets until the expected amount of reinvestment funding for that year is exhausted. Using this prioritization, COST then determines for each year, what assets undergo reinvestment actions, what assets do not (and enter the SGR backlog) and what projects result from the investment actions.

2.4 Development of COST's Prioritization Criteria Metrics – Overview

The remaining sections of this report describe:

- The identification and development of the prioritization metrics now embedded in RTA's COST and
- The application of those prioritization metrics, both within the tool (for analysis purposes) and in support of actual investment planning.

This includes discussion of the:

- Processes used to identify the region's preferred prioritization criteria
- Translation of those criteria into quantifiable metrics
- The analytic processes used to weight each criterion and
- How these measures are used by COST itself.

Finally, this Guide explains how RTA plans to apply the tool for needs analysis and budget development support purposes.

3. "How to" Guide to Select Prioritization Criteria

This chapter provides background on the processes used by RTA to select a preferred set of regional investment criteria. Given that the RTA remains focused on SGR related investments, this discussion is similarly focused on prioritization criteria relating to reinvestment (i.e., rehabilitation and replacement) in existing assets. This chapter does, however, have some high level discussion of investment criteria for investments that enhance or expand the region's transit services.

Specifically, this chapter describes each of the following:

- Prioritization Selection Workshops
- Selecting criteria that match agency TAM goals
- Can criteria be quantified?
- Selecting criteria based on investment types: SGR, enhancement and expansion investments.

Note that this chapter is focused solely on the region's approach to selecting the preferred criteria.

3.1 Prioritization Criteria Workshops

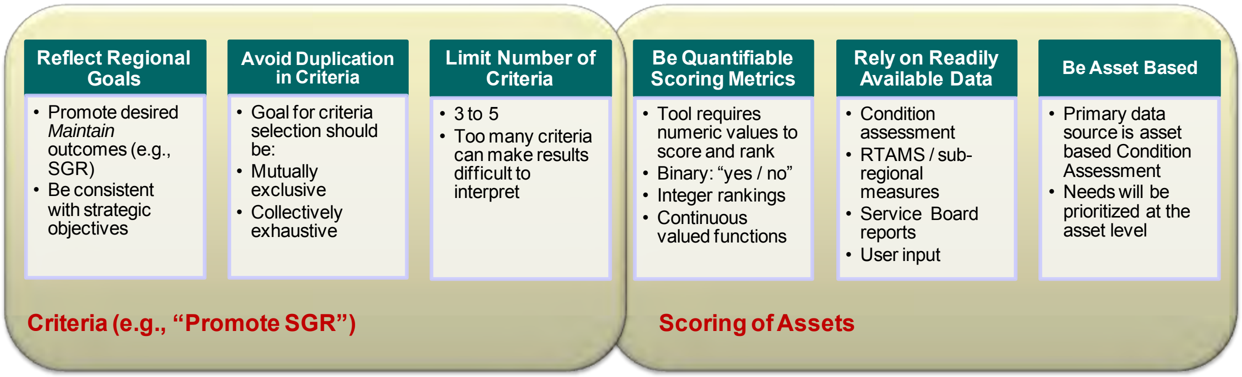
A key objective for RTA in developing COST, the Tool's prioritization capabilities and the related regional condition assessment process is to ensure regional consensus on how these and other regional capital planning issues are addressed. To help build this consensus with respect to prioritization criteria selection and measurement, RTA convened a series of Prioritization Criteria Workshops in early 2011. The express purpose of the workshops was to select and develop the region's prioritization criteria. The workshops were attended by select capital planning and engineering staff from RTA and each of its three Service Boards. Members of the RTA workshops are hence referred to as "working group". Note that many of the workshop participants were also members of a Capital Working Group that meets regularly to address other issues relating to regional capital investment needs. The workshops were facilitated by consultant staff from CH2M HILL, that were also tasked with overall development of COST. The remaining sections of this chapter review the basic approach and steps taken to identify the region's preferred investment prioritization criteria.

3.2 Principles of Criteria Selection

Prior to reviewing and considering specific investment criteria, the Prioritization Criteria Workshop participants first agreed on the principles for criteria selection as outlined in Figure 3-1. These principles breakout into the following groups:

> <u>Reflect Regional Strategic Goals:</u> The selected criteria should be consistent with the region's strategic goals – including those relating to SGR, service performance, safety, service expansion, etc. – as outlined in the agency's strategy and policy documents and mission statement. The criteria should, of course, also align with any adopted Transit Asset Management (TAM) policies. While the RTA and its Service Boards have yet to adopt formal TAM policies, attaining a regional "state of good repair" is nonetheless a clear and primary reinvestment objective, and hence needs to be reflected in criteria selection.

Figure 3-1: Criteria Selection Principles



Avoid Duplication: A recognized principle to prioritization criteria selection is to ensure that the selected criteria are:

- Mutually Exclusive: No two criteria rate an investment on essentially the same measure. A simple example of two non-mutually exclusive criteria would be (1) asset age as a proportion of useful life and (2) asset condition. Given that asset condition is generally (though not always) closely correlated with proportion of asset age consumed, these two criteria carry much of the same "information" on the need to reinvest in any given asset. Therefore, including both measures in a prioritization evaluation would tend to reinforce much of the same information while adding little new information on the state of the asset. It is better to stick with the most comprehensive criterion among those that are correlated (e.g., asset condition in the example above). In practice it can be challenging to avoid some overlap between prioritization criteria as many types of transit investment activities (e.g., fleet replacements) tend to always perform well with respect to many seemingly unrelated criteria (e.g., impacts on condition, reliability, safety, operating costs) while other investment types (e.g., maintenance equipment replacement) have little impact on the same criteria.

- Collectively Exhaustive: In a perfect world, the selected investment criteria would also cover all factors the agency considers important to prioritization. This is generally not feasible in practice as the number of "important factors" may prove to be extensive (too many criteria to monitor) and some investment factors may not be measured with sufficient reliability (e.g., "rider comfort"). In this regard RTA opted to focus on a limited set of criteria that together provide a wide, if not fully comprehensive, coverage of prioritization factors.

Limit the Number of Criteria: Scoring investments using numerous investment criteria can make it difficult to interpret why some investments score better than others and whether investments with very similar scores are really equally desirable. Participants in RTA's Criteria workshops agreed it would be best to limit the number of criteria to a relatively short list – thus sacrificing some comprehensiveness in favor of more understandable, and hence more credible, prioritization results.

Quantifiable: As already noted, RTA's ultimate goal with the criteria selection process was to have COST assign a numeric prioritization score (and weighting) to all regional transit asset reinvestment needs. This prioritization score assesses how reinvestment in a specific asset (e.g., replacement of a bus fleet) is expected to satisfy a mix of preferred investment criteria. Given that this overall prioritization score is numeric, it follows that each of the component criteria within that score must also be assigned a numeric value. In other words, all of the selected criteria must be quantifiable. While this requirement does *not* mean that the underlying criteria cannot be qualitative in nature, it does mean that the group selecting the preferred criteria must come to terms with (1) *how* qualitative criteria might be quantified in such a way that (2) the resulting prioritization scoring for those qualitative criteria will be considered credible when compared to naturally quantitative measures. A good example here is "rider comfort": how can rider comfort be quantified such that the quality of this measure is credibly comparable to more measurable criteria like number riders impacted by an investment?

Rely on Readily Available Data: The prioritization scoring within RTA's COST was to be fully automated due to the number of asset records (i.e. the Tool assigns prioritization scores based on information on the individual assets documented in the region's asset inventory). Therefore the scoring must rely on that same asset data and other existing data sources that can be tied to those assets. RTA must also be able to update and rerun the prioritization routines on a repeatable basis, well into the future. Moreover, the RTA and the Service Boards did not wish to develop and maintain new primary data collection processes to support this prioritization scoring. Hence, the scoring process needed to rely on existing data sources.

Given that RTA's current asset inventory (as of this writing) includes close to twelve thousand asset records, there is very little to no opportunity to fine tune the prioritization scoring for individual assets. Hence, prioritization routine must be fully automated and the data used to run the prioritization routine must be available for all asset types included in the inventory.

Asset Based: RTA's asset inventory houses data on and evaluates the life cycle needs of individual transit assets. Hence the current prioritization routine and the criteria are also focused primarily on the reinvestment needs of individual transit assets. Therefore, the tool does not technically evaluate the investment needs of "projects", where projects may represent the bundled reinvestment needs for multiple assets. While the tool increasingly has the capability to bundle related assets into projects, this is done primarily to help RTA and the Service Boards "recognize" *potential* investment projects, not as a means of prioritizing *actual, programmable* projects.

Override: On occasion, it should be expected that the reinvestment needs for individual assets will not be well represented by the selected investment criteria. To help address this issue, RTA and the Service Boards identified the need to be able to "override" the automated prioritization scoring to ensure that some asset reinvestment needs attain high investment priority, despite their calculated scoring against the selected criteria. This function permits early replacement of assets that have failed well before the end of their useful life, or to address a special government mandate.

3.3 Criteria Evaluated for Selection

Having agreed on the principles for selecting a preferred set of criteria, the Workshop next assembled a detailed listing of the potential investment criteria to choose from. Once again, this list is intended to focus on prioritizing investments related to the rehabilitation or replacement of existing assets (and not investments to expand capacity or to acquire new technologies to enhance service). This list was assembled from a variety of sources:

- RTA and Service Board Policy and Mission Statement documents: RTA and Service Board strategy, policy and mission statement documents were reviewed to identify potential investment criteria
- RTA and its Service Boards: Prioritization criteria currently or recently used by RTA and its Service Boards
- Peer Agencies: Prioritization approaches and criteria used by peer transit operators
- Other Transportation Sectors and Sources: Criteria used by US state DOTs (highways) and in other countries (e.g., Great Britain, Australia, EU)
- Other Industries: Common prioritization criteria used for asset management purposes in other industries such as wastewater and utilities

Based on these reviews, RTA's Criteria Workshop participants identified a list of thirteen potential investment criteria from which three to five preferred criteria would be selected. This listing is presented below in Figure 3-2. As a first pass through this list, the participants were asked to rate each of these thirteen potential criteria as being:

Figure 3-2: List of Potential Investment Criteria – For Rehab and Replace Investments

Potential Investment Criteria	Critical ✓	Valuable but Not Critical ✓	Low Value / Not Relevant ✓
SGR/Asset Condition	✓		
Cost effectiveness/benefit-cost	✓		
Reliability	✓		
Safety	✓		
Security	✓		
O&M Cost Impact	✓		
Environmental		✓	
Transit Oriented Development (TOD)			✓
Regulatory Requirements/Mandates	✓		
Riders Impacted	✓		
Ridership Gain		✓	
Employee Impacts	✓		
Technology			✓

- <u>Critical:</u> Criterion is key to effective prioritization and must be included in the final listing of preferred criteria ("must have").
- <u>Valuable but Not Critical:</u> Criterion is valuable but not critical to investment prioritization ("nice to have").
- <u>Low Value / Not Relevant:</u> Criterion is of low (or no) importance or relevance to reinvestment prioritization for rehab-replace investments.

For RTA, the assignment of potential criterion as being "Critical", "Valuable but Not Critical", or "Low Value / Not Relevant" was attained through open discussion between RTA and Service Board Workshop participants. This process did yield general (but not complete) consensuses on which criteria were considered preferred. The first pass through the list also resulted in the selection nine preferred criteria, thus exceeding the target range of three to five final criteria (see checked boxes in Figure 3-2). Steps taken to reduce this list are described in the next section.

Of the remaining criterion, two were considered valuable but environmental impacts of reinvestment were considered to be primarily situation dependent and not easy to automate in COST and ridership gains from SGR investments are difficult to measure credibly. Two other criteria – Transit Oriented Development and technology impacts – were considered not sufficiently relevant to reinvestment projects (these criteria are considered better suited to prioritization of enhancement and expansion investments).

3.4 Narrowing the List

The working group next adopted two approaches to reducing the resulting list of nine preferred investment criteria to a more manageable list of five at the most:

- Criteria Correlation Assessment: Evaluate correlations between criteria to determine if sufficient correlation exists between pairs of criteria to remove some criteria from this list
- Other Solutions: Consider approaches to combining criteria and or adopting other strategies to prioritize some criteria without directly including them in the final list of criteria.

Criteria Correlation Assessment: The results of the criteria correlation assessment are presented below in Figure 3-3. Based on this assessment, participants determined to do the following:

- Select Riders Impacted and Drop Cost Effectiveness: There is significant correlation between the number of riders impacted by a reinvestment action and the cost effectiveness of that action (i.e., cost of action divided by number of riders impacted). Moreover, cost effectiveness measures for piecemeal reinvestment actions (i.e., where only a portion of a full transportation system is replaced) can yield problematic prioritization results. For example, replacement of an inexpensive radio that supports service to a modest number of riders can yield a very low cost per rider value whereas replacement of an important rail bridge that is very expensive but important to a very high number of riders will likely yield a higher cost per rider value. But is it really less cost effective? In practice this approach will favor low cost items (like radios) at the expense of higher cost but critical items (like bridges). In general, the cost effectiveness measure is better suited to replacement or initial acquisition of complete transportation systems (as with New Starts projects) and not for individual asset replacements modeled in RTA's COST. For this reason, number of riders impacted was selected over cost-effectiveness.

Figure 3-3: Correlations between Potential Criteria

Criteria	SGR (Condition)	Safety	Security	Reliability	Cost Effective	Rider Impacts	Ridership Gain	Operating Cost	Investments to:
SGR (Condition)									Improve asset condition
Safety	High								Reduce likelihood of accidents
Security	Low	Moderate							Reduce likelihood of assault, theft, vandalism
Reliability	High	High	Low						Improve service reliability
Cost Effective				Moderate					Cost per rider / employee impacted
Riders Impacted	High	Moderate	Moderate	High	High				Number of riders impacted
Regulatory	?	?	?	?	?	?			Attract new riders / maintain existing
Operating Cost	Moderate	Low		Low					Reduce O&M costs
Employee Impacts	Low	High	Moderate			Moderate		Moderate	Employee comfort, safety and productivity

- Employee Impacts: This criterion was intended to capture the impacts of reinvestment on the safety, productivity and general work environment of transit agency staff (e.g., vehicle operators, maintenance and operations staff). The working group determined that while this consideration was very important, the impacts of reinvestment on the transit staff safety, productivity and general work environment were actually fairly well to very well correlated with other criteria (specifically, safety & security, and O&M cost impacts) and hence did not warrant a separate measure.

- No Other Changes Based on Correlation Analysis: While it was determined that several of the preferred criteria were moderately to highly correlated with one another, the working group also determined these criteria were sufficiently different from one another that they should not be eliminated or combined. For example, it was agreed that investment actions that tend to favor reliability also frequently favor safety and O&M cost improvements (e.g., replacement of an aging fleet). Yet, these three criteria are each focused on different investment outcomes and there are times or asset types when they are not well aligned.

Other Solutions to Address Preferred Criteria: The objective under this approach was to consider methods of combining criteria and/or adopting other strategies to prioritize some criteria without directly including them in the final list.

- Safety/Security: The working group made the decision to combine safety and security into a single prioritization criterion. This was done given (1) the common association of these two criterion and (2) the eventual solution used to score these two criterion supported their combination (as discussed in the next chapter; the decision to group these two criteria actually occurred after the Criteria Workshops were completed and RTA had initiated criteria scoring).

- Regulatory Requirements/Mandates and Environmental: Ensuring that the prioritization process takes regulatory requirements, state and federal mandates and environmental impacts into consideration was also considered to be critical. However, implementation of these criteria within an automated COST was also considered to be problematic as these types of issues tend to be very situation specific (e.g., they may apply to some assets of a given type and not others, or may apply to one reinvestment cycle and not follow-on cycles, etc.). Moreover, the nature of new regulations and mandates frequently require that the regulation/mandate be addressed in the short - to medium-term – implying that the impacted assets should be assigned a very high overall replacement priority, regardless of current age or condition. Therefore, to address these related criteria and also to aid with similar situation specific high prioritization assignments (e.g., early replacement of failed assets), the working group developed a prioritization "override". Specifically, the override is a "yes/no" value that COST users assign to assets that need to be replaced as soon as possible based on safety, regulatory, and/or failure prior to expected end of useful life considerations. COST sets all assets to "no" as a default. When assets are assigned an override value of "yes" by the user (e.g., to replace existing train control with positive train control, as required for commuter rail operators), those assets are assigned a very high, overall prioritization score (regardless of how the assets score based on the five automated criteria).

The final list of preferred criteria as selected by RTA for rehab and replacement investments is identified below in Figure 3-4.

Figure 3-4: RTA's Selected Investment Criteria

Investment Criteria	Assesses Impact of Reinvestment Action on…
SGR	Improvement to asset condition
Reliability	Improvement to service reliability
Safety & Security	Reduced likelihood of accidents, assaults, robbery or vandalism
O&M Cost Impact	Reduction in O&M costs
Riders Impacted	Number of riders impacted by asset rehab/replacement

3.5 Reinvestment, Expansion and Enhancement

As noted above, it is intended that RTA's COST will ultimately be capable of prioritizing service enhancement and expansion investments (e.g., New Starts projects), in addition to the rehabilitation and replacement of exiting assets. With its own funds, the RTA has developed a preliminary view of how to approach prioritization of these differing types of investments going forward based on their strategic and TAM goals. The key takeaway from that work is that different types of investment criteria are appropriate for different types of investments. For example, SGR investments do not tend to generate significant ridership increases while expansion investments, by definition, do increase ridership.

4. "How to" Guide to Develop Criteria Measures

The preceding chapter focused on the selection of a preferred set of five prioritization criteria for SGR related investments that are automated in COST. In contrast, this chapter focuses on the identification and development of actual measures for the selected criteria. Consistent with the selection process, the identification of preferred criteria *measures* was ultimately conducted in a workshop setting with members of the same group of RTA, Service Board and consultant staff participating (working group).

4.1 Criteria Scoring Measure Identification

The first step in implementing the preferred criteria was to identify specific measures used to assess how different investments will score with respect to each of the five criteria (SGR, reliability, safety and security, rider impacts and O&M cost impacts). The list of scoring options for these five criteria, including each metric's pros and cons, is presented below in Figure 4-1. The final selections made by the working group participants are identified by a check mark. For agencies working to develop their own prioritization criteria, the primary "takeaways" from Figure 4-1 are the following:

- Developers should consider a range of potential measures for each criterion
- The selected metric should both (1) provide a credible measure for that criteria and (2) be supported by available data sources.

Figure 4-1: Criteria Scoring Measure Identification

Scoring Method	Pros	Cons	Ongoing Data Requirements	Final ?
SGR				
Asset Condition: FTA's 5 to 1 decay curves	• Increasing score as assets age • Consistent by asset type		• Asset age • Utilization (opt)	✓
Asset Condition: Condition Assessment Age Quintile "buckets"	• Easy to implement/ • understand	• No change in score once asset exceeds useful life	• Asset age	
Override: Allow user to predetermine condition values for *some* assets	• Addresses assets with premature replacement needs		• User input for specific assets	
Reliability				
Binary: "Yes / No" (by asset type)	• Easy to implement/ • understand	• Yes/no too coarse		
Fixed Ranking Scale: e.g., 1 to 5 (by asset type)	• Easy to implement/ • understand	• Invariant with asset condition		
Dynamic: Driven by condition (Reliability declines as condition declines)	• Better reflects relationship of condition and reliability	• Actual relationship not known	• Condition inputs • Relationship	✓
Dynamic: Driven by age (Reliability declines as age	• Relationship between vehicle age and MDBF	• Actual relationship not known for non-	• Age inputs • Relationship	

Scoring Method	Pros	Cons	Ongoing Data Requirements	Final ?
increases)	somewhat known	vehicle asset types		
Safety & Security				
Binary: "Yes / No" (by asset type)	• Easy to implement/ understand	• Yes/no too coarse		
Fixed Ranking Scale: e.g., 1 to 5 (by asset type)	• Easy to implement/ understand	• Invariant with asset condition		✓
Riders Impacted				
Count: Count of riders serviced by each asset	• Easy to understand	• How many riders per admin/maintenance facility? • Large magnitude differences in riders serving different assets	• Matching assets to number of riders utilizing those assets (by division, rail line, station)	
Fixed Ranking Scale: e.g., 1 to 5 integer based scale based on differing volumes of riders	• Easy to understand	• Big jumps between levels	• Matching assets to number of riders utilizing those assets (by division, rail line, station)	
Logarithmic Ranking Scale: e.g., 1 to 5 continuous based scale on differing volumes of riders	• Easy to understand	• What's a five and what's a one?	• Matching assets to number of riders utilizing those assets (by division, rail line, station)	✓
O&M Cost Impacts				
Binary: "Yes/No" (by asset type)	• Easy to implement/ understand	• Yes/no too coarse	• Binary: "Yes/No" (by asset type)	
Fixed Ranking Scale: e.g., 1 to 5 (by asset type)	• Easy to implement/ understand	• Invariant with asset condition	• Fixed Ranking Scale: e.g., 1 to 5 (by asset type)	✓
Dynamic: Driven by condition: • O&M costs increase as condition declines	• Better reflects relationship of condition and reliability	• Actual relationship not known	• O&M costs increase as condition declines	**TBD**

There are a number of common approaches used to develop the metrics for the preferred set of criteria listed in Figure 4-1:

- <u>Binary (yes/no) Scores:</u> In some instances, investment criteria can be scored as being either "yes" or "no" meaning that they either contribute to the desired outcome associated with that criterion or they do not. While this "yes"/"no" situation does not apply to any of the five criteria selected by RTA, it does apply to the override function used to bypass the prioritization score. For example, if a set of assets need to be replaced immediately due to a government mandate, applying the RTA override for these assets effectively says "yes" these impacted assets attain the override priority score and "no", all non-impacted assets do not.

- 1 to 5 scales: Each of the five criteria selected by RTA have been scored on a common 1 to 5 scale. While this scale is not associated with any specific units (e.g., "feet" or "dollars"), the scores for the individual criteria ultimately have been derived from unit quantities associated with those criteria (e.g., condition ratings for the SGR score and number of riders for the riders impacted score).
- Fixed Scoring vs. Dynamic Scoring: RTA's approach to scoring for some criteria is driven at least in part by asset type. The logic being that investment in some asset types tends to yield more of the desired outcome than does investment in other asset types. For example, replacing aging bus vehicles tends to yield better impacts to service reliability than does replacement of bus shelters. Under fixed scoring based on asset type, each asset type is assigned a specific score from the 1 to 5 scale (e.g., in the example above 5 for buses and 1 for bus stops), regardless of any other contributing factors. In contrast, RTA adopted scoring measures for the reliability, safety and security criteria that are a mix of (1) fixed scoring by asset type and (2) dynamic scoring to reflect the estimated physical condition of the asset (see Figure 4-2). Hence for the example above, replacing aging buses will always yield a better impact on service reliability than bus shelter replacements, but replacing a 16 year old bus will yield a better reliability return than will replacing a 12 year old bus. Hence, the criteria score is "dynamic" as it will continually change with the age of the asset. Eventually, O&M cost impacts will also have a mixed prioritization score

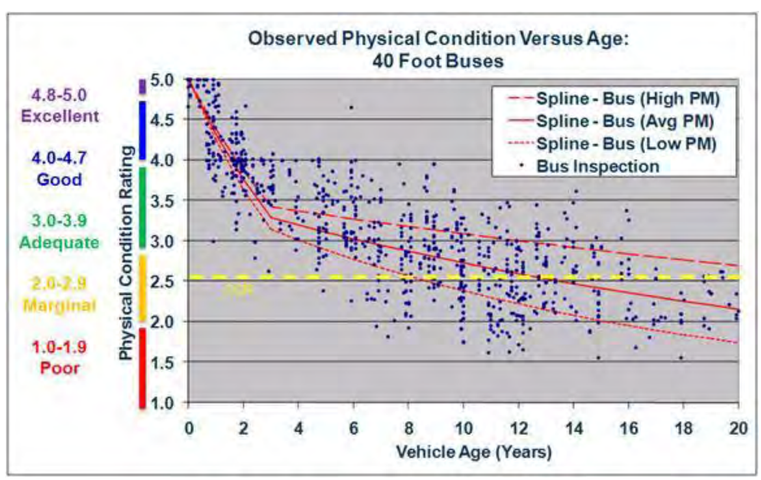
4.2 Criteria Scoring Measure Quantification

The final step in developing criteria measures was to identify the specific approach to quantifying the score for each criterion. This section considers the development of metrics individually:

- SGR/Condition
- Reliability
- Safety and Security
- O&M Cost Impact
- Riders Impacted

State of Good Repair/Condition

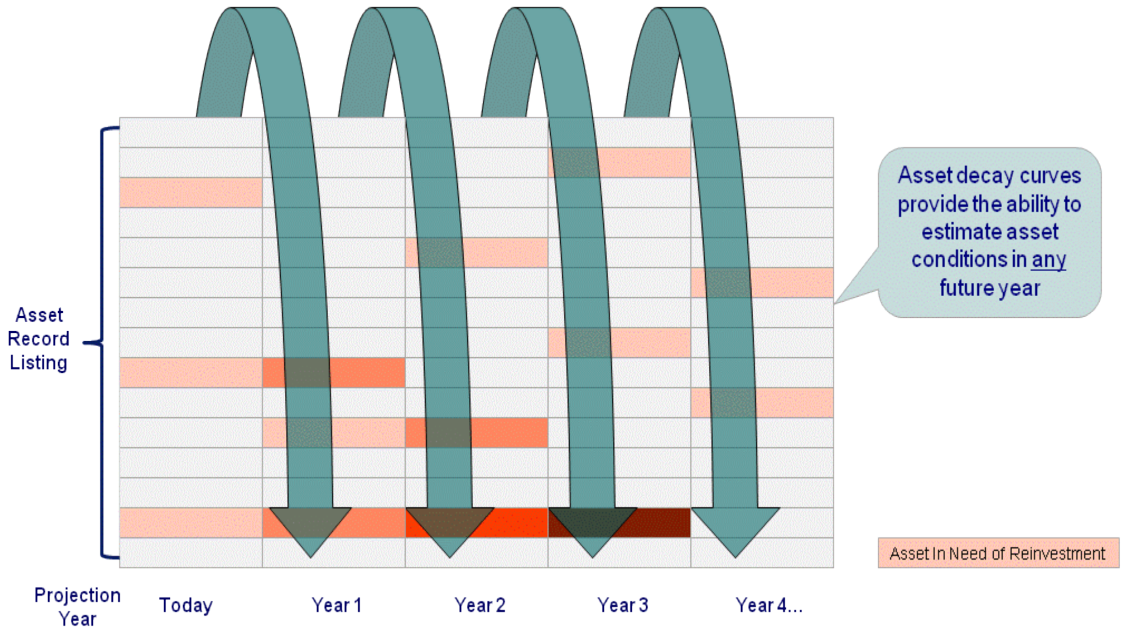
RTA and the working group members quickly identified FTA's decay curves as the preferred approach for assigning SGR criteria scores. FTA's decay curves were considered to offer the following benefits:



- Based on a 5 (like new / excellent) through 1 (poor) condition scale common to all asset types, so wide differences in asset useful life across asset types are addressed by a common scale

- Available for all transit asset types
- Decay curves predict condition as function of age for all assets and include asset utilization and other factors for some assets
- Age and other required factors are already recorded in RTA's asset database
- Dynamic: decay curves allow the condition/SGR measure to be reevaluated continuously over every year of COST's twenty-year model run as actual assessments of current condition today, will not work to assess replacement prioritization of a given asset 5, 10 or 15 years into the future, when the condition of that asset will have changed significantly
- No need to conduct expensive on-site condition assessments for all transit assets
- Decay curves reflect the actual decay experiences of US transit assets

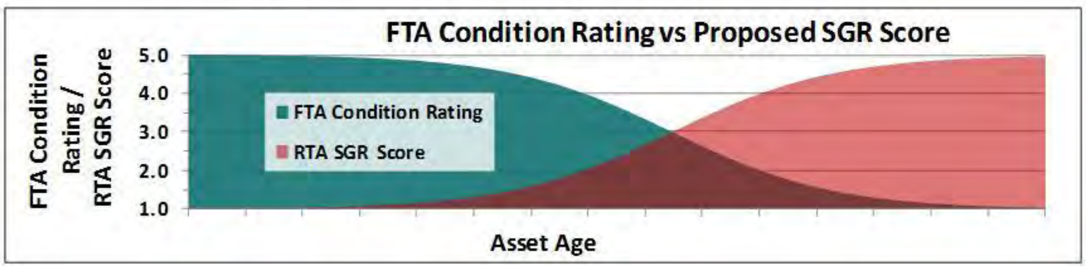
Figure 4-2: FTA Decay Curves Allow COST to Continuously Update Condition Estimates via Dynamic Scoring



Adjustment to 1 to 5 Scale: As noted above, FTA's condition scale runs from 5 through 1 – hence higher values reflect better condition than lower values. Note, however, that RTA's approach for prioritization scoring called for higher priority assets to attain the highest value of priority scores (hence, where asset reinvestment is concerned, lower condition assets should receive higher value scores). To address this issue, and strictly for the purpose for prioritization scoring, COST developers simply "inverted" the 5 to 1 FTA condition scale to a 1 to 5 score for use in COST's prioritization (see Figure 4-3).

Figure 4-3: Inversion of FTA Condition Scale to Obtain Condition Scores

Condition	FTA Rating	RTA SGR Score	Description
Excellent	5	1	▸ New asset ▸ No visible defects
Good	4	2	▸ Asset showing minimal signs of wear ▸ Some (slightly) defective or deteriorated component(s)
Adequate	3	3	▸ Asset has reached its mid-life (condition 3.5) ▸ Some moderately defective or deteriorated component(s)
Marginal	2	4	▸ Asset reaching or just past the end of its useful life (reached between condition 2.75 and 2.5) ▸ Increasing number of defective or deteriorated component(s) and increasing maintenance needs
Poor	1	5	▸ Asset is past its useful life and is in need of immediate repair or replacement ▸ May have critically damaged component(s)



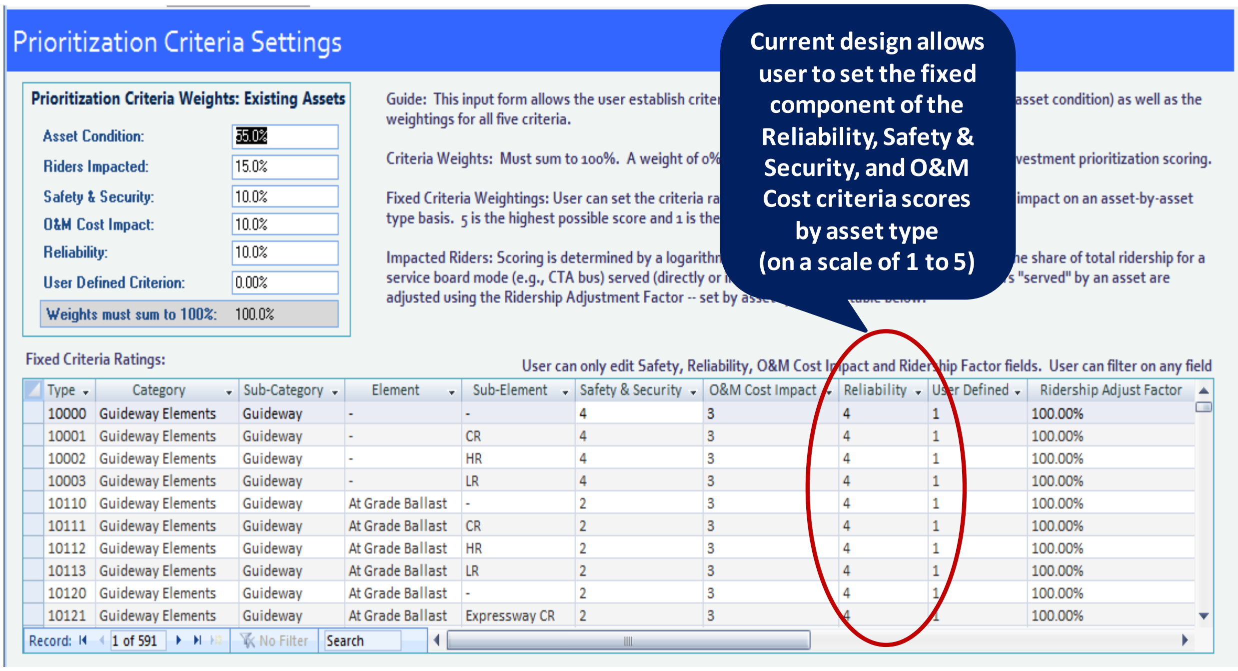
Reliability and Safety & Security

A common approach was taken to developing prioritization scores for two criteria: reliability and safety & security. At the time of writing, O&M cost impacts are assigned a fixed score only, but the same methodology of mixed scoring for O&M costs is under development. For each of these criteria, the criteria score is a mix of a fixed and a dynamic component score as already outlined above (see Fixed Scoring vs. Dynamic Scoring):

- Fixed Scoring by Asset Type: For each of these three criteria, each asset type was assigned a fixed score from 1 to 5 based on whether reinvestment in that asset type yield negligible (1) through measureable (5) impacts on the criterion in question. For example, for revenue vehicles RTA assigned a "5" for each of these three criteria as replacement of aging fleet vehicles can be expected to provide good returns on service reliability, reduced likelihood of safety problems, and reductions to maintenance costs. In contrast, replacement of aging bus shelters received "1"s for reliability and O&M cost impacts and a "2" for safety & security as it is not anticipated that these replacements provide much or any return with respect to these criteria. As a practical matter, these fixed criteria scores can be easily altered within RTA's COST (see Figure 4-4 below).

- Dynamic scoring component to capture Condition: In addition to fixed component of prioritization scoring based on asset type, scores for these three criteria are also driven by estimated asset condition. Specifically, it is assumed that as asset condition declines, the likelihood of safety issues tends to increase and O&M costs increase, while reliability declines. To capture this effect, the fixed scores are multiplied by each individual asset's current condition score to come up with a combined prioritization score that takes into account both asset type and asset condition (as depicted below in Figure 4-5).

Figure 4-4: Fixed Component of Reliability, Safety and Security and O&M Cost Impact Scores in COST


Prioritization Criteria Settings

Prioritization Criteria Weights: Existing Assets

Asset Condition:	55.0%
Riders Impacted:	15.0%
Safety & Security:	10.0%
O&M Cost Impact:	10.0%
Reliability:	10.0%
User Defined Criterion:	0.00%
Weights must sum to 100%:	100.0%

Guide: This input form allows the user establish criter… asset condition) as well as the weightings for all five criteria.

Criteria Weights: Must sum to 100%. A weight of 0%… vestment prioritization scoring.

Fixed Criteria Weightings: User can set the criteria ra… impact on an asset-by-asset type basis. 5 is the highest possible score and 1 is the…

Impacted Riders: Scoring is determined by a logarithm… he share of total ridership for a service board mode (e.g., CTA bus) served (directly or i… s "served" by an asset are adjusted using the Ridership Adjustment Factor -- set by ass…

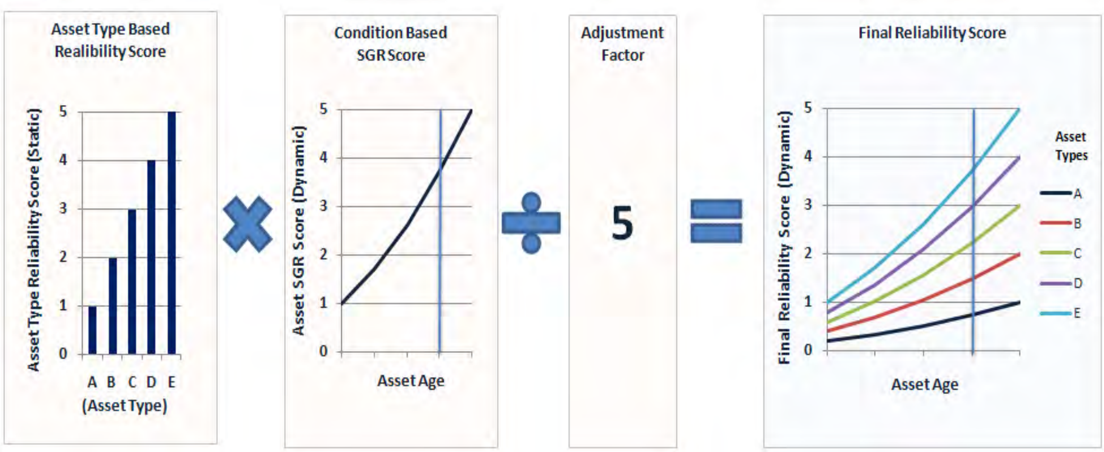
Fixed Criteria Ratings:

User can only edit Safety, Reliability, O&M Cost Impact and Ridership Factor fields. User can filter on any field

Type	Category	Sub-Category	Element	Sub-Element	Safety & Security	O&M Cost Impact	Reliability	User Defined	Ridership Adjust Factor
10000	Guideway Elements	Guideway	-	-	4	3	4	1	100.00%
10001	Guideway Elements	Guideway	-	CR	4	3	4	1	100.00%
10002	Guideway Elements	Guideway	-	HR	4	3	4	1	100.00%
10003	Guideway Elements	Guideway	-	LR	4	3	4	1	100.00%
10110	Guideway Elements	Guideway	At Grade Ballast	-	2	3	4	1	100.00%
10111	Guideway Elements	Guideway	At Grade Ballast	CR	2	3	4	1	100.00%
10112	Guideway Elements	Guideway	At Grade Ballast	HR	2	3	4	1	100.00%
10113	Guideway Elements	Guideway	At Grade Ballast	LR	2	3	4	1	100.00%
10120	Guideway Elements	Guideway	At Grade Ballast	-	2	3	4	1	100.00%
10121	Guideway Elements	Guideway	At Grade Ballast	Expressway CR	2	3	4	1	100.00%

Record: 1 of 591 No Filter Search

Figure 4-5: Combining Fixed Asset Type and Dynamic Condition Scores for Full Reliability Score



Note from Figure 4-5 that under this combined fixed asset type scoring and condition-based dynamic scoring approach:

- Scores Increase with Age: Reliability, Safety and Security and O&M impact scores continually rise as assets age, even after the asset attains and exceeds its expected useful life
- Fixed Score is Ceiling Score: This increase in scoring cannot exceed the fixed score value

Developing the Fixed Scores: As with most other aspects of COST criteria development, the fixed scores described above and illustrated in Figure 4-4, were developed in workshop settings. Specifically, each Service Board developed their own, internal scoring for the full range of transit asset types owned and operated by their agency. The results of these Service Board specific scores were then presented and discussed in a group meeting, including participants from each Service Board and RTA, leading to a group consensus on the region's preferred fixed scoring values to be used by COST. Note that each Service Board has the flexibility to alter these asset type specific scores when using COST for internal analyses. When making these fixed score assignments, workshop participants were provided with the scoring guidance outlined below in Figure 4-6. Considerable care was taken to avoid over scoring of any individual asset types.

Figure 4-6: Fixed Scoring Guidance – Reliability

Fixed Score	Rating	Description
5	Very High	• Reinvestment has a significant and measureable impact on reliability at the system-wide or mode-wide level
4	High	• Reinvestment has a significant impact on reliability (intermediate between rating 3 and 5)
3	Medium	• Reinvestment has material/measureable impact on reliability at the asset type level
2	Low	• Reinvestment has minor impact on reliability (intermediate between rating 1 and 3)
1	Very Low	• Reinvestment has little to no impact on reliability

Criteria Definition Summaries: The final definitions of reliability, Safety and security and O&M cost impacts are presented in Figure 4-7 below.

Figure 4-7: Summary Criteria Definitions: Reliability, Safety and Security, and O&M Cost Impacts

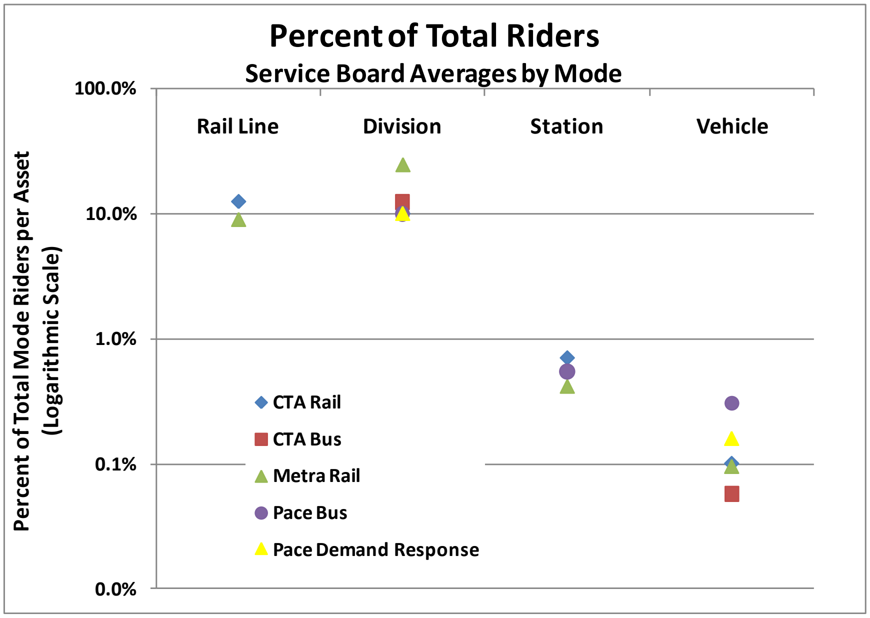
Investment Criteria	Definition
Reliability	• Degree to which reinvestment contributes to improved service reliability (i.e., reduced service failures) • Failure events are lower cost/higher probability
Safety & Security	• Degree to which reinvestment contributes to improved safety (reduced injuries and fatalities) or improved security (reduced assaults, theft or vandalism) • Events are higher cost/lower probability
O&M Cost Impact	• Degree to which reinvestment reduces operating and maintenance costs or increases revenues

Riders Impacted

"Riders impacted" is the last of the five investment criteria adopted by RTA. The riders impacted criterion is defined in terms of the share of passengers of a given mode that are impacted by a reinvestment activity. The greater the number of riders impacted by a reinvestment action, the higher the overall investment benefit.

A key challenge for this metric is the very wide range of riders served by different asset types. The magnitude of this range is evident in Figure 4-8. Based on this analysis, RTA opted for a logarithmic based scoring for the Riders Impacted criterion – also on a 1 to 5 scale.

Figure 4-8: Shares of Mode Riders Served by Asset Type



5. "How to" Guide to Aggregating Criteria into a Single Prioritization Score

This chapter describes RTA's approach to aggregating the scores for the individual investment criteria – including SGR, reliability, safety and security, O&M cost impact and riders impacted – into a combined, multi-criteria prioritization score. Specifically this chapter considers:

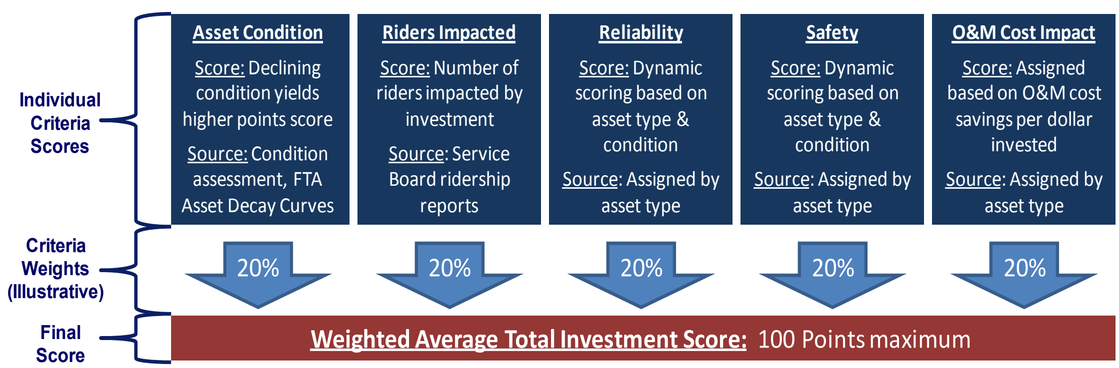
- RTA's Approach to Criteria Score Aggregation
- Selecting Criteria Weights
- Sample Scoring Results

5.1 RTA's Approach to Criteria Score Aggregation

Having developed prioritization scores for each of the five investment criteria (including conversion of those scores to a common 1 to 5 scale), the RTA Criteria Workshop participants next considered options for grouping individual criterion scores into a single, overall prioritization score. A basic requirement for the aggregation process was to ensure that each criterion could receive its own weighting in the combined score, adjustable within COST, to reflect the relative importance of each criterion to RTA and the Service Boards.

After briefly considering a number of potential approaches to criteria aggregation, most of which involved sophisticated mathematical formulas, the RTA working group quickly settled on the simple weighted average approach outlined in Figure 5-1.

Figure 5-1: Criteria Scoring Aggregation



This choice offered the following benefits:

- Easy to calculate
- Easy to explain
- Easy to understand.

Note that even with a relatively limited set of five investment criteria, the outcomes of different prioritization scores can be difficult to understand if embedded in complex (or even multiplicative based) aggregation formulas. Use of the simple weighted average approach ensured that scoring outcomes – including those resulting from adjustments to scoring weights – can be easily understood and explained.

Base 100 Scores: While the individual investments criteria scores are all based on a 1 to 5 scale, RTA made the decision to convert the weighted average score to a 100 point scale. The reason for this was simple: a 100 point scale makes it easier to visually compare differences in the overall prioritization scores of assets. The process used to combine the individual criteria scores into a total, base 100 score is presented below and consists of the following steps:

1. Multiply each criteria score by its criteria weight (selection of weights discussed below)
2. Multiply the product from step 1 by 20 – to convert from base 5 to base 100
3. Sum across all criteria.

Figure 5-2: Conversion of Individual Criteria Scores to Combined, Base 100 Prioritization Score

Criteria	Score (1 to 5)		Criteria Weight		Convert to Base 100		Base 100 Score
SGR / Condition	3.75	x	20%	x	20	=	15.00
Reliability	2.62	x	20%	x	20	=	10.48
Safety	3.11	x	20%	x	20	=	12.44
Riders Impacted	4	x	20%	x	20	=	16.00
O&M Cost Impact	1	x	20%	x	20	=	4.00
Total			**100%**			=	**57.92**

User input

5.2 Selecting Criteria Weights

Establishing criteria weights is, in many respects, one of most challenging aspects of developing any prioritization process. This is particularly true for any prioritization processes driven by a mathematical investment selection process, as is the case with the RTA's COST. The key sources of these challenges are:

- <u>Investment selections can be sensitive to criteria weights:</u> While minor changes to weights will not yield significant differences in investment selections, more significant weighting adjustments can lead to very different investment rankings across the same group of assets. These differences have repercussions not just in the short-term, but also in the long-term – as different prioritization weightings can have a significant impact on both the composition and even the size of the SGR backlog.

- <u>To represent policy, prioritization weightings should have "official recognition"</u>: The challenge here is that senior agency staff and Board members may have firm ideas on what the agency's reinvestment policies (and hence priority weightings) should be – "safety is always the highest priority" – but may not be fully aware of the actual investment outcomes the prioritization process will generate when those weights are based on an *a priori* concept of "what's most important". For example, placing too high a weight on safety may lead to a very safe but not terribly reliable or efficient system.

Based on these two observations, prioritization weights for these types of mathematically based prioritization process should be developed through a trial and error process – where weights are adjusted to attain a preferred mix of investment outcomes (e.g., a tolerable mix of asset types in the future SGR backlog). The mix should represent the agency's key policy directives but perhaps not interpret those directives so literally or restrictively that the analysis tool generates outcomes that are counter to what is truly preferred.

How did RTA Develop the Initial Prioritization Weights?: The prioritization weights currently used by RTA were established based on technical analysis of how changes to prioritization weights leads to different mixes of investment outcomes. Specifically, RTA's initial prioritization weights were developed using the following three-step process:

1. Unconstrained Needs by Asset Type: Assess the region's total, unconstrained twenty-year needs by asset type (using RTA's COST). This is the total, financially unconstrained level of investment required to attain and maintain SGR for all asset types.

2. Constrained and Prioritized Needs: Run COST multiple times with a constrained funding amount where each run:
    a. Uses the RTA's historical rate of reinvestment (on the order of $600 million annually)
    b. Uses a different set of prioritization weights

3. Compare Outcomes and Select Preferred Weighting: Determine the proportion of each asset type's unconstrained needs (from 1) that were addressed by each run from step 2. As recent regional funding levels are not sufficient to address all reinvestment needs, some asset types will fare better (and others worse) under alternative prioritization weightings. The preferred weighting, then, is the one that addresses the most desirable mix of outstanding needs.

In practice, step 3 can lead to very hard choices as for many transit agencies there is not sufficient funding capacity to address all outstanding needs – implying that while the SGR investment backlog may decline for some asset types it must inevitably increase for others. The preferred mix then (provided by the preferred criteria weighting), thus generates a "best of all possible worlds" but not necessarily a perfect or even desirable investment outcome (sometimes referred to as the "least undesirable outcome").

But which asset types should prioritization favor? And is it possible to assign priority weights such that while the backlogs for some assets may be projected to increase, those asset types still receive some reinvestment funding?

RTA first chose nine different approaches to test for weighting, shown in Figure 5-3. These ranged from equal weightings on each criterion to weightings that placed high emphasis on one individual criterion. Analyses of these initial weightings then led to tests of more mixed and "hybrid" criteria weightings – with the investment characteristics of each weighting being thoroughly evaluated.

Figure 5-3: Criteria Weightings Tested

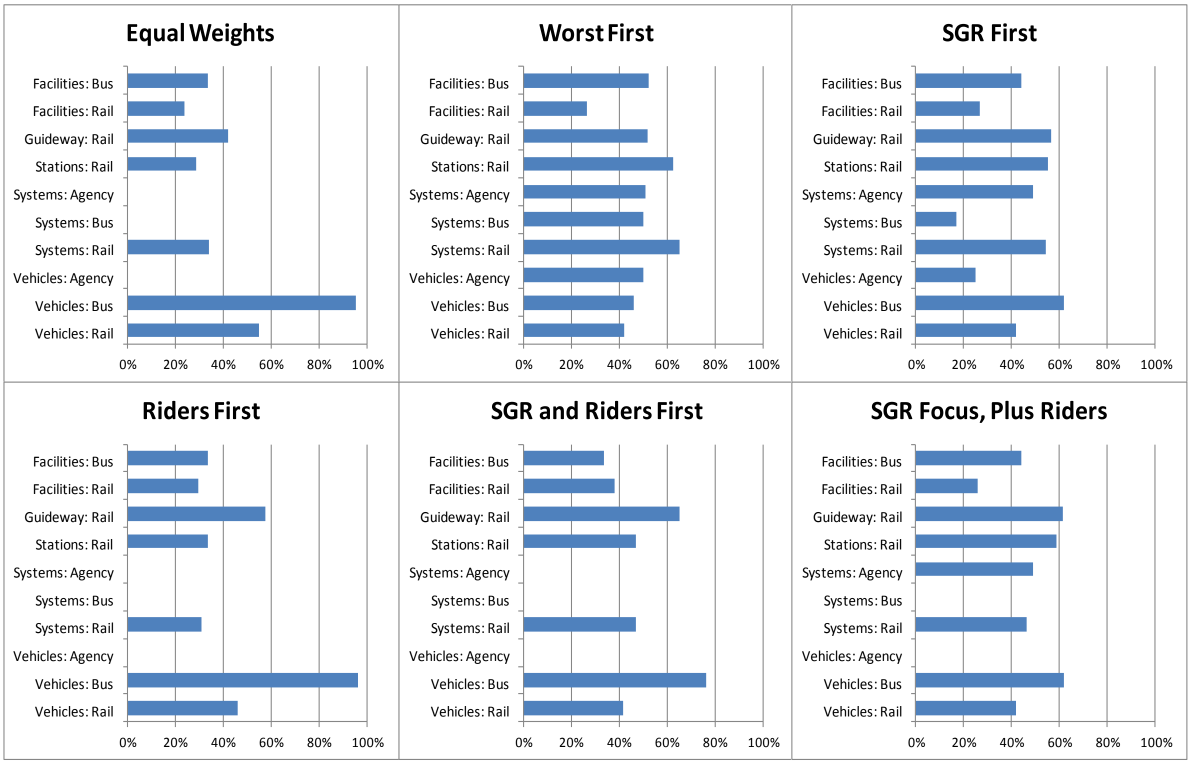
Scenario	Equal Weights	Worst First	SGR First	Reliability First	Safety First	Riders First	O&M Cost First	SGR and Riders	SGR Focus + Riders
Condition	20%	100%	60%	10%	10%	10%	10%	35%	45%
Reliability	20%	0%	10%	60%	10%	10%	10%	10%	10%
Safety / Security	20%	0%	10%	10%	60%	10%	10%	10%	10%
Riders Impacted	20%	0%	10%	10%	10%	60%	10%	35%	25%
Cost Impact	20%	0%	10%	10%	10%	10%	60%	10%	10%

The investment outcomes generated by a sample of these weightings is presented in Figure 5-4 (step 3 from above). Specifically, Figure 5-4 shows the proportion of unconstrained needs addressed under each alternative criteria weighting. Note here that each mix of criteria generates a different distribution of addressed needs – with different weightings favoring different asset types. The first option tested was equal weights for each criterion which, upon review, was considered undesirable as this option left some asset type needs fully unaddressed. The "Riders First" weightings suffered the same issue.

In contrast, the "Worst First" option – which placed a 100% weight on asset condition and zero weights on all other criteria – was believed to reinvest too heavily in assets that do not directly support rider services, thus reducing available reinvestment dollars for key assets required to support service reliability, safety and efficiency. In the end, the "SGR First" option was found to offer a good mix between these initial options. Specifically, "SGR First" placed a high weight on investments that improved asset condition, and ensured that all asset types obtained at least some reinvestment funding. It also recognized that some asset types are more critical to service reliability, safety, efficiency and high ridership corridors (such that these asset types were generally more favored by reinvestment).

Note once again that the preferred weights identified by this process were solely the result of a technical analysis of how changes to criteria weights yield investment outcomes with differing characteristics. Hence, while the current weights represent reasonable mixes of standard criteria they do not represent an adopted or approved policy. At the same time, the analysis in Figure 5-4 also makes it clear that any process that assigns priority weights solely on the basis of *a priori* opinions of what's important – without reference to the expected outcomes – may not yield the best possible outcome. Rather, there is significant value to assessing the outcome resulting from a range of potential priority policies, and then adopting the policy most likely to yield the most desirable investment outcome.

Figure 5-4: Percent of Unconstrained Needs Addressed Under Alternative Criteria Weightings



5.3 Sample Scoring Results

The analysis above provides a sense of the investment outcomes from differing prioritization criteria weightings but not of the actual prioritization scores themselves. To help provide a better sense of the scoring outcomes, Figures 5-5 through 5-8 present average prioritization scores by asset type for RTA's regional transit assets, as of the end of 2011—with each figure using one of the alternative criteria weighting options. It is important to emphasize that these are *average* prioritization values and hence represent the mean values for a range of individual prioritization scores. Asset types are presented in the same order in each figure to facilitate comparisons between each of the criteria weighting options.

Comparison of these four charts highlights the impact of altering the criteria weights on the prioritization scoring for each asset type. Alternatively, the charts help develop an understanding of how some asset types provide a greater contribution to some types of investment benefits than others (as determined of course by the scoring process developed in Chapter 4).

Figure 5-5: Average Prioritization Scores by Asset Type – Equal Weighting

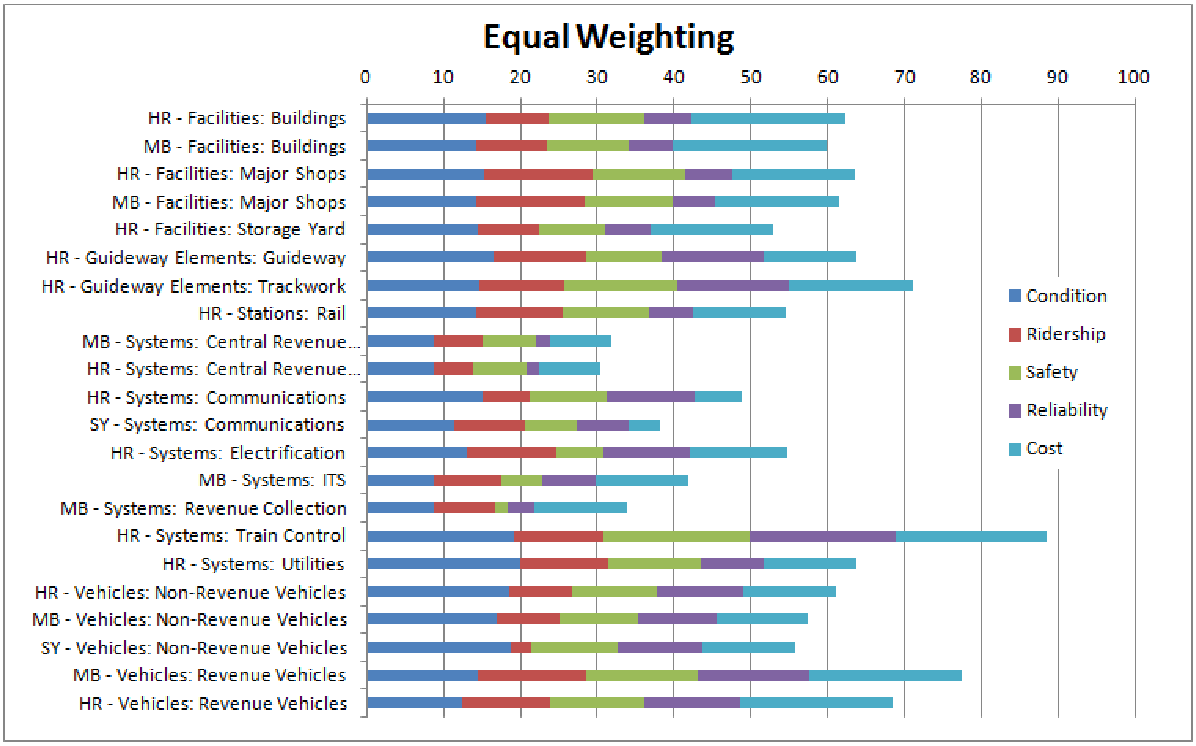


Figure 5-6: Average Prioritization Scores by Asset Type – Worst First

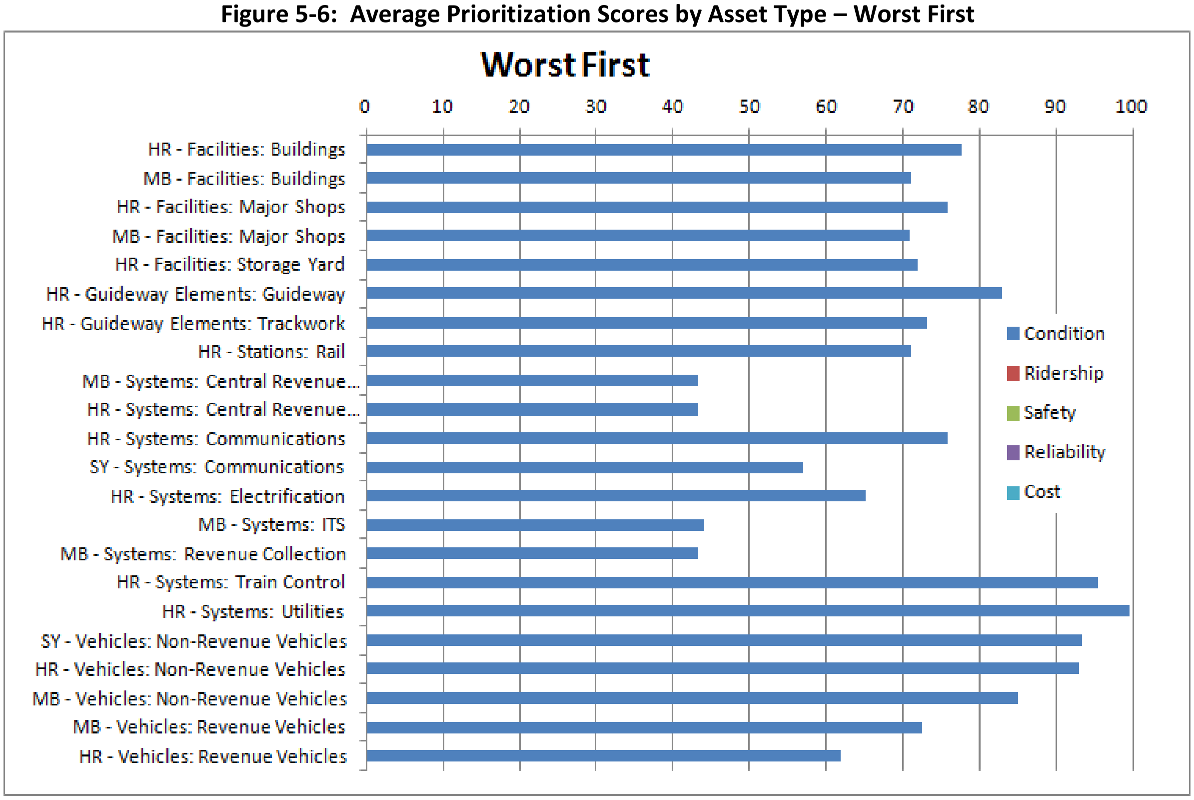


Figure 5-7: Average Prioritization Scores by Asset Type – SGR First

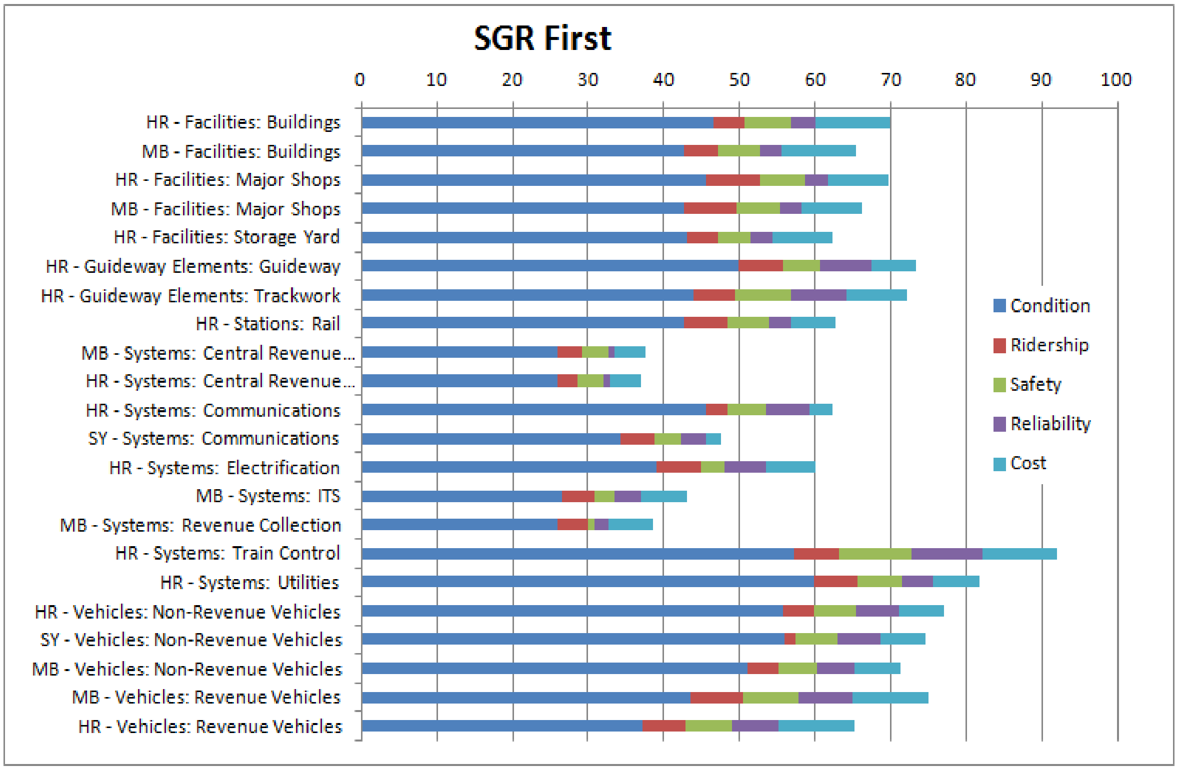
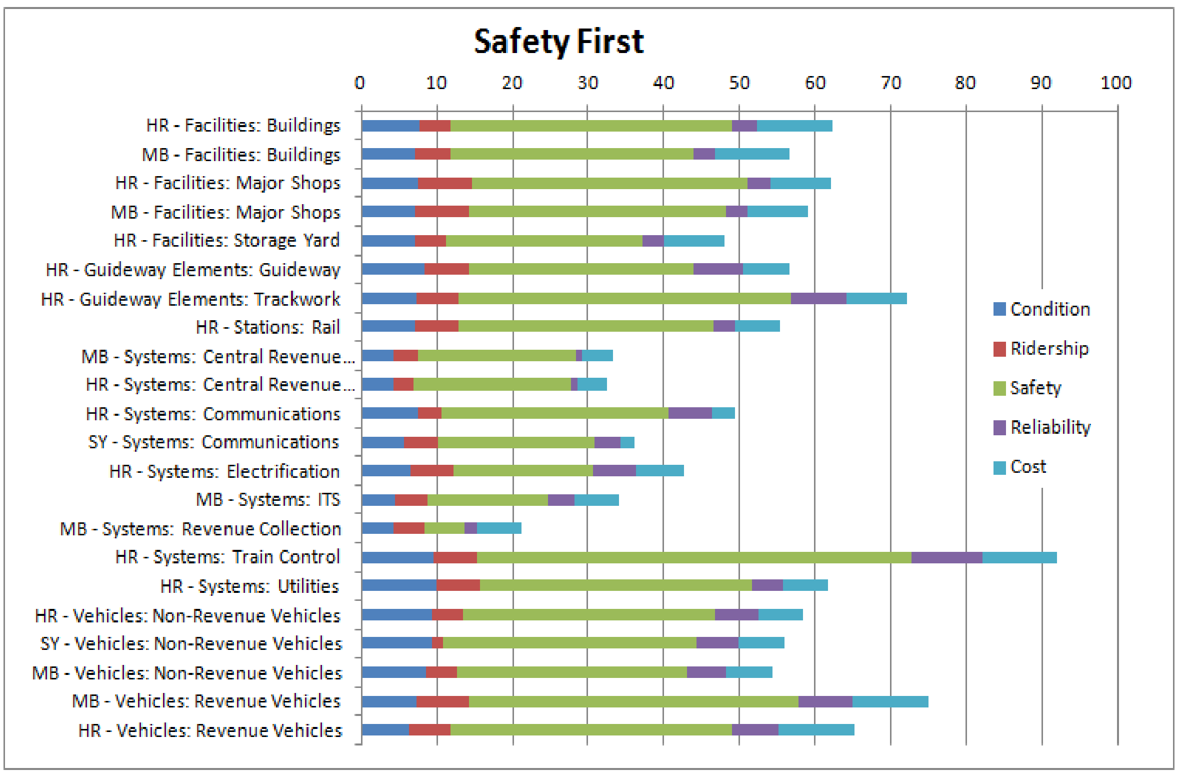


Figure 5-8: Average Prioritization Scores by Asset Type – Safety First



6. Other Issues

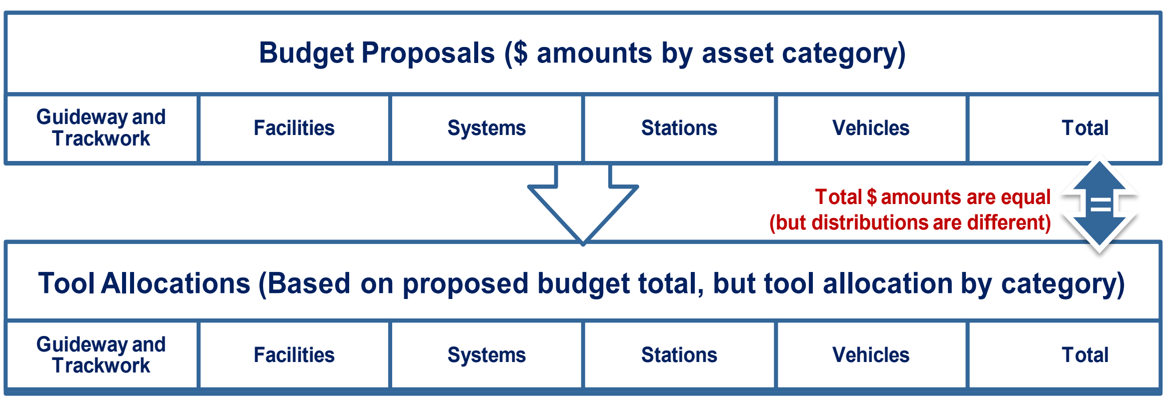
6.1 RTA Applications of COST's Prioritization Routine

One of RTA's primary interests in developing COST was to be able to use the Tool's prioritization capability take an independent look at the capital budget proposals developed by the region's Service Boards. Specifically, the tool could help to both (1) assure that the projects in the proposed capital budgets addressed the mix of preferred investment priorities and (2) Service Boards could also use the Tool as one source of input to help identify what they should include in their capital budgets.

A conceptual overview of the approach to comparing budget proposals with COST's prioritization of needs is presented below in Figure 6-1. In general, the steps used to compare budget proposals with COST's prioritized needs are to:

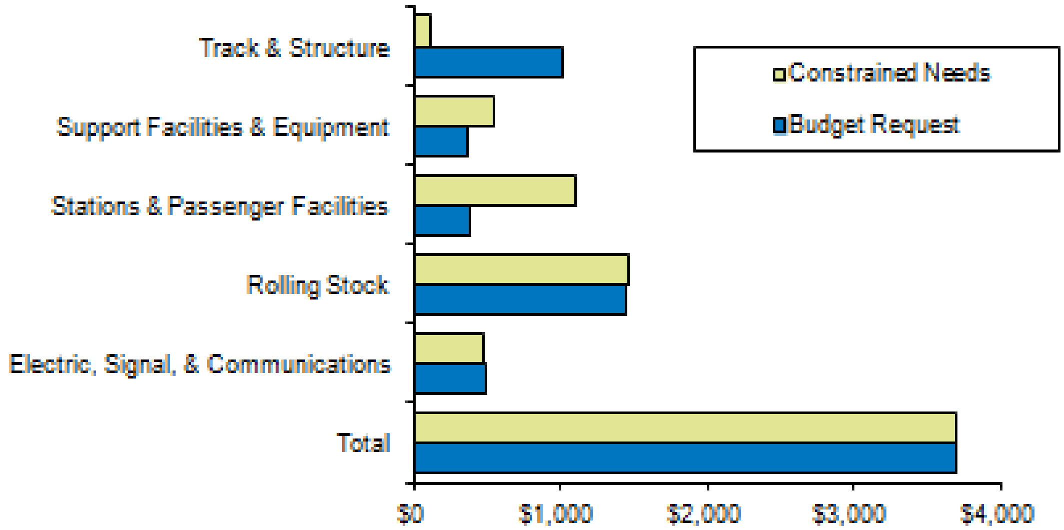
1. Group budget proposal investment amounts by asset category
2. Run COST constrained using the same total budget amount as is assumed in the regional investment budgets – then group the Tool's resulting prioritized needs into the same five asset categories
3. Given the same total budget amount, compare the allocation of budget amounts by asset categories as specified in the budget proposals with that determined by COST's prioritization process. How closely aligned are the budgeted and Tool prioritized needs?
4. Understand and address differences between the budget proposal and COST allocations. Did COST identify any specific needs not included in the budget proposals? Alternatively, were there needs the Tool was not aware of but should have been (implying the need for a Tool or data improvement).

Figure 6-1: General Approach to Budget Proposal and COST Prioritization Comparisons



Finally, Figure 6-2 below presents an example comparison of the budget proposal and COST prioritization allocations by asset type.

Figure 6-2: Illustrative Comparison of Budget Proposal and COST Prioritization Allocations



6.2 Compatibility with TERM Lite

Another primary RTA objective in developing COST and its prioritization routine was to support the industry as a whole in advancing these approaches. Publication of this Guide represents one aspect of that intended industry support. Another was to also help support TERM Lite development. RTA's COST was developed using the TERM and TERM Lite models as a starting point. Hence:

- The mechanisms and analyses used by the prioritization were built off the analytical capabilities pre-existing in TERM and
- The prioritization routine currently embedded in TERM Lite represents an adopted and slightly modified version of RTA's COST prioritization routine

Hence, the prioritization routines developed by RTA for its COST have largely been embedded in TERM Lite.

Appendix A: Glossary and Abbreviations

- Prioritization: For this Guide, prioritization is the process of identifying a preferred or optimal order in which reinvestment events should occur. Implicit in this statement is the assumption that:
  - *Funding is insufficient to address all needs.* Hence prioritization is required to determine which assets should be addressed first (and which assets have needs that may not be addressed).
  - *Investment needs can be ranked.* In other words, there are good analytic or other bases on which to ranked investment needs – from highest to lowest—to determine in which outstanding needs are most effectively addressed (and potentially leaving some needs unaddressed).

- Prioritization Criteria: Prioritization criteria provide the basis for determining the priority of individual investments. In general, investments are made with the expectation that the completed investment will yield improvements to one or more aspects of agency operations (e.g., improvements to reliability, efficiency, safety, rider comfort or other characteristic). Within a prioritization routine, the most desirable or important of these types of investment outcomes are referred to as "investment criteria". Investments that perform best with respect to these criteria (i.e., tend to be provide the best mix of desired outcomes) are assigned the highest priority. Investments that perform poorly may receive a low priority ranking.

- Prioritization Criteria Scores: From the viewpoint of this Guide (and RTA's COST), prioritization criteria should be quantifiable so investments can be assigned a numeric score reflecting their potential contribution to the desired outcome associated with that criterion (e.g., contribution to SGR). Note that numeric criteria scores facilitate objective comparisons between investment options. Given that different criteria may naturally be associated with specific unit quantities (e.g., condition rating for SGR and dollar values for impacts to operating costs), these score need to be converted to a common basis if the intention is to generate a multi-criteria prioritization score.

- Multi-Criteria Investment Prioritization (criteria weighting): Multi-criteria investment prioritization refers to the process of evaluating and prioritizing investment options based on each investment's performance against a mix of multiple investment criteria. In the context of this Guide and RTA's COST, multi-criteria investment prioritization implies the (1) all criteria are individual scored on a common scale (e.g., running from 1 to 5) and (2) these criteria scores are combined into a weighted average score, with the weight placed on each criterion reflecting the relative importance of that criterion.

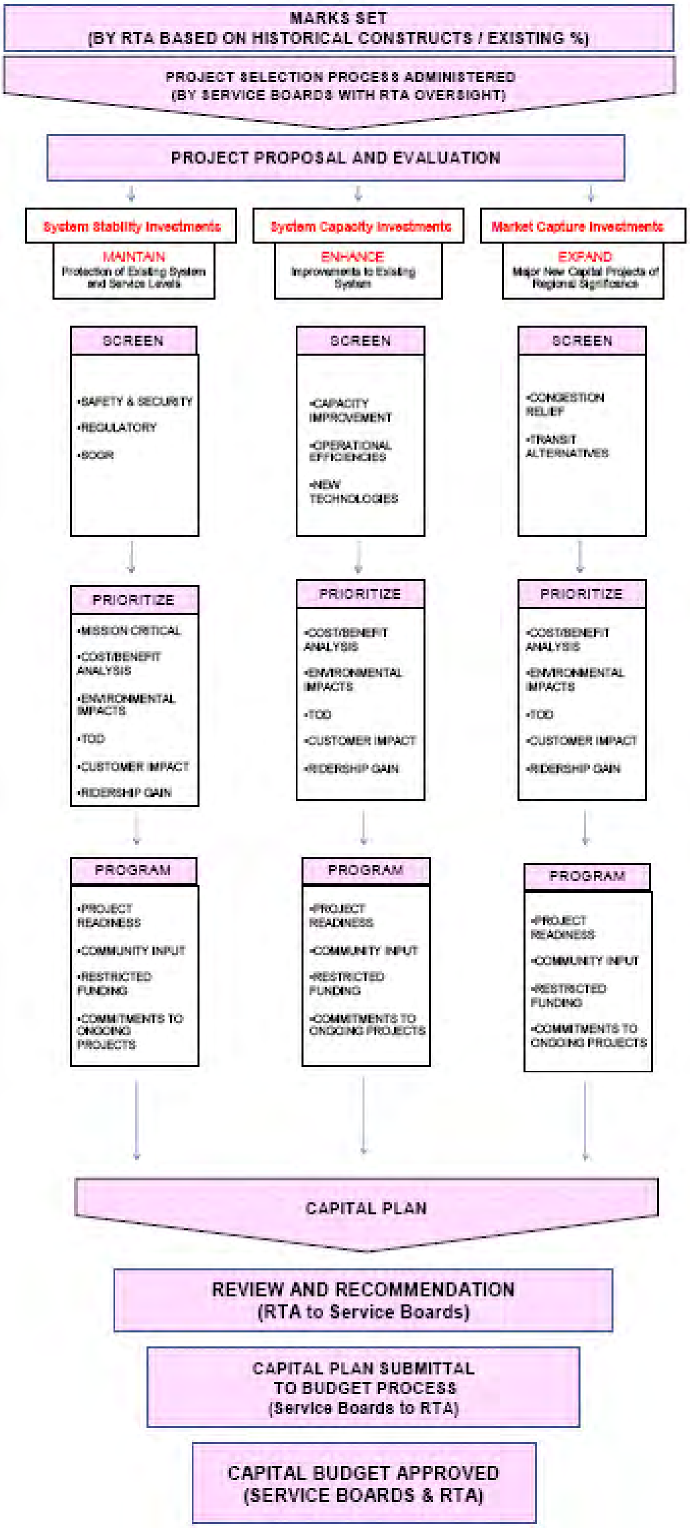
The following definitions for State of Good Repair (SGR) separate the asset level from aggregate level.

- Asset Level SGR: An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

- Mode, Service Board, or Regional Level (Aggregate) SGR: A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.

- Reinvestment in existing assets versus Investment in New Expansion or Enhancement Assets: COST is designed to assess and prioritize investment needs for both existing and expansion assets. In general, these investment types fall into the following categories:
    - *Reinvestment in Existing Assets:* Refers to rehabilitation and replacement or SGR investments in assets that are currently in service
    - *Investment in expansion assets:* Refers to the planned/proposed future purchase of new assets that either: (i) expand existing service capacity (e.g., fleet expansion), (ii) adds a new service (e.g., New Starts) or (iii) enhances existing service (e.g., new technologies such as real-time arrival information).

The prioritization criteria discussed in this Guide generally refer to reinvestment choices, as the capability to prioritize new acquisitions, or expansion assets, is being developed in COST.



RTA CAPITAL PLAN DEVELOPMENT PROCESS

STEP 1: Marks set. As part of its Budget Call, RTA determines the funding level based on the historical process utilizing existing percentage allocations between the Service Boards.

STEP 2: Project selection process administered. Each Service Board independently administers a uniform process to allocate the assigned level of resources among projects within their agency. RTA oversight ensures consistent management of the process and application of the criteria amongst the Service Boards.

STEP 3: RTA review and recommendation. RTA reviews the proposed capital plan from each agency, provides comment and makes recommendations to the Service Boards regarding the capital plan.

STEP 4: Capital Plan submittal to budget process. The Service Boards submit their final capital plan proposal to RTA as part of the Budget Process. Public hearings are held by RTA and the Service Boards for comment on the capital plan as part of the overall budget.

STEP 5: Capital Budget approved. The Service Boards have their agency capital budgets approved by their respective boards. RTA has the combined budgets approved by its Board.

PROJECT SELECTION PROCESS
(step 2 above)

SUBSTEP 1: Projects are solicited for consideration from within each agency.

SUBSTEP 2: An initial screening is performed to sort projects into one of three categories of investment: Maintain / Expand / Enhance. Criteria unique to each investment type are used to facilitate the sort.

SUBSTEP 3: Projects are prioritized within each category using another set of criteria that is identical across categories.

SUBSTEP 4: Projects are programmed within each category using still another set of criteria that is also identical across categories.

SUBSTEP 5: Projects are assembled into a five year capital plan by each agency.

RTA

CAPITAL PLAN DEVELOPMENT PROCESS

CRITERIA GLOSSARY

Note: All criteria are not necessarily applicable to all projects.

SCREEN – The process of using criteria to sort proposed capital projects into the MBC categories of Maintain/Enhance/Expand.

CAPACITY IMPROVEMENT – Addition of another dimension or improvement to existing capacity.

CONGESTION RELIEF – Alleviation or elimination of traffic congestion in measureable terms, most notably through the impact of getting people to switch from automobiles to public transportation.

NEW TECHNOLOGIES – Implementation of specific technologies that improve operations and/or service, which is also distinct from implementation of technological advances as part of maintenance or replacement of existing assets.

OPERATIONAL EFFICIENCIES – Modifications, improvements, and/or repairs of existing infrastructure as well as additions of new infrastructure that results in operational savings.

REGULATORY – Modifications, improvements, and/or repairs of existing infrastructure as well as additions of new infrastructure that is necessary to address legal requirements such as those imposed by Federal Railroad Administration (FRA), Americans with Disabilities Act (ADA), etc.

SAFETY & SECURITY – Changes, improvements, and/or repairs of existing infrastructure as well as additions of new infrastructure that is necessary to address the safety and security of people and property.

SOGR – State of Good Repair. Regular replacement, rehabilitation and maintenance based on the life cycle of the infrastructure asset.

TRANSIT ALTERNATIVES – Additions to the current transit system that provide for mobility options.

PRIORITIZE –The process that utilizes criteria to organize proposed capital projects by level of importance.

MISSION CRITICAL – Projects which are required based on safety, regulatory, and state of good repair conditions for continued operations.

COST/BENEFIT ANALYSIS – The application of various tests that compare the quantification of the costs to benefits of proposed capital projects and include business principles such as Net Present Value and Life-Cycle Costing.

CUSTOMER IMPACT – An outcome that directly affects the rider and/or their behavior.

ENVIRONMENTAL IMPACTS - Outcomes that affect the broader sense of environment including environmental justice as well as air quality.

RIDERSHIP GAIN – A measurable increase in ridership.

TOD – Transit Oriented Development. Development that occurs near transit facilities, particularly rail, which encourages the use of public transportation through characteristics such as density and mixed use.

PROGRAM – The process that utilizes criteria to organize proposed capital projects by factors that determine practicability.

COMMUNITY INPUT – Participation from stakeholders, including public officials, citizens, and special interest groups, that takes place through the public hearing process or other forums to provide observations, comments and recommendations.

PROJECT READINESS – The stage in which a project is currently in with regards to plans, schedule, manpower or other resources that would allow for its immediate implementation.

COMMITMENTS TO ONGOING PROJECTS - Projects that are currently underway in some capacity, but need additional resources for completion.

RESTRICTED FUNDING – Funding, such as earmarks or designations that can only be used for a specific project or type of project.

Volume 2, Part 3:

RTA Asset-to-Project Mapping "How To" Guide

Pilot Product #3: Asset-to-Capital Project Numbering Convention

Prepared for

Regional Transportation Authority

Regional Transportation Authority of Northeastern Illinois

September 2013

CH2MHILL®

Table of Contents

1. Introduction

1.1 FTA TAM Grant

In 2011, the Regional Transportation Authority of Northeastern Illinois (RTA) received an $800,000 Transit Asset Management (TAM) Pilot Project grant from the Federal Transit Administration (FTA). This pilot project includes TAM improvements that build on existing RTA TAM processes already in progress, namely the Capital Asset Condition Assessment, Capital Decision Prioritization Support Tool (now called the Capital Optimization Support Tool, COST), and management approaches already in use. The objectives of RTA's TAM grant include:

- Document RTA's existing policies; goals and objectives; performance targets and evaluation processes; and inventory/condition data collection, management, and reporting processes such that other local and regional operators can benefit from RTA's experience;
- Advance the TAM "state-of-the-art" capabilities in the areas of estimated capital reinvestment needs and investment prioritization; and
- Develop asset-to-project groupings using the analytical foundation provided by RTA's existing project screening and prioritization process and FTA's Transit Economic Requirements Model (TERM) model as a foundation for tool development.

The TAM Pilot Project is an 18 month process for RTA, which is documented in two volumes and the four work papers:

- Volume 1: Asset Inventory and Condition Assessment Guide
- Volume 2: Part 1 – RTA COST Model "How To" Guide, Pilot Product #4: Capital Prioritization Decision Support Tool
- Volume 2: Part 2 – Multi-Criteria Investment Prioritization Process "How To" Guide, Pilot Product #2: Multi-Criteria Investment Prioritization Process
- Volume 2: Part 3 – Asset to Project Mapping "How To" Guide, Pilot Product #3: Asset-to-Capital Project Numbering Convention.

This document presents the third "how to" guide on development and application of processes to bundle asset level data into potential investment projects. This document is intended to be helpful to other operators or funding agencies developing and applying similar asset to project mapping processes.

1.2 Overview – Asset-to-Project Mapping

In 2008 RTA and its three Service Boards – the Chicago Transit Authority (CTA), Metra and Pace – initiated development of a comprehensive regional transit asset inventory. The inventory was subsequently updated in 2011 and annually since then. This inventory was developed for the purpose of assessing long-term capital reinvestment needs for all transit assets serving metropolitan Chicago and its suburbs. Since that time, RTA has institutionalized this process – and now conducts an annual update of both the regional asset inventory data and the assessment of reinvestment needs, which relies on that data. Moreover, RTA and the Service Boards have also jointly developed COST, which provides the ability to analyze and prioritize capital reinvestment needs using data from the regional transit asset inventory.

Projects vs. Assets: Prior to the asset-to-project mapping initiative, all regional needs analyses were performed on an "asset level" basis. In other words, all prior analyses determined regional investment needs by (1) independently assessing the 20-year reinvestment needs of individual transit assets (e.g., the timing and cost of rehab and replacement actions for each individual station, track segment, etc.) and then (2) summing these individual asset needs to the asset type, Service Board and finally regional levels. While this process provides a reasonable assessment of total, long-term reinvestment needs it provides only a gross approximation of actual reinvestment practices. Specifically, rather than planning for the reinvestment needs of individual assets, the region's Service Boards more typically group related asset needs into reinvestment *projects*. The Service Boards then focus on the planning, prioritization, programming and eventual execution of these projects – which typically address the coincident reinvestment needs of multiple related assets. Examples here would be the replacement of related components of a maintenance facility (e.g., coordinated replacement of a roof and HVAC equipment housed on the roof) or the upgrade of multiple components of a rail segment (e.g., rail, ties, drainage and perhaps traction power components and even civil structures).

Objective and Approach: The object of the asset-to-project mapping initiative is to develop analytic approaches to grouping reinvestment needs for related assets into "investment bundles" that more closely resemble the types of *projects* that the Service Boards actually plan. Note that the intent here is *not* to develop actual reinvestment projects based on the asset level data housed in the asset inventory. Rather, the intent is to group related asset level reinvestment needs, as identified by RTA's COST, such that these related needs are easily recognized (and prioritized). These related needs can then help support the identification, development and prioritization of actual reinvestment projects. Hence, rather than identifying projects, the asset-to-project mapping can be more accurately described as identifying "patterns of related asset reinvestment needs."

To be considered "related", asset reinvestment needs:

- Must be roughly coincident (needs occur over roughly the same time period)
- Must offer potential cost efficiency from being bundled together (i.e. simultaneous replacement of assets located on a shut-down rail segment)
- May be (but do not have to be) located in the same geographic area or facility.

The actual strategies used to identify related needs are discussed in greater detail in subsequent chapters.

Challenges: The ability to identify and group assets into meaningful representations of projects is ultimately limited by the level of asset detail. Consider the example of maintenance facilities. In the real world, a transit agency might reasonably group coincident roof replacement needs for several agency buildings. However, doing so would require that the region's asset inventory maintain asset data at the facility roof level of detail. At present this is not the case, though there are future expectations to attain this level of detail. Hence while grouping roof reinvestment needs at multiple sites into a single reinvestment project may offer potential investment efficiencies (planning, contracting, etc.), the current level of asset detail is not sufficient to support identification of coincident roofing needs as a potential project in COST.

Asset-to-Project Mapping and RTA's COST: The Asset-to-project mapping process is being developed as a sub-routine to RTA's COST. Specifically, COST is designed to assess the long-term (20-year) reinvestment needs of all individual assets identified in the region's asset inventory, including both deferred "state of good repair" (SGR) reinvestment needs as well as future SGR reinvestment needs. COST also prioritizes each of these individual asset reinvestment needs based on a set of five investment criteria:

1. Asset condition
2. Number of riders impacted
3. The investment's contribution to service reliability
4. The investment's contribution to safety and security
5. The investment's contribution to O&M cost savings.

Following the completion of these analyses, COST then runs the asset-to-project mapping sub-routine to:

- Group the needs for related assets into projects (as described in subsequent chapters)
- Prioritize each project (based on a weighted average prioritization score of the project's individual asset components).

A detailed description of COST and its capabilities is provided in a separate "How-to" guide. For the purpose of this overview, RTA's COST is an MS Access based analysis model (based on FTA's TERM Lite Model) designed to perform the following analyses for RTA and its three Service Boards:

1. Assess current size of SGR backlog.
2. Assess (estimate) current asset conditions.
3. Conduct assessment of 20-year unconstrained capital reinvestment needs.
4. Assess the impact of constrained reinvestment on:
    a. SGR backlog
    b. Asset Conditions
    c. Proportion of assets in SGR
5. Prioritize reinvestment (rehab and replacement) needs based on the five investment criteria listed above. Includes the prioritization of reinvestment needs for expansion assets assumed to be acquired during the period of analysis.
6. Prioritize investment in expansion/enhancement assets (as proposed by RTA and its Service Boards) based on investment cost per rider impacted.
7. Assess the impact of expansion/enhancement investments on:
    a. SGR backlog
    b. Asset Conditions
    c. Proportion of assets in SGR

Document Overview: This Guide covers each of the following:

Chapter 2: Approach to Asset-to-Project Mapping
Chapter 3: Prioritization of Mapped Projects
Chapter 4: Application of Mapping Results

1.3 Define Terms

Following are definitions of key terms as used by this Guide:

- <u>Needs Analysis:</u> In the context of COST, needs analysis refers to the process of determining the level of investment required to attain specific investment objectives and also with how those investment dollars are allocated to different uses (e.g., between various asset types). In general, needs analysis falls into two broad categories:

  - *Unconstrained needs:* The level of investment required to address all outstanding and future needs, irrespective of actual or expected funding availability
  - *Constrained Needs:* As the name suggests, under constrained needs analysis, there is insufficient funding to address all needs. This analysis shows the level of investment required to attain more realistic investment objectives (e.g., maintain the size of the current investment backlog, or eliminate the backlog over 20 years).

- <u>Reinvestment in Existing Assets (SGR) vs. Investment in New Expansion or Enhancement Assets:</u> COST is designed to assess and prioritize investment needs for both existing and expansion assets. In general, these investment types fall into the following categories:
  - *Reinvestment in Existing Assets:* Refers to SGR (i.e., rehab and replace) investments in assets that are currently in service (i.e., *existing* assets).
  - *Investment in expansion assets:* Refers to the planned/proposed future purchase of new assets that either: (i) expand existing service capacity (e.g., fleet expansion), (ii) adds a new service (e.g., New Starts) or (iii) enhance existing service (e.g., new technologies such as real-time arrival information).

- <u>Scenario Analysis:</u> In the context of COST, scenario analysis refers to the process of identifying specific investment objectives and then assessing the investment needs associated with attaining that scenario. Examples include:
  - Maintain historic funding levels
  - Maintain the current backlog
  - Eliminate the backlog over a set time period (e.g., 20 years)

- <u>Prioritization:</u> For this guide, prioritization is the process of identifying a preferred or optimal order for reinvestment events. Implicit in this statement is the assumption that:
  - *Funding is insufficient to address all needs.* Hence prioritization is required to determine which assets should be addressed first (and which assets have needs that may not be addressed).
  - *Investment needs can be ranked.* In other words, there are good analytic or other bases on which to rank investment needs – from highest to lowest—to determine in which outstanding needs are most effectively addressed (and potentially leaving some needs unaddressed).

- <u>Asset Condition and Decay:</u> Asset condition refers here to the estimated physical condition of a transit asset. Specifically, COST includes a set of embedded asset decay curves that predict the current and future physical condition of a transit asset based on its type, age and other factors (e.g. , use and maintenance history). COST uses these condition relationships to prioritize reinvestment needs (in part) based each asset's predicted physical condition (both currently and in the future). COST also uses these same asset decay curves to generate current and future distributions of asset conditions.

The following definitions for State of Good Repair (SGR) separate the asset level from aggregate level.

- <u>Asset Level SGR:</u> An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

- Mode, Service Board, or Regional Level (Aggregate) SGR: A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.

2. Approach to Asset-to-Project Mapping

This chapter describes each of the following:

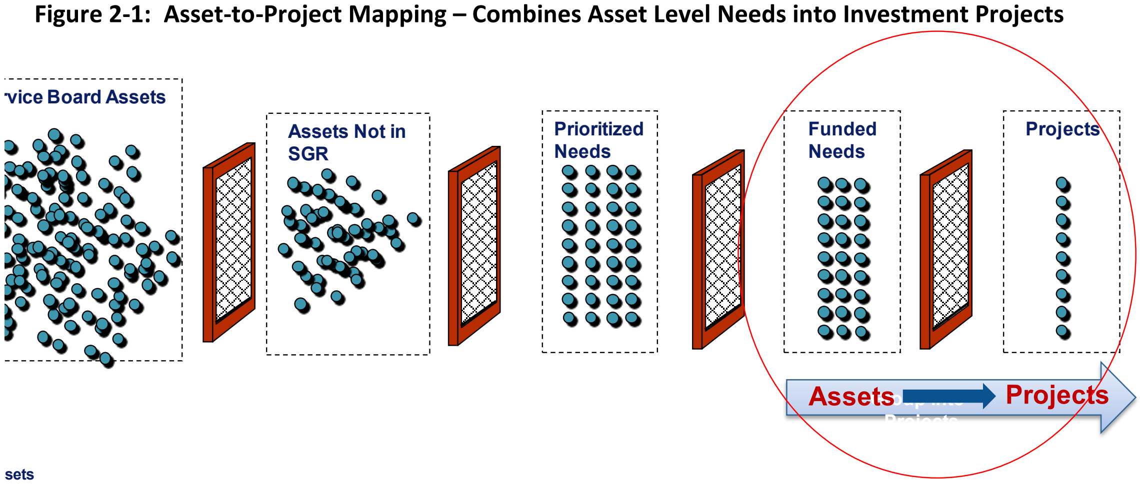
- Asset-to-project mapping methodology
- Types of Mappings
    - Asset type based mappings
    - Location based mappings
    - Time based mappings (coincident needs)
- Implementation and recalibration
- Asset to Project Mapping Reports
- Data requirements

2.1 Approach to Asset-to-Project Mapping

As described in Chapter 1, the asset-to-project mapping process is designed to take the prioritized reinvestment needs for individual transit assets (as identified by RTA's COST) and combine those needs into logical groupings that more closely resemble the actual reinvestment "projects" carried out by the region's Service Boards. Once again, the intent is not to identify actual reinvestment projects but rather to identify "patterns of related asset investment needs" that the Service Boards can then use to *help* identify and prioritize actual reinvestment projects.

The relationship between COST's assessment of asset level reinvestment needs and the eventual mapping of those asset-level needs into potential investment projects is presented conceptually in Figure 2-1. Here, RTA's COST first identifies those assets that require SGR investment actions (e.g., rehabilitation or replacement). The Tool then prioritizes those needs and, if funding is constrained, determines which needs are funded. The role of the asset-to-project mapping sub-routine then is to group the funded needs into potential (and logical) reinvestment projects.

Figure 2-1: Asset-to-Project Mapping – Combines Asset Level Needs into Investment Projects



Project Mapping Guiding Principles: Prior to initiating development of asset-to-project mapping, RTA, the Service Boards and the CH2M HILL consultant team identified the following three guiding principles for methodology development:

I. Keep it Simple:
   - RTA's COST already provides many types of analyses
   - Guiding principle was to make mapping "user friendly"

II. Ensure Asset-to-Project Mappings are:
   - Realistic/meaningful: mappings should represent logical groupings of assets types and as much as possible reflect actual Service Board projects
   - Yield helpful insight to Service Boards: Mapping output should help Service Boards identify potential reinvestment projects

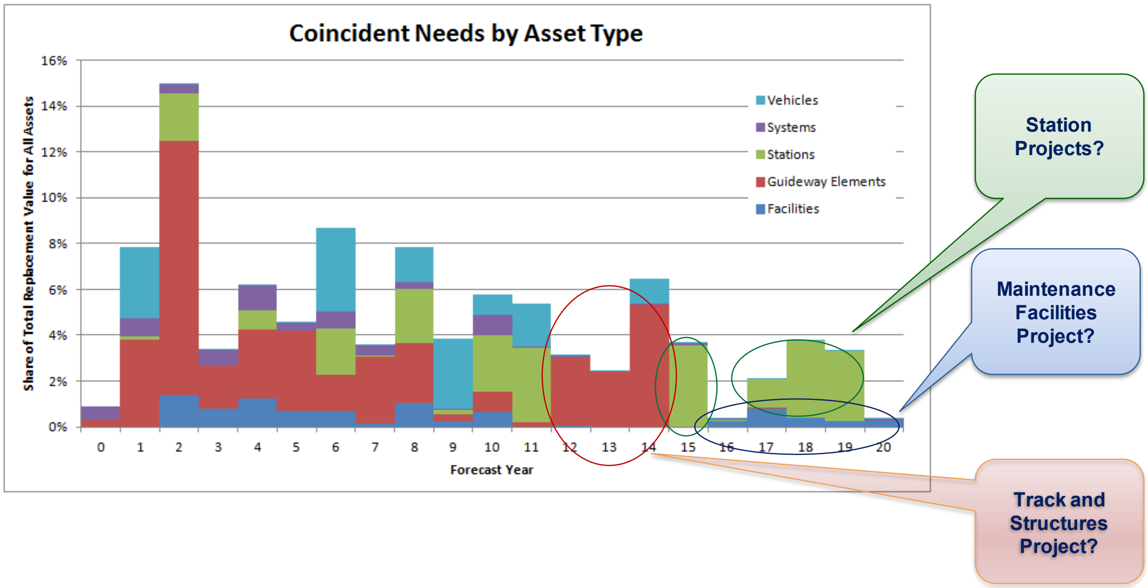
III. COST is not intended for project planning/scheduling:
   - RTA's COST is designed to *help support* decision making, not to be the sole basis for actual reinvestment plans
   - It is not intended that the mappings yield a prioritized and scheduled list of *executable* projects - just to identify patterns of related assets with coincident reinvestment needs

Related Assets: As noted, asset-to-project mapping is intended to identify "patterns of related asset investment needs". In this context, assets are expected have the following in common to be considered "related" and thus suited for mapping into a common project:

- <u>Coincident Needs:</u> Must be roughly coincident, meaning needs occur over roughly the same time period
- <u>Joint Investment Efficiencies:</u> Must offer potential cost efficiency from being bundled together (i.e. simultaneous replacement of assets located on a shut-down rail segment)
- <u>Co-Located:</u> Assets may be (but do not have to be) located in the same geographic area (e.g., at a common maintenance facility or located on the same rail line or segment). This requirement is better suited to some asset types than others (see next section)

The principle of coincident needs for related assets is presented conceptually in Figure 2-2. Specifically, this graphic shows the timing of reinvestment needs (under a constrained scenario) for a broad range of asset types that have been grouped into related asset categories. While a very simplified presentation, the graphic illustrates the patterns of reinvestment needs for each asset category (i.e. vehicles, systems, stations, etc). Service Board staff can then use this information, along with asset location and other data, to help identify and schedule future reinvestment projects.

Figure 2-2: Coincident Needs by Asset Type



2.2 Types of Mappings

Given the guiding principles and conceptual approach to grouping assets into projects as described above, the next step was to develop the actual mapping process. The solution adopted by RTA and its Service Boards utilizes what is essentially a two-step mapping process:

- Project Group Assignment: Assign related asset types (i.e., assets types likely to be grouped together in an actual project) to a common project group name. Creation of project group names and assignment of asset types to those group names (called "Project Name" in the model) is entirely user defined and can be changed at any time.
- Project Scope Assignment: Each project group name is assigned a project Scope which determines project size and geographic extent (with project scope ranging from agency-wide down to a specific location, such as a single building).

Hence, within this system, each type of asset identified in the region's asset inventory (i.e. bus, trackwork, radio, etc) is first assigned to a Project Name and then that group itself is assigned a geographic Scope. Implementation of this solution relies heavily on COST's use of an asset types table that identifies all asset types use by the model (for Project Name assignments) and also on RTA's use of hierarchical asset location data (i.e., mode, line/division, branch/facility and sub-branch/building), for project Scope assignments. A more detailed description of each of these mappings follows.

Project Group Assignment: The first step in developing a comprehensive asset-to-project mapping is to create Project Names for all expected project types and then to map all asset types to their logical Project Name (it is critical that all asset types be assigned to a Project Name). This mapping of Project Names to individual assets is illustrated in Figure 2-3. When the COST model is run, asset types are grouped by Project Name and the relevant Scope of the project.

Figure 2-3: Illustrative Assignments of to RTA Asset Types to Project Group Names and Scopes

Project Names Table

tblAssetToProject_GroupNames

Proj Group Name	Proj Group Scope
Office Furniture & Equipment	Modewide
On-Vehicle Revenue Collection	Modewide
Passenger Communications Systems	Modewide
Phone System	Modewide
Radio	Modewide
Retained Cut	Line/Region
Revenue Vehicles	Modewide
Roadway Traffic Signals	Line/Region
Safety and Security	Modewide
SCADA	Modewide
Signal Bridge	Line/Region
Signals/Interlockings/Special Trackwork	Sub-Branch/Building
Special Structures	Line/Region
Station Access	Line/Region
Station Platform	Line/Region
Station Signage & Graphics	Line/Region
Stations	Line/Region
Storage Yards	Modewide
Systems	Line/Region
Trackwork	Sub-Branch/Building
Underground	Branch/Division

Asset Types Table

tbl05AssetTypeData

Type	Project Group Name	Category	Sub-Category	Element	Sub-Element
45000	Station Platform	Stations	Platform	-	-
45400	Station Platform	Stations	Platform	-	-
45410	Station Platform	Stations	Platform	Surface	-
45411	Station Platform	Stations	Platform	Surface	Concrete, asphalt, tile
45412	Station Platform	Stations	Platform	Surface	Wood
45413	Station Platform	Stations	Platform	Ferry Dock	-
45420	Station Platform	Stations	Platform	Shelters	-
45430	Station Platform	Stations	Platform	Canopy	-
45440	Station Signage & Graphics	Stations	Platform	Signage & Graphics	-
45441	Station Signage & Graphics	Stations	Platform	Signage & Graphics	Electronic
45442	Station Signage & Graphics	Stations	Platform	Signage & Graphics	Static
45450	Station Platform	Stations	Platform	Lighting	-
46000	Station Access	Stations	Access	-	-
46100	Station Access	Stations	Access	Roadway	-
46110	Station Access	Stations	Access	Roadway	Auto
46120	Station Access	Stations	Access	Roadway	Bus
46200	Station Access	Stations	Access	Parking	-
46210	Station Access	Stations	Access	Parking	Garage
46220	Station Access	Stations	Access	Parking	Lot
46230	Station Access	Stations	Access	Parking & Equipment	-
46300	Station Access	Stations	Access	Pedestrian	-

Project Scope Assignment: The next step is to provide all Project Names with a project Scope assignment. As noted above, the project scope determines the geographic extent for each project type. Project scopes can range anywhere from large area projects that would cover all related assets for an entire transit mode (e.g., replacement of all over age bus shelters) down to small scope projects, that would only cover select assets at a specific location, such as a building or rail yard. At present, projects can be assigned to one of four different project Scopes. These four Scopes – including their definitions and some illustrative examples of asset types best suited to each mapping type – are presented in Figure 2-4 and are illustrated graphically in Figures 2-5 through 2-9. This system of assigning assets to Project Names and then project groupings to Scopes provides the user with significant control in determining how COST presents potential projects.

Using the example above, this process allows COST to group all of the Electrification Distribution needs occurring on the CTA Blue Line over the same time period into a "project" while all of the same asset types on the Red Line will be grouped into a separate "project."

Figure 2-4: Asset-to-Project Mapping Scopes

Mapping Scope	Description	Examples (Illustrative)
I. Mode wide	• Related assets serving the same mode, anywhere in the system • Value to agency in replacing/or planning replacement concurrently	• HVAC at multiple locations • Grade crossings • Subway fans
II. Line/Region	• Related assets serving same rail line or bus service region in the system	• Bridges or stations on same rail line
III. Branch/Division	• Related assets serving the same rail branch or bus division/garage in the system	• Bus shelters within a bus Division's service area
IV. Sub Branch/ Building/Yard	• Related assets serving same rail sub-branch, building or yard in the system	• Signals, interlockings and special trackwork • Building sub-components

Figure 2-5: Illustrative Scopes for Asset-to-Project Mapping Groupings

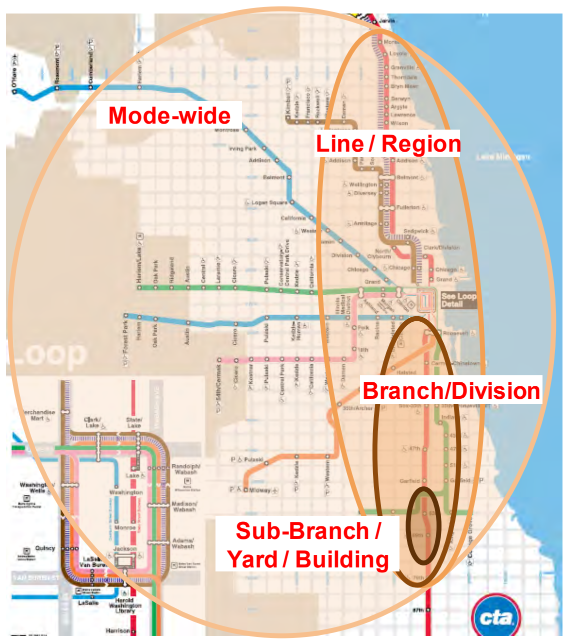


Figure 2-6: Mapping Mode-wide – Assets of Same Type Anywhere in System

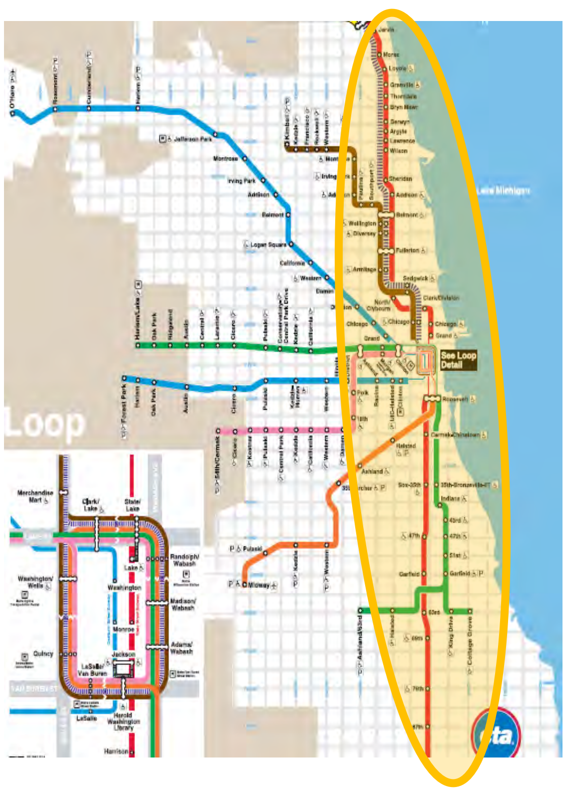
<u>Examples of Mode-wide</u>:

- HVAC at multiple locations
- Grade crossings
- Subway fans

<u>Data Requirements – Assets Tagged by:</u>

- Asset type
- Scope: Mode-wide

Figure 2-7: Mapping Line/Region – Related Assets Serving Same Rail Line/Bus Region



<u>Examples of Type II</u>:

- Guideway Structures
- Stations
- Shelters

<u>Data Requirements – Assets Tagged by</u>:

- Asset type
- Location (Line/Region)
- Scope: Line/Region

Figure 2-8: Mapping Branch/Division – Related Assets Serving the Same Rail Branch/Bus Division

Examples of Type II:

- Guideway Structures
- Stations
- Shelters

Data Requirements – Assets Tagged by:

- Asset type
- Location (Line/Region & Branch/Division)
- Scope: Branch/Division

Figure 2-9: Mapping Sub-Branch/Building/Yard – Related Assets Serving Same Rail Sub-Branch or Facility

Examples of Type III:

- Rail: Comprehensive overhaul of rail segment including:
  - Guideway structure/ballast
  - Rail, ties
  - Traction power
  - Train control
- Bus: Overhaul of related bus facility components:
  - Roof and HVAC segment
  - Drainage and waste water

Data Requirements – Assets Tagged by:

- Asset type
- Location (Line/Region, Branch/Division & Sub-Branch/ Building/Yard)
- Scope: Sub-Branch/Building/Yard

2.3 Calibration and Recalibration

Calibration: The original mappings of asset types to Project Names and then of Project Names to project Scopes was developed as a joint effort between RTA, the Service Boards and RTA's consultant team. It is important to note that this initial calibration is likely to be modified over time as each Service Board applies the asset-to-project mapping capability to address their individual analysis needs. Moreover, it should also be noted that there are no universal standards for grouping assets into projects. Rather, all agencies tend to have their own practices and policies in this area. For example, some rail agencies may prefer to address all investment needs in a given rail corridor simultaneously (e.g., all structure, trackwork and systems needs) whereas other agencies may prefer to manage reinvestment in the different asset types on an asset-by-asset basis.

Recalibration: A key strength of the approach adopted by RTA is the ease with which any asset type can be assigned to a different asset-to-project mapping group or scope (Mode-wide, Line/Region, Branch/Division, or Sub-Branch/Building/Yard) by modifying the Project Name assignments using the Asset-to-Project Builder interface provided for Input Data. To access the Asset-to-Project Builder, users can click on the Input Data button on COST's Main Menu and the Asset-to-Project Mapping tab, see Figure 2-10 and Figure 2-11.

Figure 2-10: COST's Main Menu

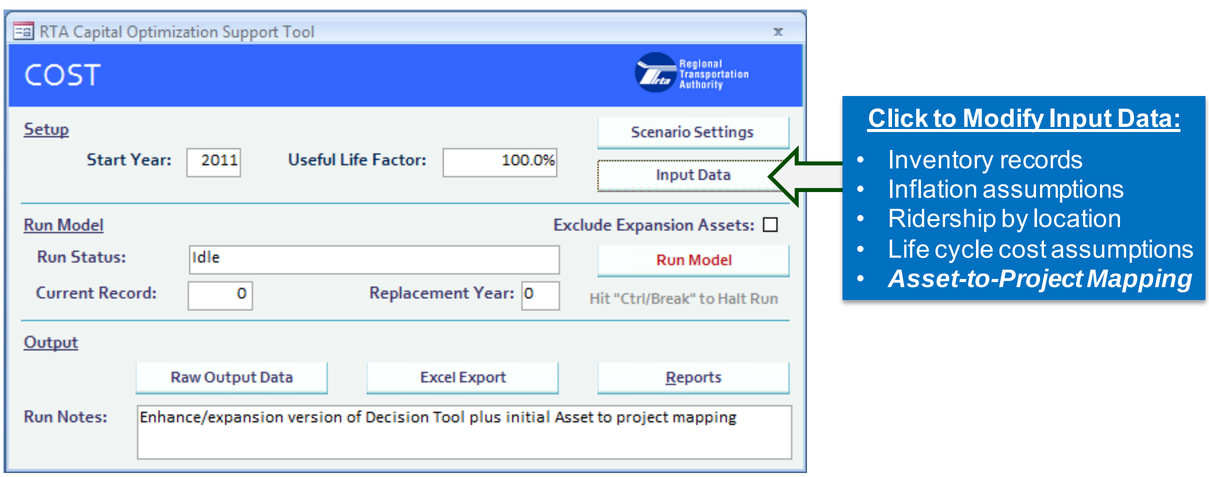
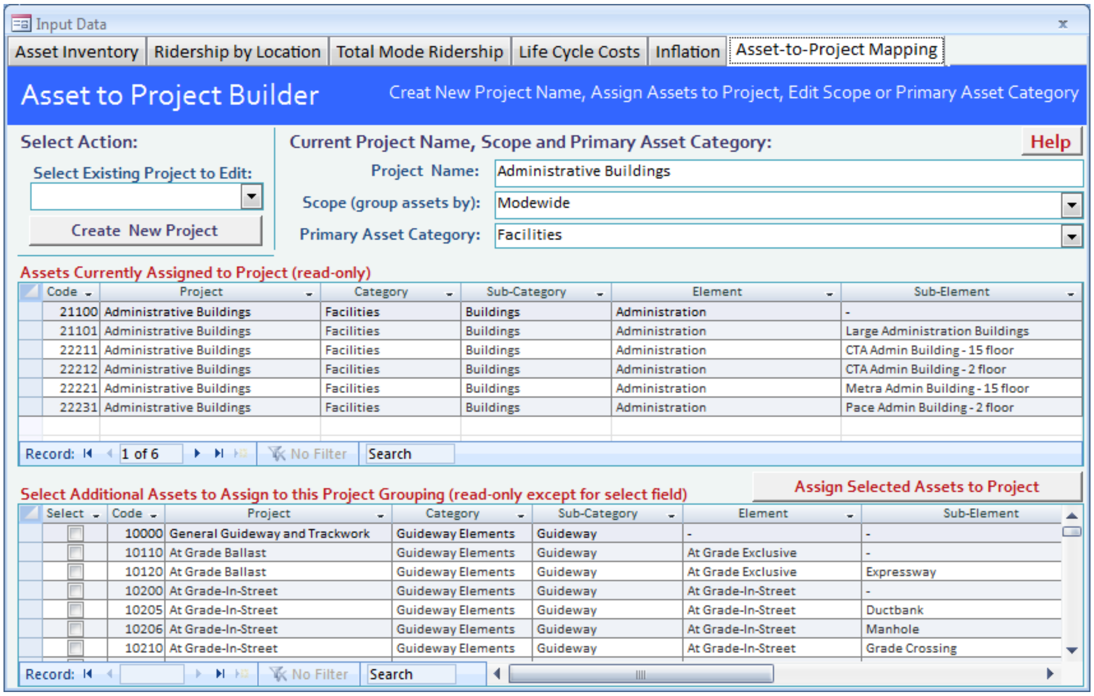
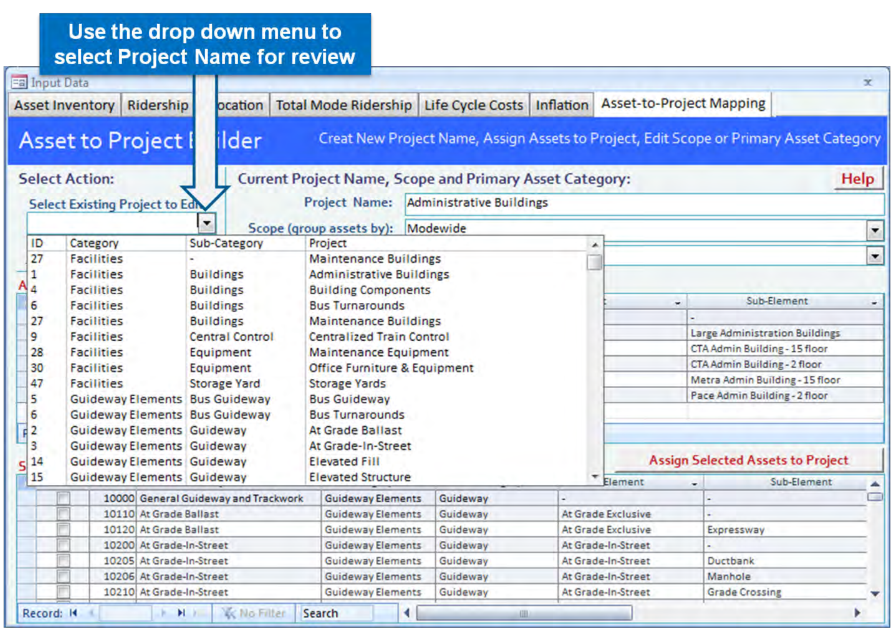


Figure 2-11: Asset-to-Project Builder Showing Current Assignments for Mapping



Users can review the current grouping of assets under Project Names by selecting the Project Name, sorted by asset type, from the drop down menu in the top left as seen in Figure 2-12. The "Assets Currently Assigned to Project" will appear in the top list below the menu, along with the Scope and Primary Asset Category in the top right. The Primary Asset Category is assigned based on the type of asset needs primarily addressed by each project grouping and is used for reporting purposes only (see Section 2.4).

Figure 2-12: Asset-to-Project Builder Project List



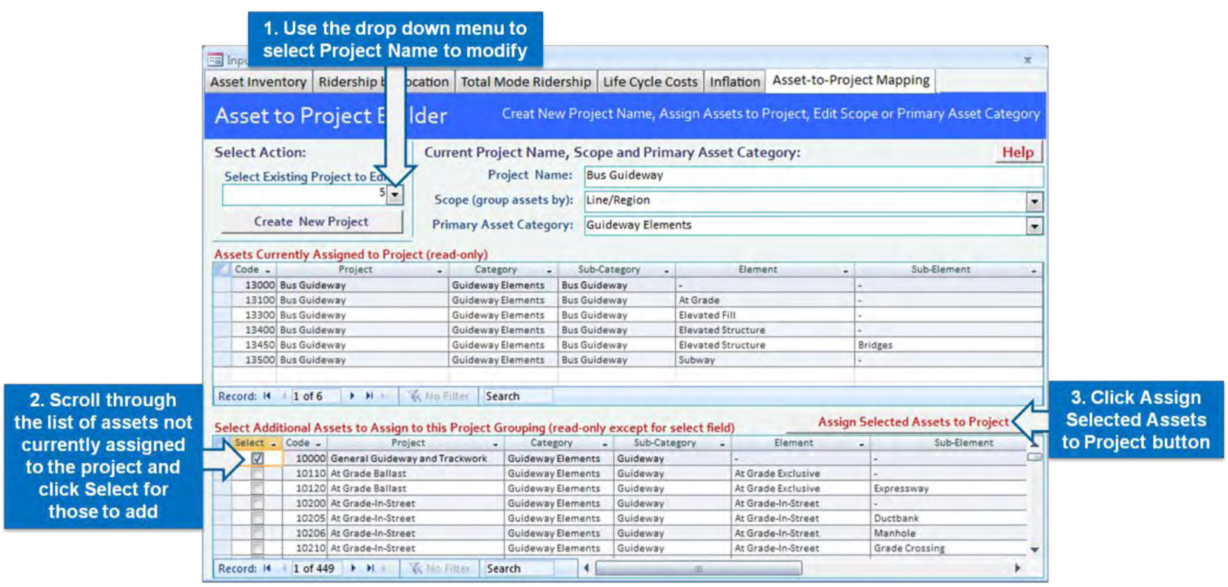
If a user wants to modify the grouping of an asset type to reflect their Service Board's approach to project planning or to see the impact of various grouping approaches and Scopes they can also use this form to make modifications. There are three ways to recalibrate the Asset-to-Project groupings on this form.

1. To revise the assigned Scope of the project to a higher or lower level: The user can select an existing Project Name from the drop-down menu at the top left and then change the assigned Scope using the drop-down menu at the top right. For example, Elevators are grouped under one Project Name and assigned a Line/Region Scope. However if a Service Board addresses Elevators by Branch/Division, they can choose that option from the drop-down for the Elevators project.

2. To change the default grouping of assets under a Project Name: The user can select that project and add assets from the bottom list by selecting the tick box in the left column as seen below in Figure 2-13. The user then clicks the "Assign Selected Assets to Project" button to make the addition. It is important to note that a single asset type can only be assigned to one Project Name in COST. Therefore if the user selects an asset type in the far left column and clicks the "Assign Selected Assets to Project" button, COST will remove that asset type from another project grouping and add it to the one currently listed on the form. Since all assets must be assigned to a Project Name, the only way to remove an asset from one project is to add it to a different one.

3. To create a new Project Name: Creating new Project Names is also possible on this form by clicking the "Create New Project" button in the top left corner. The user will then type a new Project Name into the top right field and select a corresponding Scope and Primary Asset Category. Assets can be added to this new project as per the steps above. These assets will then be removed from their default project groupings.

Figure 2-13: Asset-to-Project Mapping Form



COST's Asset-to-Project Mapping sub-routine groups individual assets with coincident needs after generating the 20-year needs profile, as seen in Figure 2-1. Therefore, if a user changes asset or Scope assignments or adds Project Names the model must be run again (by clicking the Run Model button on the Main Menu) to generate outputs based on these new groupings.

2.4 Asset-to-Project Mapping Output: Reports

As noted above, the asset-to-project mapping process is intended to identify "patterns of related asset investment needs" and the data source for these "patterns" are the asset level needs analysis produced by COST. It is important to understand then, that the asset-to-project mapping process can most accurately be described as a "post processing" of COST's needs analysis that groups related reinvestment needs into projects based on the four Scopes of mapping assignments discussed above.

The "project level" report is accessed by clicking the "Reports" button found on the lower panel of the Main Menu (Figure 2-14). Clicking this button will open a pop-up form listing all of the reports. Scroll through and then select the "Project Level Constrained Needs" report. At this point the user can either (1) click the "Report" button on the pop-up form – this action will open the report for viewing or (2) click the "Data (Read Only)" button to view the data underlying the selected report. If the "Report" button is selected the user will be viewing the report in "report" form and has the choice to select the Print Preview form using the View menu seen in Figure 2-15. The report can then be printed or exported to PDF (in Print Preview mode, click "PDF" in the Data section of the MS Access Menu) or MS Word format.

Figure 2-14: Model Output – Accessing the Report

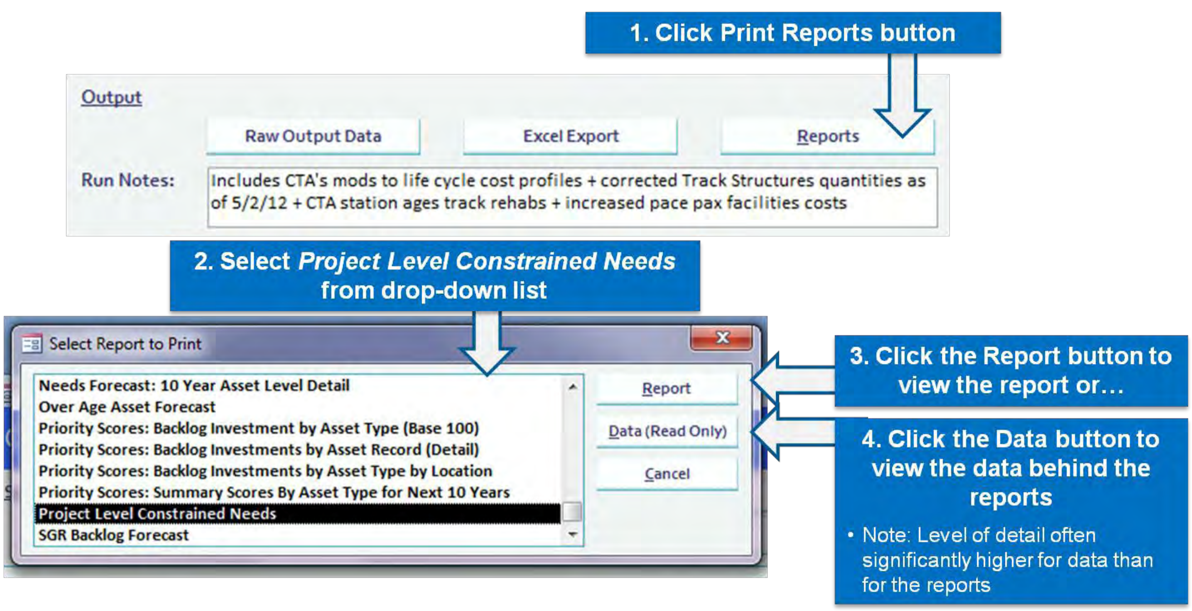
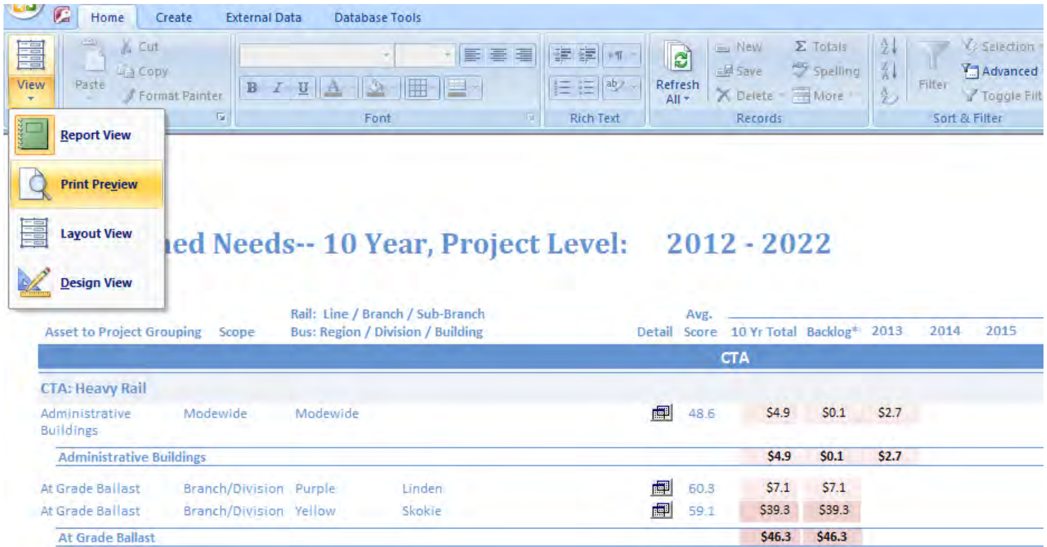


Figure 2-15: Changing Views of the Project Level Needs Report



An example of a "project level" (vs. asset level) needs report is presented below in Figure 2-16. This report groups Project Names by Service Board, Mode and Primary Asset Category. It also shows the Scope of the project and the relevant location information. Based on this report, the user might identify coincident reinvestment needs for traction power on the Forest Park branch of the Blue line as a potential reinvestment project. The level of need in each "project" is shown in total and annually over ten years with darker color values indicating higher reinvestment needs.

Figure 2-16: Project Level Needs Report

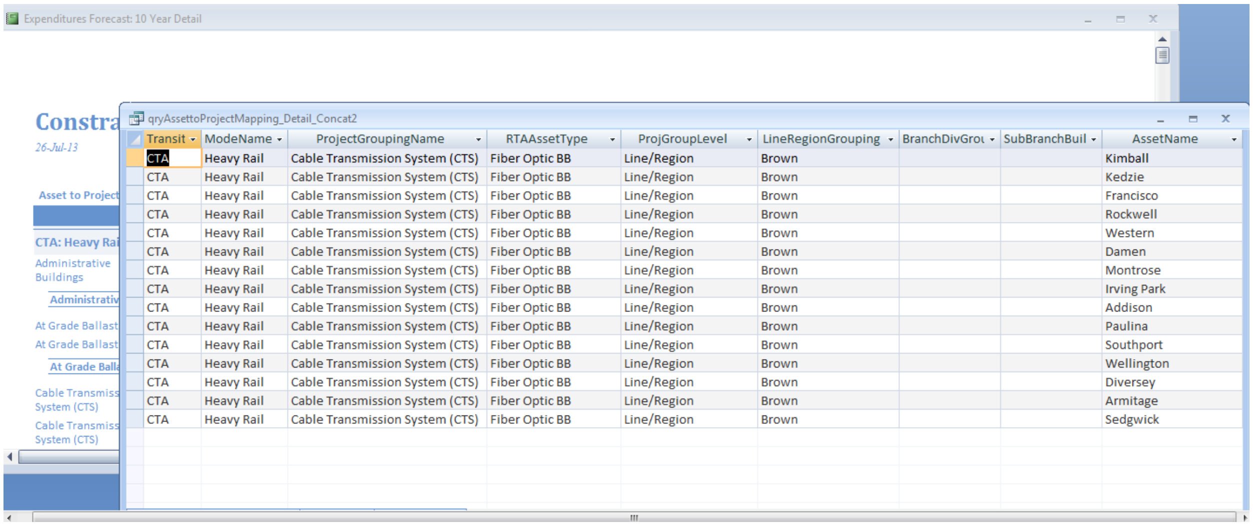
Constrained Needs-- 10 Year, Project Level: 2012 - 2022 — Summary Report

Note: Results presented by Service Board, then Mode. Project Names are sorted alphabetically under Primary Asset Category. *02-Aug-13*

Asset to Project Grouping	Scope	Rail: Line / Branch / Sub-Branch Bus: Region / Division / Building		Detail	Avg. Score	10 Yr Total	Backlog*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
								Annual Needs ($M)									
CTA																	
CTA: Heavy Rail																	
Facilities																	
Administrative Buildings	Modewide	Modewide			48.6	$4.9	$0.1	$2.7									$2.0
Administrative Buildings						**$4.9**	**$0.1**	**$2.7**									**$2.0**
Maintenance Buildings	Modewide	Modewide			68.3	$193.3	$95.4	$5.9	$5.9	$6.2			$3.4	$3.4	$7.7	$15.4	$50.4
Maintenance Buildings						**$193.3**	**$95.4**	**$5.9**	**$5.9**	**$6.2**			**$3.4**	**$3.4**	**$7.7**	**$15.4**	**$50.4**
Storage Yards	Modewide	Modewide			66.5	$810.7	$531.8						$56.5	$222.4			
Storage Yards						**$810.7**	**$531.8**						**$56.5**	**$222.4**			
Guideway Elements																	
At Grade Ballast	Branch/Division	Purple	Linden		60.3	$7.1	$7.1										
At Grade Ballast	Branch/Division	Yellow	Skokie		59.1	$39.3	$39.3										
At Grade Ballast						**$46.3**	**$46.3**										

In addition, the report includes an interactive button related to each "project" which allows the user to view all of the individual assets included in a "project." This feature is only available in "Report View" and will not function in "Print Preview." When clicked the button brings up a query with the individual asset details related to that "project", including the timing of reinvestment needs for each asset and its value (if any) in the SGR backlog from year to year – illustrated in Figure 2-17. Timing of investments and backlog changes can be seen by scrolling to the right in the query.

Figure 2-17: Project Level Needs Report with Asset Detail Query



Transit	ModeName	ProjectGroupingName	RTAAssetType	ProjGroupLevel	LineRegionGrouping	BranchDivGrou	SubBranchBuil	AssetName
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Kimball
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Kedzie
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Francisco
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Rockwell
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Western
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Damen
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Montrose
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Irving Park
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Addison
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Paulina
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Southport
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Wellington
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Diversey
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Armitage
CTA	Heavy Rail	Cable Transmission System (CTS)	Fiber Optic BB	Line/Region	Brown			Sedgwick

Impact of Changes to COST Scenario Definitions on Asset-to-Project Mappings: It is important to note that the timing of asset replacement needs produced by COST and the subsequent grouping of those asset needs to the project level is driven by the scenario assumptions used for the underlying COST model run. In particular, adjustments to COST's budget constraint values (assuming funding levels are less than required to address all needs) or to the investment prioritization criteria weights, will lead to changes in the composition and timing of proposed asset replacements and their related asset-to-project mappings. To view project level needs without budget constraint impacts, the user should run an "Unconstrained" scenario – described in *Volume 2: Part 1 RTA COST Model "How To" Guide*.

2.5 Mapping Data Requirements

Prior to initiating a COST model run the following additional information must be added to asset records to facilitate asset-to-project mapping. The Location fields seen below are included in the Asset Inventory form for Input Data, and are captured in the annual inventory update for RTA's assessment of needs. Project Names are linked to the inventory by asset types, and can be added or changed as described above in Section 2.3. All asset types must be assigned to a Project Name in order to be captured in the Asset-to-Project mapping reports.

Figure 2-18: Data Requirements by Asset-to-Project Mapping Scopes

Mapping Scope	Location Requirements	Project Name
I. Mode wide	• Not required	Required for assigning asset types
II. Line/Region	• Line/Region	Required for assigning asset types
III. Branch/Division	• Line/Region • Branch/Division	Required for assigning asset types
IV. Sub Branch/ Building/Yard	• Line/Region • Branch/Division • Sub-Branch/Building/Yard	Required for assigning asset types

3. "How to" Guide to Prioritize Mapped Projects

This chapter briefly describes the prioritization routine built into COST which can be used to support project prioritization based on the project groupings described above. For a more detailed description of the multi-criteria prioritization process embedded in COST, refer to *Volume 2: Part 2 Criteria Investment Prioritization Process "How To" Guide*.

Specifically this chapter considers:

- RTA's approach to asset-level multi-criteria scoring
- Aggregation of asset-level scoring to project-level scoring
- Application of project-level scoring

3.1 Asset-Level Prioritization Scores

As noted above, the asset-to-project mapping sub-routine identifies patterns of coincident asset investment needs as a "post processing" of COST's needs analysis. Thus any prioritization of projects is based on the prioritization scoring of the individual assets grouped within that project. This section provides the background on the criteria and aggregation method used by COST to determine the prioritization score of each asset in a constrained scenario. With unconstrained funding, prioritization scoring is not relevant for funding decisions in COST.

Figure 3-1 provides an overview of the five investment criteria used to score and rank all potential SGR reinvestment actions – including asset condition, number of riders impacted, and the contribution of reinvestment actions to each of service reliability, rider and agency staff safety and security, and finally O&M cost reduction. The weight placed on each criterion is variable within COST and hence can be varied to reflect agency policies or to conduct sensitivity analysis. The process used to score each SGR reinvestment criterion is highlighted in Figure 3-2.

Figure 3-1: COST – SGR Investment Prioritization Criteria and Scoring

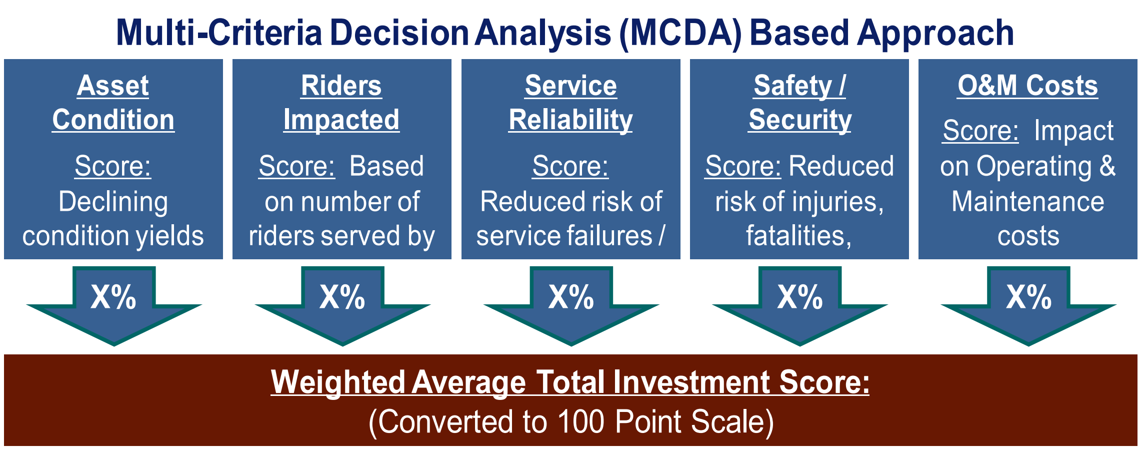
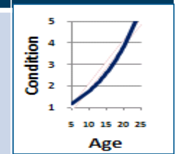
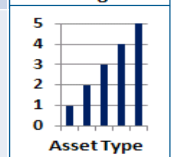
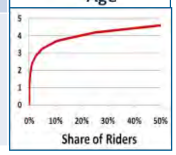


Figure 3-2: Approach to Scoring by SGR Investment Criterion

Criterion	Approach	Dynamic or Static?	Illustration
Condition	• Decay curve based condition estimate – Age based 1 to 5 scale	• Dynamic	
O&M Cost Impact	• Fixed score by asset type	• Static	
Reliability and Safety/ Security	• Combination of: – Fixed score by asset type – Dynamic score by asset age	• Mixed	
Riders Impacted	• Logarithmic score based on share of total agency riders impacted – Scale ensures all assets obtain score	• NA	

Scoring is "dynamic" throughout the 20-year period covered by each model run for some criteria. Specifically, COST assesses each asset's condition at the start of each analysis year (including the start or "backlog year"). This evaluation is then used to score and rank potential SGR investments with respect to asset condition, reliability and safety/security (with scoring for reliability and safety/security driven in part by condition). Due to this constant re-evaluation, the scoring for all assets is constantly changing (i.e., is "dynamic") throughout the 20-years of each model run.

With constrained funding COST will determine which assets to reinvest in based on the highest priority scores in any given year of the model run. Those assets which do not score highly enough for reinvestment but require replacement or rehabilitation will enter the SGR backlog. If funding is constrained enough to delay the timing of a normal reinvestment need (i.e. scheduled replacement or rehabilitation), this prioritization routine will determine when an individual asset receives reinvestment actions (i.e. what year the need will appear on the project level output report).

3.2 Aggregation of Asset Prioritization Scores (RTA Approach)

Even though prioritization scoring is dynamic for each asset and changes in each year of the model run, the asset-to-project mapping process only identifies projects that have been funded by COST (i.e., investments with sufficiently high priority scores that can be funded subject to the user entered budget constraint). Therefore COST calculates project-level priority scores using the highest priority score of an asset for the first ten years of needs analysis (including the backlog year). This maximum priority score for each asset is then weighted by the total investment costs of the asset over the 10-year needs analysis, which is then used for asset-to-project mapping so it can be aggregated with the other assets in the same project. The project-level priority score is then the sum of all the weighted maximum prioritization scores for the assets in the project, divided by the total 10-year cost for all project investments.

Using this methodology, assets with high prioritization scores but low total investment costs and assets with low prioritization scores but high total investment costs will contribute a similar amount to the score of a project. The priority score for a project containing two such assets would be as follows:

	Priority Variable	Calculation	Asset 1	Asset 2
A	10-Year Max Prioritization Score		50	80
B	Total 10-Year Needs (millions)		$60	$40
C	Weighted Priority for each Asset	(AxB)	3000	3200
D	Total 10-Year Project Needs (millions)	(B+B)	$ 100	
E	Sum of Weighted Priorities	(C+C)	6200	
	Project Priority Score	**(E/D)**	**62**	

3.3 Project Scoring

The methodology described above for aggregating individual asset prioritization scores results in a single priority score for each Project Grouping Name and Project Scope combination listed in the asset-to-project mapping output report, as seen below in Figure 3-3. This score represents a weighted average of the maximum prioritization scores for all of the assets included in the project grouping. These project priority scores allow for easy comparison across project groups, particularly if budget constraints increase over time. In this example the project with the highest priority score is Maintenance Buildings. This project also has the highest total investment needs over the 10-year analysis period.

Figure 3-3: Example Project Priority Scores

Constrained Needs-- 10 Year, Project Level: 2012 - 2022

Note: Results presented by Service Board, then Mode. Project Names are sorted

Asset to Project Grouping	Scope	Rail: Line / Branch / Sub-Branch Bus: Region / Division / Building	Detail	Avg. Score	10 Yr Total	Backlog*
CTA						
CTA: Heavy Rail						
Facilities						
Administrative Buildings	Modewide	Modewide		48.6	$4.9	$0.1
Administrative Buildings					$4.9	$0.1
Maintenance Buildings	Modewide	Modewide		68.3	$193.3	$95.4
Maintenance Buildings					$193.3	$95.4
Storage Yards	Modewide	Modewide		66.5	$810.7	$531.8
Storage Yards					$810.7	$531.8

With asset-to-project mapping, the individual asset prioritization scores determine the timing of investments in a constrained scenario, along with the regular timing of reinvestment needs. The aggregated project-level scores also allow for comparison of prioritization of assets between projects.

4. "How to" Guide to Apply Project Mapping Results

This chapter describes potential applications of the asset-to-project mapping outputs. Specifically it describes use of the project-level report in the budgeting process and for potential Service Board project identification.

4.1 RTA Budget Support: Independent Validation of Proposed Investments

For RTA a primary application of COST is the review of the annual capital budgets submitted to RTA by its Service Boards. RTA is responsible for funding and oversight of all public transportation in Northeastern Illinois. Hence, each year RTA's three Service Boards submit their capital plans for the following year, which RTA must then review and approve. Within this process, RTA uses COST's prioritization capability to take an "independent look" at the Service Boards capital budget proposals to help assure that the mix of investments in the proposed capital budgets is consistent with the region's preferred mix of investment priorities (as determined by COST's prioritization scoring).

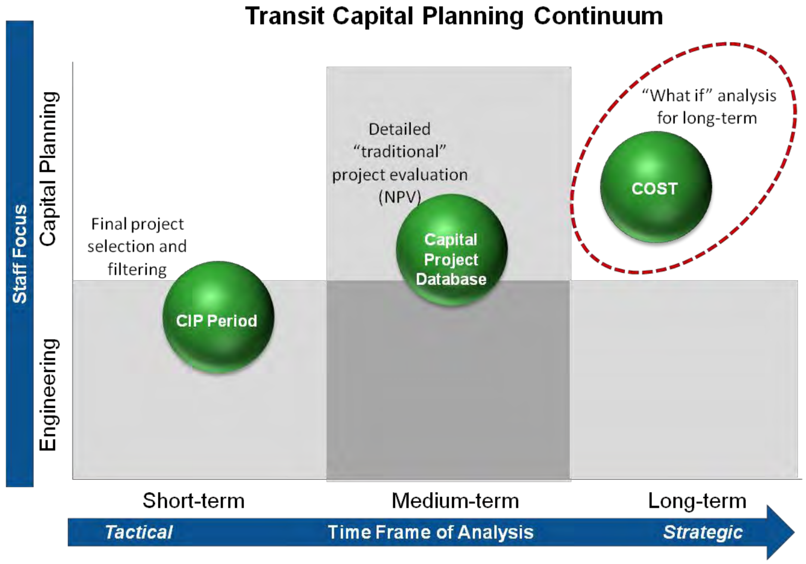
The asset-to-project mapping process described above provides RTA and the Service Boards with an additional tool for comparison of capital plans for specific projects. While the sub-routine is not meant to provide project planning, it does identify coincident needs which may or may not be addressed in the proposed capital budgets. Differences between the proposed budgets and COST generated projects can then be used to help determine whether to (1) reconsider the Service Board's proposed investment decisions and/or (2) reconsider and potentially recalibrate and improve COST's investment prioritization or asset-to-project mapping project groupings or scopes.

4.2 Direct Project Identification

In addition to providing an independent view of priority investment decisions, COST also provides a longer-term view of capital planning. As seen in Figure 4-1, the timeframe for COST's analysis is longer than those generally used for transit capital improvement plans (CIPs) and even the capital projects pipeline. As such, the longer-term view that COST provides can be used to help identify future investment projects that are not yet on the planning horizon.

In addition to providing project identification beyond the horizon of capital budgets, the project groupings developed in the asset-to-project mapping process can be used to identify potential projects that may not surface during the normal capital planning process. For example, by grouping assets of a similar type and similar location a project may eventuate in COST which a Service Board did not identify through their own internal processes. These new "projects" can then be discussed for potential inclusion in future plans if they provide the efficiencies expected in their groupings.

Figure 4-1: Example Continuum of Capital Planning in Transit



Appendix A: Glossary and Abbreviations

- Prioritization: For this guide, prioritization is the process of identifying a preferred or optimal order in which reinvestment events should occur. Implicit in this statement is the assumption that:
    - *Funding is insufficient to address all needs.* Hence prioritization is required to determine which assets should be addressed first (and which assets have needs that may not be addressed).
    - *Investment needs can be ranked.* In other words, there are good analytic or other bases on which to ranked investment needs – from highest to lowest—to determine in which outstanding needs are most effectively addressed (and potentially leaving some needs unaddressed).

- Prioritization Criteria: Prioritization criteria provide the basis for determining the priority of individual investments. In general, investments are made with the expectation that the completed investment will yield improvements to one or more aspects of agency operations (e.g., improvements to reliability, efficiency, safety, rider comfort or other characteristic). Within a prioritization routine, the most desirable or important of these types of investment outcomes are referred to as "investment criteria". Investments that perform best with respect to these criteria (i.e., tend to be provide the best mix of desired outcomes) are assigned the highest priority. Investments that perform poorly may receive a low priority ranking.

- Prioritization Criteria Scores: From the viewpoint of this guide (and RTA's Decision Tool), prioritization criteria should be quantifiable so investments can be assigned a numeric score reflecting their potential contribution to the desired outcome associated with that criterion (e.g., contribution to SGR). Note that numeric criteria scores facilitate objective comparisons between investment options. Given that different criteria may naturally be associated with specific unit quantities (e.g., condition rating for SGR and dollar values for impacts to operating costs), these score need to be converted to a common basis if the intention is to generate a multi-criteria prioritization score.

- Multi-Criteria Investment Prioritization (criteria weighting): Multi-criteria investment prioritization refers to the process of evaluating and prioritizing investment options based on each investment's performance against a mix of multiple investment criteria. In the context of this guide and RTA's Decision Tool, multi-criteria investment prioritization implies the (1) all criteria are individual scored on a common scale (e.g., running from 1 to 5) and (2) these criteria scores are combined into a weighted average score, with the weight placed on each criterion reflecting the relative importance of that criterion.

- Needs Analysis: In the context of COST, needs analysis refers to the process of determining the level of investment required to attain specific investment objectives and also with how those investment dollars are allocated to different uses (e.g., between various asset types). In general, needs analysis falls into two broad categories:
    - *Unconstrained needs:* The level of investment required to address all outstanding and future needs, irrespective of actual or expected funding availability
    - *Constrained Needs:* The level of investment required to attain more realistic investment objectives (e.g., maintain the size of the current investment backlog, or eliminate the

backlog over 20 years). As the name suggests, under constrained needs analysis, there is insufficient funding to address all needs.

- Reinvestment in Existing Assets (SGR) vs. Investment in New Expansion or Enhancement Assets: COST is designed to assess and prioritize investment needs for both existing and expansion assets. In general, these investment types falls into the following categories:
    - *Reinvestment in Existing Assets:* Refers to SGR (i.e., rehab and replace) investments in assets that are currently in service (i.e., *existing* assets).
    - *Investment in expansion assets:* Refers to the planned/proposed future purchase of new assets that either: (i) expand existing service capacity (e.g., fleet expansion), (ii) adds a new service (e.g., New Starts) or (iii) enhances existing service (e.g., new technologies such as real-time arrival information).

- Scenario Analysis: In the context of COST, scenario analysis refers to the process of identifying specific investment objectives and then assessing the investment needs associated with attaining that scenario. Examples include:
    - Maintain historic funding levels
    - Maintain the current backlog
    - Eliminate the backlog over a set time period (e.g., 20 years)

- Asset Condition and Decay: Asset condition refers here to the estimated physical condition of a transit asset. Specifically, COST includes a set of embedded asset decay curves that predict the current and future physical condition of a transit asset based on its type, age and other factors (e.g., use and maintenance history). COST uses these condition relationships to prioritize reinvestment needs (in part) based each asset's predicted physical condition (both currently and into the future depending on needs and funding availability). COST also uses these same asset decay curves to generate current and future distributions of asset conditions.

The following definitions for State of Good Repair (SGR) separate the asset level from aggregate level.

- Asset Level SGR: An asset is in a state of good repair (SGR) if (i) its age does not exceed its expected useful life and (ii) all rehabilitation and annual capital maintenance activities are up to date. Under these circumstances, an asset has no deferred capital reinvestment needs and, by definition, has an estimated condition score of 2.5 or higher (RTA/TERM Lite decay curves are defined such that assets attain their useful life and a condition score of 2.5 concurrently). If an asset has undergone a major life extending rehabilitation, it can exceed its expected useful life and still be in SGR. Non-attainment of SGR does not imply an asset is unfit for service or unsafe but it may increase the likelihood of sub-optimal performance (i.e. reliability and availability performance may decrease).

- Mode, Service Board, or Regional Level (Aggregate) SGR: A transit mode, Service Board or the region is considered to be in SGR if each of its component assets is in SGR (as defined above). Mode, Service Board and regional level SGR represents an ideal state and is not attainable in practice as (i) rehabilitation and replacement needs arise continuously and (ii) mode, Service Board and regional level budgets are generally insufficient to meet these continuous needs. As such, a more realistic view of SGR at an aggregate level is based on the region's target/tolerance for achieving reinvestment goals – such as halving the current SGR backlog over a certain timeframe or not allowing the SGR backlog to grow beyond current levels.