State of Good Repair: Prioritizing and Evaluating Implications of Investments in Transit Capital Asset Rehabilitation and Replacement

prepared for the

TRB 9th National Conference on Transportation Asset Management

presented by

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Outline

- TCRP E-09 project description
- Review of state-of-good-repair (SGR) literature and existing practice
- Relating SGR to performance
- Framework for transit asset rehabilitation and replacement
  - Overview
  - Framework steps
  - Examples
- Tools for evaluating and prioritizing asset rehabilitation and replacement
- Conclusions

TCRP E-09 Project Description
Overview

- TCRP E-09: Prioritizing the Rehabilitation and Replacement of Existing Capital Assets and Evaluating the Implications for Transit
- Objectives
  - ***Develop a framework*** for public transportation organizations to use to prioritize asset rehabilitation and replacement
  - ***Identify methods*** for assessing the positive and negative consequences of varying investment levels on key indicators of public transportation service and performance
- Project team
  - Spy Pond Partners, LLC
  - KKO & Associates, LLC
  - Harry Cohen
  - Joseph Barr

TCRP E-09 Project Description
Tasks

- Phase I Tasks
  - Literature Review
  - Define Impacts and Implications of Rehabilitation/Replacement Investments
  - Identify Organizations for Interviews
  - Evaluation Prioritization Methods
- Phase II Tasks
  - Prepare Framework
  - Develop Assessments Methods
  - Prepare Final Report
- Current Status
  - Phase I completed in Summer 2011
  - Preliminary Draft Final Report submitted
  - Now finalizing the report and assessment methods

SGR Review Summary

- Reviewed asset and transit management literature over past 10 years and conducted 11 agency interviews
- Key findings
  - Predominant measures for SGR analysis are cost to perform recommended work and asset age/remaining life
  - Numerous definitions of "SGR" and no consensus on any particular definition
  - Notable analytical approaches
    - FTA TERM Model – 5-point condition scale for assessing SGR, assets assigned a condition based
    - MBTA SGR Database – includes approach for prioritizing limited SGR funds
    - MTC Regional Transit Capital Inventory – uses an approach conceptually similar to that of TERM to predict SGR needs, costs
    - London Underground - uses lost customer hours (LCH) to characterize SGR impacts
  - Asset management approaches used for pavement and bridges are highly applicable to transit, though U.S. asset management guidance is geared towards highways

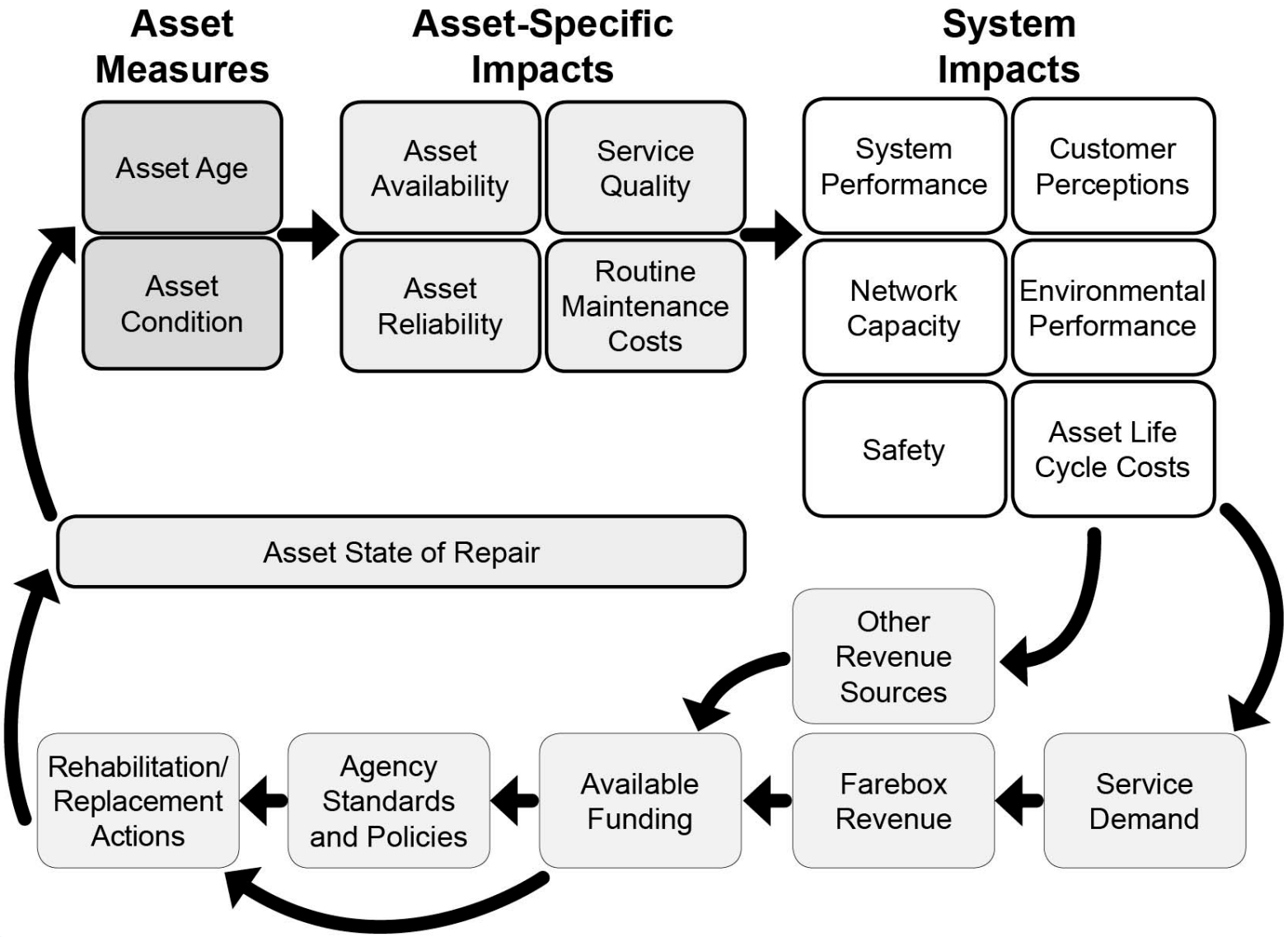
Relating SGR to Performance
Case Studies

- New York City Transit (NYCT)
  - Steep decline in condition in the 1970's, followed by remarkable restoration of the system
  - Subway MDBF dropped from 23K miles to 7K - now 156K
  - Significant deferral in rail replacement – over 50% classified as requiring replacement
  - 80% increase in delays – subsequently dropped 59%
  - 17% reduction in ridership – subsequently grew 58%
- Other Examples
  - Chicago Transit Authority (CTA) Douglas Branch
  - Toronto Transit Commission (TTC)
  - Details on bus agency experience in the FTA report *Useful Life of Buses and Vans*

Source: Boylan

Relating SGR to Performance

Categorizing Impacts and Implications



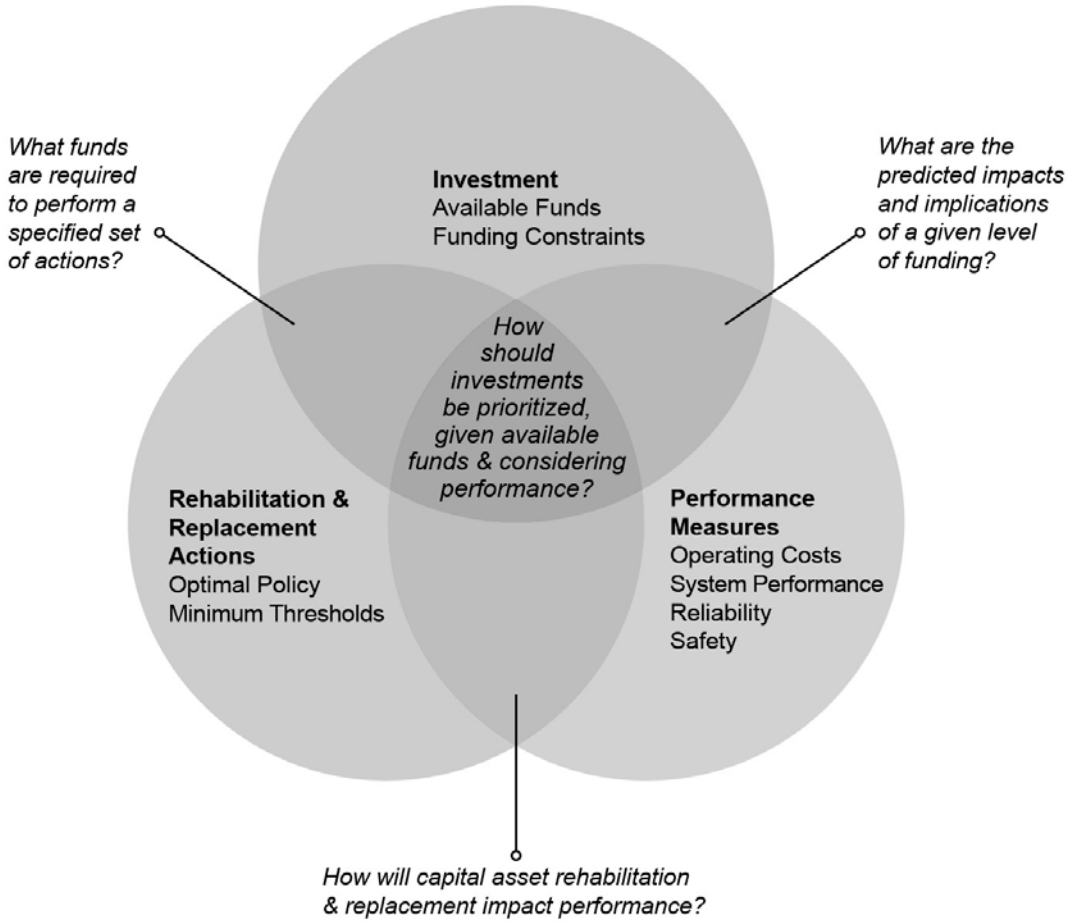
Relating SGR to Performance
Implications

- There is a strong - but indirect - relationship between asset measures (age, condition) and system impacts shown in the figure
- Better analytic methods are needed to
  - Predict asset-specific and system impacts
  - Relate asset conditions to performance, and convert measures of performance to agency and user costs
  - Provide an economic justification for achieving a given state of repair
- Recommended performance measures
  - Asset measures
    - Age
    - Condition
  - Asset-specific impacts
    - Availability
    - Hours of delay
    - Maintenance costs
    - % of assets enhanced/improved

} use to communicate investment impacts and predict life-cycle agency and user costs

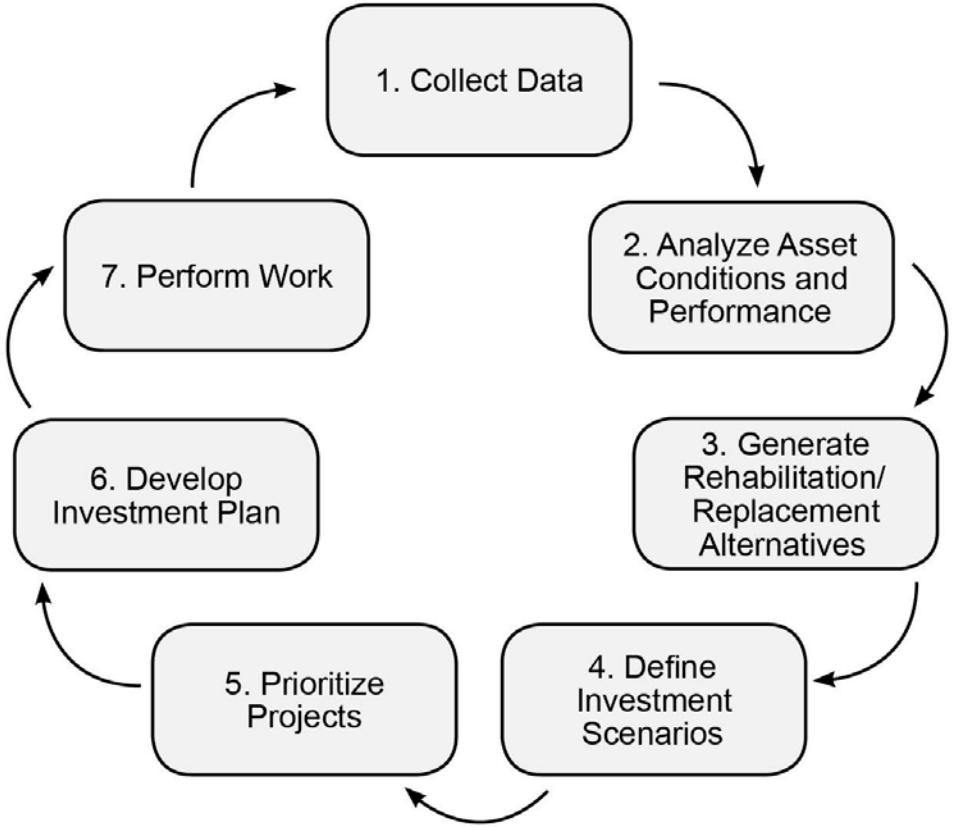
Framework for Asset Rehabilitation and Replacement

Elements of the Framework



Framework for Asset Rehabilitation and Replacement

Process for Evaluating and Prioritizing Rehabilitation/Replacement Projects



Framework for Asset Rehabilitation and Replacement
Process Steps

- Collect Data
  - Establish the Capital Asset Inventory
  - Define Data Collection and Inspection Protocols
  - Implement an Asset Management System
- Analyze Asset Conditions and Performance
  - Define Performance Measures
  - Calculate Current Conditions and Performance
  - Project Conditions and Performance
- Generate Rehab/Replacement Alternatives
  - Develop a Rehabilitation/Replacement Policy
  - Determine Candidate Actions
  - Quantify Costs and Impacts of Each Alternative

Framework for Asset Rehabilitation and Replacement
Process Steps

- Define Investment Scenarios
  - Develop Funding and Prioritization Assumptions
  - Define Scenarios
  - Simulate Future Decisions, Conditions and Performance
- Prioritize Projects
  - Specify the Utility Function
  - Refine Project Scope and Budgets
  - Apply the Utility Function
- Develop the Investment Plan
  - Define Funding Level and Constraints
  - Select Projects
  - Prepare the Plan
- Perform Work

Framework for Asset Rehabilitation and Replacement

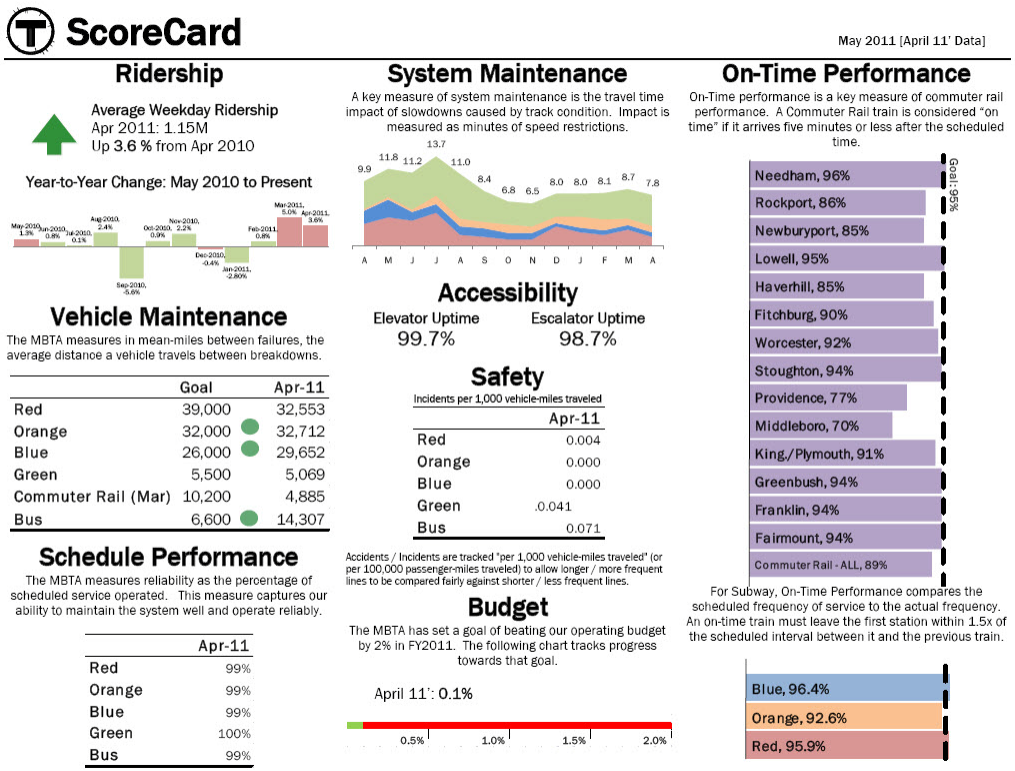
Recommended Minimum Set of Measures for SGR Analysis

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

Framework Examples

Performance Reporting – MBTA Performance Scorecard

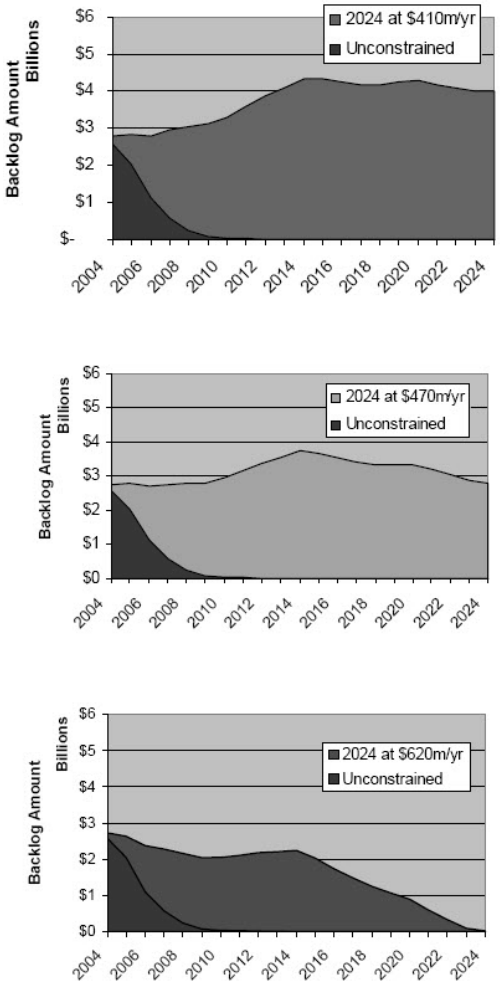
- One-page scorecard for reporting asset conditions
- Summary measures for each mode, with additional details by mode
  - Ridership
  - Vehicle/System Maintenance
  - On-time Performance
  - Schedule Performance
  - Elevator/Escalator Accessibility
  - Safety
  - Budget
- Updated on the MBTA web site on a monthly basis



Source: MBTA

Framework Examples
Analysis Approaches – MBTA and MTC

- MBTA
  - Established SGR Database for analysis of SGR needs
  - SGR database is notable in its ability to prioritize SGR work given a constrained budget
  - MBTA uses the SGR Database for scenario analysis
  - Project prioritization is handled as a separate process using published weights for key investment objectives
- MTC
  - Uses the Regional Transit Capital Inventory (RTCI) to support analysis of asset replacement needs for Bay Area transportation agencies
  - Refer to the MTC presentation for more details
  - Like MBTA, handles project prioritization as a separate process, also using published weights for key objectives

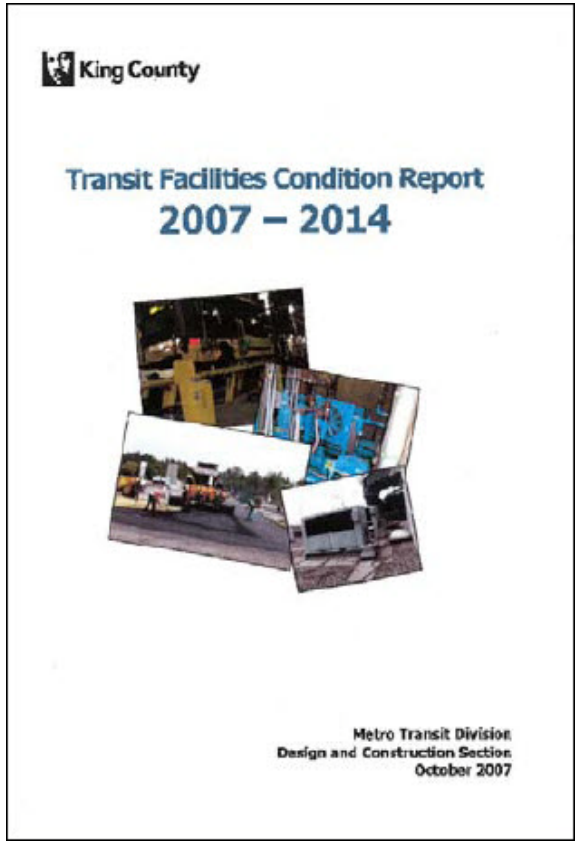


Source: MBTA

Framework Examples

Investment Plan – King County Metro

- Established the Transit Asset Management Program (TAMP) for managing its fixed assets to address investment needs for facilities and infrastructure
- Assets that are within six years of requiring replacement or rehabilitation are inspected on a yearly basis
- The TAMP team develops an annual work plan based on inspection results, budget and other factors
- Summary information provided in the Transit Facilities Condition Report



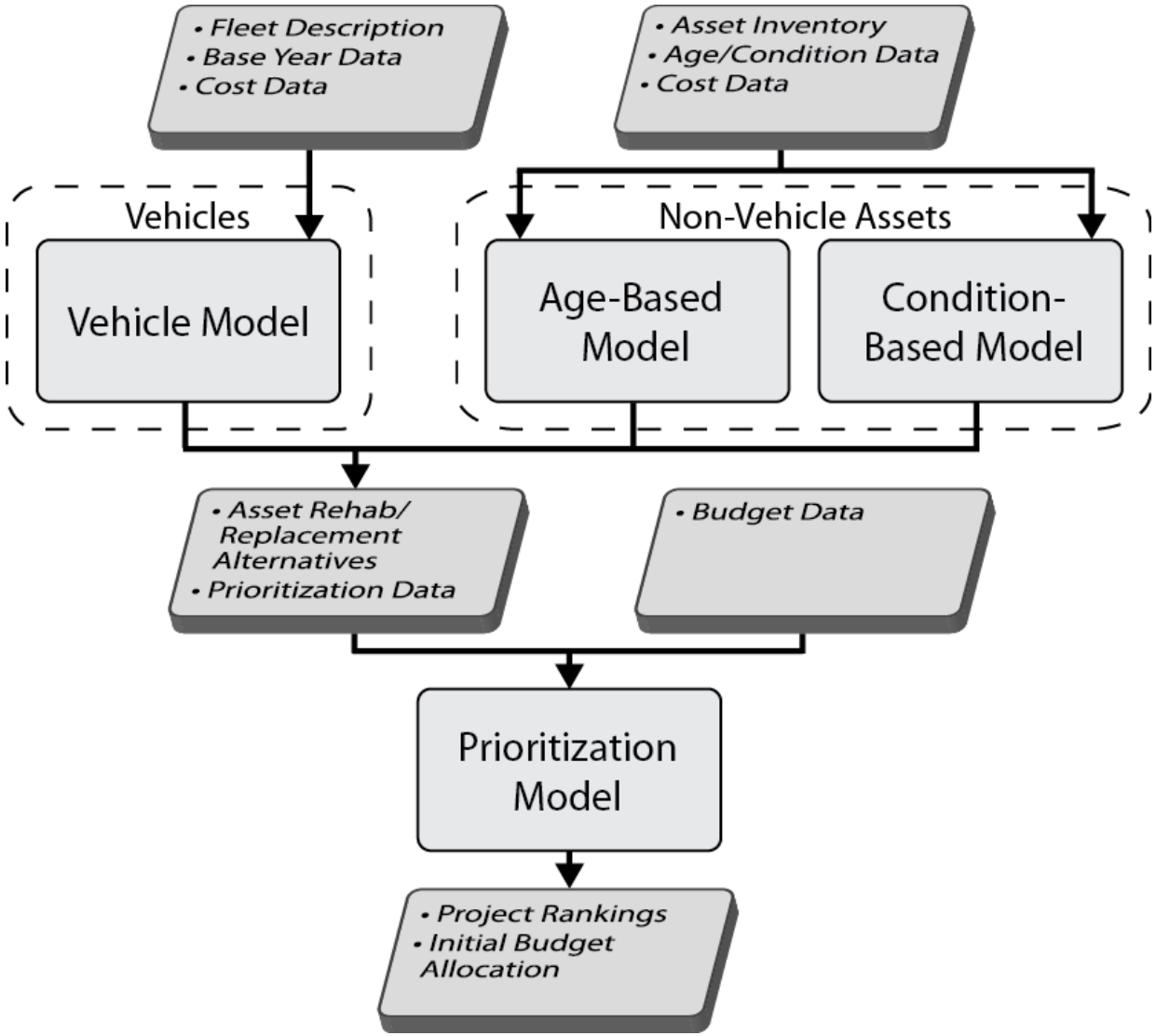
Source: King County Metro

Tools for Evaluating Asset Rehabilitation and Replacement
Overview

- Tools were developed to support the asset rehab/replacement framework
- Support converting key measures of asset performance into agency and user costs
- Three tools developed to analyze asset-specific rehabilitation and replacement needs
  - Vehicle Modeling Tool
  - Age-Based Modeling Tool
  - Condition-Based Modeling Tool
- Prioritization Tool uses data from the other tools to rank projects and simulate allocation of a budget
- See TRB Annual Meeting presentation, upcoming webinar for more details

Tools for Evaluating Asset Rehabilitation and Replacement

Relationship Between the Tools



Tools for Evaluating Asset Rehabilitation and Replacement

Vehicle Tool - Inputs

TCRP E-09
TRANSIT STATE OF GOOD REPAIR
VEHICLE REPLACEMENT MODEL - INPUTS

Click to Edit Details

Click for Results

INSTRUCTIONS

Note: this model is used to predict the average annual cost, the cost-minimizing replacement age, and prioritization data for transit vehicles.
To use this model please follow these instructions, and see the TCRP E-09 report for more information.

1. Open the spreadsheet with macros enabled
2. Select an asset type from the dropdown or select "User-Specified" if developing a new model.
3. Enter accumulated mileage (per vehicle) and number of vehicles for up to 20 subfleets of the same vehicle type.
4. Enter the base year and base year fleet statistics.
5. Enter the cost of a new vehicle.
6. If desired enter an estimate of other replacement benefits per vehicle mile (e.g., reduced emissions).
7. If desired enter the delay cost, typical schedule headway, recovery time, vehicles per consist, and/or the discount
8. If desired click the "Click to Edit Details" button to edit additional details (necessary only for a new model).
9. To view results click the "Click for Results" button.

REQUIRED INPUTS

Vehicle Type: Bus

Inventory Description:

Group	Accumulated Milegage	Number of Vehicles	Group	Accumulated Milegage	Number of Vehicles
1	147,882	90	11	162,325	6
2	114,252	25	12	212,726	60
3	456,352	117	13	25,063	26
4	296,374	25	14	18,970	54
5	418,462	159	15		
6	246,390	40	16		
7	245,590	60	17		
8	285,708	165	18		
9	272,171	10	19		
10	191,941	39	20		

Base Year Statistics:

	Default	Override Value	Notes
Base Year	2009	2009	
Passenger Miles (000)	1	259,208	
Unlinked Trips (000)	1	58,485	
Vehicle Miles (000)	1	31,006	
Revenue Vehicle Miles (000)	1	23,747	
Revenue Vehicle Hours (000)	1	1,747	
Number of Road Calls (buses) or Failures (rail)	1	4,299	
Energy Cost for Vehicle Operations (000)	1	22,956	
Vehicle Maintenance Cost (000)	1	58,574	

OPTIONAL INPUTS

	Default	Override Value	Notes
New Vehicle Cost ($ per vehicle)	397,000		
Other Benefits of Replacement ($/vehicle mile)	0.00		results in higher benefit for replaceme
Passenger Delay Cost ($ per hour)	48.40		
Typical Schedule Headway (min)	30		
Typical Recovery Time After Road Call/Failure (m	60		
Vehicles per Consist	1		leave blank for buses
Discount Rate (%)	7%		

Select vehicle type: bus, light rail, heavy rail

Enter inventory description – vehicles and accumulated mileage

Enter base year statistics – based on NTD data

Enter vehicle replacement cost and other parameters

Tools for Evaluating Asset Rehabilitation and Replacement

Vehicle Tool - Results

TCRP E-09
TRANSIT STATE OF GOOD REPAIR
VEHICLE REPLACEMENT MODEL - RESULTS

SUMMARY RESULTS

Vehicle Type:	Bus
Cost-Minimizing Replacement Mileage (miles)	530,920
Cost-Minimizing Replacement Age (years)	15
Average Annual Agency Cost:	$155,300.82
Average Annual User Cost:	$4,965.36
Average Annual Total Cost:	$160,266.19

Click for Inputs

Click to Edit Details

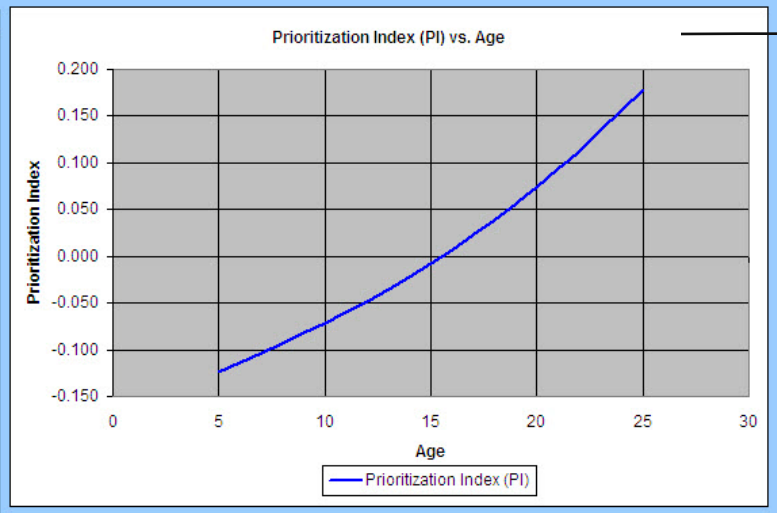
PRIORITIZATION DATA

Prioritization Index (PI) Coefficients (copy and paste into the prioritization model)
Note: PI = C0 + C1 * Age + C2 * Age^2

C0	C1	C2
-1.498E-01	4.084E-03	3.586E-04

Sample PI Results

Age	PI
5.00	-0.12
6.00	-0.11
7.00	-0.10
8.00	-0.09
9.00	-0.08
10.00	-0.07
11.00	-0.06
12.00	-0.05
13.00	-0.04
14.00	-0.02
15.00	-0.01
16.00	0.01
17.00	0.02
18.00	0.04
19.00	0.06
20.00	0.07
21.00	0.09
22.00	0.11
23.00	0.13
24.00	0.16
25.00	0.18



Cost-minimizing replacement mileage considering:
-Replacement cost
-Rehabilitation and maintenance
-Energy (fuel) costs
-Delay costs from road calls/failures

Average annual agency and user costs

Prioritization data – including Prioritization Index (PI) by year and coefficients for a PI curve used in the Prioritization Tool

Note: PI is calculated by dividing the net benefit of replacement relative to a one-year deferral divided by replacement cost – used to determine economically optimal actions

Conclusions

- Results of the research are intended to help transit agencies
  - Better prioritize asset rehabilitation and replacement
  - Better communicate investment impacts and implications
- The TCRP E-09 project report will detail the materials presented here
  - Review of SGR materials
  - Approach for relating SGR and performance
  - Asset rehabilitation/replacement framework
  - Supporting tools
- Funding has been approved for the next phase of the TCRP E-09 project – this phase is likely to focus on
  - Testing the framework through a set of agency pilots
  - Revisions to the framework and tools
  - Developing guidance for applying the framework