Outline

Lecture 2 – Investment Planning and Programming

- Objectives of programming
- Program structure
- Investment planning/programming framework
- Condition assessment and needs
- Levels of analysis
- Revisit benefit-cost analysis
- Priority setting and program tradeoffs
- Investment planning support tools
Objectives of Programming

- Allocate resources across investment program categories and modes
  - Preservation and maintenance (“state of good repair”)
  - System operations
  - Capacity/service expansion
- Selecting the best mix of projects and project designs (scopes) within each program category
Program Structure

While conceptually, a programming process could evaluate all projects against all other projects, in practice, a program structure is used to create a hierarchy of choices.

Program categories may reflect:
- Policy or functional objectives (e.g., preservation, operations, capacity, etc.)
- Funding sources
- Institutional structure and system owner/operator responsibilities
- Modes

Program Structure (continued)

Program structure will influence the investment issues and tradeoffs examined.

Project selection criteria may vary by program category (reflecting different objectives, impacts, etc.)

Best mix of projects and project designs will vary depending on overall program funding levels.

Program categories reflecting policy/functional objectives facilitate tying budget decisions to system performance.
Example Capital Program Structure
Massport

Facility Types

- Logan Airport
- Hanscom Field
- Maritime
- Tobin Bridge
- Development
- Agencywide

Program Categories

- Logan Airport
  - Logan Airside
  - Logan Landside
  - Logan Noise Abatement and Mitigation
  - Logan 2000
- Hanscom Field
  - Hanscom Airside
  - Hanscom Landside
- Maritime
  - Mystic Piers
  - Moran Terminal
  - Revere
  - Sugar Terminal
  - Conley Terminal
- Tobin Bridge
  - Tobin Bridge
- Development
  - Development
- Agencywide
  - Administration
  - Engineering
  - Legal

Investment Planning and Programming Framework

- Capital programming process
- Factors influencing programming
- Characteristics of a good programming process
- Common problems
Overview of The Capital Project Planning and Delivery Process

- Policy Direction and Planning
  - Strategy/Objectives
  - System Planning

- Programming Process
  - Identification of Needs by Category
  - Identification and Evaluation of Range of Solutions
  - Identification of Programs/Projects
  - Prioritization within Categories
  - Annual Budget Proposal

- Budget Review and Approval
  - Review Requests versus Constraints
  - Approve Budgets
  - Establish Program Delivery Parameters

- Design
  - Designer Selection
  - Design Reviews
  - Permits/Hearings
  - Final Cost and Schedule Estimates
  - Formation of Documents

- Construction
  - Bid and Award
  - Construction Monitoring
  - Completion/Start Up/Turn Over to OPS

- Operations
  - Project Delivery and Performance Monitoring
  - Feedback to Programming Process

Capital Programming Process

- Establish Program Categories
- Need Analysis by Category
- Program Evaluation and Ranking within Each Category
- Program Development
- Program Selection
- Project Scope
- Project Phase/Timing
- Final Program Fund Allocations and Budget
- Program Delivery and Performance Monitoring

- Funding
- Policy
- Stakeholder Input
- Preservation
- Operations
- Capacity Expansion
Factors Influencing Capital Programming

**Institutional**
- Statutory requirements/regulations
- Funding sources and levels
- Policy goals and objectives
- Intergovernmental relationships

**Organizational**
- Geographic extent/size of system and facilities
- Centralized/decentralized
- Management philosophy
- Degree of outsourcing
- Staff skills/capabilities

Factors Influencing Capital Programming (continued)

**Other**
- Current system conditions
- Degree of data and analysis tools available
- Balance between technical/political factors
- Economic and social factors
Characteristics of a Good Programming Process

- Clear connection to policy objectives
- Consistent criteria for
  - Identifying needs
  - Evaluating projects
  - Setting priorities
  - Monitoring performance
- Project evaluation
  - Feasibility/evaluation prior to funding commitment
  - Examination of alternatives
  - Consistent evaluation criteria across projects
- Program tradeoffs
- Performance monitoring
  - Program/project delivery
  - Program impact

Common Problems

- Lack of connection to policy direction
- Projects selected and programmed with poorly defined scope and budget
- Inadequate project development and change order controls
- Lack of consideration of program budget constraints during project design
- Lack of integration of capital and maintenance options
- No program performance monitoring and reporting
Condition Assessment and Needs

- Condition assessment
  - Basic engineering and service data necessary to evaluate facility condition
  - Structure and maintenance of facility data key issue and cost
  - New technology making task easier
  - Timing and allocation of inspection resources are important management decisions

Use of Needs Studies

- Define level of investment required to achieve some goal
- Guide allocation of resources to different
  - Jurisdictions
  - Facility classes or specific facilities
  - Types of improvement or maintenance
- Catalyst to improve resource allocation process
- Make the case for more funding
Definitions of Needs

Traditional approaches

- Uniform design/improvement standards
- Replacement cycle
- Extrapolation of past trends

Problems with Traditional Approach

- No policy choices
- No information on consequences of meeting or not meeting needs
- Often unrelated to what will be done with less than the “needed” resource level
- Define many projects that are not cost effective
- Little help in making tough priority decisions
Alternative Approaches

- Net social benefit
- Life-cycle cost
- Cost to meet alternative facility/service objectives or performance goals

Resource Allocation Process versus Needs Studies

- Defining needs and required resource levels are only part of resource management process
- Many needs should be met, but key issue is the effective use of whatever resources are available
- Must move beyond arbitrary needs definition to more creative public works management
Needs Study versus Investment Planning

Inventory and Condition Assessment

Identification of Specific Deficiencies

Alternative Funding and Policy Choices

Cost Estimates for Specific Improvements or Standards

Needs

Develop and Evaluate Alternative Programs and Projects

Recommended Funding Levels and Consequences

Levels of Analysis

- Project level
- Network or program level
Project Analysis

- Selection of best project design
- Selection of best timing
- For some facilities – best sequence of actions over life of the facility or planning period

A and B – Economically justified
B – Best alternative if no budget constraint
C – “Needs” alternative
Network Analysis

- Selection of best sites for some action
- Selection of best action at each site
- Selection of best timing for each action

Project Interdependencies

- Network effects
  - Impact and “value” of one project may be affected by other projects

- Budget constraint
  - Funding constraint creates interdependence among all investment options
  - Creating a program by selecting among the “best” project alternatives (designs) at each site typically will not maximize program benefits
Revisit Benefit Cost Analysis

- When programming and selecting project alternatives across multiple sites, selecting among the “best” alternative at each site generally will not maximize program benefits.

- Objective is to maximize NPV of the program.

Incremental Benefit-Cost Analysis at One Site

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>WC</td>
</tr>
<tr>
<td>X</td>
<td>XC</td>
</tr>
<tr>
<td>Y</td>
<td>YC</td>
</tr>
</tbody>
</table>

W, X, Y, Z are alternatives for the same project:
- W, X, Y justified
- X is best
Incremental Benefit-Cost Analysis Across Sites

Site 1

Benefits

Costs

B = C

Best alternative at each site X, B
Best program W, A (if budget = 3)

Impact of Budget Constraint

Sites

1 2 3 4

Budget

Constraint

Sites/Alternative Actions

Best Program

1 2 4
Priority Setting and Program Tradeoffs

Overview

Three levels of priority setting

• Relative merit of alternatives for a given need (project evaluation)
• Relative merit of projects with similar characteristics or objectives
• Tradeoffs in funding among programs with different objectives or characteristics

Levels of Priority Setting

Level 1 (Project Evaluation)

Relative Merits of Different Safety Alternatives at Site 1

Level 2 (Project Selection/Programming)

Best Set of Safety Projects (Alternatives and Sites) GIVEN different Budget Levels

Level 2 (Program Tradeoff)

Relative Merits of Different Congestion Relief Alternatives at Site 2

Best Set of Congestion Projects (Alternatives and Sites) GIVEN different Budget Levels

Appropriate Resource Allocation Between Safety and Congestion Programs
Priority Setting within a Program Category

Criteria
- Consistent measures of relative merit
- Capture key benefits and costs
- Quantitative and qualitative factors
- No one “score” or index
- Will vary by type of project

Priority Setting and Tradeoffs Between Programs

- Evaluation of benefits and costs of shifting funds between program categories
- Set final program budgets
- Examine implications of shifting funds (±10 percent) among key programs
Program Tradeoffs

<table>
<thead>
<tr>
<th>Program Funding Level ($)</th>
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<tbody>
<tr>
<td>Logan Airside</td>
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<td>Maritime</td>
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Option 1

<table>
<thead>
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<th>Program Funding Level ($)</th>
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<td>Logan Airside</td>
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</table>

Option 2

Benefits

- Investment Planning and Programming
- Technical Support Methods

- Incremental benefit-cost analysis
- Optimization techniques such as linear programming, integer programming, and dynamic programming (may be used with incremental B-C)
- Multi-criteria analysis
- Facility management systems (maintenance/preservation)
Examples

- GA DOT
- NYMTC

Georgia DOT

- Developing new programming approach to increase statewide consistency and reduce influence of purely political judgment
- Project priority criteria and weights given to each criterion vary by program category and goal and objective
- Decision support tool developed to rank projects and test sensitivity to various criteria and weights
- B/C is one factor in the array of priority criteria
## GA DOT Performance Measurement Framework

### SWTP Goals

<table>
<thead>
<tr>
<th>Program</th>
<th>Preservation</th>
<th>Safety</th>
<th>Congestion (70%)*</th>
<th>Connectivity Access and Mobility</th>
<th>Economic Growth</th>
<th>Benefit/Cost</th>
<th>Total Score</th>
<th>Other Factors</th>
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*Atlanta region only.

## GA DOT Proposed Performance Measures

### SWTP Goals

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<th>Benefit/Cost</th>
<th>Total Score</th>
<th>Other Factors</th>
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*Atlanta region only.
New York Metropolitan Transportation Commission

- Needed method to sort major regional projects into priority groupings and gain consensus of key stakeholders

- There were over 50 projects with a total cost in excess of $200 billion

- Various quantitative and qualitative information arrayed in a priority matrix

- Regional plan goals used as framework to define priority criteria

### New York Metropolitan Transportation Commission (continued)

<table>
<thead>
<tr>
<th>Project</th>
<th>Description Need</th>
<th>Cost</th>
<th>Improve Regional Economy</th>
<th>Enhance Environment</th>
<th>Improve Quality of Life</th>
<th>Flexible Transportation Access</th>
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<tbody>
<tr>
<td>Project A</td>
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<td>Access to growth areas</td>
<td>Air quality</td>
<td>Congestion</td>
<td>State of Good Repair</td>
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<td>Project B</td>
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<td>Freight mobility</td>
<td>Energy</td>
<td>Safety</td>
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<td>Project D</td>
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<td>Project E</td>
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<td>Project F</td>
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</table>
Case Study
Massachusetts Bridges

Objective – Massachusetts wants to reduce the number of Structurally Deficient (SD) bridges over time

Challenge – Which bridges to select and what work should be done?

Summary of Massachusetts Bridges

Massachusetts bridge counts
- 4,993 bridges
- 38,750,208 sq. ft.
- Approx 1% of the national total

Ownership
- 58% MHD owned
- 31% city/town owned
- 11% other (turnpike, Federal, parks)

Bridges included in the MHD analysis
- 4,444 MHD-managed bridges
  - 2,888 MHD-owned bridges
  - 7 state park-owned bridges
  - 1,549 town or city-owned bridges
Typical characteristics relative to the U.S. average

- Older (63% built before 1960 versus 41% nationally)
- More urban (69% urban versus 23% nationally)
- Greater use of steel (62% steel versus 33% nationally)

Conditions

- 12% considered structurally deficient by count
- 15% considered structurally deficient by area
- National average for structurally deficient bridges
  - 13% by count
  - 10% by area

### New England SD Bridges

<table>
<thead>
<tr>
<th>State</th>
<th>Count</th>
<th># SD</th>
<th>% SD by Count</th>
<th>Area</th>
<th>SD Area</th>
<th>% SD by Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Hampshire</td>
<td>2,352</td>
<td>367</td>
<td>16%</td>
<td>1,022,217</td>
<td>110,466</td>
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<tr>
<td>Connecticut</td>
<td>4,172</td>
<td>339</td>
<td>8%</td>
<td>3,191,168</td>
<td>365,736</td>
<td>11%</td>
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<tr>
<td>New Jersey</td>
<td>6,377</td>
<td>854</td>
<td>13%</td>
<td>6,231,036</td>
<td>720,024</td>
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<td>Maine</td>
<td>2,364</td>
<td>365</td>
<td>15%</td>
<td>1,156,411</td>
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<td>New York</td>
<td>17,382</td>
<td>2,234</td>
<td>13%</td>
<td>12,739,699</td>
<td>1,562,604</td>
<td>12%</td>
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<tr>
<td>Massachusetts</td>
<td>4,999</td>
<td>624</td>
<td>12%</td>
<td>3,621,109</td>
<td>539,565</td>
<td>15%</td>
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<tr>
<td>Vermont</td>
<td>2,686</td>
<td>491</td>
<td>18%</td>
<td>801,583</td>
<td>154,138</td>
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<tr>
<td>Pennsylvania</td>
<td>22,176</td>
<td>5,474</td>
<td>25%</td>
<td>11,920,729</td>
<td>2,494,519</td>
<td>21%</td>
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<td>Rhode Island</td>
<td>748</td>
<td>191</td>
<td>26%</td>
<td>734,109</td>
<td>292,184</td>
<td>40%</td>
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</table>

**TOTALS**

- 63,256
- 10,939
- 17%
- 41,326,061
- 6,377,663
- 15%
Needs Analysis Results

- A budget of approximately $200 million per year is required to maintain bridge conditions at current levels.
- An annual bridge budget of $150 million or less would result in a deterioration of bridge conditions by 2009.
- A budget of $85 million per year is expected to result in considerable worsening of conditions.
- Current replacement/rehab needs are $582 million and will increase substantially if left unaddressed.
Project Tradeoffs
Impact of Deferral

Bridge B0200518
- ST122 Worcester Road over the Prince River
- Length – 61 feet
- 2-lane bridge with AADT of 2,900 vehicles

Needed work – $235K
- Deck – $188K
- Girders – $26K
- Bearings – $9K
- Railings – $12K

Increase due to deferral – $408K

Impact of Deferral
Reducing the Number of SD Bridges
Short-Term and Long-Term

- MHD has a goal of reducing the number of SD bridges – a key component of the Fix It First program
- The bridge portfolio is continuing to deteriorate, new SD bridges are entering the SD list every year
- Need to balance resource allocation between fixing SD bridges today and preventing SD bridges in the future

Impact of Deterioration

![Impact of Deterioration Graph](image)
Balancing Preservation and Replacement Work

- Manage deterioration
- Reduce the number of SD bridges in the short term

### Current SD Bridges

<table>
<thead>
<tr>
<th>Year</th>
<th>Current SD Bridges</th>
</tr>
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<tbody>
<tr>
<td>2004</td>
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<tr>
<td>2005</td>
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<td>2007</td>
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<td>2008</td>
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<tr>
<td>2009</td>
<td></td>
</tr>
</tbody>
</table>

### SD Bridges in Future Due to Deterioration

<table>
<thead>
<tr>
<th>Year</th>
<th>SD Bridges in Future Due to Deterioration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
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<tr>
<td>2005</td>
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<td>2006</td>
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<td>2008</td>
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<td>2009</td>
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</table>

### Total Number of SD Bridges

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Number of SD Bridges</th>
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<tbody>
<tr>
<td>2004</td>
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<td>2008</td>
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<td>2009</td>
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</table>
MHD Bridge Programming

- Organize entire bridge program into rehabilitation/replacement work and preservation work
- Conduct annual long-term needs analysis review
- Establish budget targets by program area
- Prioritize projects under each program area
- Conduct tradeoff analysis across program categories to develop final bridge program
- Monitor program impacts

Results of Good Asset Management

- EOT and MHD able to make strategic decisions that are comprehensive, long-term, policy driven, performance-based
- Able to consider options and tradeoffs during policy making, planning, and programming activities
- Able to set performance goals and measure results
- Able to justify resource requests
Conclusions

- Effective programming process builds on strong project evaluation
- Wide-range of factors used to select projects
- Challenge to provide effective information on program and project tradeoffs
- Ultimate decisions on funding levels for various programs and projects selected in each program are key policy/political choices