Project Evaluation and Programming II
Programming

presented to
MIT 1.201 Class

presented by
Lance Neumann
Cambridge Systematics, Inc.

November 25, 2008

Transportation leadership you can trust.

CAMBRIDGE SYSTEMATICS

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**

CAMBRIDGE SYSTEMATICS

Outline (continued)

- Examples
- Case study
- Conclusions

2

CAMBRIDGE SYSTEMATICS

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

3

CAMBRIDGE SYSTEMATICS

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**

4

CAMBRIDGE SYSTEMATICS

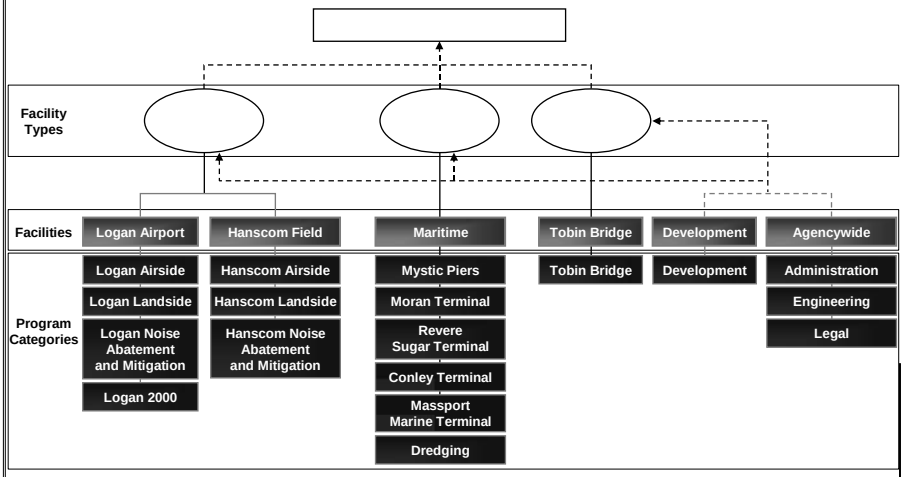
Program Structure (continued)

- **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**

5

CAMBRIDGE SYSTEMATICS

Example Capital Program Structure
Massport



6

CAMBRIDGE SYSTEMATICS

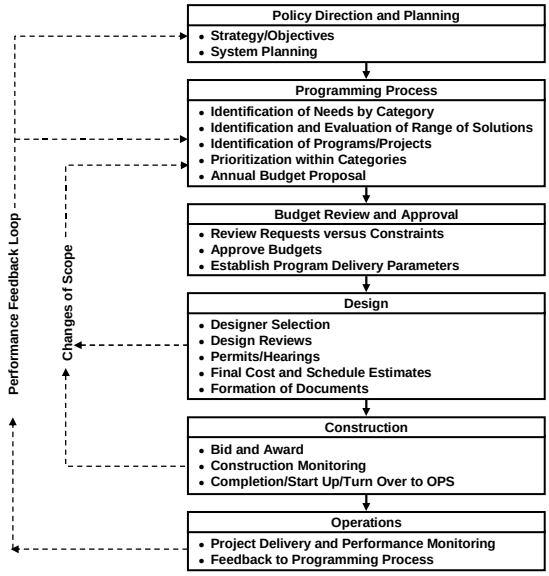
Investment Planning and Programming Framework

- Capital programming process
- Factors influencing programming
- Characteristics of a good programming process
- Common problems

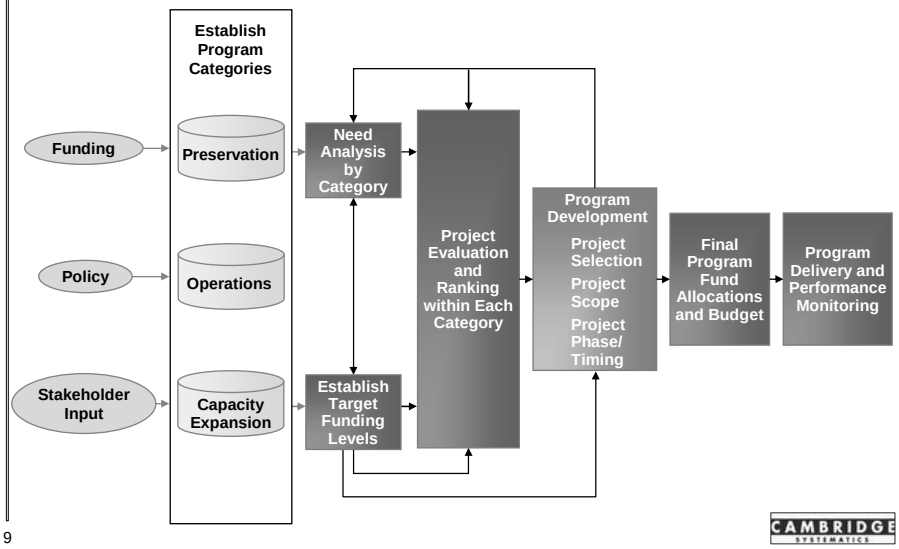
7

CAMBRIDGE SYSTEMATICS

Overview of The Capital Project Planning and Delivery Process



Capital Programming Process



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**

10

CAMBRIDGE SYSTEMATICS

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**

11

CAMBRIDGE SYSTEMATICS

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

CAMBRIDGE SYSTEMATICS

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

CAMBRIDGE SYSTEMATICS

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**

CAMBRIDGE SYSTEMATICS

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**

CAMBRIDGE SYSTEMATICS

Definitions of Needs

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

16

CAMBRIDGE SYSTEMATICS

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**

17

CAMBRIDGE SYSTEMATICS

Alternative Approaches

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

18

CAMBRIDGE SYSTEMATICS

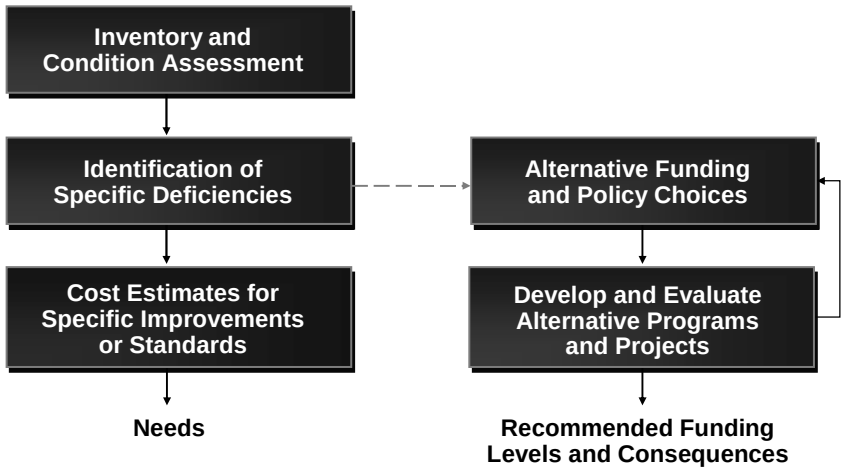
Resource Allocation Process versus Needs Studies

- **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**

19

CAMBRIDGE SYSTEMATICS

Needs Study versus Investment Planning



20

Levels of Analysis

- Project level
- Network or program level

21

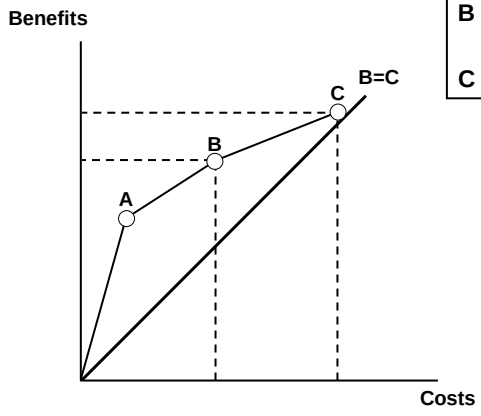
Project Analysis

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

22

CAMBRIDGE SYSTEMATICS

Project Analysis



A and B – Economically justified

B – Best alternative if no budget constraint

C – "Needs" alternative

23

CAMBRIDGE SYSTEMATICS

Network Analysis

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

CAMBRIDGE SYSTEMATICS

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

CAMBRIDGE SYSTEMATICS

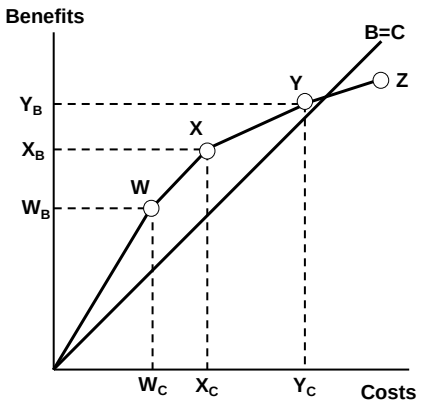
Revisit Benefit Cost Analysis

- 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

26

CAMBRIDGE SYSTEMATICS

Incremental Benefit-Cost Analysis at One Site



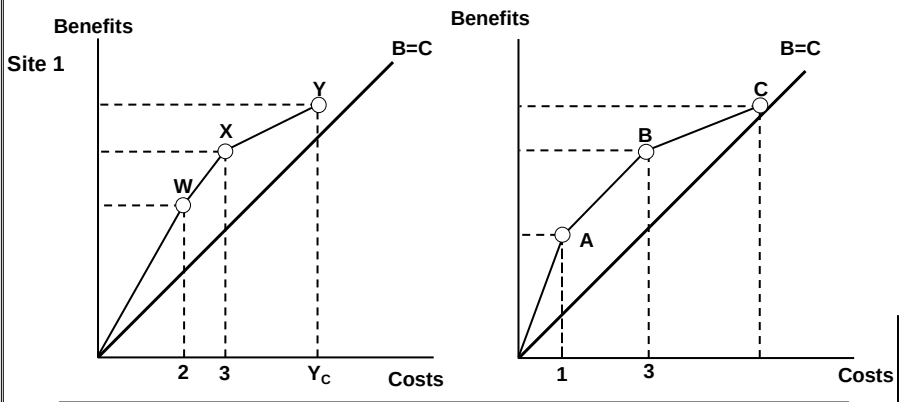
W, X, Y, Z are alternatives for the same project

- W, X, Y justified
- X is best

27

CAMBRIDGE SYSTEMATICS

Incremental Benefit-Cost Analysis Across Sites



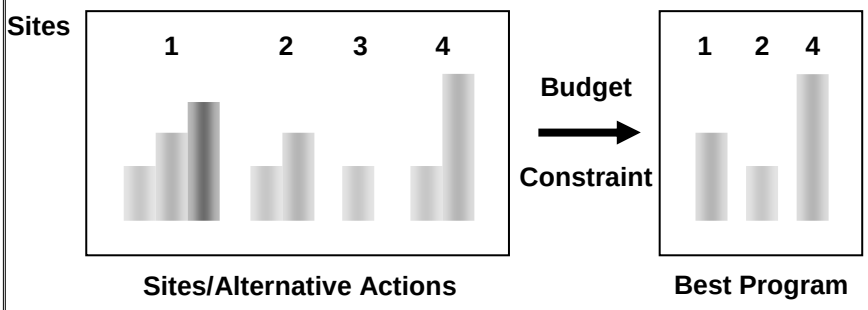
Best alternative at each site X, B

Best program W, A (if budget = 3)

CAMBRIDGE SYSTEMATICS

28

Impact of Budget Constraint



CAMBRIDGE SYSTEMATICS

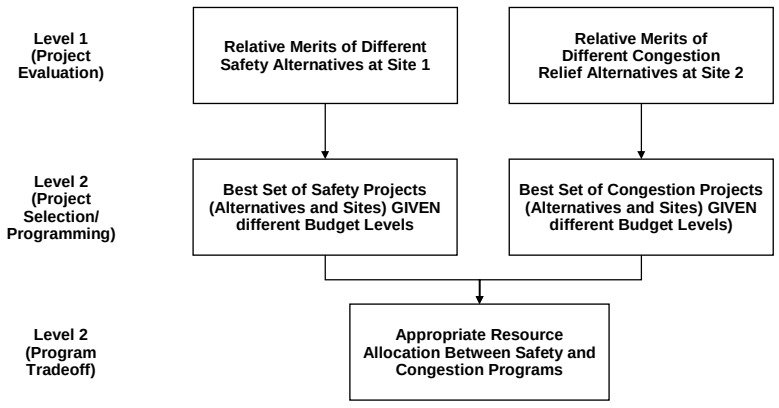
29

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**

30

Levels of Priority Setting



31

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**

32

CAMBRIDGE SYSTEMATICS

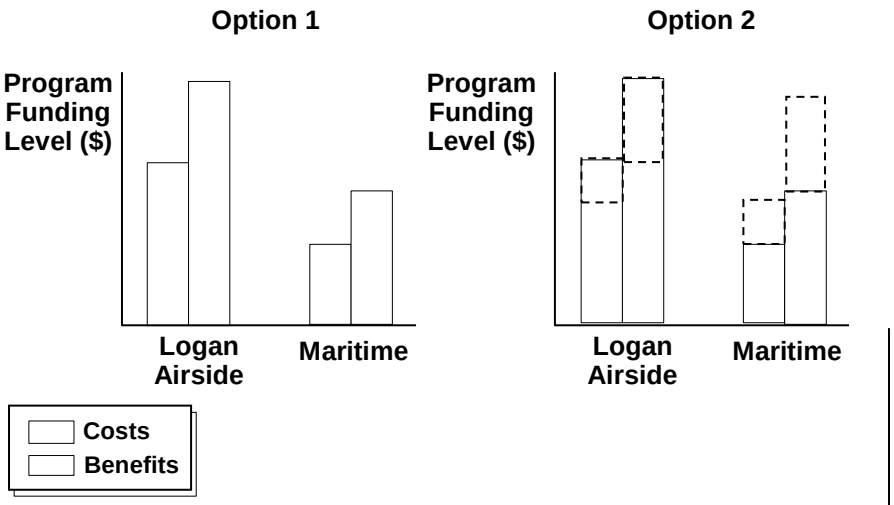
Priority Setting and Tradeoffs Between Programs

- **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**

33

CAMBRIDGE SYSTEMATICS

Program Tradeoffs



34

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)

35

Examples

- GA DOT
- NYMTC

CAMBRIDGE SYSTEMATICS

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

CAMBRIDGE SYSTEMATICS

GA DOT Performance Measurement Framework

	SWTP Goals							
Program	Preservation	Safety	Congestion (70%)*	Connectivity Access and Mobility	Economic Growth	Benefit/ Cost	Total Score	Other Factors
Roadway Capital Maintenance	Primary	Secondary						
Roadway New Capacity	Secondary	Secondary	Primary	Primary	Secondary			
Roadway Traffic Operations		Secondary	Primary					
Roadway Safety		Primary	Secondary					
Transit			Primary		Primary			
Intermodal				Primary				
Demand Management			Primary		Primary			
Economic Development					Primary			
Enhancement				Primary				

Atlanta region only.

38

CAMBRIDGE SYSTEMATICS

GA DOT Proposed Performance Measures

	SWTP Goals							
Program	Preservation	Safety	Congestion (70%)*	Connectivity Access and Mobility	Economic Growth	Benefit/ Cost	Total Score	Other Factors
Roadway Capital Maintenance								
Roadway New Capacity	1. SD 2. PACES	3. Crash Reduction (by severity)	4. Delay Reduction	5. Travel Time: Truck Route/ IM Conn./STRAHNET 6. Activity Center 7. Land Use Plan 8. Access Mgmt.	9. GSP 10. Economic Development Policy Area	B/C		Deliverability, Funding Sources, Readiness, etc.
Roadway Traffic Operations		1. Crash Reduction (by severity)	2. Delay Reduction	3. Travel Time: Truck Route/ IM Conn./STRAHNET 4. Activity Center	5. GSP 6. Economic Development Policy Area	B/C		Deliverability, Funding Sources, Readiness, etc.
Roadway Safety								
Transit								
Intermodal								
Demand Management								
Economic Development	1. SD 2. PACES	3. Crash Reduction (by severity)	4. Delay Reduction	5. Travel Time: Truck Route/ IM Conn./STRAHNET 6. Activity Center 7. Land Use Plan 8. Access Mgmt.	9. GSP 10. Economic Development Policy Area	B/C		Deliverability, Funding Sources, Readiness, etc.
Enhancement								

39 * Atlanta region only.

CAMBRIDGE SYSTEMATICS

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

CAMBRIDGE SYSTEMATICS

New York Metropolitan Transportation Commission (continued)

Project	Description Need	Cost	Improve Regional Economy • Access to growth areas • Freight mobility	Enhance Environment • Air quality • Energy • Land use	Improve Quality of Life • Congestion • Safety	Flexible Transportation Access • State of Good Repair • Travel choices
Project A						
Project B						
Project C						
Project D						
Project E						
Project F						

CAMBRIDGE SYSTEMATICS

Case Study
Massachusetts Bridges

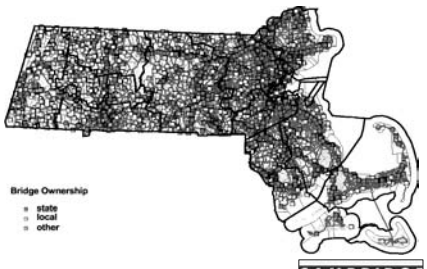
- **Objective – Massachusetts wants to reduce the number of Structurally Deficient (SD) bridges over time**
- **Challenge – Which bridges to select and what work should be done?**

42

CAMBRIDGE SYSTEMATICS

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**



43

CAMBRIDGE SYSTEMATICS

Current State of Massachusetts Bridges (continued)

- **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**

44

CAMBRIDGE SYSTEMATICS

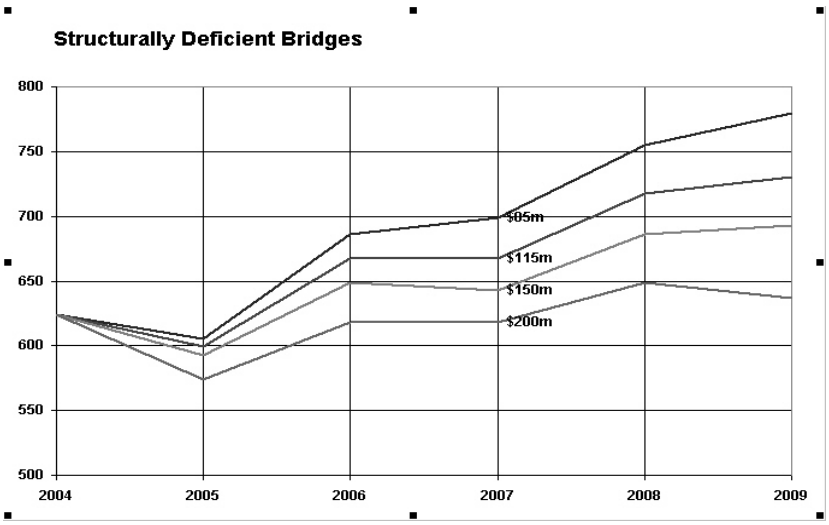
New England SD Bridges

	Count	# SD	% SD by Count	Area	SD Area	% SD by Area
NEW HAMPSHIRE	2,352	367	16%	1,022,217	110,466	11%
CONNECTICUT	4,172	339	8%	3,191,168	365,736	11%
NEW JERSEY	6,377	854	13%	6,231,036	720,024	12%
MAINE	2,364	365	15%	1,156,411	138,427	12%
NEW YORK	17,382	2,234	13%	12,739,699	1,562,604	12%
MASSACHUSETTS	4,999	624	12%	3,621,109	539,565	15%
VERMONT	2,686	491	18%	801,583	154,138	19%
PENNSYLVANIA	22,176	5,474	25%	11,828,729	2,494,519	21%
RHODE ISLAND	748	191	26%	734,109	292,184	40%
TOTALS	63 256	10 939	17%	41 326 061	6 377 663	15%

45

CAMBRIDGE SYSTEMATICS

Deficient Bridges versus Budget Forecast
Final Results from the Pontis® Model



46

CAMBRIDGE SYSTEMATICS

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**

47

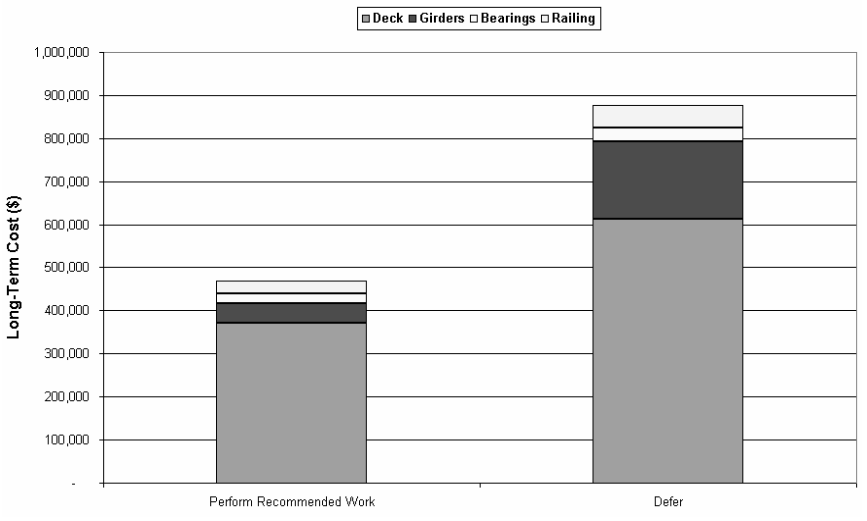
CAMBRIDGE SYSTEMATICS

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**

48

Impact of Deferral



49

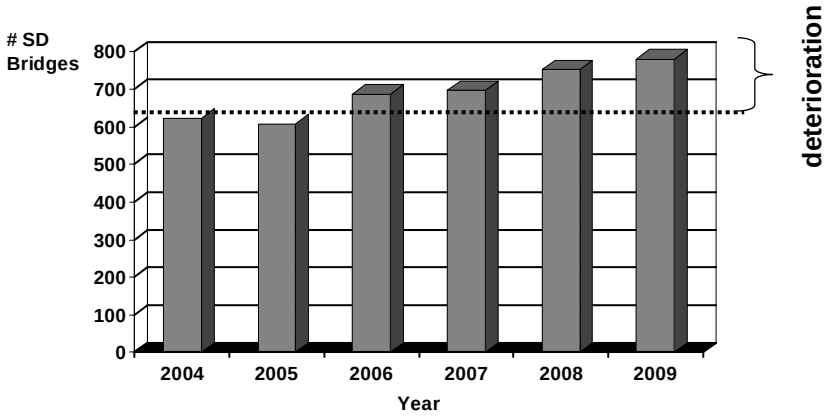
Reducing the Number of SD Bridges Short-Term and Long-Term

- 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

50

CAMBRIDGE SYSTEMATICS

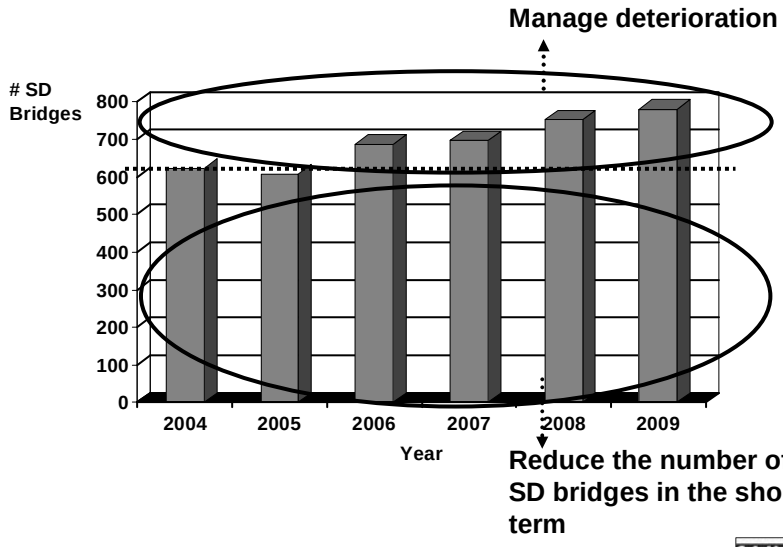
Impact of Deterioration



51

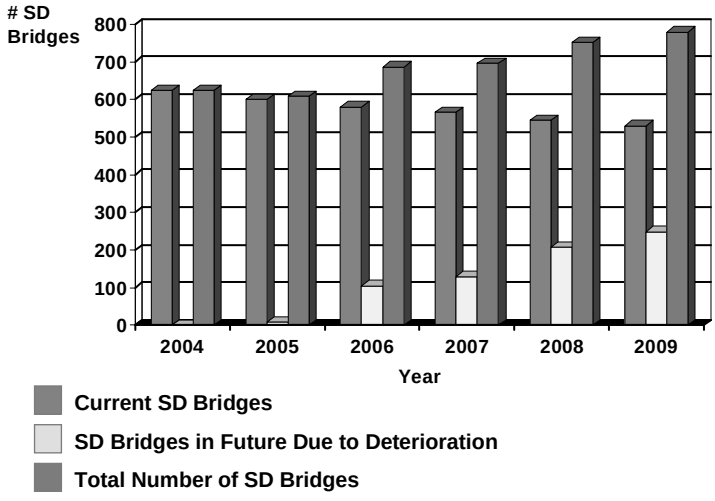
CAMBRIDGE SYSTEMATICS

Balancing Preservation and Replacement Work



52

Balancing Preservation and Replacement Work



53

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

54

CAMBRIDGE SYSTEMATICS

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

55

CAMBRIDGE SYSTEMATICS

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

CAMBRIDGE SYSTEMATICS

1.201J / 11.545J / ESD.210J Transportation Systems Analysis: Demand and Economics
Fall 2008